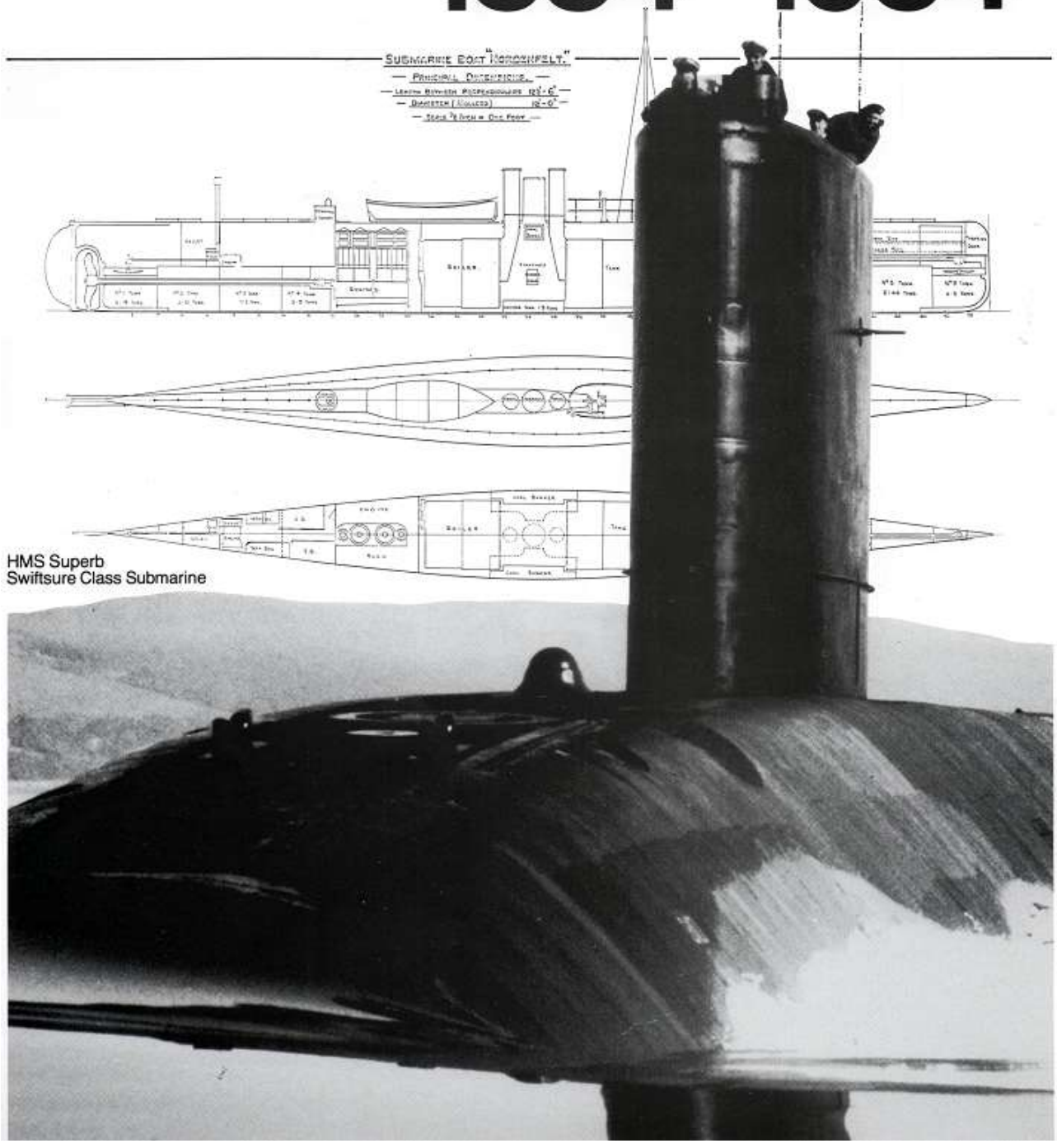
VSEL

Vickers Shipbuilding and Engineering Limited

A subsidiary of British Shipbuilders

SUBMARINE BUILDERS 1884~1984



HMS Superb
Swiftsure Class Submarine

Through the 20th Century and into the 21st

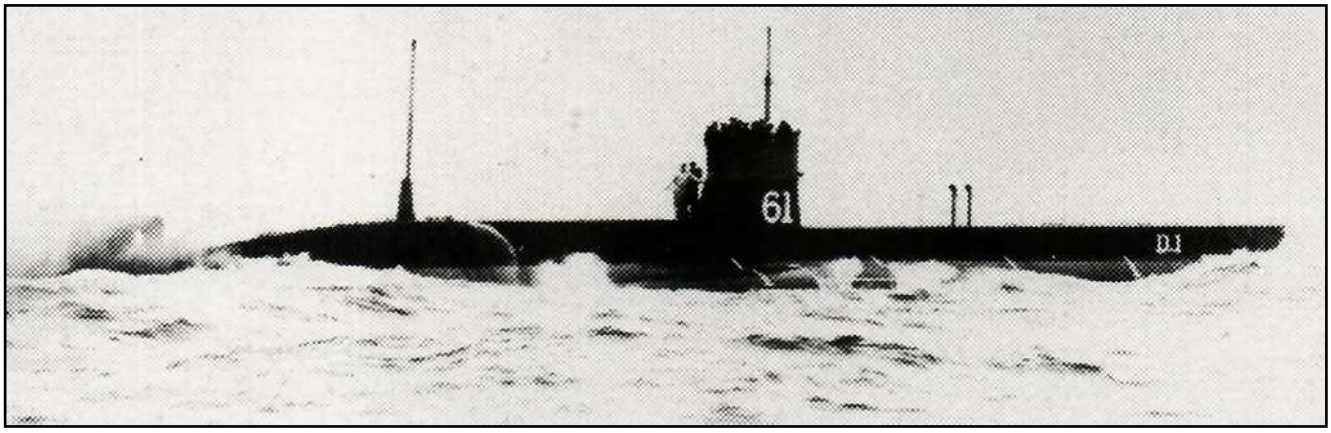
In 1884, Thorsten Nordenfelt, a Swedish industrialist and international arms supplier, sought the help of Barrow Shipbuilding Company to build an improved version of his first submarine design and construction which led to the Royal Navy's first submarine – Holland No.1 – in 1901.

Some examples of Vickers' continuous association with the Royal Navy since that date are illustrated in this leaflet

Holland Class

HM Submarine No.1, built by Vickers, was launched at Barrow on 1st October, 1901, the first of five ordered by the Admiralty. Only 63 feet long, with a displacement of 120 tons, she carried two officers and seven ratings. She had one propeller, driven by a four cylinder petrol engine when surfaced and by an electric motor when submerged. She achieved speeds of 8 knots on the surface and 6 knots submerged and could dive to 100 feet. Despite early problems with this class, sufficient success was achieved for the Royal Navy to proceed with improved submarine designs.

D Class 1908



With the D Class submarine design took a large leap forward, both in capability and size. These submarines, with their large conning towers, were the first to have saddle tanks instead of internal ballast tanks. The 'D' boats were a real improvement in all respects, being the first submarines with a proper patrol capability.

K Class 1915

The evolution of such a radically new weapon as the submarine inevitably led to some 'hybrid' designs. The K Class were designed to work with the main battle fleet at surface speeds of 24 knots.

They were large, powerful boats driven by steam turbines. They had two oil fired boilers, each with a funnel which had to be folded down into a watertight well. They could dive faster than any previous steam submarine, but the delay caused by shutting down the boilers and sealing off the funnels was still impossibly long. With long hulls and poor longitudinal stability they proved dangerous and difficult to handle and were eventually scrapped. Later submarines reverted to the conventional diesel-electric system.

H & L Classes 1916-1918

A transitional design in the development of the submarine, the later H Classes were the first to be fully armed with 21-inch torpedoes. They had a surface range of 1600 miles at 10 knots. The L Class had a submerged displacement of 1055 tons and a surface range of 2800 miles at 10 knots.

T Class 1937

Between 1937-45, Vickers built 29 of these splendid submarines which proved to be far more reliable than the preceding 'O', 'P' and 'R' Classes. The enclosed 4-inch gun provided a relatively stable platform for surface action and the bow salvo of ten torpedo tubes was the largest in any submarine. Later T Class submarines were fitted with stern tubes, air and surface warning radar sets and shortly after the war, with snort masts

A Class 1945

Patrol submarines with a submerged displacement of 1620 tons, this class was designed primarily for service in the Pacific, hence the high surface speed of 18 knots. They were the first RN submarines to be fitted with snort masts. They had air conditioning and a radius of action of 10000 miles.

500 Class

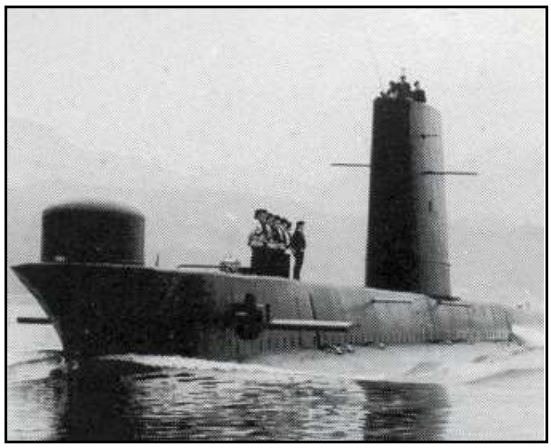
One of the Vickers fleet of privately designed submarines. The 500 Class patrol submarine, designed in association with IKL, has been developed to meet the needs of navies requiring coastal and medium-range patrols. The class has been operational overseas for several years.

Other current designs include the 150-tonne Piranha Class, the 550 Class, 1100 Class and the new type 2400. Customers can choose from the Vickers fleet a submarine best suited to their operational requirements.

Dreadnought 1960

On Trafalgar Day 1960, Vickers entered the nuclear era when HMS Dreadnought was launched at Barrow by HM Queen Elizabeth II. Dreadnought was Britain's first nuclear submarine and was constructed in collaboration with Rolls Royce & Associates Ltd, using an American reactor. Two of Britain's four nuclear-powered ballistic missile submarines, Resolution and Repulse, were built by Vickers between 1964 and 1968.

Oberon Class 1961

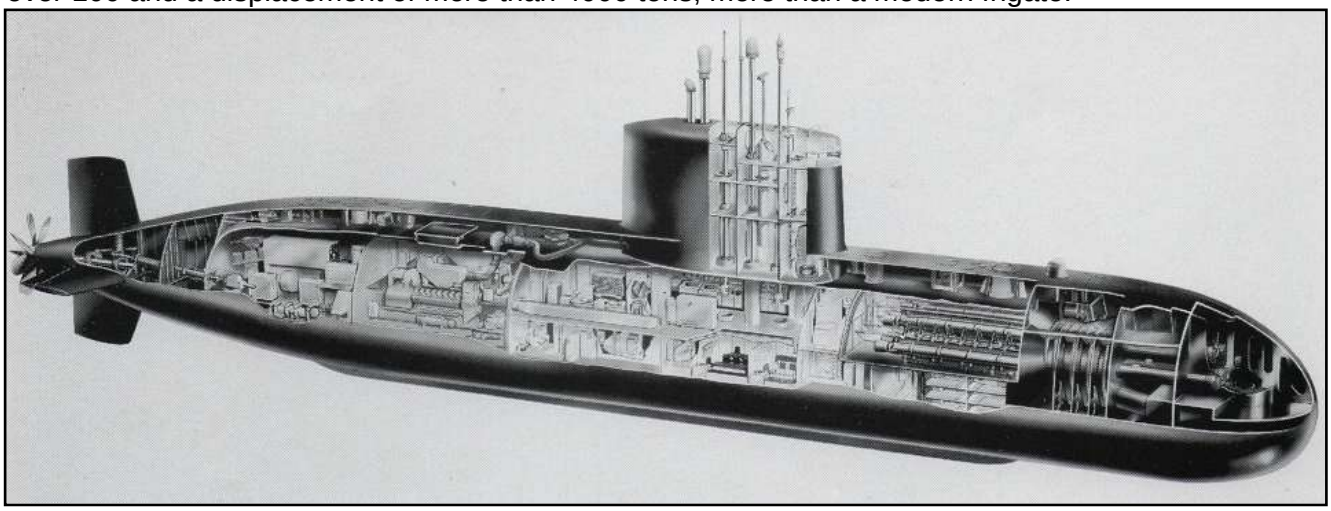


The Oberon Class, a development of the Porpoise Class, are probably the best diesel engined boats to enter operational service. They are outstanding boats in every respect and have an enviable reputation for performance and efficiency.

Valiant, Churchill, Swiftsure and Trafalgar Classes 1963

Vickers are now sole builders of the Royal Navy's nuclear-powered fleet submarines, all of which have evolved from the Dreadnought prototype: the Valiant Class, followed by the Churchill and Swiftsure Classes and now the Trafalgar Class. The latest edition to Britain's nuclear-powered submarine fleet, the first-of-class Trafalgar, was commissioned on 27th May, 1983.

Nuclear-powered fleet submarines have become the modern capital ships of the high seas, the main striking power of the fleet and the most effective weapons available against other submarines. Fitted with computer-assisted sensors and the latest torpedoes, they can silently shadow a target for long periods at high speed, while hundreds of feet below the surface. They have a crew of over 100 and a displacement of more than 4000 tons, more than a modern frigate.



Vickers Shipbuilding and Engineering Limited have over a century of experience in the design and construction of submarines – some 320, mainly, but not exclusively, for the Royal Navy. This expertise has been incorporated into the design of the Type 2400 submarine – a natural successor to the Oberon Class. The 2400 represents an extension of technology derived from the nuclear submarine programme into the design and construction of conventionally-powered submarines. VSEL has worked closely with the Royal Navy in producing the design, which recognizes the important role still to be played by diesel-electric submarines. The Type 2400 will have a submerged displacement of 2400 tonnes and will be capable of a submerged speed of over 20 knots. Within the geometric confines of the hull, the design is adaptable and can accept a wide variety of weapons fits, fire control systems and communications equipments, with some variations in crew numbers and endurance. The 2400 provides 28 days patrol endurance after a transit of over 2500 nautical miles at normal cruising speeds. The large battery capacity, supported by a comprehensive air purification regeneration system, permits submerged periods of several days at a time.

How They Have Grown

In 1901 Vickers, Sons and Maxim built their first submarine for the Royal Navy – Holland 1. Eighty years later, Vickers' 293rd Royal Navy submarine – HMS Splendid – was commissioned. Comparing the two vessels, it is plain to see why that 'damned un-English weapon' has developed into the main striking power of the fleet.

Underhand, unfair and 'damned un-English' was the popular view in the country when, on 2nd October, 1901, the Royal Navy's Submarine Service came into being with the launch of HM

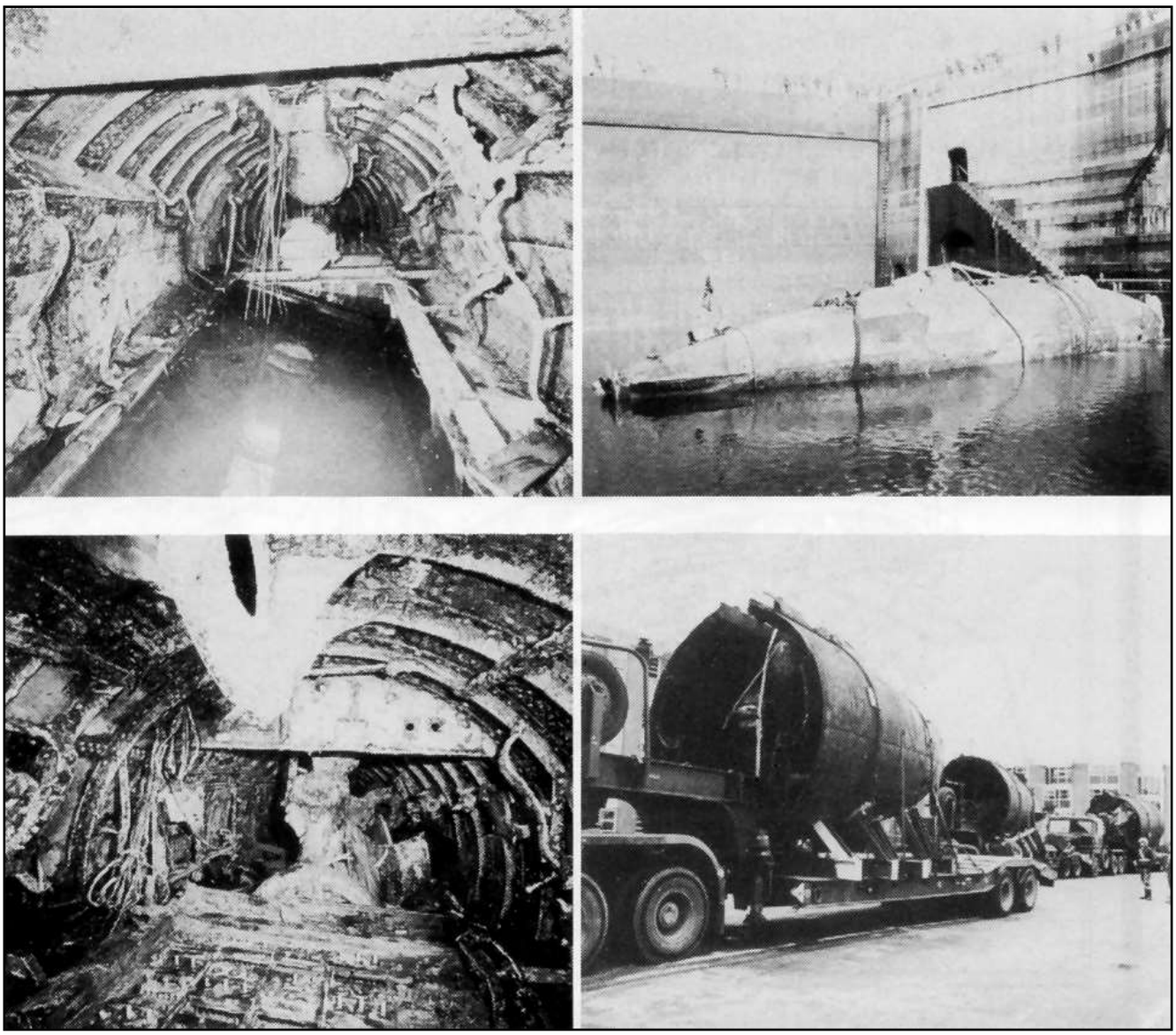
Submarine No. 1. Such was the low regard for the submarine as a practical weapon that the 'Naval and Military Record' stated:

'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 every privacy'.

There were many setbacks in the early days and tragic losses. But steadily the Royal Navy's confidence, experience and knowledge grew and by 1914 the submarine service was formidable, effective and efficient.

In the quest for speed, endurance and fighting efficiency many submarines were fitted with a vast array of additional contraptions and appendages. Some were fitted with funnels and looked like small destroyers; one was given a huge hangar complete with aircraft; another was equipped with a massive 12-inch gun turret. In short, the Royal navy spent considerable effort making the submarine more effective as a surface vessel, using its submersible capability mainly to transit secretly.

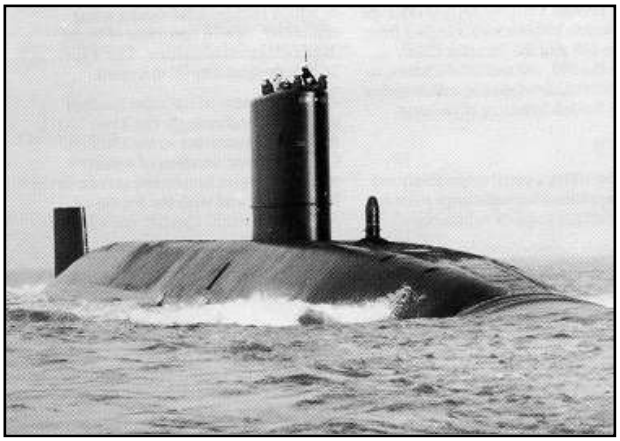
Only after the Second World War were concentrated efforts made to fit the submarine for its true role - to operate continuously beneath the waves. A variety of experiments were carried out; one result was the snort mast – yet another piece of strange equipment, but one which gave the submarine enormously increased submerged endurance.



After 70 years on the seabed, Holland 1 shows herself to the world. Her final resting place is at the Royal Navy Submarine Museum at HMS Dolphin in Gosport

	HOLLAND I	HMS SPLENDID
Length overall	63ft 10in	272ft
Breadth	11ft 10in	32ft 3in
Displacement,		
surface	113 tons	3500 tons
submerged	122 tons	4500 tons
Diving depth	100 feet	In excess of 1000 feet
Speed,		
surface	7.4 knots	In excess of 25 knots
submerged	6 knots	30 knots
Armament	One 18-inch bow tube (3 torpedoes carried)	Five 21-inch bow tubes (25 torpedoes carried)
Main Machinery	One 160hp petrol engine One 74hp main motor	One nuclear pressurized water-cooled reactor providing steam for geared turbines.
Complement,		
design	8	97

1901 - Holland to 1983 - Trafalgar



Eventually the era of nuclear propulsion dawned, which at last freed the submarine from any dependence on the earth's natural atmosphere. Total undetectability became a reality.

Thus, from the undistinguished beginnings of the Holland Class 'submersibles', which had a submerged endurance of only 20 miles at 5 knots, the Royal Navy now has true submarines – vessels which can circumnavigate the globe without surfacing. It is these fleet submarines that are proof of the faith John P Holland and his contemporaries had in the potential of the submarine – although even their expectations could never have envisaged such advanced technology beneath the waves.

It has never been consistent with the principles of Vickers or the Royal Navy to rest content with past or present-day successes. Forward thinking and design are constantly in hand by both partners. What role can Vickers play in the design and construction of future submarines?

Despite the success of the nuclear submarine, particularly in long-range, deep-water roles, there is still a considerable demand for diesel-electric submarines: nuclear submarines are too large

and costly to risk by using them in shallow or restricted waters and they are of course, an unrealistic proposition for many maritime nations.

Vickers Private Venture designs offer six diesel-electric submarines, ranging from the Type 100 and the Piranha Class, through the 500, 550 and 1100 Classes, to the Type 2400, developed in collaboration with the British Ministry of Defence.

TYPE 100

The Type 100 is a small torpedo-armed vessel capable of limited-range patrols against surface ships or submarines

PIRANHA

Piranha is a small surveillance/attack vessel, with good tactical range and relatively high transit speed. The main armament is mines or two two-man chariots armed with mines and limpet mines. The chariots can be launched and recovered while Piranha remains fully submerged. Combat swimmers and chariot operators are released and recovered through a diver lock-out chamber

500 CLASS

The 500 Class is a relatively small submarine, developed for coastal and medium-range patrols.

550 CLASS

The 550 Class is an up-to-date ocean going submarine, capable of carrying out coastal and medium range patrols. It can accept a weapon and sensor fit normally associated with larger ocean patrol submarines.

1100 CLASS

With a design compliment of 32 men, the 1100 Class is a medium sized vessel intended for ocean-going patrols.

TYPE 2400

Market assessments indicate that countries with long coastlines to defend, or which require a full ocean-going capability, need a new class of larger diesel-electric submarines. The Type 2400 is designed to fill this need.

A development of the most modern submarine technology, the Type 2400 is a natural successor to the Oberon Class, updated versions of which continue to give invaluable service in the Royal Navy and with the Navies of Australia, Brazil, Canada and Chile.

‘BARROW BUILT’

This pictorial history is dedicated to employees past and present whose skills and efforts have given pride to the phrase ‘Barrow built’ and made the name Vickers known and respected throughout the world

Vickers and Barrow are names synonymous with the development of the submarine. Three hundred and twenty submarines covering virtually every class have been built for the Royal Navy and foreign Navies.

Up to 1900, the British Admiralty had stolidly to have anything to do with submarines, considering them to have a defensive role only for the weaker maritime nations and to be a ‘damned un-English weapon’. But the fact that the French were rapidly building up a submarine fleet, undoubtedly helped persuade them to ‘test the value of the submarine boat as a weapon in the hands of our enemies’.

Accordingly, five submarines were ordered, to be built at Barrow by Vickers, Sons and Maxim, under licence from the Holland Torpedo Boat Company of America (later to become the Electric Boat Company).

The founder of the Holland Torpedo Boat Company was John P Holland, an Irish emigrant to America. He had long had an interest in submarines – seeing them as means of demoralizing, or even destroying the English Fleet. His first submarine design was for a one-man boat, 16 feet long, the propeller being mechanically driven by the occupant. But the later development, Holland No. 1 was fitted with a 4hp Brayton petrol engine.

By 1893, development of the working submarine was well advanced and the US Naval Board recognized that there was a place for the submarine in naval warfare and laid down a set of requirements for naval submarines.

These requirements were met by a boat of Holland’s design and in 1895 he was awarded a contract to build a submarine boat for the US Government.

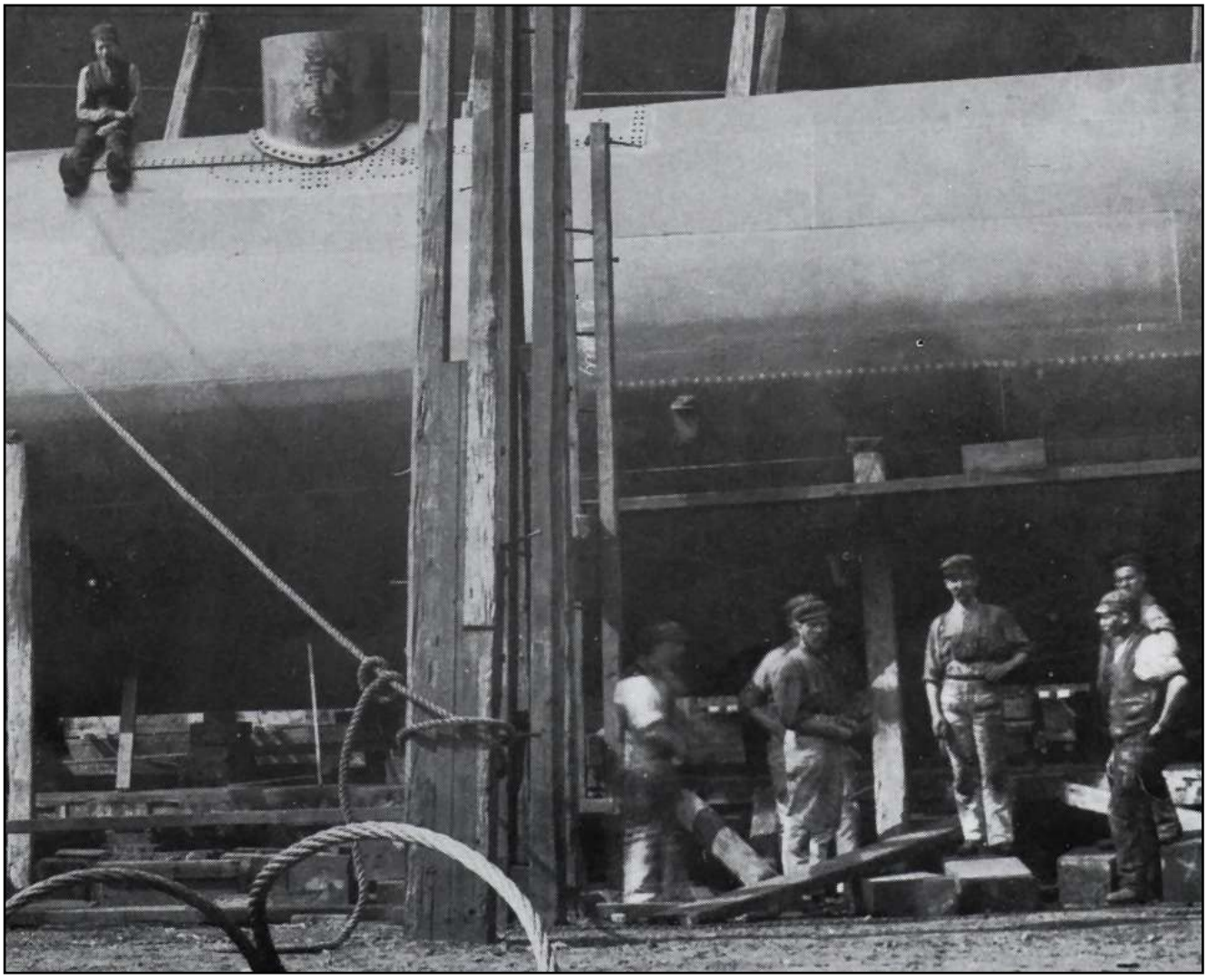
Development proceeded rapidly from here and the design destined to become the Royal Navy’s Holland No. 1 was, it is thought, America’s Holland Number 10 – known as the Adder Class.

Working drawings supplied to Vickers had many discrepancies and in some particulars were obviously incorrect. But building went on to these plans, and it was only after the boat almost turned on end during dock trials that Vickers were allowed to make modifications. The problems were due, in part, to the difficulties of communications with the Holland Boat Company and the fact that the construction of the RN Holland 1 was ahead of the prototype Adder Class – the drawings had not been proved.

In the American design no periscope was fitted; the only way to see was to look through a scuttle in the conning tower. A periscope of British design was fitted to one of the Hollands. This was a hinged periscope, raised and lowered on a ball and socket joint in the hull. The target was only upright when ahead; when abeam it was on its side; when astern it was upside down.

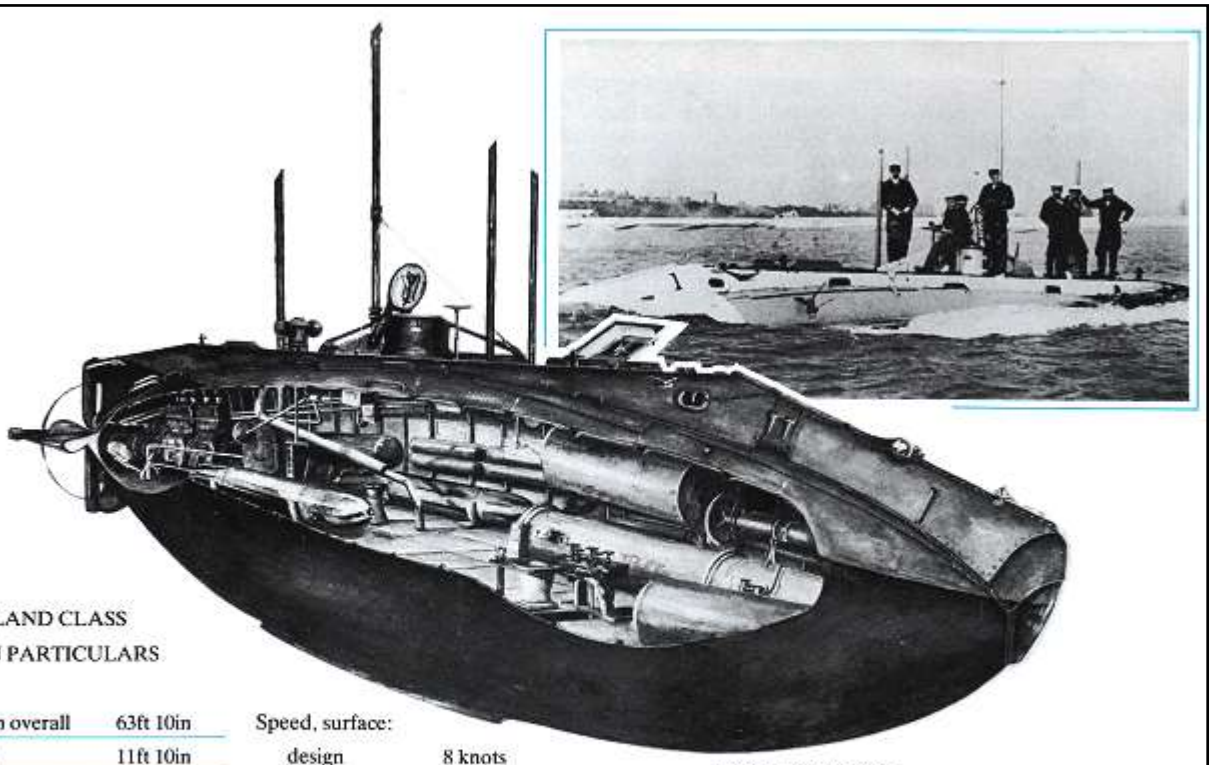
During the Holland construction programme, association with the Electric Boat Company was severed and Vickers seriously began the task of designing submarines themselves. It is interesting to note that Vickers association with the Electric Boat Company was renewed in the 1960's, with the construction of Britain's first nuclear-powered submarine HMS Dreadnought.

The five Holland Class were completed by mid-1903 at a cost of £35000 each. Although they were poor sea boats and could dive to only 100 feet, they were sufficiently successful to convince the Admiralty to continue the development of the submarine.



Although the Hollands were the first submarines for the Royal Navy, the first Barrow-built submarine was the Nordenfelt built in 1886 on the instruction of Thorsten Nordenfelt, a Swedish industrialist and arms dealer.

Hollands 1 to 3 were sold to T W Ward for breaking up in 1913, but Holland 1 foundered off the Eddystone Lighthouse, while on tow. Holland 4 was deliberately sunk by gunfire during experiments in October 1912 and Holland 5 sank while on tow from Portsmouth to Sheerness. Incredibly, in April 1981, the wreck of Holland 1 was found, she has been raised and takes her place alongside HMS Alliance at the submarine museum at Gosport.



HOLLAND CLASS
MAIN PARTICULARS

Length overall	63ft 10in
Beam	11ft 10in
Depth,	
pressure hull	11ft 10in
Displacement,	
surface	113 tons
submerged	122 tons
Diving Depth	100 feet

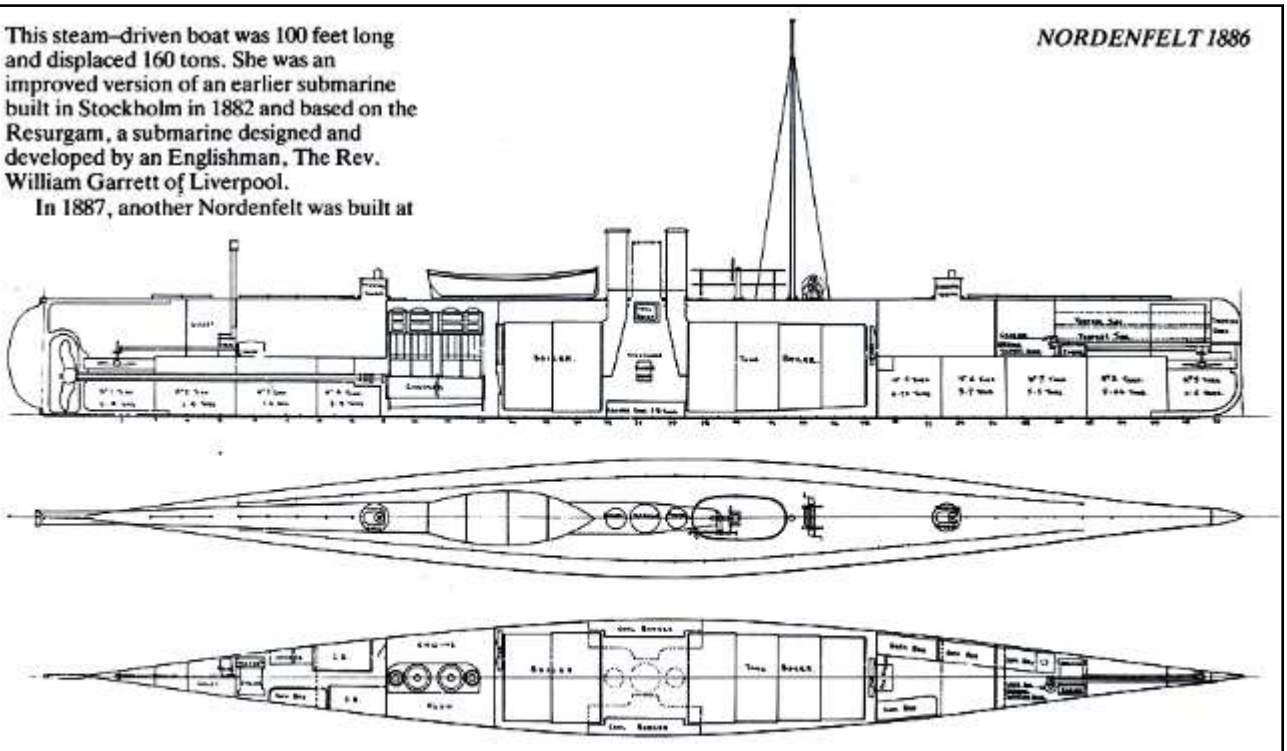
Speed, surface:	
design	8 knots
service	7.4 knots
submerged:	
design	7 knots
service	6 knots
No. of shafts	1
Propeller	1, three blades, 6ft diameter

Endurance, surface:	
design	355 miles (max)
service	235 miles (max)
submerged:	20 miles at 5 knots
Armament:	1 18 inch bow torpedo tube (three torpedoes carried)

NORDENFELT 1886

This steam–driven boat was 100 feet long and displaced 160 tons. She was an improved version of an earlier submarine built in Stockholm in 1882 and based on the Resurgam, a submarine designed and developed by an Englishman, The Rev. William Garrett of Liverpool.

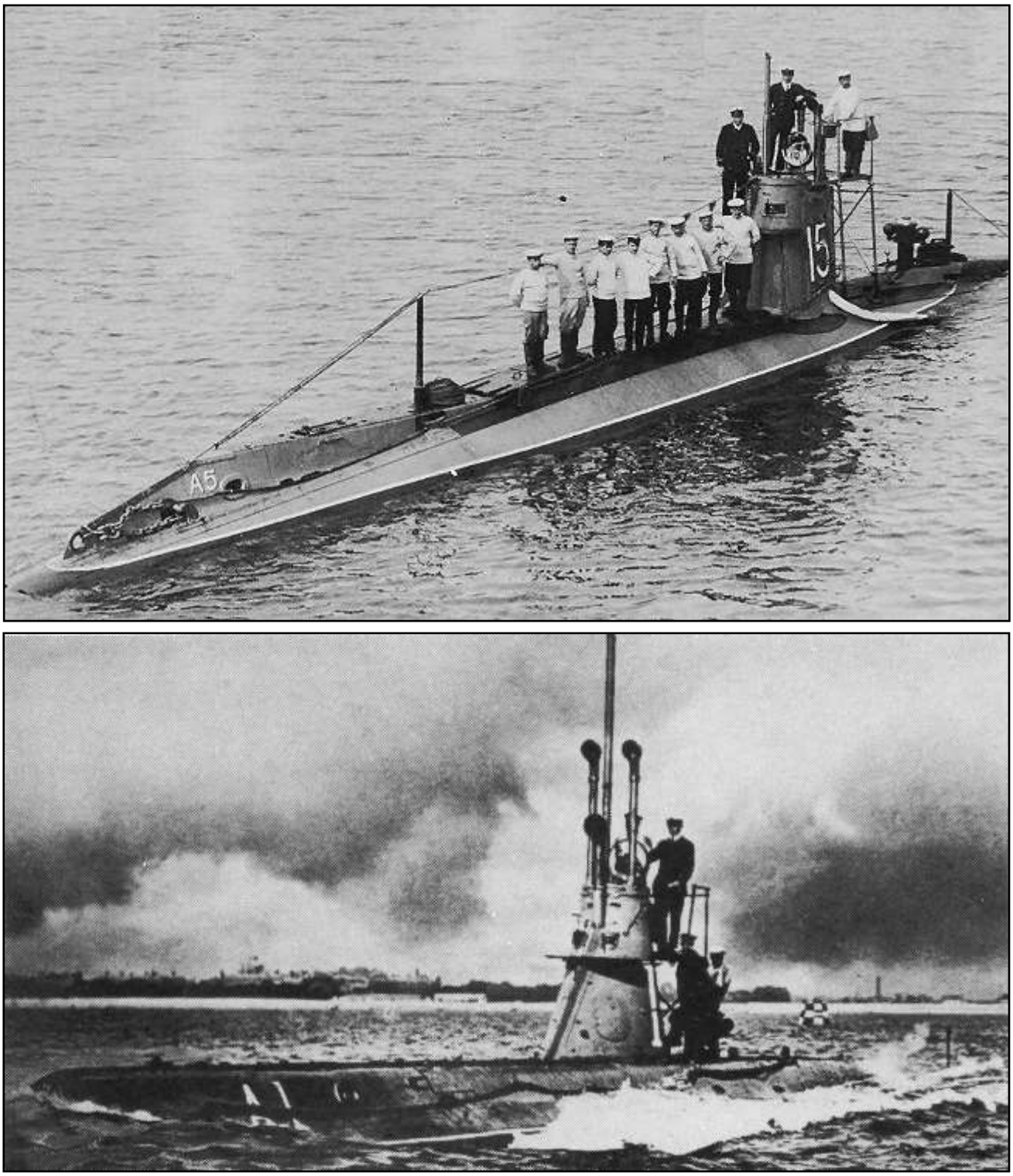
In 1887, another Nordenfelt was built at Barrow. This vessel was 125ft long, displaced 230 tons, had a hull form more like that of a conventional ship, and achieved a speed of 14 knots.



The Nordenfelts were not particularly successful. When operating near the surface they were fast and manageable, but when completely submerged they lacked longitudinal stability. The first was sold to Turkey but never entered service: the second sank on her delivery trip to Russia.

However, when the advent of nuclear power put steam propulsion back into submarines, Vickers could surely reflect: 'So what's new? We did it in 1886.'

1902-1910 A, B and C CLASS SUBMARINES



Top A5 1904-1916 and below the ill fated A1

These were designed for coastal defence work and had a limited range. They became known in Naval Circles as 'Fisher's Toys' a reference to Admiral Sir John Fisher who was a keen advocate of the submarine as a weapon of war.

Even before trials, it was apparent that the Holland boats would have limited speed and endurance on the surface and, as a result – which highlighted the changing attitude within the Admiralty – a larger submarine was ordered with the hope of overcoming these problems.

This, the submarine A1, although based on the Holland Class was of all British design (Capt Bacon, Inspecting Captain of Submarines and Vickers, Sons and Maxim). She was 40feet longer than the Hollands and at 207 tons, of about two-thirds more displacement. Power was also increased.

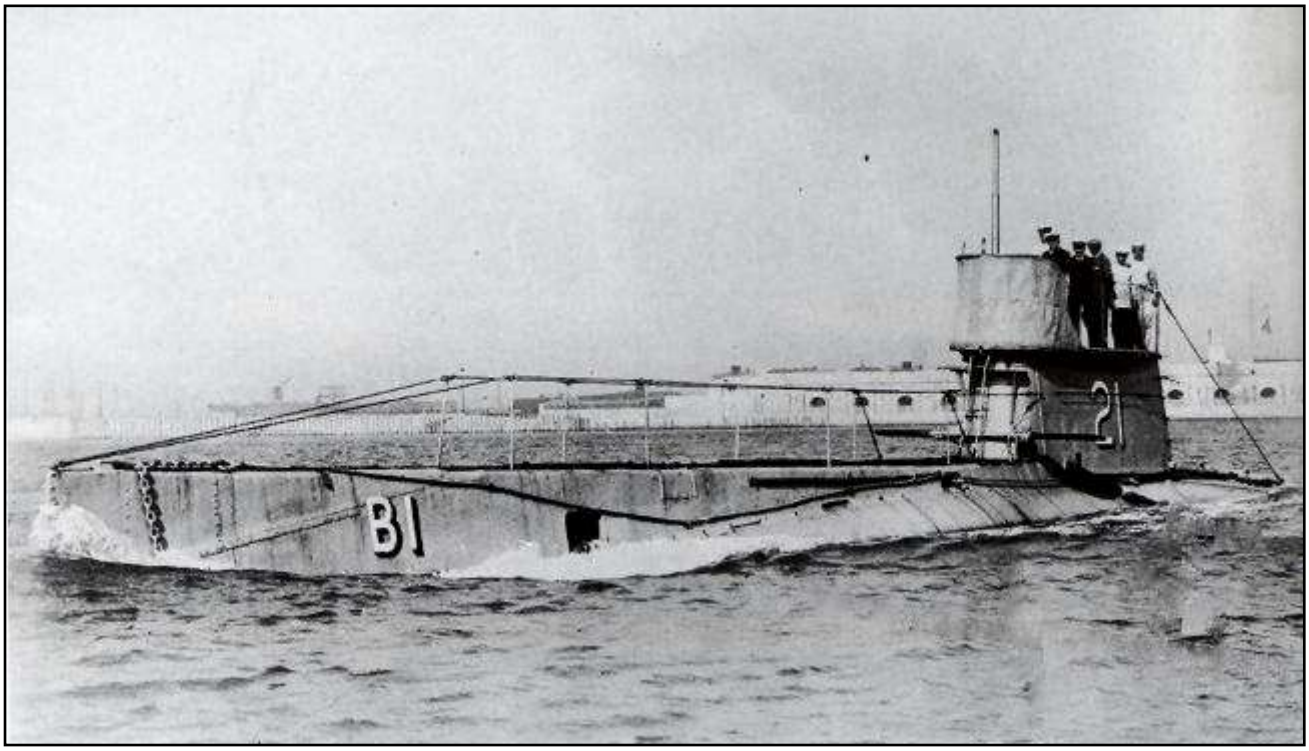
Laid down in 1902, she was the first of a class of thirteen, all completed at Barrow between 1903 and 1905, except for A13 which was an experimental craft, fitted with diesel engines instead of petrol engines, which was completed in 1908.

The hoped for improvements in surface performance were achieved as the class developed and further changes in power were made, but in underwater performance there was little gained over the Hollands.

During the building of A1, it was decided that greater torpedo capability was required and from A2 onwards two bow tubes were fitted, side-by-side. So many modifications were made to the various boats during the building programme, that the A Class could be considered as four classes: A1: A2 to A4: A5 to A12 and A13, the diesel version.

But the A Class still had limitations in speed and endurance, accommodation was cramped and they were not good sea boats.

FISHERS TOYS



Above; submarine B1 going to sea.

Once more, in an attempt to improve on these shortcomings, a larger vessel was designed, some 40 feet longer than A1, 10 inches more in the beam and 100 tons more displacement. This was the start of the B Class of which eleven were built between 1903 and 1906. The B Class were the first to be fitted with deck casings.

Surface performance was improved over that of the A Class, but underwater performance was substantially the same.

The C Class followed and 38 were built between 1905 and 1910, all but six being built at Barrow. The other six were built at Chatham, first instance of Lead Yard?

The B and C Classes were almost identical, being larger versions of the A Class, with petrol engines for surface propulsion and batteries for propulsion when submerged.

Many improvements were made from B1 to C38, particularly in the superstructure, to improve surface running and seaworthiness.

These infant submarines led eventful lives.

The unluckiest vessel of the era was surely the submarine A1. Some of the things that happened in her have served as a warning to all submariners from that day to this. Before delivery, A1 suffered the first explosion in a submarine, this was due to a pocket of hydrogen gas.

When on passage off Lands End the crew had to abandon ship when seawater entered the batteries, filling the submarine with choking chlorine gas. When she was eventually delivered to Portsmouth, A1 was berthed in a remote part of the harbour, ‘so that this dangerous craft’ could do as little damage as possible if she blew up.

In the summer of 1904, during manoeuvres against the fleet, A1 was dispatched to attack a battleship. When she neared Spithead, the ocean liner SS Berwick Castle made an approach. No one on watch noticed the tiny periscope jutting from the waves, nor did any of her crew feel anything than a slight tremble as the massive ship ran over a small unknown object. When A1 failed to report that night, it was realised that a disaster had occurred. Eleven men lost their lives in this tragedy, which caused great concern throughout the country.

The early years of submarine building were a time of innovation:
In 1908, approval was given to fit C12 to C16 with 'airlocks' or 'air-traps' as they were sometimes known. Divided into three airlocks, with a fourth fitted on the starboard side, the enclosed spaces had stowed in them sixteen diving helmets, one for each member of the crew. The escape route was through the torpedo hatch. These airlocks were subsequently fitted to all B and C Class submarines.

The first submarine to carry a boat appears to have been C1, which had a 10 foot berthon boat, a practise that was adopted for the remainder of the class. In 1905, the hitherto unknown dangers of petrol vapours caused an explosion in A5, which killed her commander and several others and led to the move to adopt diesel engines, which used heavy oil with a higher flash point and A13 was fitted with an experimental diesel engine for trials at sea. During these trials, the B and C Class vessels continued to be fitted with the same 16 cylinder Wolseley petrol engine as in A5 to A12, but now made by Vickers and called the Vickers engine. In C19 to C38 the number of cylinders was reduced to twelve. Following the trials in A13, diesels were adopted for the D Class and the use of petrol engines came to an end.

On 1st December 1914, the B11, commanded by Lt Holbrook RN, negotiated the Dardanelles to torpedo the Turkish battleship Messoudieh. For this action Lt Holbrook received the first submarine VC.

C Class submarines fitting out 1909

MAIN PARTICULARS	**A CLASS**	**B CLASS**	**C CLASS**
Length overall	105 ft ½ in	142 ft 2½ in	142 ft 2½ in
Beam	12 ft 8¾ in	13ft 7 in	13 ft 7 in
Depth, pressure hull	12 ft 8¾ in	13 ft 7 in	13 ft 7 in
Displacement: surface	190 tons	287 tons	290 tons
Submerged	205.5 tons	316 tons	320 tons
No. of shafts	One	One	One
Propeller	One 3 blade	One 3 blade	One 3 blade
	4 ft 4 in diameter	5 ft diameter	5 ft 7 in diameter
Speed surface	11.5 knots	13.5 knots	13 knots
Speed submerged	7 knots	7 knots	7.5 knots
Endurance, surface design	600 miles	1300 miles	1300 miles
	at full power	at 9 knots	at 9 knots

Endurance surface service	325 miles at full power	740 miles at full power	910 miles at full power
Endurance submerged	20 miles at 6 knots	22.5 miles at 6.5 knots	16 miles at 8 knots
Armament	2 18 in bow tubes 4 torpedoes	2 18 in bow tubes 4 torpedoes	2 18 in bow tubes 4 torpedoes

B Class submarine being fitted out in Devonshire Dock.

1907 - 1919 D CLASS SUBMARINES

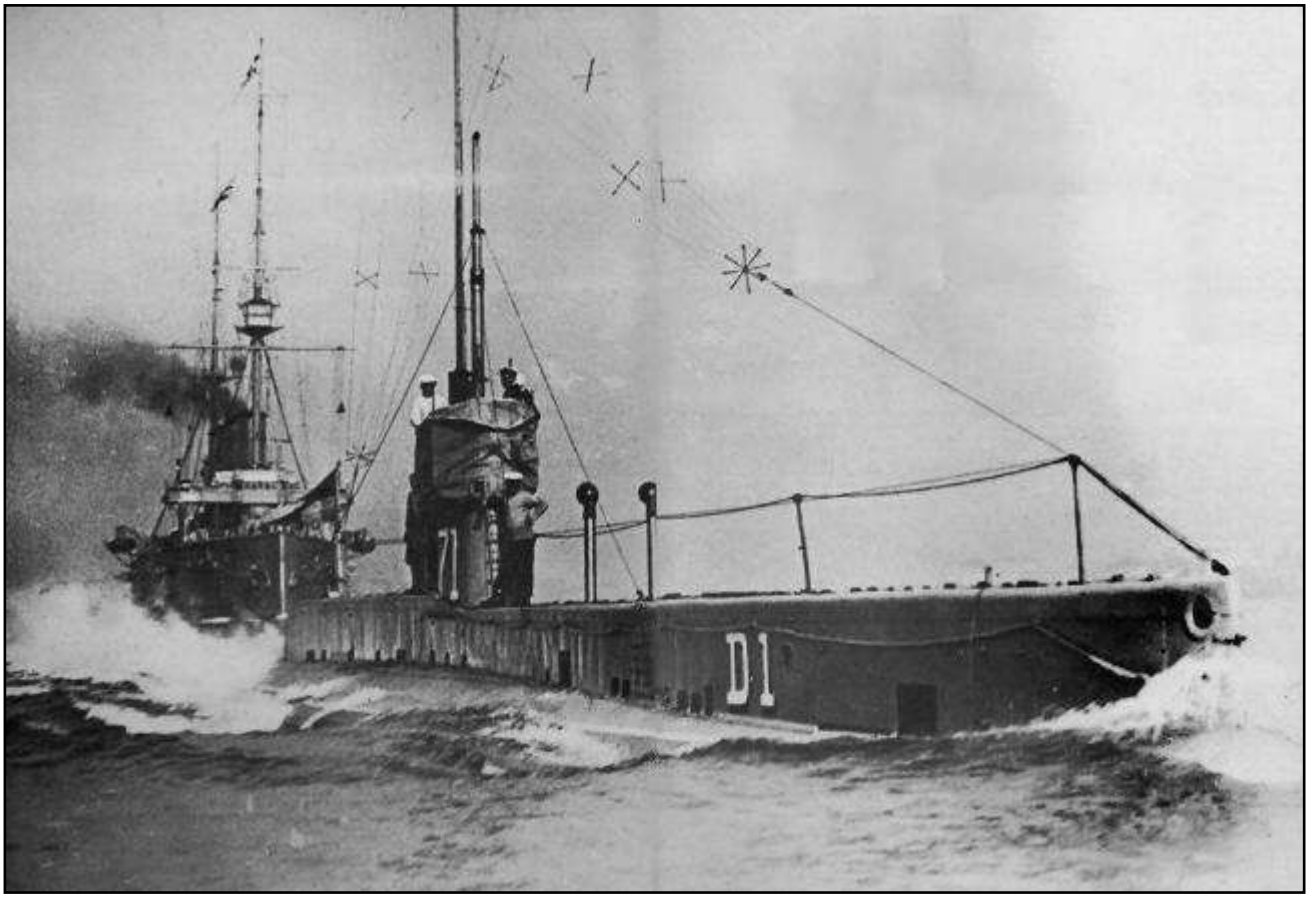
The D Class, approved by the Admiralty Board in 1906, was designed to overcome, as far as possible, the limitations of the earlier submarine classes. Initial design work was carried out by the Admiralty for the first time on a submarine project, but with the usual procedure for other Admiralty vessels. Between 1907 and 1912, eight of the class were built, six at Barrow and two at Chatham. The class had far better endurance than previous boats and can be regarded as the first submarines to have a proper patrol capability. The introduction of twin screws meant that better manoeuvring power was obtained and the conning tower being much larger than previously gave the class a profile similar to that of modern-day submarines.

D1 was the prototype for the first class of diesel driven submarine, a development which signalled the end of the petrol engine era with its attendant dangers to crews from petrol fumes and D4 was the first British submarine to be fitted with a gun, a 12-pounder on a mounting housed inside the superstructure.

A significant innovation was the use of saddle tanks to hold the main ballast water. The use of external tanks provided additional inboard space and improved habitability standards. However, with the introduction of a stern torpedo tube (the first in a British submarine), an increased engine size to give greater power and an increased complement in a vessel of the same hull diameter as the C

Class and with only 20 ft increase in length, it is doubtful whether the additional space was properly utilized to improve accommodation standards.

A major advance in the D Class was the incorporation of a wireless system for the first time, the aerial being rigged to the submarine's mast. Before diving, the mast had to be lowered by hand and the wireless aerial stowed away along the side of the vessel. Previous submarines had been equipped with receiving sets, but the D Class was the first to have both receiving and transmitting facilities: unfortunately, wireless signals could neither be received or transmitted when submerged, that problem remained unsolved until the late 1920's.



D4 without and D1 with wireless aerials rigged

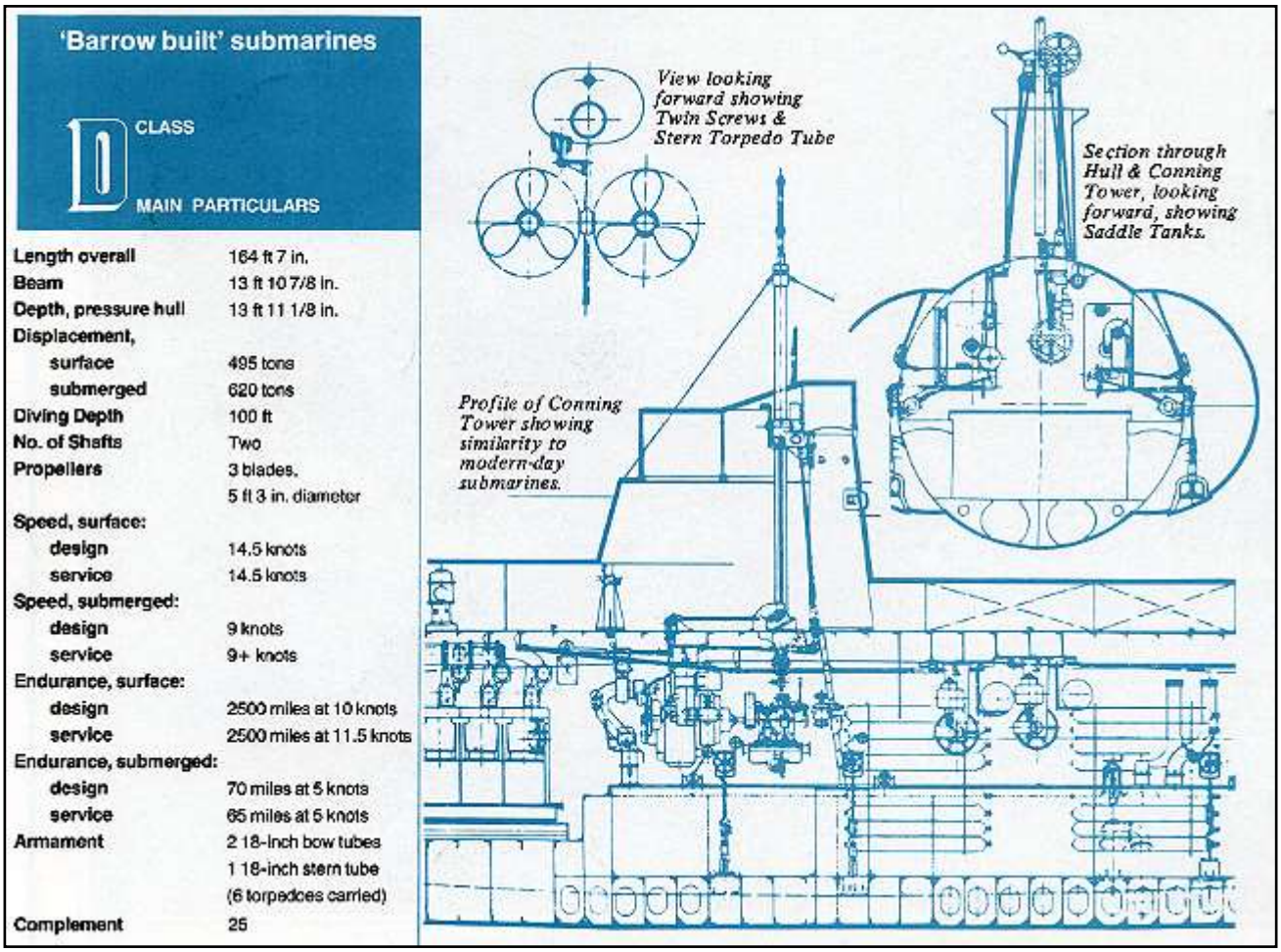
D Class submarines at war

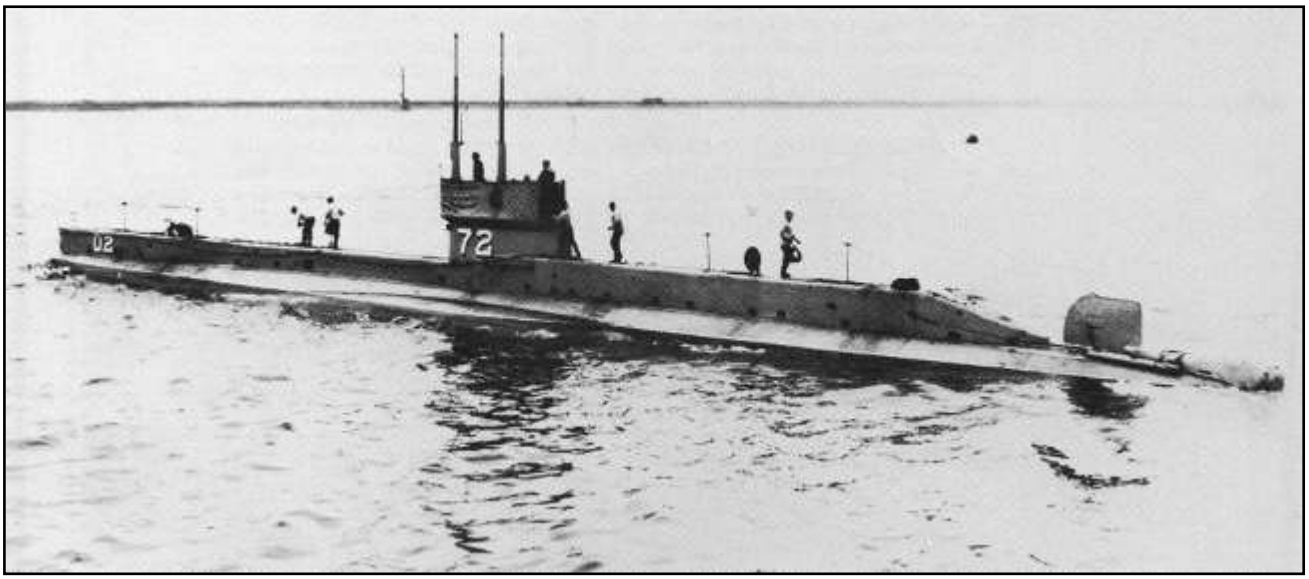
All eight D Class submarines were in commission at the start of the First World War and took up station on the east coast of England, where their long range potential was exploited to the full with overseas patrols in the Heligoland Bight.

During the first three months of the war, two of the class were lost in the North Sea, D 5 hitting a mine and D2 going on patrol never to be heard of again.

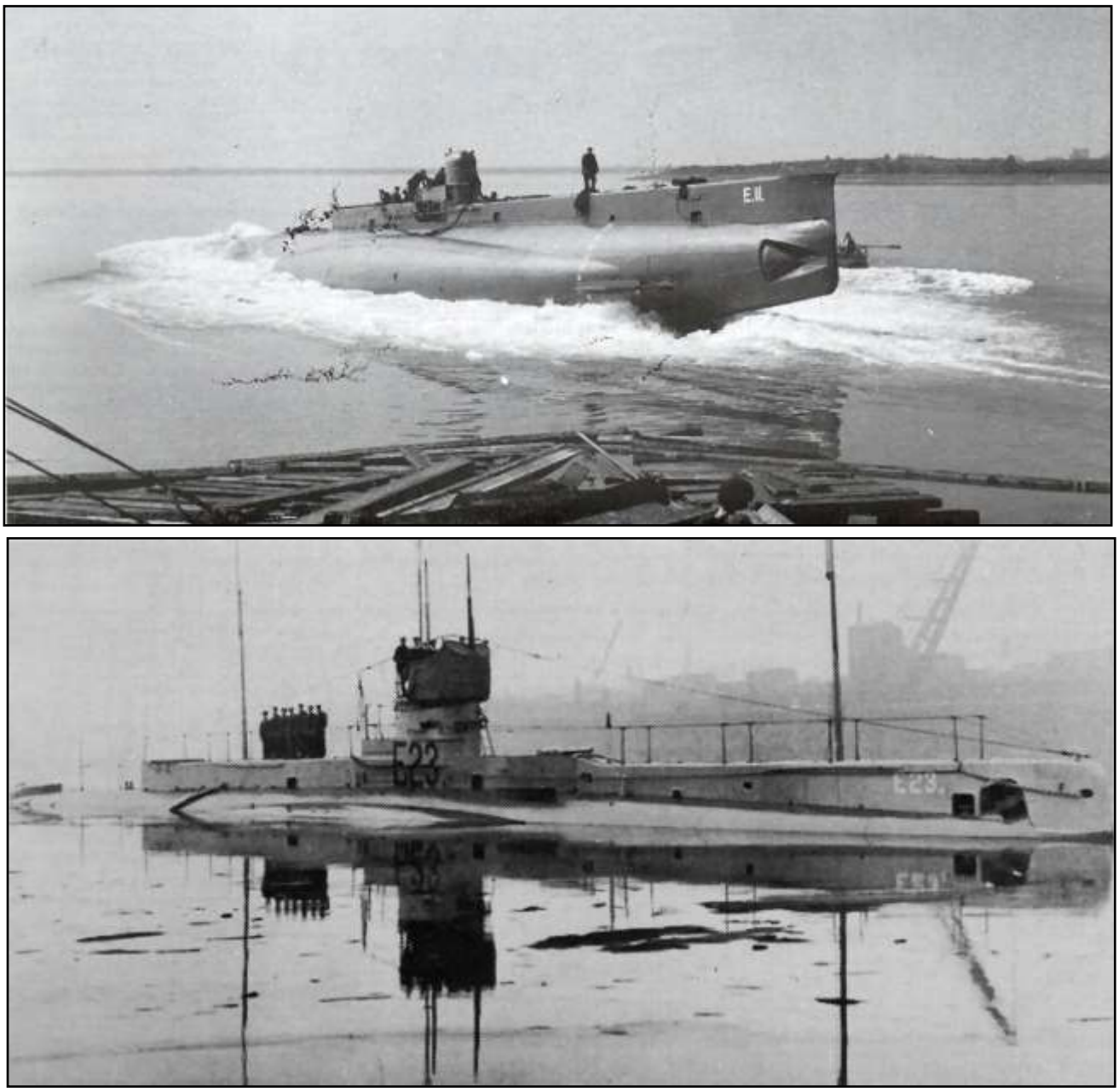
Towards the end of the war two more of the class were lost, D3 was accidentally sunk in the English Channel in March 1918 and three months later D6 was sunk by a U-Boat off the north coast of Ireland.

Of the remainder, D1 was sunk deliberately as a target in October 1918 whilst D4, D7 and D8 survived the war, to be taken out of service in July 1919, bringing to an end of the great D Class era.





1911 - 1924 E CLASS SUBMARINES



The launch of E11 in 1914 and E23, 1915-1922.

The results of experience gained with D1, the prototype diesel driven submarine, were incorporated in the design of the famous E Class submarines, which such outstanding work during the First World War.

The boats were considerably larger than the D Class, to accommodate the introduction of broadside torpedo tubes, a major change in the design. Six of the later E boats were fitted as minelayers. This meant that the broadside torpedo tubes were omitted and 20 mines were carried in vertical tubes in the saddle tanks. The mines were released by a mechanism operated from inboard.

The E Class were the first British boats to be fitted with internal watertight bulkheads. These internal bulkheads strengthened the pressure hull and as events during the war proved, the E Class were eventually designated as being capable of diving to a depth of 200 feet.

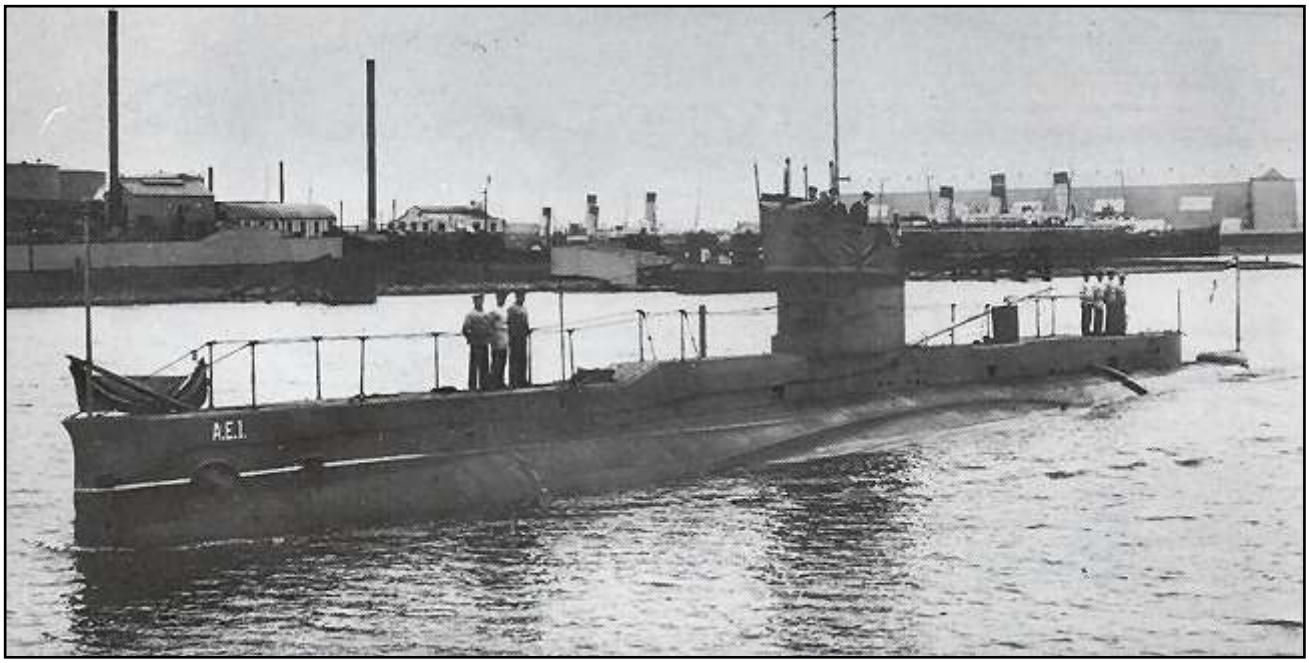
Fifty-six E Class were built between February 1911 and August 1917. Of the first twenty-six, 20 were built and completed at Barrow between January 1913 and January 1916, including two built at Beardmore's at Dalmuir and fitted out by Vickers and six were built at Chatham. The remaining 30 were divided between twelve other shipyards who were entering the field of submarine construction for the first time, including Armstrongs at Newcastle, Cammell Lairds at Birkenhead and Scotts on the Clyde.

A further two boats of this class, AE1 and AE2, were built at Barrow for the Royal Australian Navy and these sailed to the Antipodes under their own power. One of these actually completed 30000 miles before a complete refit of her propelling machinery was thought to be desirable.

Boats ordered before the war took 20 to 30 months to complete, but, E19 ordered in November 1914, was built, equipped and handed over in the record time of eight months, setting the pace for several later boats. This achievement was aided by the fact that the class were fitted with engines being built at the time by Vickers for the newly-ordered G Class submarines.

As with the D Class, the E boats had twin screws. Their diesels developed 1600 hp which gave a surface speed, in service, of 14 knots. The submerged speed was 9.5 knots, produced by 840 hp electric motors. The radius of action for the E Class was 3000 miles on the surface at 10 knots and up to 65 miles submerged, at approximately 5 knots.

Although a large class, building over a number of years, the characteristics between the various groups within the class did not alter appreciably. Changes in form, dimensions and displacement were not sufficient to make any marked difference in speed and endurance. However as a result of war experience, large guards were fitted around the hydroplanes, the appendages restricting the class to a surface speed of 14 knots and a submerged speed of 9 knots. With extensive superstructure, combined with a navigating bridge built over the conning tower, the class were a big advance as sea boats and were easy to navigate even in the roughest weather.



AE1, built at Barrow for the Royal Australian Navy

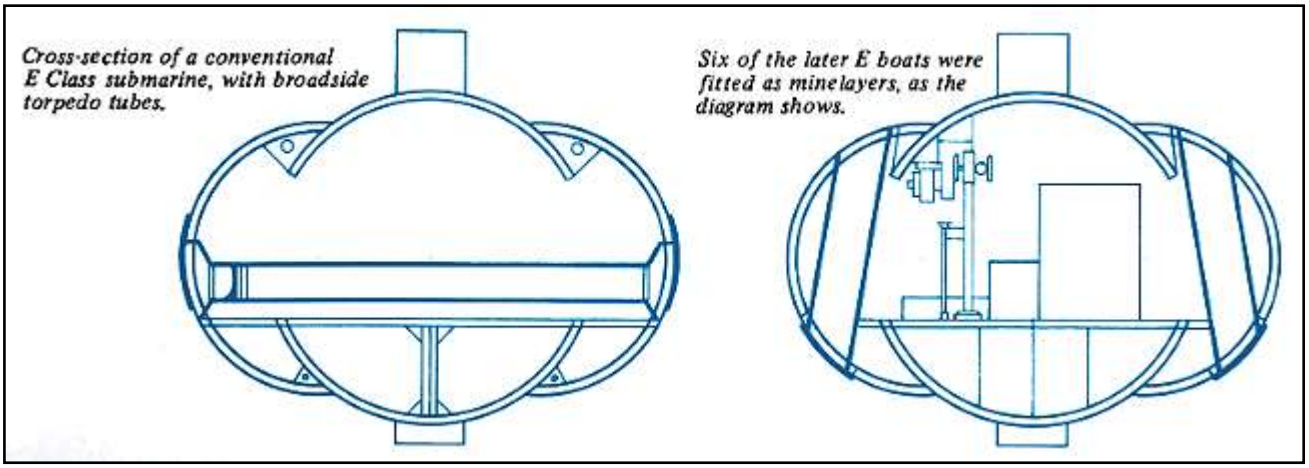
The War Years

At the outbreak of the First World War nine of the new E Class submarines had been delivered and six were used in the Heligoland Bight, first for reconnaissance patrols only and subsequently with a free hand.

The first offensive success by a British submarine was scored by E9, commanded by Lieutenant Commander Max Horton, who had 'stood by' his boat during her construction at Barrow. On 13th September 1914, Horton sighted the German cruiser Hela near Heligoland, he closed to 600 yards and fired two torpedoes, one of which struck amidships. Hela sank and E9 was hunted for the rest of the day but successfully escaped. During her next patrol in the Bight, E9 sank the destroyer S116.

These first successes were followed by many other courageous exploits. Particularly important were the operations carried out in the enemy waters of the Baltic and the Sea of Marmara where our submarines operated with devastating effect during the early years of the war. So much so, that E11s' career of destruction earned her commander, Lieutenant Commander Martin Dunbar-Nasmith, the Victoria Cross. The commander of E14, Lieutenant Commander Geoffrey White, was also awarded (posthumously) the Victoria Cross for his bravery in the Dardanelles in January 1918.

Very rarely did British and German submarines come into direct action but in October 1914, when U27 and E3 met off the German coast, the latter was cut in two by a torpedo and was lost with all hands.



MAIN PARTICULARS	E CLASS		
		Endurance, surface:	
		design	3000 miles at 10 knots
Length overall	181 ft		
Beam	15 ft 1½ in.	**service**	1500 miles (full power) or 3000 miles at 10 knots
Depth, pressure hull	15 ft 1¾ in.		
Displacement,			
surface	667 tons	**Endurance, submerged:**	
submerged	807 tons	**design**	99 miles at 3 knots
Diving depth	200 ft	**service**	10 miles at 9 knots or 65 miles at 5 knots
No. of shafts	2		
Propellers	3 blades, 5 ft 7 in. diameter	**Armament**	2 18-inch bow tubes 2 18-inch beam tubes 1 18-inch stern tube (10 torpedoes carried)
Speed, surface:			
design	15.25 knots		
service	14 knots		
Speed, submerged:			1 12-pounder gun
design	10.25 knots	**Complement**	
service	9.5 knots	**design**	30

Throughout the war the E Class served with conspicuous success; but they also suffered severely, more than half their number being lost.

1912 - 1921 V, N AND G CLASS SUBMARINES

V Class 1912 -1919

Taking the identifying letter from the name of the builder, the V Class was Vickers' interpretation of a coastal-type submarine designed to meet the requirements of the 1912 Submarine Committee.

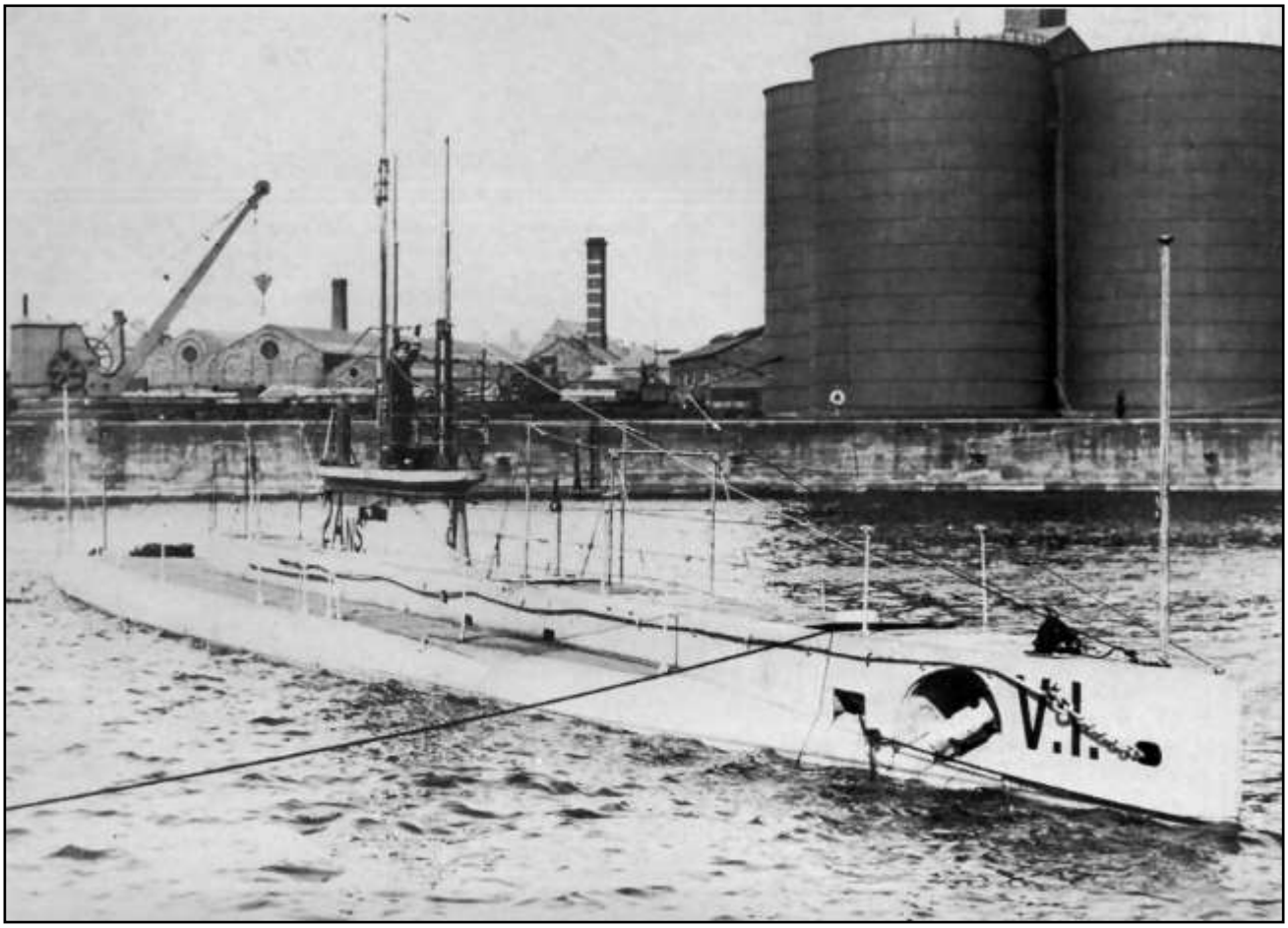
Four of the class were ordered, the first being laid down in November 1912. The principal design feature was in the hull form. Although classed as double-hulled vessels, the double hull being limited to the middle portion of the boat, with the outer half fairing into the pressure hull at the forward and after ends. Vickers carried out a number of tank experiments on several hull forms before opting for this design. The estimated cost of the four V Class submarines was £76000 each, but this was later amended to £75799.

The diesel engines of the V boats developed 450 bhp at 450 rev/min and were the first Vickers built submarine engines to have steel cylinder jackets, previously these had been of cast iron. The battery consisted of 132 Exide cells, small for the size of the boat; the A Class of less than half the displacement carried 120 cells. But the designed submerged speed was still attained, although at the expense of endurance.

Vickers claimed that the V Class could dive to 150 feet as against 100 feet in the conventional submarines of the period. Although the pressure hull sections were far from circular, this depth was possible because the strength of the hull was increased by the external framing between the inner and outer hulls.

The armament of the class was two 18-inch bow torpedo tubes, positioned low in the vessel. Two spare torpedoes without warheads, were stowed on the starboard side of the torpedo room on above the other, with the warheads nearby on the flat. The torpedo hatch was mechanically operated as in the E Class. Some records state that a 12 pounder gun was fitted, this was presumably after completion.

All four V Class submarines were taken out of service in 1919.



The Nautilus 1913 - 1919

Nautilus was a bold experiment with an increase in surface displacement and a change from the saddle tank type of construction to a double-hull. She was a twin shaft vessel with two Vickers diesel engines, each of 1850 hp, two main motors of 500 bhp and 352 Exide cells in two battery banks.

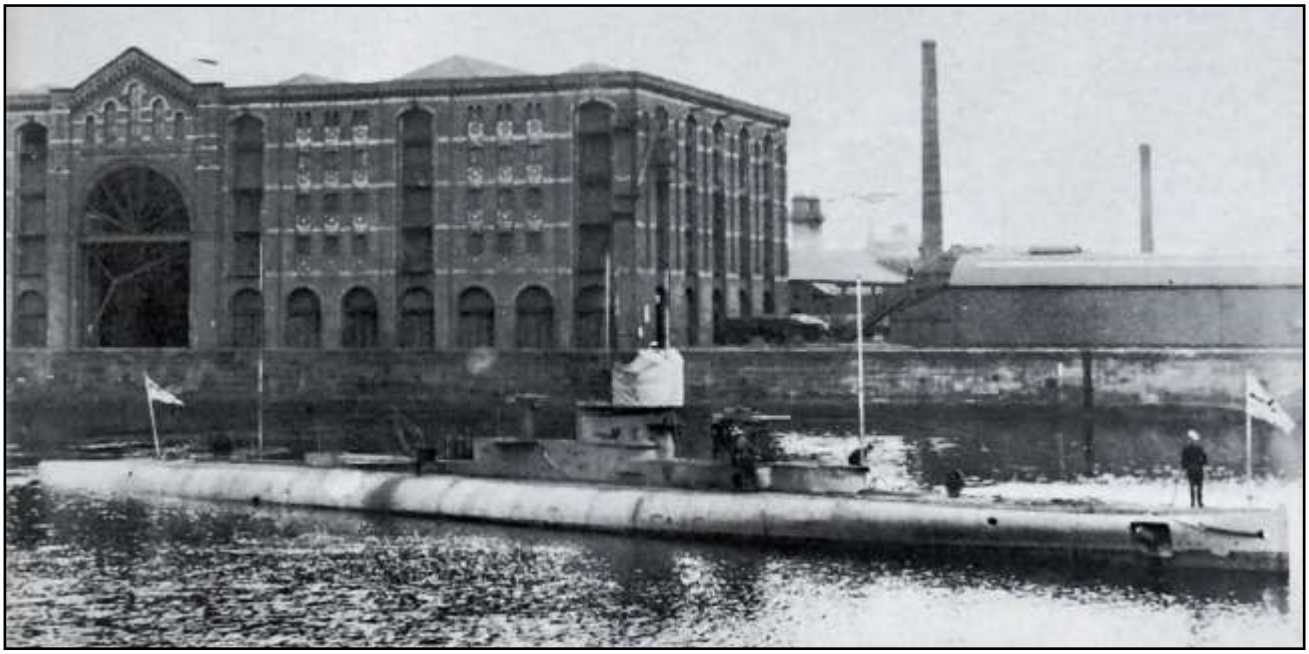
The Nautilus, renamed N1 in June 1917, was designed by Vickers to have good sea-keeping qualities for extended operations in all weather conditions. Regarded by submarine officers as 'an exceedingly interesting experiment', Nautilus was laid down in March 1913 and with an overall length of nearly 260 feet, was twice the size of any existing submarine.

The estimated cost of building Nautilus is given as £203850 but, because of the extended building time, the changes that occurred, the increase in displacement and additions such as hydroplane guards, this figure was undoubtedly exceeded.

Although the designed surface speed is given as 17 knots, it is doubtful whether any reliable 'in service' figures for speed and endurance were obtained since she did not complete until October 1917 and had little if any service as an operational submarine. Her designed diving depth is given as 200 feet and compared with that achieved by previous classes would seem to be reasonable.

Her armament consisted of two 18-inch bow tubes, four 18-inch beam tubes and two 18-inch stern tubes (with 16 torpedoes carried). A 3-inch High-Angle (HA) gun was fitted on the superstructure just forward of the bridge and this was raised and lowered on a vertical ram.

It is said that Nautilus was a failure. This may be true in that she had little real service experience, being used mainly as a Depot Ship for instructional purposes. However Nautilus was significant because the step from small to large size submarines, with greatly increased engine power, had been taken and this provided considerable experience and confidence for building later classes.



1914 - 1921 G Class Submarines

In December 1913, after discussing the German submarine programme, the Admiralty decided that they should prepare a design for an overseas patrol boat of about E Class surface displacement, of partial double hull construction and with single 21-inch torpedo tubes forward and aft and two 18-inch beam tubes. This would be called the G Class.

In June 1914, five G Class submarines, G1 to G5 were ordered from Chatham Dockyard and one month later G6 and G7 were ordered from Armstrong Whitworth. Vickers engines of the E Class type were fitted in all seven boats, although it was originally intended to fit G6 and G7 with Nuremberg (MAN) and Sultzer engines. (Difficulties obtaining the Sultzer engine and the impracticability of a MAN design prevented this.) Vickers were given orders for six more boats, G8 to G13, and to build the engines for four of the class building at Chatham. G14 was ordered from Scotts on the Clyde.

Costing an estimated £125000, the G Class were twin shaft vessels, with two eight cylinder diesels that together generated 1600 bhp, giving a surface speed of 14 knots. Two single armature

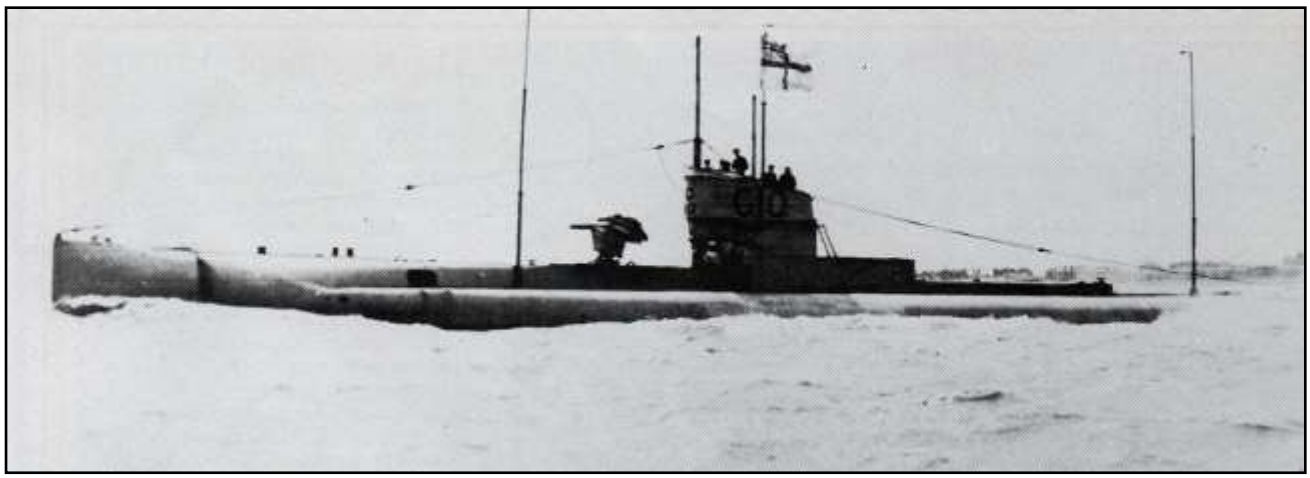
motors, each of 420 bhp, gave a submerged speed of 9 knots. The class carried 200 cells in two battery tanks, which gave a submerged endurance of 95 miles at 3 knots.

Early war experience gained by other classes led to the proposed G Class armament being changed to two 18-inch bow tubes, two 18-inch beam tubes and one 21-inch stern tube. This signalled the beginning of the 21-inch torpedo in Royal Navy submarines, although the experimental submarine Swordfish, ordered from Scotts a year earlier, but launched after G1, was also fitted with 21-inch tubes. The class also carried one 3-inch Quick Fire High Angle (QF HA) gun which was fitted just forward of the bridge and a portable 2-pounder which could be fixed to a pedestal at the after end of the bridge.

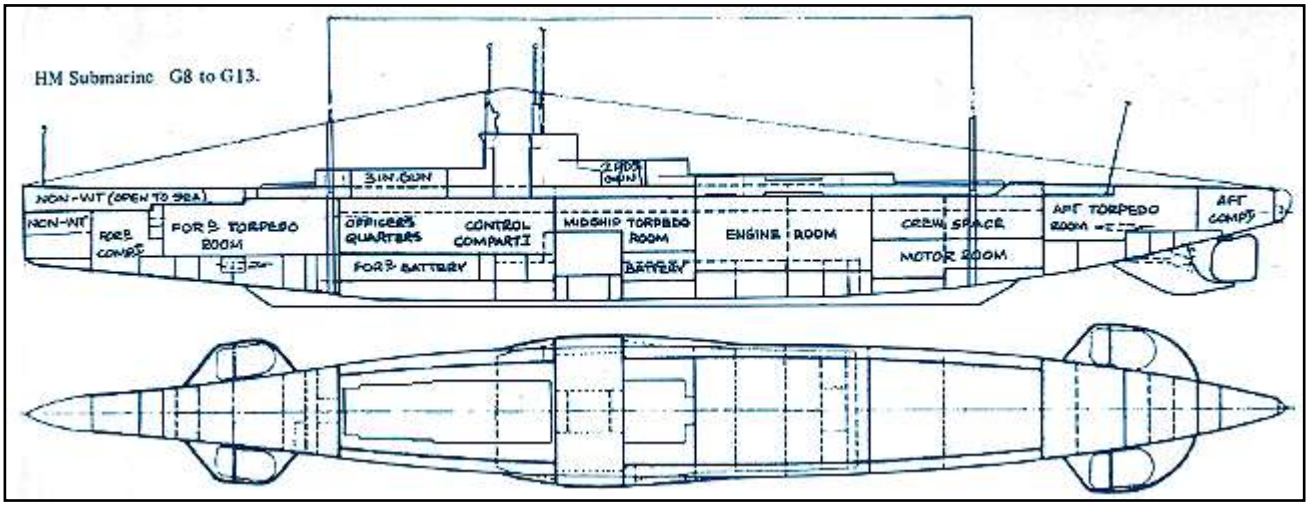
Living conditions on board were considered by crew members to be good, because the G boats boasted such luxuries as an electric oven.

Although the designed diving depth of the G Class was given as 200 feet, the operational depth was probably 100 feet. However, it was noted that in 'an exceptional circumstance one G boat dived to 170 feet when chased by mistake by British destroyers'.

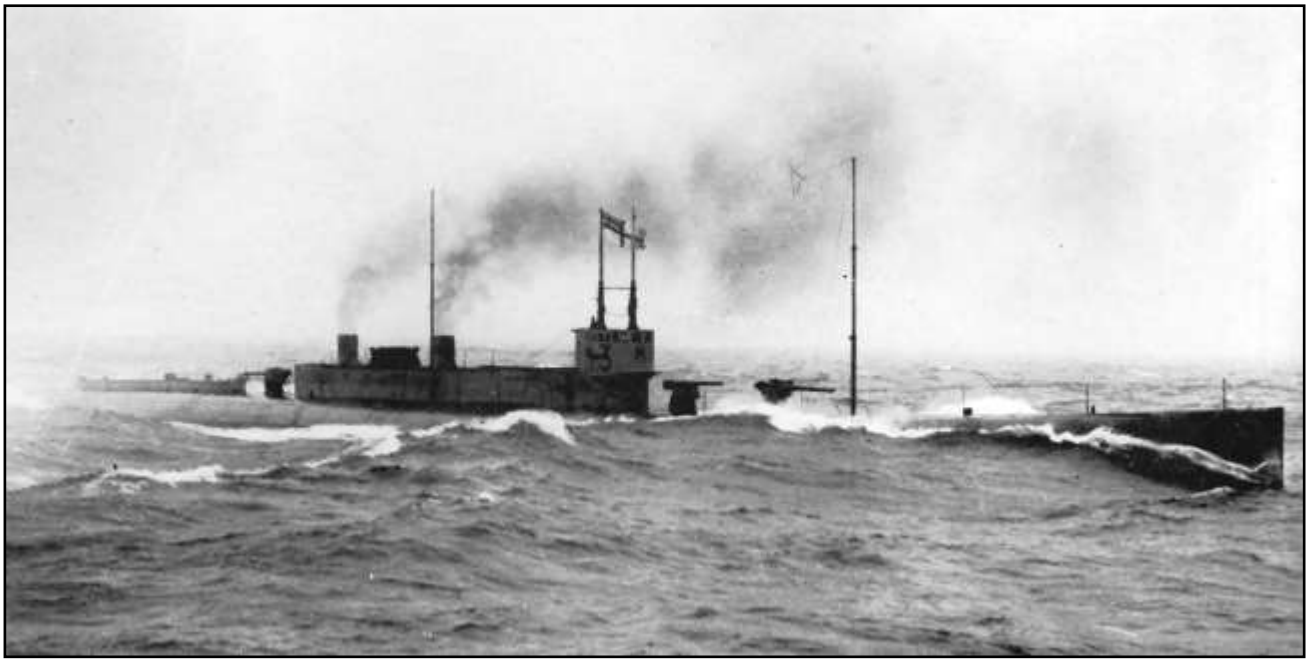
During the First World War G7, G8 and G11 were lost on active service through unknown causes and in September 1917 G9 was sunk in error by HMS Petard off the Norwegian coast. Of those that survived, four were taken out of service at the end of the war and the remaining six were withdrawn from service in January 1921.



MAIN PARTICULARS	V Class	Nautilus	G Class
Length overall	147 ft 6 in	258 ft 4½ in.	187 ft 1 in
Beam	12 ft 9 in	20 ft 6 in.	15 ft 4 in
Depth, pressure hull	13 ft 4 in	22 ft 6½ in.	16 ft 7 in
Displacement,			
surface	391 tons	1441 tons	703 tons
submerged	457 tons	2026 tons	837 tons
Diving depth	150 ft	200 ft	200 ft
No. of shafts	2	2	2
Propellers	3 blades, 4 ft 6 in diameter	3 blades, 6 ft 3 in. diameter	3 blades, 5 ft 8 in diameter
Speed, surface:			
design	13 knots	17 knots	15.5 knots
service	14 knots		14 knots
Speed, submerged:			
design	8.5 knots	10 knots	9.5 to 10 knots
service	9 knots	9 knots	9 knots
Endurance, surface:			
design	*1200 miles (full power)	5300 miles at 11 knots	2600 miles (12.5 knots)
service	*1130 miles (full power)	4400 miles at max 5 knots	1650 miles (full power)
Endurance, submerged:			
design	74 miles (5 knots)	72 miles max	99 miles (3 knots)
service	50 miles (5 knots)		95 miles (3 knots)
Armament	2 18-inch bow tubes (4 torpedoes carried)	2 18-inch bow tubes	2 18-inch bow tubes
		4 18-inch beam tubes	2 18-inch beam tubes
		2 18-inch stern tubes	1 21-inch stern tube
	1 12-pounder gun	(16 torpedoes carried)	(10 torpedoes carried)
		1 3-inch HA gun	1 3-inch QF HA gun
			1 2-pounder gun
Complement:			
design	20	42	30



1915 - 1931 K CLASS AND K26 SUMARINES



K Class submarines were the most bizarre and ill-fated submarines of the First World War period. Their conception, in the spring of 1915, arose from the demand for a submarine that could accompany the Grand Fleet at speeds of up to 24 knots. A 1913 Admiralty design was adopted and given the outline particulars, form and general arrangements, Vickers were requested to proceed with the detailed drawings.

The first of class, K 3, was laid down by His Majesty the King in May 1915 and was completed at Vickers within 15 months of being ordered. As a result of her trials, additional fans were fitted in the turbine room to combat the very high temperature generated by the steam turbines.

Of the 17 of the class, six were built at Vickers, each at an estimated cost of £340000. Originally 28 K Class submarines were ordered, but of these several were later cancelled. K18 to K21 were redesigned and became the M Class and K26 was an experimental submarine, built in an attempt to overcome the defects of the earlier K boats. At the time, they were not only the largest submarines in the world, but also the fastest, their phenomenal speed being attained from 10500 shp oil-fired steam turbines. In addition to the steam turbines, the class had an auxiliary diesel generator for charging the batteries and powering the electric motors.

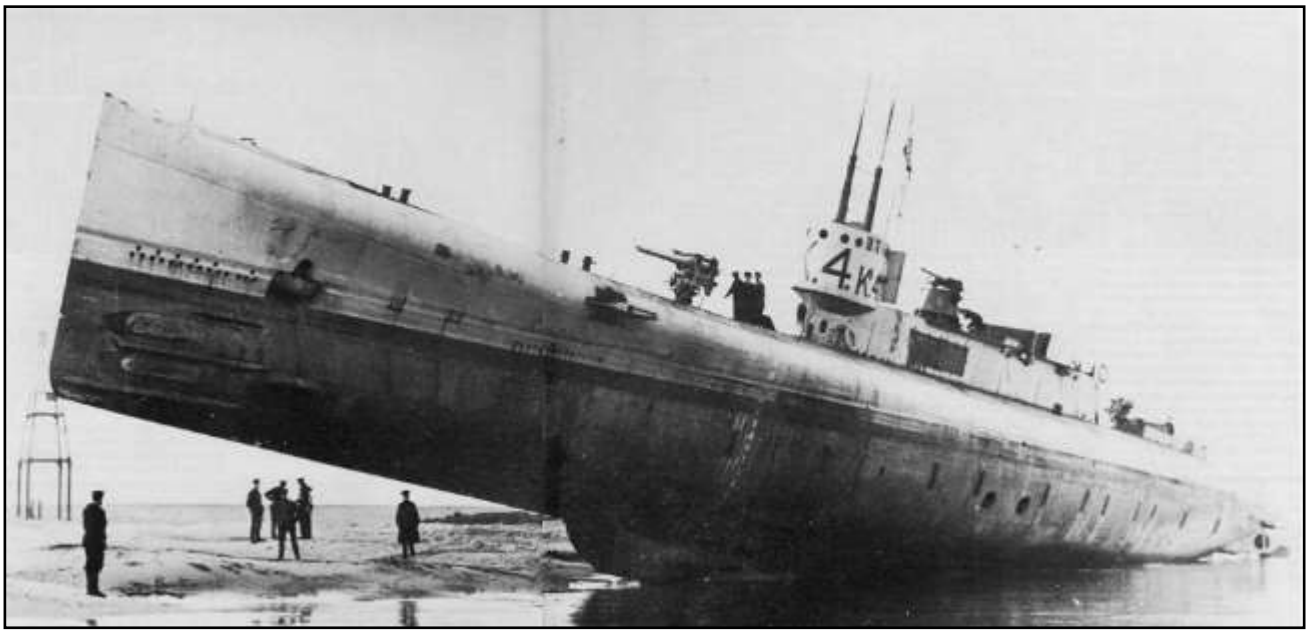
The pioneer vessels of the K Class had a flush deck with a slight sheer forward but, because of a tendency to dive into head seas, later boats were redesigned to overcome this alarming habit and were fitted with large clipper bows and buoyancy tanks. In order to allow this change, the

armament and torpedo tubes were rearranged, the guns were removed to the superstructure and when fitted, twin 18-inch deck tubes for use on the surface at night were removed.

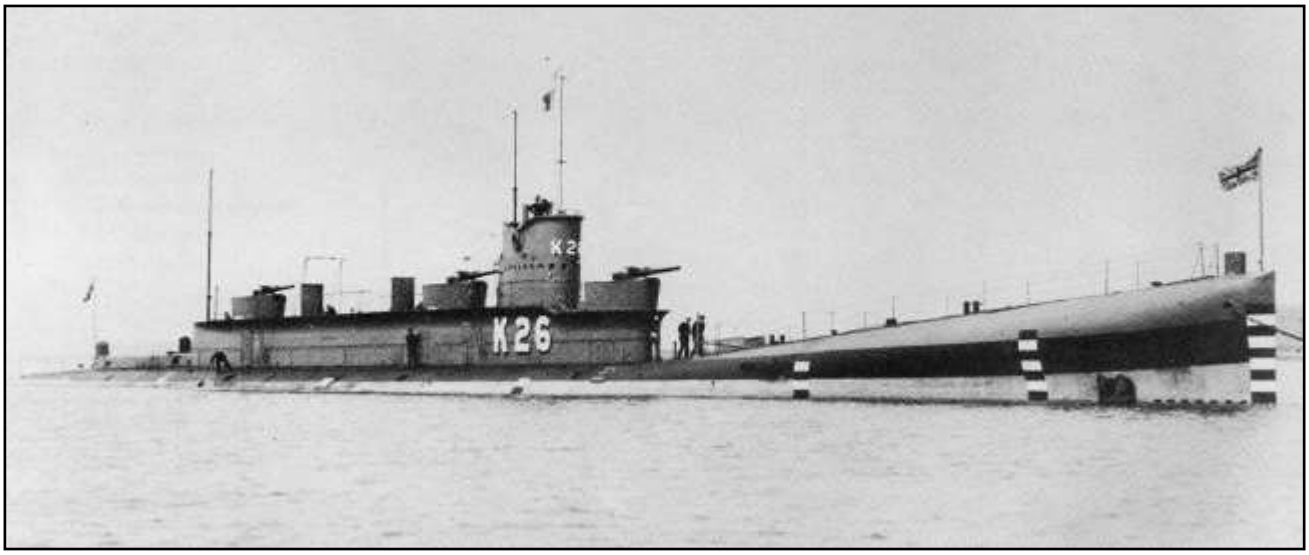
The outline of the K boats was broken by two small funnels which were hinged to fold down into a watertight well. The large air intakes for the two oil fired boilers also required watertight seals. In the concise words of a contemporary submariner, the K Class had ‘too many damned holes’ and a minor obstruction or wire rope was sufficient to jam a vent open just as the submarine was ready to dive. An added disadvantage was that the highly ingenious design of the class was so complex that it was vulnerable to small defects.

K Class submarine could submerge faster than any previous steam submarines, but the delay was still impossibly long. Although the specified time to close down and secure the boiler room, funnels, etc was only 30 seconds, the class still took about 5 minutes to dive. Once submerged the class could dive to a depth of 200 feet.

The K boats being high speed Fleet submarines, were fitted with a deckhouse built over and around the conning tower, forming in fact, a fully enclosed bridge and giving for the first time in Royal Navy submarines protection to bridge personnel other than by canvas screens.



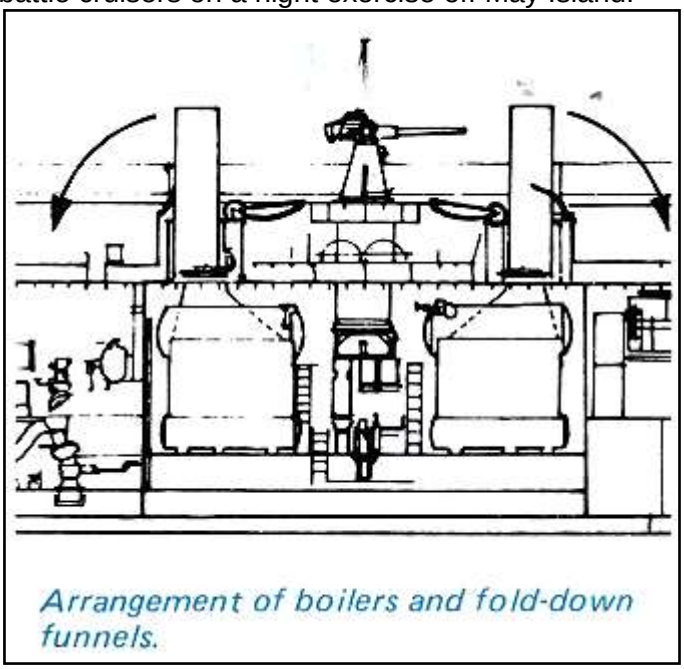
Although embarrassing to the shipbuilder, this rare photograph gives a good impression of the size, and a seldom seen view, of a K Class Submarine



The experimental K26 with its large conning tower and raised ‘swan bow’, which contained quick blowing tanks for faster surfacing.

K Class submarines began to enter service in 1916, but because of their role with the fleet they were unduly exposed to the risk of collision and a chapter of accidents befell the class. The

worst accident occurred on the night of 31st January 1918 when ten K boats were operating with battle cruisers on a night exercise off May Island.



Arrangement of boilers and fold-down funnels.

During the night the helm in K14 jammed to starboard and she swung round and collided with K22, which was actually the K13 renamed after she had drowned most of her crew on her maiden voyage. The two boats locked together and in a series of collisions K4 was sunk by K6 (losing all hands) and K7 was sunk by HMS Fearless (also losing all hands). Four other submarines were also damaged. This incident also added further to the suspicion of a hoodoo on the class, because just two months earlier K1 had been sunk by the gunfire of HMS Blonde off the Danish coast.

These disasters finally sealed the fate of the K Class submarines and most were taken out of service at the end of the war. The class never had an opportunity to prove themselves as Fleet submarines, only six of the 17 boats built were in commission for six years or more and the maximum time in service was nine years. However experience gained from the K Class led to the building of the experimental submarine K26.

MAIN PARTICULARS	K CLASS	K26
Length overall	339 ft	351 ft
Beam	26 ft 6¾ in	28 ft
Depth, pressure hull	20 ft 11½ in	19 ft 9 in
Displacement,		
surface	1980 tons	2140 tons
submerged	2566 tons	2530 tons
Diving depth	200 ft	250 ft
No. of shafts	2	2
Propellers	3 blades, 7 ft 6 in diameter	Details unknown
Speed, surface:		
design	24 knots	23.5 knots
service	24 knots	23.5 knots
Speed, submerged:		
design	9 knots	9 knots
service	8+ knots	8+ knots
Endurance, surface:		
design	960 miles at full power	1200 miles at full power
service	(i) 800 miles at full power (ii) 12 500 miles at 10 knots	1200 miles at full power (ii) 12 670 miles at 10 knots
Endurance, submerged:		
design	13.5 miles at 9 knots	13.5 miles at 9 knots
service	8 miles at 8 knots 30 miles at 4 knots	8 miles at 8 knots 30 miles at 4 knots
Armament	(iii) 4 18-inch bow tubes 4 18-inch beam tubes (16 torpedoes carried) 2 4-inch guns 1 3-inch gun	6 21-inch bow tubes 4 18-inch beam tubes (20 torpedoes carried) 3 4-inch guns
Complement:		
design	59	59

(i) Endurance using normal stowage of oil fuel.
(ii) Endurance when using diesel engine only.
(iii) Twin 18-inch deck tubes, for use on the surface at night, were included in the K Class design, but were subsequently removed where fitted.

K26 1918 - 1931

K26 was laid down in June 1918 and launched at Vickers 14 months later. In 1920 she was towed to Chatham for completion and was completed in June 1923

Based on the K Class design, K26 was intended to eliminate or at least reduce the known defects of that class. Although the general layout in K26 was practically the same as the K Class, the introduction of six 21-inch bow tubes in lieu of four 18-inch bow tubes was responsible for an overall increase in length of 12 feet.

The main machinery of K26 was the same as that fitted in the K Class, but her designed surface speed of 23.5 knots was 0.5 knots slower. At the time the loss in speed was blamed on repositioned after hydroplanes being in the wake of the propellers and the increased draught. The increased displacement was the reason. K26 had a displacement of 2140 tons with 300 tons of fuel oil. The 24 knots for the K Class was achieved at 1980 tons displacement carrying the normal load of 197 tons of fuel oil.

A great advance was made in K26 by the introduction of battery compartments, which became standard in the designs of the 1920s. K26 could submerge more rapidly than previous steam submarines and her diving depth was increased to 250 feet, although there is no apparent reason for the 50 feet increase over that of the K Class.

In 1924 K26 began a world voyage which excited considerable attention. She proceeded via Gibraltar, Malta and the Red Sea to Colombo and Singapore and after a short stay there voyaged back again. K26 was taken out of service in April 1931.

1916 - 1932 M CLASS SUBMARINES

Inspired by the news of German U-cruisers with 5.9-inch guns, the Committee on Submarine Development decided to construct submarine monitors, the M Class with 12-inch guns.

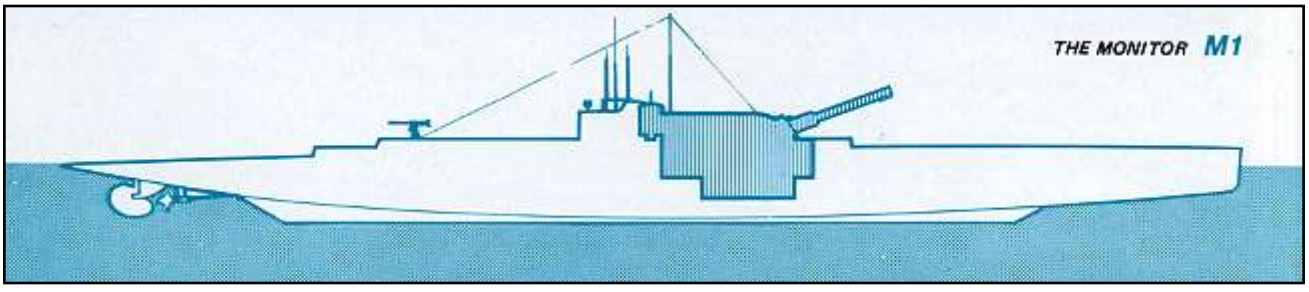
Four K Class submarines, K18 to K21 had been ordered in February 1916, but when Vickers received an order to build a boat to the new design K18 was remodelled and became M1. M2 (ex K19) was ordered from Vickers in May 1916 and two more, M3 (ex K20) and M4 (ex K21) were ordered from Armstrong Whitworth in August 1916.

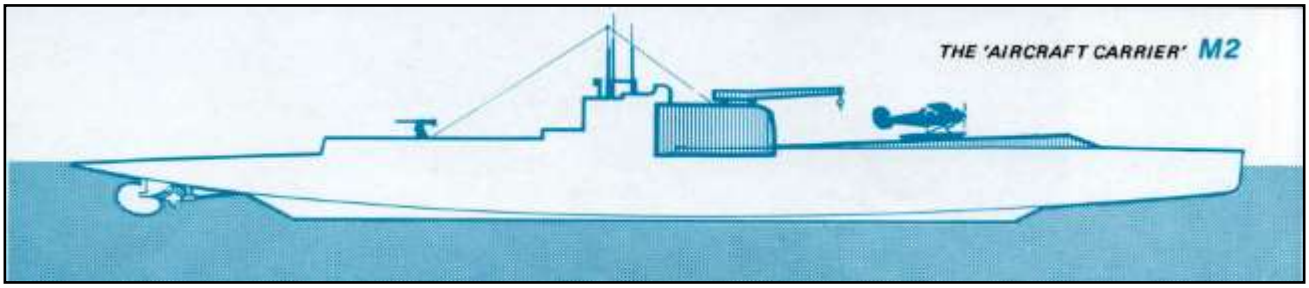
Of the three m Class submarines built (M4 was scrapped before completion) only M1 was completed before the end of the war, though she was never used in because it was thought that if she was copied by the enemy Britain was likely to suffer more from the use of the 12-inch gun Germany. Why this was never thought of before construction remains a mystery. M2 and M3 were completed in 1920.

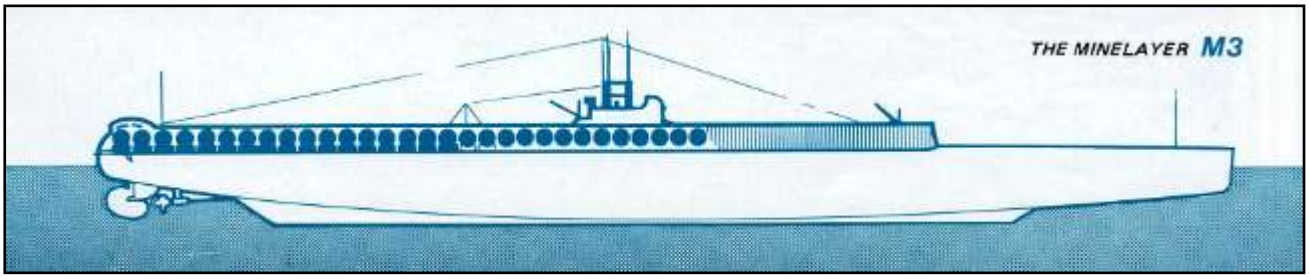
The fact that the M Class design got further than the conference table is a reflection of the failure by the Admiralty to recognize the proper nature of submarine operations. Although their 12-inch guns were ideally suited for bombarding coastal defences, their method of attack at sea was rather primitive. The attack procedure was to cruise at periscope depth until the target was ‘lined up’. The submarine was then brought up until about six feet of the gun barrel protruded from the water. A round was fired and the submarine would then make a rapid dive, unable to fire the gun again as the gun could not be reloaded under water. Known as the ‘dip-chick’ method, this attack procedure took about 30 seconds to complete.

The M Class were partial double-hulled submarines with the double-hull extending for about 65% of the length of the boat. A surface speed of 15 knots was attained from two Vickers 12 cylinder diesel engines, each of 1200 bhp. Under water, four double armature type main motors, generating 400 bhp each, gave a submerged speed of 9 knots. Power for submerged operations was supplied from three battery tanks containing a total of 336 Exide cells.

The contrasting lives of M Class submarines



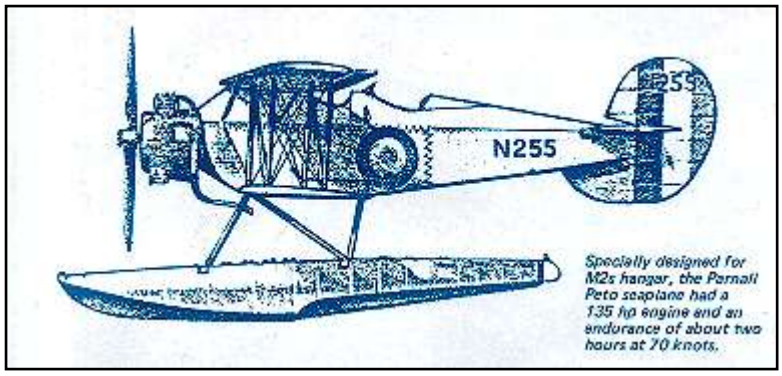




M CLASS MAIN PARTICULARS

Length overall	295 ft 9 in	**Endurance surface:**	
Beam	24 ft 8 in	**design**	2500 miles at 16 knots
Depth, pressure hull	18 ft 8 in	**service**	2000 miles (full power)
Displacement,			4500 miles (maximum)
surface	1594 tons	**Endurance, submerged:**	
submerged	1946 tons	**design**	10 miles at 10 knots
Diving depth	200 feet	**service**	9 miles at 8+ knots
No. of shafts	2	**Armament**	*4 18-inch bow tubes
Propellers	3 blades,		(8 torpedoes carried)
	5ft 10in diameter		1 12-inch gun
Speed, surface:			1 3-inch gun
design	16 knots	**Complement:**	
service	15 knots	**design**	64
Speed, submerged:			
design	10 knots		
service	8 to 9 knots		

In M3 these were replaced by four 21-inch bow tubes, which were responsible for an overall increase in length of 10 feet.



Specially designed for M2's hangar, the Parnall Peto seaplane had a 135 hp engine and an endurance of about two hours at 70 knots.

At the end of the war, the question of future employment arose as there were no targets and the enemy had not initiated anything bold in submarine policy. Consequently during the 1920s, the three M Class submarines led contrasting lives.

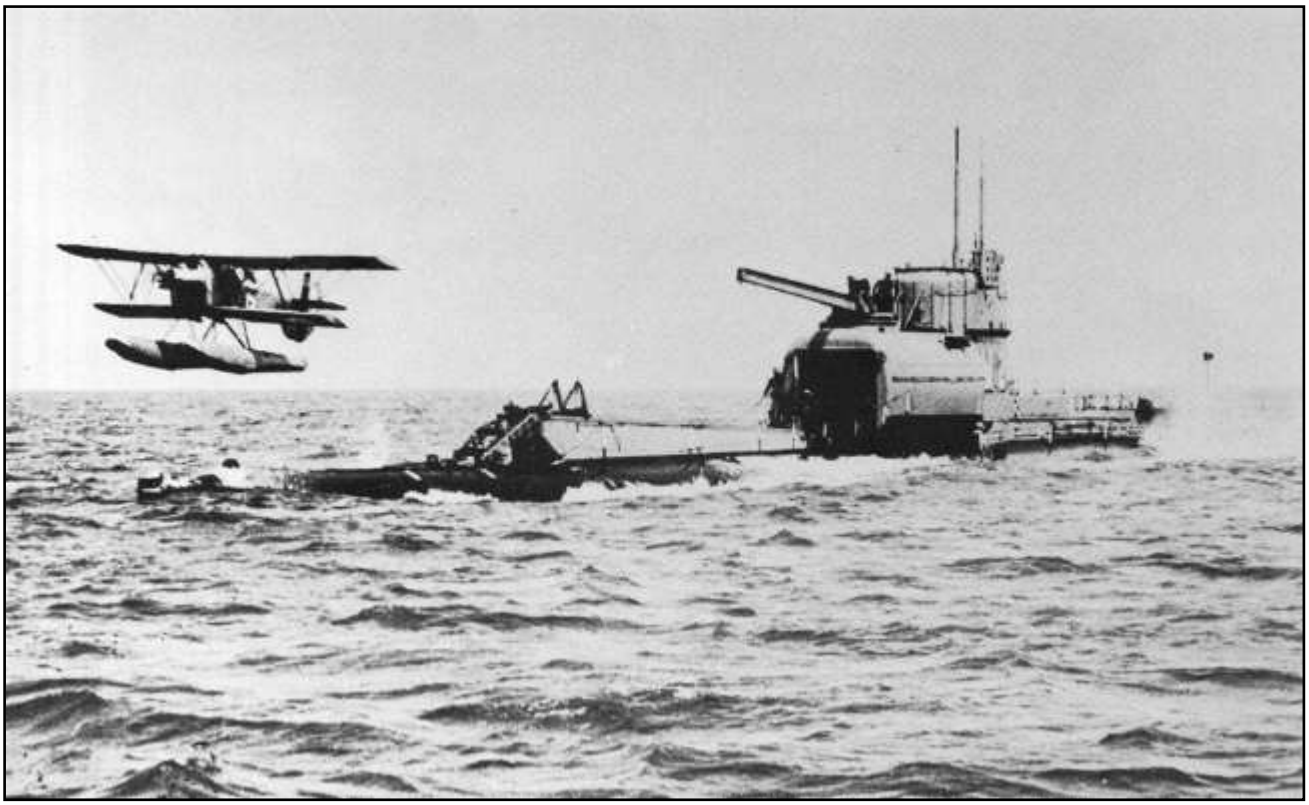
On October 25th 1925 M1 was rammed by the SS Vidal off Start Point and was lost without survivors.

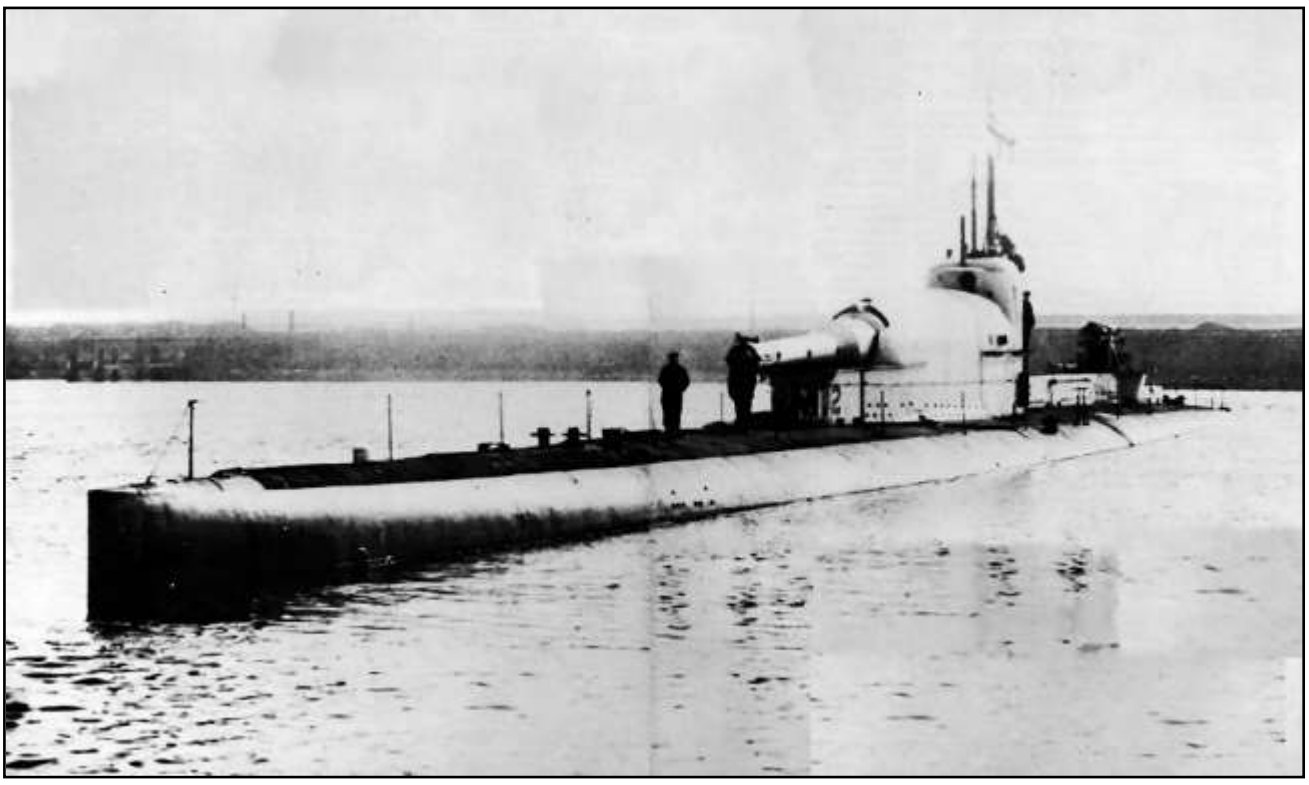
M2 and M3 had their large 12-inch guns removed in the late 1920s to conform with the Washington Disarmament Treaty, which stated that no submarine should have

larger than 8-inch calibre guns. M2 was refitted with a seaplane hanger forward of the conning tower and a catapult to launch a small Parnall Peto seaplane. This conversion was a success and M2 and M2 could surface from periscope depth, open the hangar door, catapult the plane, close the door and dive again within 5 minutes. She was subsequently lost during exercises in the English Channel in 1923 when her hangar doors were left open.

In 1927 M3 was converted to an experimental minelayer, stowing her 100 mines on rails in a large free flooding casing outside the hull. The mines were laid over her stern by means of a chain conveyer belt. M3 was finally taken out of service in April 1932 and scrapped in 1933.

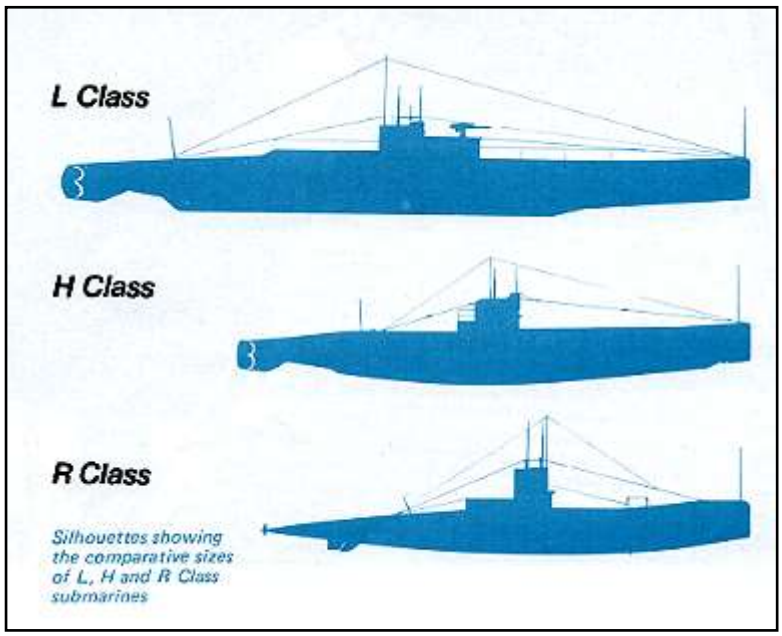
Although the M Class may be considered unsuccessful because their big guns were never used for the purpose intended, they were popular with their crews and were claimed to be handy under water, quick to dive and easy to handle.





1916 - 1945 L, H AND R CLASS SUBMARINES

L Class submarines 1916 – 1945



Silhouettes showing the comparative sizes of L, H and R Class submarines

Delighted with the success of the E Class submarines, the Admiralty decide in 1916, to revert to the saddle tank type of construction, but incorporating the lessons learned from war experience. Two submarines to a new Admiralty design were ordered from Vickers in February 1916 and being practically elongated E's they were called E57 and E58. However overall improvements so distinguished the design that a new class title was adopted, the L Class and the two boats were later renamed L1 and L2.

By December 1916 a total of 34 L Class submarines had been ordered but of these only 27 were commissioned, L28 to L32 were broken up after commencement and L34 and L35 were cancelled. L13 was never ordered, presumably for superstitious reasons (memories of the K13?). Eighteen of the class were built at Vickers, three of which were completed in other yards.

L Class submarines can be divided into three groups: L1 to L8 with 18-inch bow and beam tubes: L14, L17 and L24 to L27, which were fitted as minelayers, with 21-inch bow tubes; and L9 to L33 (excluding the minelayers) which had 21-inch bow tubes and 18-inch beam tubes.

In addition to torpedo armament, the class carried a gun mounted forward of the bridge. Although the earlier boats (L1 to L8) carried a 3-inch HA gun, all the class were eventually fitted with a 4-inch gun of various descriptions, for a three man increase in the compliment: this increase meant that the L boats had a 38 man crew, but even so, they carried only one 12ft 6in collapsible lifeboat.

The L Class were the first submarines to carry some of the normal fuel stowage in external tanks. Although only about 20 tons of fuel was carried in two lightly constructed tanks, this started the practice, which was developed in the 1920s, of carrying a large amount of fuel externally.

The main engines of the class were two twelve cylinder diesels, giving a total of 2400 bhp at 380 rev/min, but this was the bench test power of the engines. L Class submarines carried 336 cells in three battery tanks, grouped to allow working at 220 volts in series and 110 volts in parallel, producing submerged power for four main motors of the open shunt wound double armature type, developing a total of 1600 bhp at 300 rev/min for 1½ hours. Also an auxiliary drive consisting of a 20 hp motor, driving the starboard shaft through a worm drive, could give a slow running submerged speed of 1.75 knots.

A surface speed in excess of 17 knots was hoped for in the L Class and even when carrying additional fuel in the external tanks, there is no doubt that this speed was attained. The first boat on trials, L1, actually obtained 17.2 knots and in 1930, 17.6 knots was given as the design surface speed for the class. Although a designed submerged speed of 11 knots was anticipated in L1, the fitting of a 5ft 6in high fixed bridge screen reduced this to 10.5 knots.

Although it has been stated that the designed diving depth of the L Class was 250 feet, the officially used maximum diving depth, given in 1925, was 150 feet, based on the age of the boats, their wartime construction, etc. However, depths in service, of more than 250 feet have been recorded and on one occasion L2 accidentally submerged to 300 feet and except for minor faults withstood the pressure.

Of the L Class, only one was lost during the war, L10, in the North Sea. In August 1929 L9 foundered in Hong Kong Harbour in a typhoon and was later salvaged, but was not refitted. In January 1924, L24 was accidentally rammed and sunk off Portland by the battleship HMS Resolution. At the time prolonged efforts were made to salvage her and a team of German divers, with a new type of diving suit which enabled them to work in deeper waters, was brought over. Unfortunately the strong underwater currents proved too difficult and the L24 still lies where she sank. In October 1945 L23 was the last L boat to be taken out of service, 28 years after she was laid down, thus reflecting the success of the class.

The building of the L boats led to the construction of the L50 Class, which was the L Class modified to give increased armament. Although none were built at Vickers, a total of 25 L50 submarines were ordered from seven yards, but of these only seven were completed.

L12 and H28 fitting out in Devonshire Dock in May/June 1918. Note L12s saddle tank construction and the 4-inch gun mounting.

H21 Class Submarines 1917 – 1945

While L Class submarines were under construction, Vickers received an order in January 1917, to build 12 boats to the American H Class design. Twenty boats of this class had been contracted from the Bethlehem Steel Works, USA in November 1914 for the Royal Navy. Fourteen were delivered (H1 to H12, H14 and H15), the other six were forfeited to Chile as compensation for warships seized in 1914. H14 and H15 were transferred to the Royal Canadian Navy in April 1919.

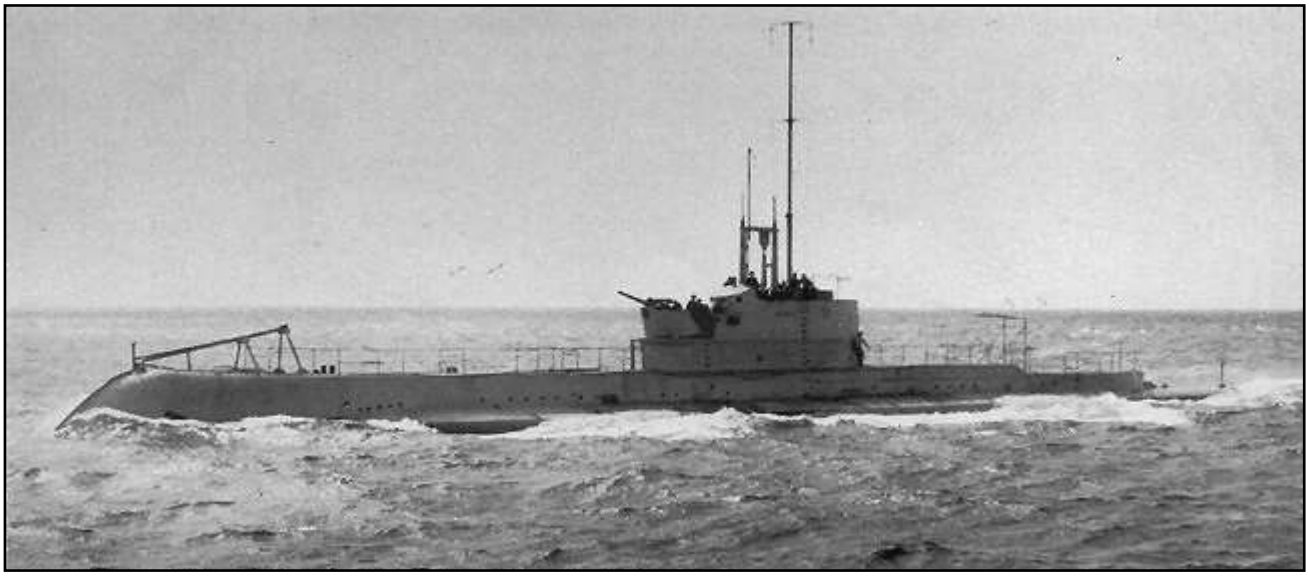
The British H boats, known as the H21 Class, were a modification of the American design and accommodated a heavier torpedo armament (21-inch bow tubes replacing 18-inch tubes) which increased the overall length of the class by 21 feet. Using engines, main motors and other fittings obtained from America speeded up production and the Vickers built first of class H21 was completed in January 1918, eleven months after being laid down.

In June 1917 further orders were given to five other yards for 22 additional H21 submarines (H33 to H54), with their engines and motors being made in England to the American H Class design. Ten of these boats were subsequently cancelled when it was decided in October 1917 to construct 12 new R Class submarines.

The H21 Class were the first Royal Navy twin shafted single hulled submarines and their American designed eight cylinder vertical armature diesel engines produced a total of 480 bhp. Also of American design, their main motors, powered by 120 battery cells, produced 620 bhp for one hour and had a continuous rating of 320 bhp.

MAIN PARTICULARS	L1 to L8	L9 to L33	H21 Class	R Class
Length overall	231ft 1 in	238ft 7in	171ft 9in	163ft 9in
Beam	23ft 5½in	23ft 5½in	15ft 9in	15ft 9in
Depth, pressure hull	15ft 9½in	15ft 9½in	15ft 4in	15ft 3in
Displacement,				
surface	891 tons	914 tons	438 tons	410 tons
submerged	1074 tons	1089 tons	504 tons	503 tons
Diving depth	150 feet	150 feet	150 feet	150 feet
No. of shafts	2	2	2	1
Propellers	3 blades, 5ft 7in diameter	3 blades, 5ft 7in diameter	Details unknown	Details unknown
Speed, surface:				
design	17 knots	17 knots	13 knots	9.5 knots
service	17 to 17.5 knots	17 to 17.5 knots	11.5 knots	9.5 knots
Speed, submerged:				
design	10.5 knots	10.5 knots	10 to 10.5 knots	15 knots
service	10.5+ knots	10.5+ knots	9 knots	15 knots
Endurance, surface:				
design	2800 miles (full power)	2800 miles (full power)	2000 miles (full power)	2000 miles at 9 knots
service	2850 miles (full power)	2850 miles (full power)	1100 miles (full power)	2400 miles (full power)
	3600 miles (half full power)	3600 miles (half full power)	1600 miles at 10 knots	
Endurance, submerged:				
design	14 miles (full power)	14 miles (full power)	70 miles at 3 knots	15 miles (full power)
service	14 miles (full power)	14 miles (full power)	9 miles at 8 knots	15 miles (full power)
	65 miles at 5 knots	65 miles at 5 knots	34 miles at 3.5 knots	150 miles at 1.5 knots
Armament	4 18-inch bow tubes	4 21-inch bow tubes	4 21-inch bow tubes	6 18-inch bow tubes
	2 18-inch beam tubes	2 18-inch beam tubes	(6 torpedoes carried)	(7 torpedoes carried)
	(10 torpedoes carried)	(10 torpedoes carried)		
	1 4-inch gun	1 4-inch gun		
Complement:				
design	35	38	22	22

1925 - 1946 OVERSEAS PATROL SUBMARINES



Overseas Patrol Submarine, OTWAY

The first submarines to be designed after the First World War were the O Class, a post war concept of an Overseas Patrol Submarine. With this class it appears that the Admiralty finally decided that the submarine deserved the dignity of a name, thus the pioneer of the class was called Oberon.

The L50 Class submarines were chosen as a model for the Oberon design but the new class had much greater endurance, increased diving depth, improved torpedo armament and increased wireless range. However a 75 per cent increase in displacement led to a loss of speed, surface and submerged.

During the building of Oberon the unforeseen growth in topside fittings had a devastating effect on submerged speed and although modifications were made after her completion in August 1927, a quoted underwater speed of 9 knots, attained from two twin armature motors developing 1300 bhp seems impossible.

The two Admiralty designed six cylinder diesels in Oberon developed 2700 bhp and giving a quoted surface speed of 13.75 knots, were made at Chatham. Laid down after Oberon, Oxley and Otway were built by Vickers for the Royal Australian Navy and had their engines redesigned, an increase in the bore and stroke of the cylinders giving 3000 bhp, which resulted in an increase in surface speed of approximately 1.5 knots.

Oberon was the first submarine to carry ASDIC, a device originally designed under the auspices of the Allied Submarine Detection Investigation Committee to detect submarines. However ASDIC the forerunner of SONAR, was put to good use by submariners against surface targets and took over from the hydrophone which was unable to measure with any accuracy, the speed, course or the distance of an enemy vessel.

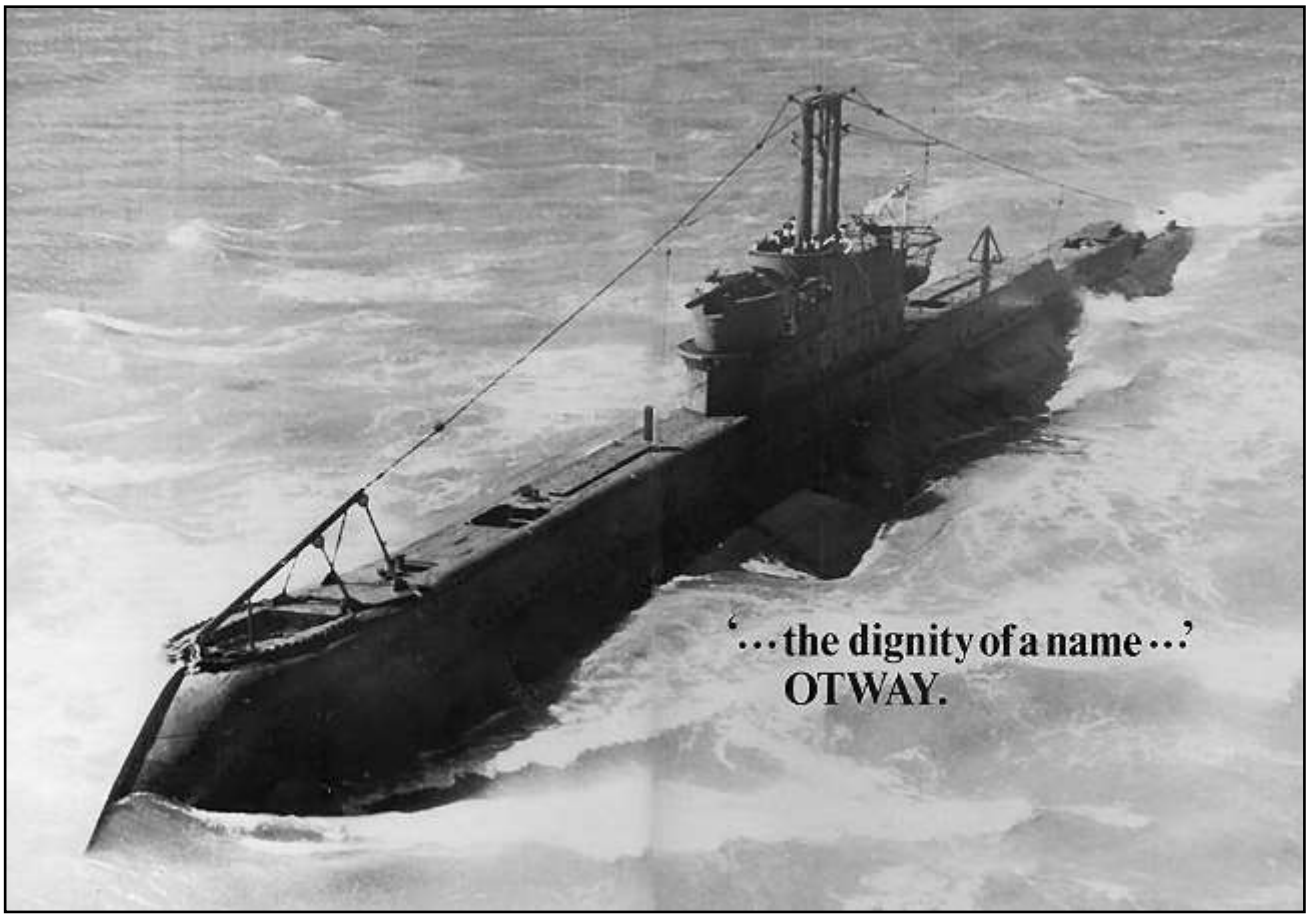
On the delivery voyage to Australia in 1928, Oxley and Otway encountered very severe weather in the Bay of Biscay which badly strained their engine columns, forcing them to remain in Malta for several months whilst British experts repaired the damage. After useful service in the Royal Australian Navy the two vessels were transferred to the Royal Navy in 1931.

In 1925 the need for a new programme of Overseas Patrol Submarine construction resulted in the Odin Class. This class was 13 feet longer than the Oberons owing primarily to a 7ft 6in increase in the engine room length. Odin was approved by the Board in August 1926 and was the first of a class of six, the others being Oswald, Osiris, Otus, Olympus and Orpheus.

In the 1927 programme six Parthian Class submarines were ordered (Parthian, Perseus, Poseidon, Proteus, Pandora and Phoenix), and in the following year six Rainbow Class (Rainbow, Regent, Regulus, Rover, Rupert and Royalist) were also ordered. Of the latter Rupert and Royalist were subsequently cancelled. Although slightly larger than the O boats the main particulars of these two classes were practically the same. But in an attempt to make living conditions more pleasant on long surface passages to the Far East, The Rainbow Class were fitted with a galley on the upper deck and a shower in the conning tower.

The Odin, Parthian and Rainbow classes were all fitted with four cycle blast injection eight cylinder diesels, accommodated in the larger engine room and designed to develop a total of 4400

bhp in the Odin's and 4640 bhp in the Parthian's and Rainbow's. In each case the engines were made by the building yard.



By the late 1920s the ability to dive quickly had become a major consideration, but it was believed that a submarine could not submerge faster than about two feet per second. The minimum time to dive from full buoyancy to periscope depth appears to have been of the order of one minute. The range of seawater density in which submarines of the period were designed to dive was quite limited and it wasn't until late in the building of the Odin Class that a requirement to be able to dive in fresh water was introduced, resulting in changes to the compensating water tanks. The ability to dive in waters with a specific gravity of 1.00 to 1.30 remained for all submarines until the Second World War, after which it decreased to 1.015 to 1.03.

The Oberon, Odin, Parthian and Rainbow classes were designed to dive to a depth of 500 feet. The Oberons were tested to 200 feet and in the three later classes the deep diving trials were to 300 feet, although it is known that some boats went deeper. Rear-Admiral Submarines (RA(S)) laid down 300 feet as the test diving depths of boats designed to withstand depth pressure at 500 feet.

It is interesting to review the policy regarding deep diving. In 1928 the Director of Tactical Division (DTD) stated: 'The ability to dive to 500 feet was introduced principally in order that pressure hulls of these submarines should be more capable of withstanding the effect of the explosion of a depth charge. Submarine officers did not visualise any intentional diving to such depths as 500 feet though the ability to do so is an asset in the event of an involuntary deep dive which might cause the submarine to go much deeper than was ever intended'.

When on patrol, the daily fuel consumption for all classes, allowing 12 hours diving, 12 hours steaming at slow speed and eight hours charging, was given as 2.1 tons per day, except in Orpheus (the only vessel to be fitted with a Vulcan clutch) where the consumption was 2.6 tons per day.

In the Overseas Patrol Submarines, practically the whole of the fuel was carried in external tanks. The tanks were riveted and tested to 20 lb per square inch, but they leaked to such an extent that they could be considered a failure. Various reasons, such as defective plating, manhole covers and bad equalising arrangements, were blamed for the leaks and many fruitless attempts were made to overcome the faults. In fact the trouble throughout had been caused by the rivets and in an era when welded ship construction was in its infancy, the externals were ultimately successfully rebuilt in welded construction.

Of the 19 Overseas Patrol Submarines built, 18 served in the Second World War, 12 of which were lost on active service. The last submarine to be taken out of service was the Vickers built Otus in April 1946.

OVERSEAS PATROL SUBMARINES MAIN PARTICULARS

	Oberon Class	Oxley & Otway Classes	Odin Class	Parthian Class	Rainbow Class
Length overall	269ft 8in	275ft	283ft 6in	289ft 2in	287ft 2in
Beam	27ft 11½in	27ft 7⅝in	29ft 10½in	29ft 10⅜in	29ft 11in
Depth, pressure hull	16ft 8⅝in	16ft 7½in	16ft 11⅝in	16ft 11⅜in	16ft 11⅞in
Displacement,					
surface	1598 tons	1636 tons	1781 tons	1760 tons	1763 tons
submerged	1831 tons	1872 tons	2038 tons	2040 tons	2030 tons
Diving depth	500 feet	500 feet	500 feet	500 feet	500 feet
No. of shafts	2	2	2	2	2
Propellers	Details unknown	Details unknown	3 blades, 6ft 5in dia.	3 blades, 6ft 5in dia.	3 blades, 6ft 9in dia.
Speed, surface:					
design	15 knots	15.5 knots	17 to 17.5 knots	17 to 17.5 knots	17 to 17.5 knots
service	13.75 knots	15.2 knots	17.5 knots	17.5 knots	17.5 knots
Speed, submerged:					
design	9 knots	9 knots	9 knots	9 knots	9 knots
service	7.5 knots	8.5 knots	8 knots	8.5 knots	8.75 knots
Endurance, surface:					
design	12 000 miles at 8 knots	14 000 miles at 8 knots	11 400 miles at 8 knots	11 400 miles at 8 knots	11 400 miles at 8 knots
service	6800 miles at 10 knots	8450 miles at 10 knots	11 400 miles at 8 knots	10 750 miles at 8 knots	10 900 miles at 8 knots
Endurance, submerged:					
design	60 miles at 4 knots	60 miles at 4 knots	60 miles at 4 knots	60 miles at 4 knots	60 miles at 4 knots
service	Details unknown	16 miles at 9 knots	8 miles at 8 knots 52 miles at 4 knots	8.5 miles at 8.5 knots 70 miles at 4 knots	8.8 miles at 8.8 knots 60 miles at 4 knots
Armament	6 21-inch bow tubes 2 21-inch stern tubes (16 torpedoes carried) 1 4-inch gun	6 21-inch bow tubes 2 21-inch stern tubes (16 torpedoes carried) 1 4-inch gun	6 21-inch bow tubes 2 21-inch stern tubes (14 torpedoes carried) 1 4-inch gun	6 21-inch bow tubes 2 21-inch stern tubes (14 torpedoes carried) 1 4-inch gun	6 21-inch bow tubes 2 21-inch stern tubes (14 torpedoes carried) 1 4-inch gun
Complement:					
design	53	53	53	53	53

1929 - 1945 THE RIVER CLASS SUBMARINES

Even though marine diesel engines of the period were incapable of propelling submarines as fast as surface craft, the Admiralty still wished, perhaps misguidedly, to build Fleet Submarines and continued to discuss, at length, the functions and requirements of such vessels. In 1928 the culmination and removal from service of the K Class submarines and the demand by Rear-Admiral (Submarines) for 'submarines which in an ocean war, would be capable of operating with the Fleet' led to the development of the River Class Fleet Submarine.

Submitted to the Board in June 1929, the River class were conventional submarines, long, well streamlined and without any large guns or any other unusual features. All three vessels of the class were built at Barrow, the first of class Thames completing in September 1931 and her slightly larger sister ships, Severn and Clyde, in 1935. The original intention was to construct 20 Thames Class submarines for the Royal Navy but a change of policy in 1933 prevented this.

Built at a cost of over £500000 each the large and comfortable Thames Class were partial double hulled boats with a pressure hull of 'keyhole' section.

In an attempt to keep down weight so as to reach the required speed, the design diving depth was reduced from 500 feet of the Odin Class to 300 feet, with the result that the pressure hull plating was reduced to 25 lb per square inch as opposed to the 35 lb per square inch in Odin.

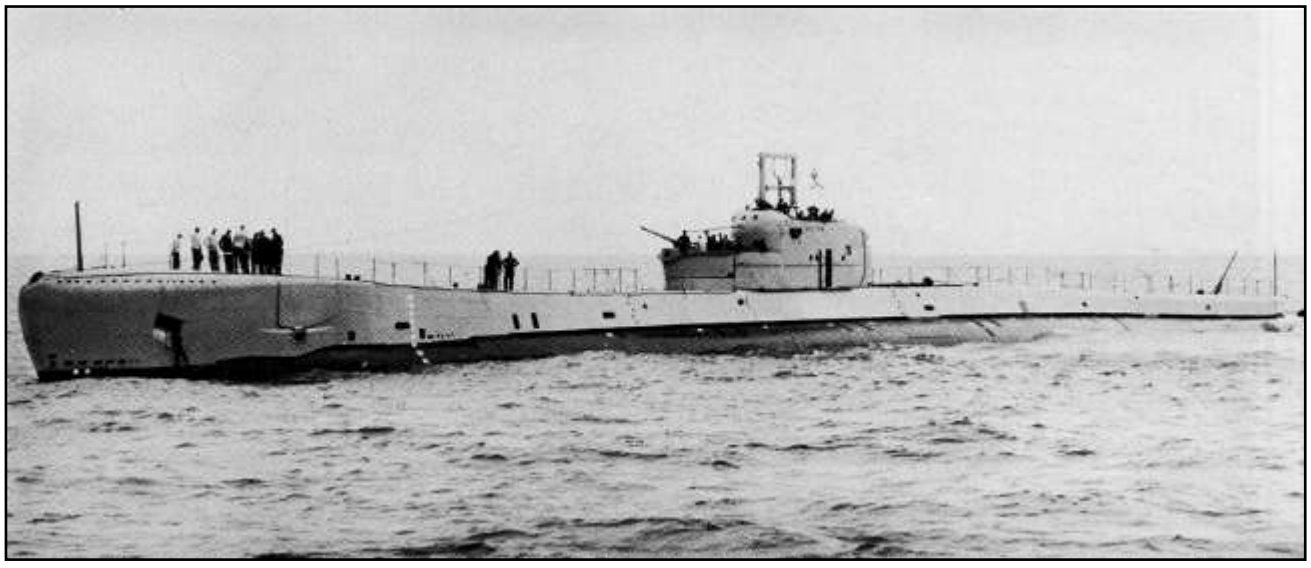
To propel the Thames Class at the unusually high surface speed of 22.5 knots (a record at that time) and at the expense of the stern torpedo tubes, two vertical four stroke blast injection ten cylinder diesels, developing a total power of 8000 bhp at 400 rev/min, were installed. Using two auxiliary generators, driven by two Ricardo sleeve valve engine, these engines could be supercharged to give a total of 10000 bhp.

The machinery was of Admiralty design and when built weighed 347 tons, 33 tons less than allowed for in the legend weights. Without this saving the Thames Class might have had serious stability problems. When first constructed, Thames, when surfacing, experienced heavy listing due to a water build-up in the main tanks on one side. The position of the flooding holes was modified to remedy this trouble. In addition, her large superstructure meant that Thames rolled heavily when surfacing 'beam on' in heavy seas and it became the practice to surface head-to-sea in rough weather whenever possible.

As with Overseas Patrol Submarines, the Thames Class carried fuel oil in external tanks, but whereas the Overseas boats were fitted with troublesome riveted tanks, the tanks of the Thames Class were of welded construction and were very satisfactory, though leaks occasionally occurred inboard, through rivets in the thick pressure hull plating.

With the abolition of the stern tubes, the torpedo armament of the class consisted of six 21-inch bow tubes (with 12 torpedoes carried). A 4.7-inch gun was originally fitted, but in keeping with submarine policy of the period was changed, after completion, to a 4-inch QF gun with 120 rounds of ammunition.

All three Thames Class submarines served in the Second World War and although misemployed in the North Sea and Mediterranean, were certainly successful, but no more so than any other British submarine of the period that cost half as much to build and operate. Oddly these submarines were never used with the surface fleet, as was intended and perhaps the highlight of their war career was the vital cargo mission to Malta in September 1941 by Clyde, carrying no less than 1200 tons of desperately needed stores.



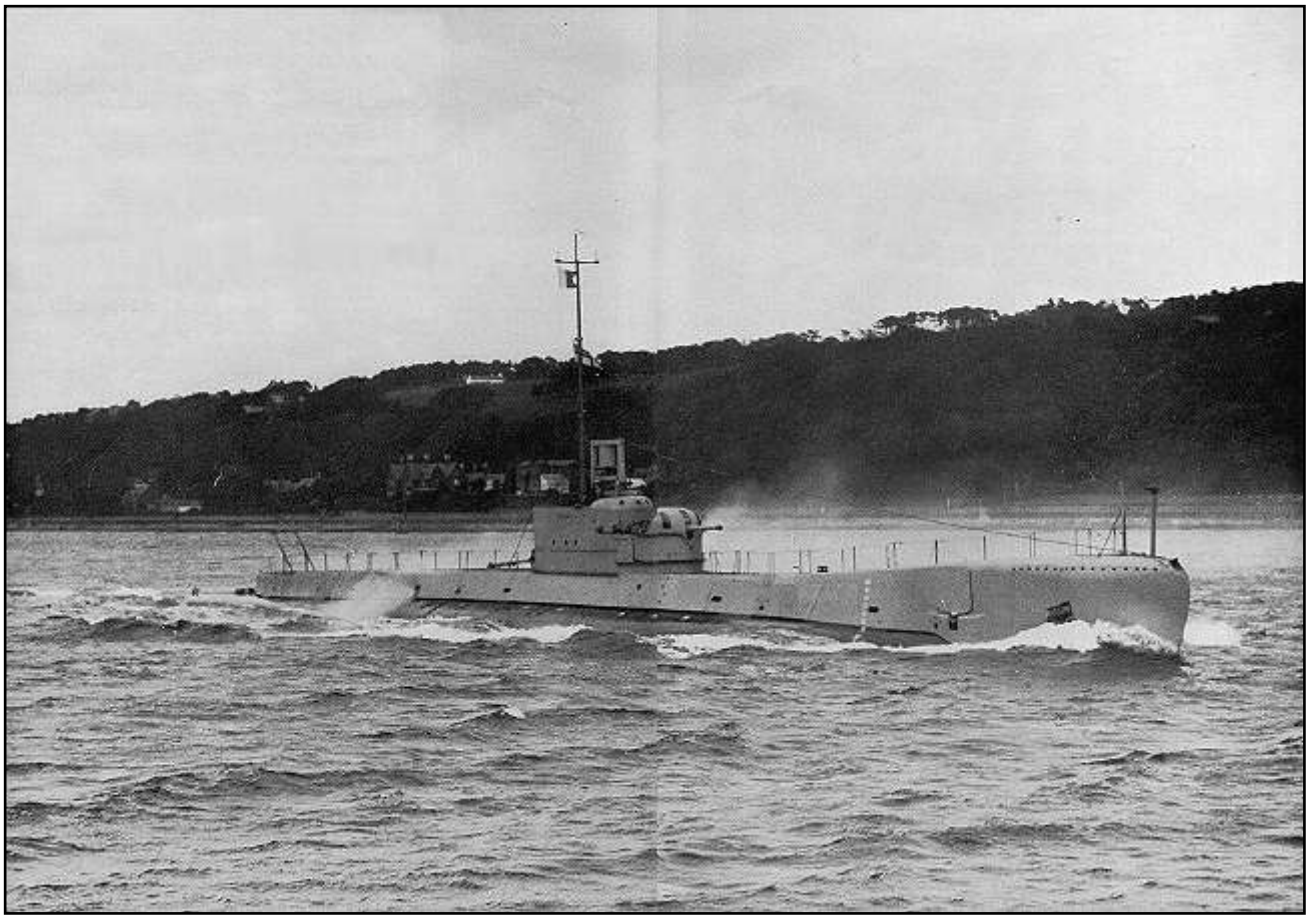
Severn a River Class submarine

Thames was lost on active service off the coast of Norway on 23rd September 1940. Although the cause is unconfirmed, it is likely that she was mined. The Severn and Clyde were taken out of service whilst on duty in the Far East, in April and October 1945 respectively.

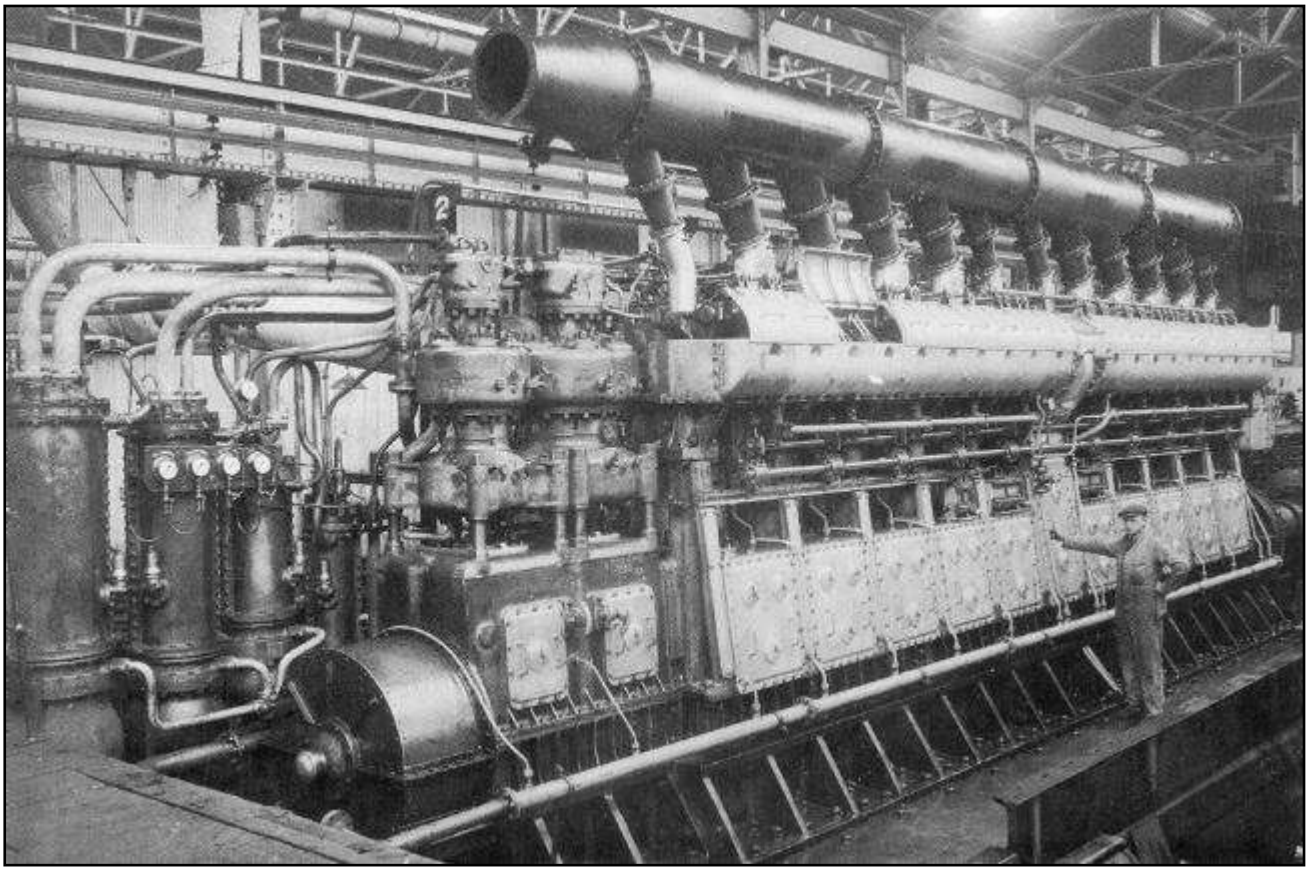
Although the Thames Class design proved successful in service it was soon realised that the concept was wrong and with its passing it became apparent that, with surface capital ships being capable of 30 knots, underwater speed was to be a principal feature of future submarines.

In conjunction with the Fleet Submarines, 12 Small Patrol Submarines were ordered in February 1929 (eight from Chatham, three from Cammell Laird and one from Scotts) and were the

forerunners of the famous S Class that served so effectively in the Second World War. Called the Swordfish and Shark Classes, they were based on the saddle tank construction of the L Class submarines, the majority of which were built by Vickers ten years earlier.



The Barrow built Thames which held the record surface speed for the period - 22.5 knots.



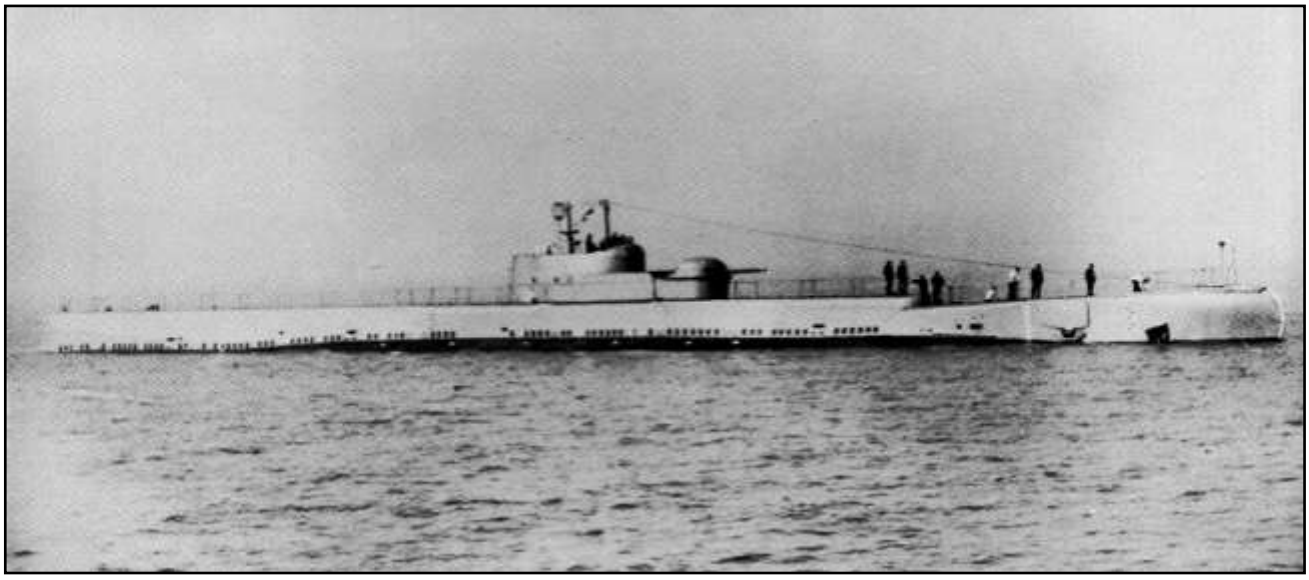
View from forward of the starboard engine of HMS Thames

FLEET SUBMARINES MAIN PARTICULARS

	Thames Class
Length overall	345 ft
Beam	28ft 3in
Depth, pressure hull	18ft 3in
Displacement,	
surface	2165 tons
submerged	2680 tons
Diving depth	300 feet
No. of shafts	2
Propellers	Details unknown
Speed, surface:	
design	21.75 knots
service	22.5 knots
Speed, submerged:	
design	10 knots
service	10.5 knots
Endurance, surface:	
design	10 000 miles at 8 knots
service	16 100 miles (maximum)
Endurance, submerged:	
design	10 miles at 10 knots
service	13 miles at 10 knots
	118 miles at 4 knots
Armament	6 21-inch bow tubes
	(12 torpedoes carried)
	1 4-inch QF gun
Complement:	
design	61

The pistons from the port engine of HMS Clyde

1930 - 1946 THE MINELAYING SUBMARINES



The Porpoise who gave her name to a class of six such minelaying submarines

The history of Royal Navy minelayers began when six of the E Class submarines ordered in 1914 were built to carry 20 mines in mine tubes in the saddle tanks. E24, the Royal Navy minelayer, was completed on 9th January 1916 and later that year it was ordered that six submarines of the L Class be fitted with mine tubes in the external tanks. In July 1920 the Naval Staff investigated the

need and requirements for submarine minelayers, the main bone of contention being whether the mines should be carried internally or externally. As an experiment, M23 was converted in 1927 to carry mines externally.

The satisfactory performance of M3 led to the design of a new submarine minelayer, the famous Porpoise Class. Specifically designed for the task of minelaying, six of the class were ordered in the 1930 programme, the first of class Porpoise, Narwhal and Rorqual from Vickers, Grampus and Seal from Chatham and Cachalot from Scotts. Slightly slimmer than the Overseas Patrol Submarine, but with a greater displacement, the new class had a capacity to carry 50 standard Mk XVI mines in a full length deck outside the pressure hull.

During the trials of M3 it was found that whilst the minelaying gear and compensating arrangements to maintain trim were satisfactory, the jigger type mine launching equipment required excessive upkeep to ensure its efficiency. Therefore this equipment was changed in the Porpoise Class to a chain and rack system fitted outside the hull in the superstructure casing. The mines and minelaying gear weighed approximately 54 tons. The conversion of M3 also had an adverse affect on its diving qualities, the time taken to flood the mine casing meant that it took about 5 minutes to dive in calm weather and 13 minutes or more in rough weather. Only by careful design arrangements was this reduced in Porpoise, she could dive, with mines on board, to periscope depth from full buoyancy in 1 minute 32 seconds and using Q tank, in 1 minute 14 seconds.

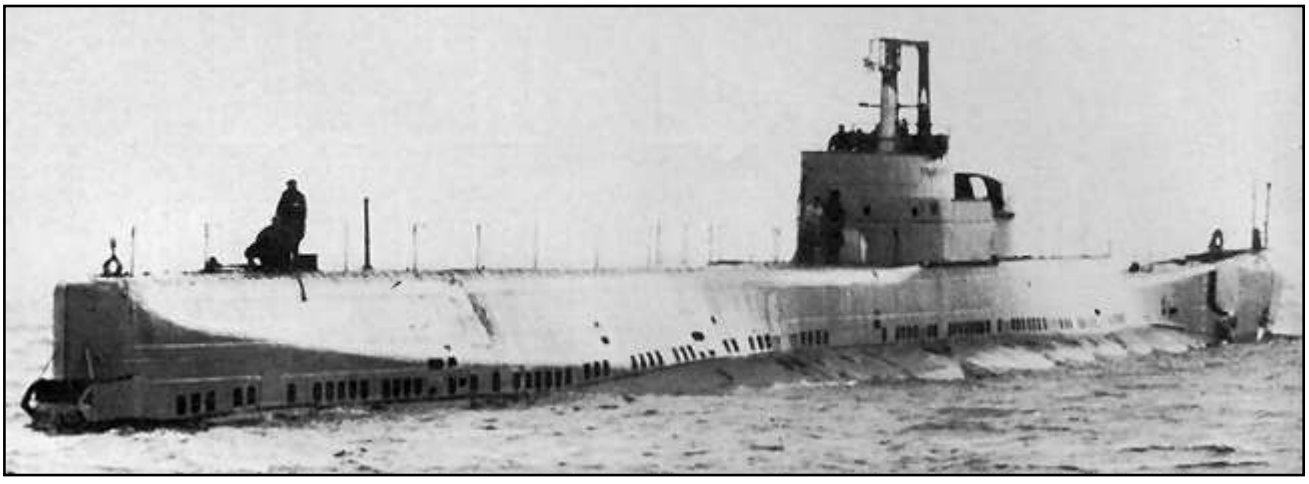
The hull form of Porpoise was very similar to that of the Overseas Patrol Submarine Parthian, but the effect of carrying 50 mines meant that the stern torpedo tubes were deleted and the main engine horse power was reduced by 25 per cent, resulting in a loss of surface speed. The design diving depth was also reduced to 300 feet.

Although the external tanks were of ‘non leaking’ welded construction, as in the Thames Class, it was thought that if exposed to depth charge attacks leaks would occur and give away the submarine’s position. Therefore the hull form for the Chatham built Grampus was radically changed (saddle tanks were extended, the pressure hull was altered, etc.) so that fuel oil, which was carried externally in Porpoise, could be carried in internal tanks. This change also increased the main ballast water carried by Grampus by about 100 tons and at the same time improved the stability and reserve buoyancy of the boat.

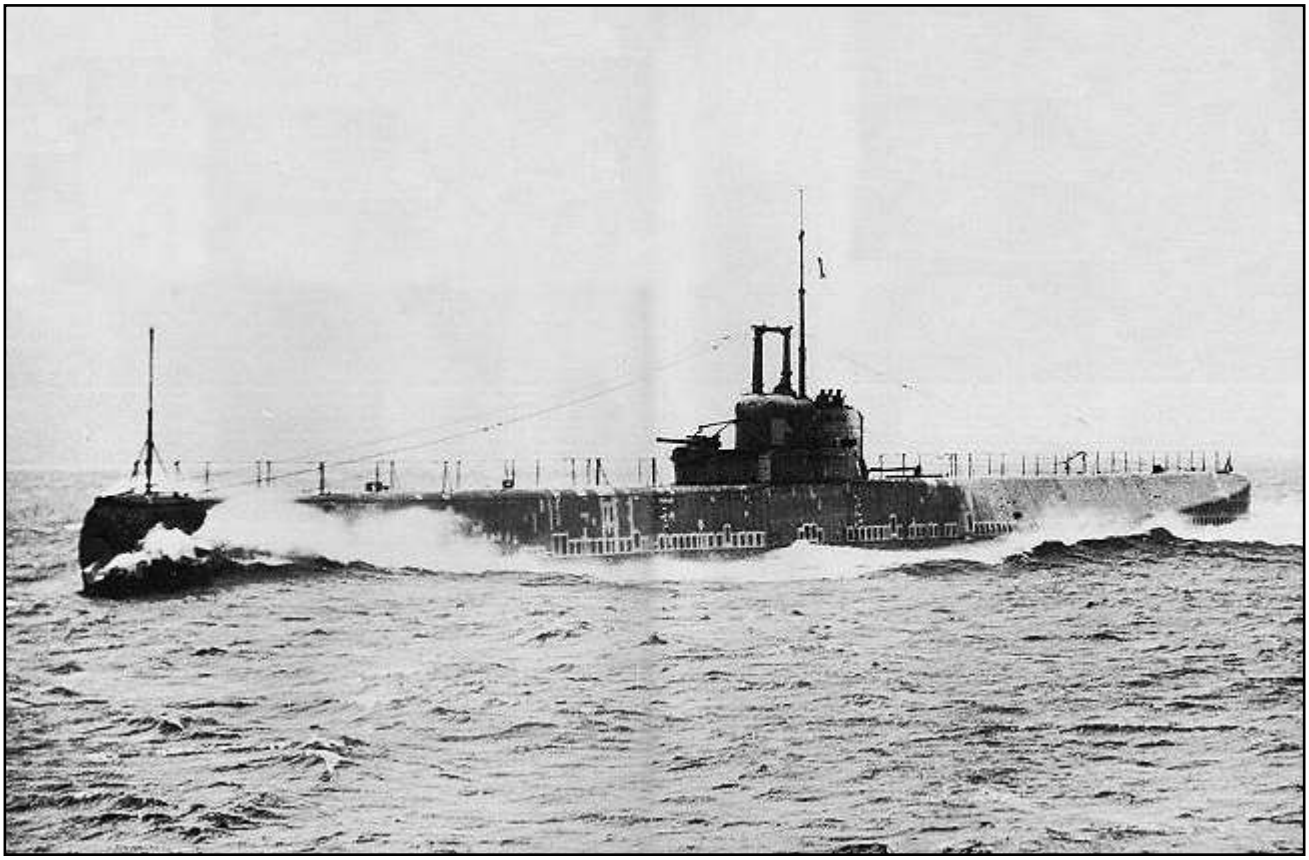
All vessels of the class had balloon tanks, i.e. pressure tight tanks, in the forward superstructure to balance the buoyancy of the mines aft and prevent the submarine diving stern first.

Built between 1930 and 1938 the six boats of the Porpoise Class were fitted with two Admiralty designed vertical four stroke blast injection six cylinder diesels that together generated 3300 bhp, giving a surface speed, in service, of 16 knots. Tandem sets of motors on each shaft developed a total of 1630 bhp giving a submerged speed of 8.9 knots. Carrying 336 cells in three battery tanks weighing a total of 139 tons, the class had a submerged endurance of 66 miles at 4 knots.

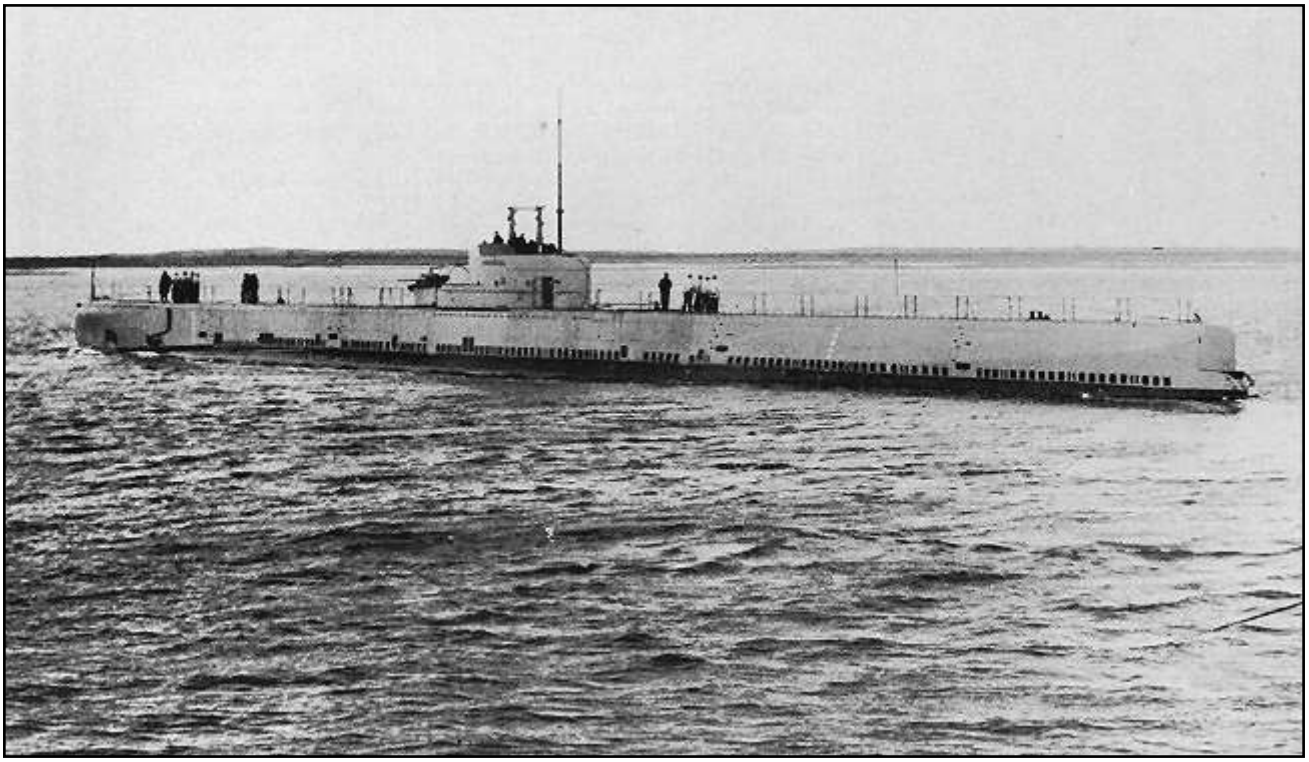
In addition to the 50 mines, the armament of the class consisted of six 21-inch bow torpedo tubes (with 12 torpedoes carried) and a 4-inch gun (a 4.7-inch gun was originally fitted in Porpoise) with 120 rounds of ammunition, this being chosen as the standard gun to be fitted to Royal Navy submarines. When the gun of Porpoise was changed to the standard calibre a weight saving of about seven tons was achieved.



Stern view of Porpoise showing rear minelaying doors.



Barrow built Porpoise Class – the Narwhal



Rorqual, the only Porpoise Class submarine to survive World War II, Taken out of service in 1946

When the Royal Navy produced a mine which could be laid from a 21-inch torpedo tube, the need for specialised submarine minelayers disappeared. Surprisingly the introduction of this newly designed mine did not lead to the redundancy of existing minelayers and these purpose built vessels proved extremely successful in the Second World War when used as supply submarines, running precious cargoes to Malta in 1941 and 1942. Their spacious mine decks were filled with such diverse items as machine gun ammunition, glycol coolant for Spitfires and Food.

Five of the six submarine minelayers were lost during the war and the history of the class produces an unhappy diary of events:
5th May 1940: Seal, the last of the class to be constructed, was captured as a wreck in the Kattegat and recommissioned as a German U-Boat. She was finally scrapped in 1941.
24th June 1940: Grampus was lost on active service in the Mediterranean, cause unknown.
1st August 1940: Narwhal was lost on active service off the coast of Norway, cause unknown.
October 1941: Cachalot was lost on active service, further details unknown.
19th January 1945: The first of class Porpoise was lost on active service in the Malacca Strait, probably sunk by aircraft.

The era of the large minelaying submarine came to an end when the only surviving member of the Porpoise Class, the Barrow built Rorqual, was taken out of service in April 1945.

MINELAYER SUBMARINES MAIN PARTICULARS

	Porpoise Class		
Length overall	289 ft	**Endurance, surface**	
Beam	29 ft 10¼ in	**design**	12 800 miles (maximum)
Depth, pressure hull	16 ft 9 in	**service**	3860 miles (full power)
Displacement,			11 500 miles at 8 knots
surface	1768 tons	**Endurance, submerged:**	
submerged	2053 tons	**design**	64 miles at 4 knots
Diving depth	300 feet	**service**	8 miles at 9 knots
No.of shafts	2		66 miles at 6 knots
Propellers	Details unknown	**Armament**	6 21-inch bow tubes
Speed, surface:			(12 torpedoes carried)
design	15 knots		1 4-inch gun
service	16 knots		50 Mk XVI mines
Speed, submerged:		**Complement:**	
design	8.75 knots	**design**	59
service	8.9 knots		

1935 - 1970 T CLASS SUBMARINES

During the 1930s the construction of overseas patrol submarines waned considerably and so the Admiralty decided in 1934/5 to build a new ocean going boat to replace the Oberon, Parthian and Rainbow classes, which had not lived up to expectations.

Requirements for the new class (defined as Patrol Submarines) demanded that they have a strong armament and a patrol duration of at least 42 days. Restricted by the limitations imposed by the London Navy Treaty, which allowed only 16500 tons total of new construction submarines, the class was designed to have a displacement of about 100 tons so that a sufficient number could be built. The first of class, approved in the 1935 programme, was built at Vickers and entered service in December 1938 under the name of Triton.

Fifty three T Class submarines were eventually constructed, making it the largest class of ocean going submarines ever built for the Royal Navy: the original order for the class was made under the growing threat of war, which forced the Admiralty to open its purse strings and no fewer than 21 riveted hull T boats, built between 1937 and 1941, followed Triton.

Displacing almost 400 tons less than the O, P and R Classes, this first group of 22 T Class submarines were noted for their simplicity of construction. They were superior to the O, P and Rs in that they had greater submerged speed, better surface and underwater handling and more torpedo tubes. However because the displacement limitations restricted the size and power of their engines to 2500 bhp (surfaced) (1450 bhp submerged) the maximum surface speed was lower.

The first T Class submarines were 275 feet long and displaced 1327 tons surfaced. Their ‘surface’ armament included one 4-inch gun and three 0.303-inch machine guns, which were later replaced by, or supplemented by, one 20mm Oerlikon cannon. They were the last Royal Navy submarines designed for overseas patrol to have insufficient range for the Pacific.

One of the most distinguishing features of the group 1 T boats was their high number of torpedo tubes, six bow tubes, which were re-loadable from inside the pressure hull, two external bow tubes, contained in a bulbous bow casing and two external tubes situated amidships and so arranged

as to fire ahead. This gave the class the phenomenal bow salvo of ten torpedo tubes which, the Royal Navy believed, would compensate for the inevitable errors that accompanied long range attacks. As an alternative to this armament a load of 18 mines could be carried.

Perhaps the most famous of the early T Class submarines was the ill fated Thetis. Sailing prior to handover in Liverpool Bay on the morning of 1st June 1939, Thetis had on board her 53 man crew and 50 passengers (Shipyard and Admiralty men concerned with her trials). For her trial dive Thetis was reluctant to submerge and so her six bow tubes were checked. When numbers 1 to 4 were correctly found empty, numbers 5 and 6 were tested to confirm that each contained seawater. The test cock of No 6 tube squirted water but, strangely, the test cock of No 5 did not and so was apparently empty. As there was only one way to be sure, the door was opened and the sea roared in. Jammed by one of its clips, the watertight door couldn't be closed and as two compartments flooded, Thetis nose dived to the sea bed 160 feet below.

With her stern protruding from the waves Thetis remained undiscovered for a whole day and although four men managed to escape, she became a tomb for the 99 men on board, despite the efforts of rescuers.

Triumph was lost on active service in the Aegean Sea in January 1942

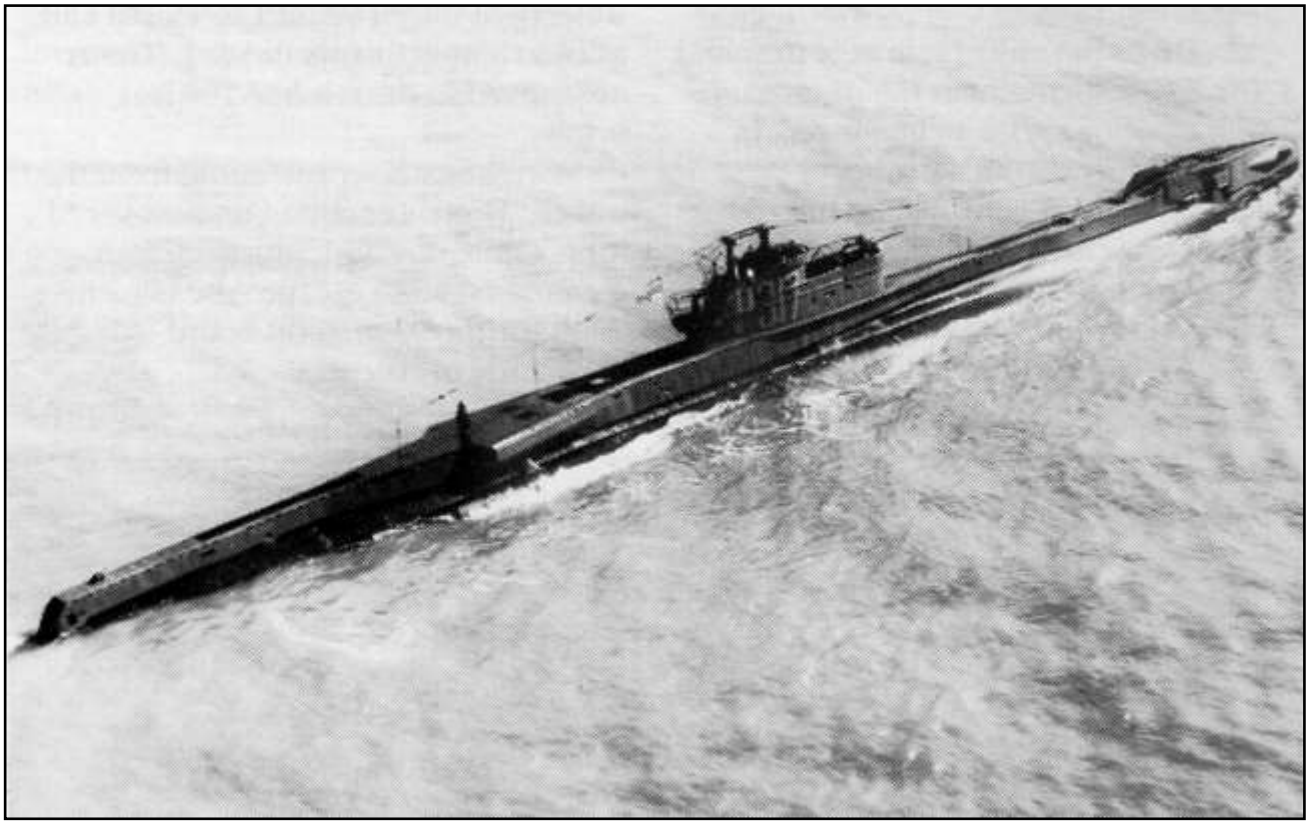
When Thetis was raised in November 1939 an investigation into the cause of this tragic accident revealed an incorrectly wired bow cap indicator, showing the cap to be shut when it was open and that the vital test cock was blocked with paint. To avoid any suggestion of a jinx on the boat, the Admiralty refitted and commissioned her, in November 1940, as Thunderbolt and as an epitaph to her previous life, she entered service with a diagonal rusty line on her hull that could not be hidden.

The War Years

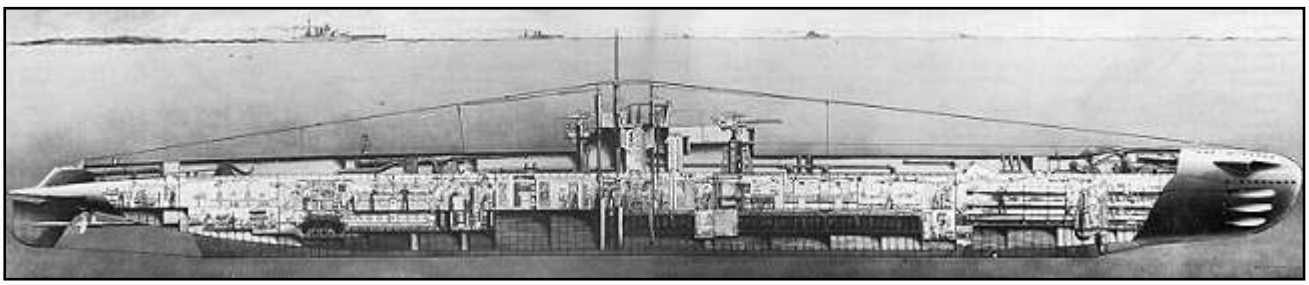
Under the 1940 War Programme, came the decision to build nine slightly modified T Class submarines.

These modifications were made in the light of experience gained with the first group of T boats and the main changes were in the number and disposition of torpedo tubes, the outer shape and the use, in most of the modified vessels, of an electrically welded rather than a riveted construction. The latter change assisted deeper diving, improved the resistance to depth charge attack and also enabled the shipbuilder to adopt the new technique of prefabricating the hull in sections in the shops and assembling large units at the building berth.

To this modified group of submarines was fitted, at the extreme stern, an additional external torpedo tube, whilst the two tubes amidships were repositioned aft of the conning tower, angled to fire astern. These changes altered the shape and silhouette of the class, as did the removal of the bulbous bow casing which had created a notable bow wave which, when running at periscope depth, hampered visibility and the correct trim of the boat. As a result of these alterations, the second group of boats were more streamlined and the openings for the two external tubes were more clearly visible.



One of the first T Class boats HMS Tally-Ho



In addition to their eleven 21-inch torpedo tubes, Group 2 T Class submarines were fitted with a 4-inch gun, a 20mm Oerlikon cannon on a platform aft of the periscopes and three .0303-inch machine guns on removable mountings.

Additional orders in the 1941 and 1942 Programmes meant that a total of 31 modified T Class submarines entered service between 1942 and 1946, 21 of which were laid down at Vickers, although a number of these were completed at other yards. Of the 22 Group 1 submarines constructed, eight were built exclusively at Barrow. Along with other British submarines, the T boats ordered in the 1941 and 1942 Programmes were fitted with surface and air search radar sets.

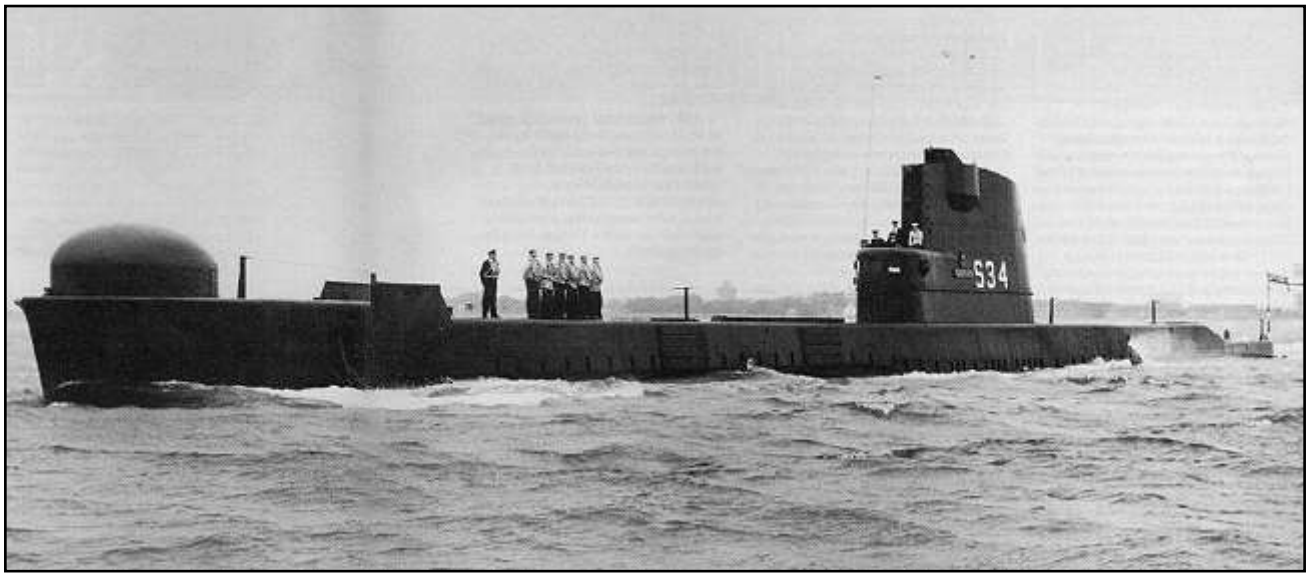
During the Second World War, T Class submarines operated successfully in all the theatres in which the Royal Navy was committed and many of the Group 2 boats were further modified for employment in the Far East, several ballast tanks were changed into fuel tanks, thereby increasing the fuel load from 132 tons to 230 tons and surface range from 8000 to 11000 miles at 10 knots. In a theatre were it took up to a week to sail from base to the operational area, this increase in range together with increased stores capacity enabled long patrols to be carried out, the record being 56 days by the Barrow built Tantalus, 40 days of which were spent in the patrol area.

Although the T Class obtained satisfactory results, the fact that they were one of the classes which bore the brunt of Second World War submarine operations meant that they were subjected to the highest loss rate. For example, 13 boats were lost in the Mediterranean, despite the fact that large enemy vessels were very vulnerable in that sea. Nevertheless, the T Class were particularly successful against submarines and 13 boats (six of which were Barrow built) sank 13 enemy submarines: six Italian, four German and three Japanese.

In January 1943, Thunderbolt, ex Thetis, transported ‘chariot’ type assault craft which penetrated the harbour of Palermo and sank the hull of the Italian light cruiser Ulpio Traiano, which was being fitted out. Other major successes included the sinking of two cruisers, the 5700 ton Kuma and the 13000 ton Ashigara, by the ‘Barrovians’ Tally-Ho and Trenchant respectively, whilst in August 1941 another Vickers boat, the Triumph, managed to seriously damage the 12000 ton cruiser Bolzano.

At the end of the war, most T Class submarines were placed in reserve, taken out of service or ceded to other countries. Most of the early T Class, with riveted hulls, could not be fully modernised, but five, Tireless, Token and the Barrow built Tapir, Talent and Teredo were streamlined and completely refitted with six bow tubes, modern sonar and a fin shaped conning tower. In 1951-56 eight of the welded hull boats were completely rebuilt in a manner similar to the American ‘Guppy’ Programme. The eight converted were the Tabard, Truncheon, Thermopylae, Totem, Turpin and the Vickers built Trump, Tiptoe and Taciturn. Their hulls were cut in two and new sections added to their length, they were streamlined and their underwater propulsion capacity was increased enormously to give twice the previous submerged speed and increased endurance. At the same time, sensing and detection equipment was updated.

Although in later years their speed of 15.25 knots surfaced and 9 knots submerged was judged to be inadequate, a proof of their high reputation for reliability is demonstrated by T Class submarines which, after many refits, were still in active service with a Foreign Navy in the early 1970s.



HMS Taciturn showing the radical changes that resulted from the 1951-56 rebuilding programme

T CLASS SUBMARINES MAIN PARTICULARS

	Group 1	Group 2
Length overall	275 ft	273ft 6in
Beam	26ft 6in	26ft 6in
Depth, pressure hull	14ft 3in	14ft 3in
Displacement,		
surface	1327 tons	1422 tons
submerged	1575 tons	1571 tons
Diving depth	300 feet	[1] 300 feet
No. of shafts	2	2
Speed, surface:		
design	15.25 knots	15.25 knots
service	15.25 knots	15.25 knots
Speed, submerged:		
design	9 knots	9 knots
service	8.75 knots	8.75 knots
Endurance, surface:		
design	7500 miles at 15.25 knots	7500 miles at 15.25 knots
service	8000 miles at 10 knots	[2] 8000 miles at 10 knots
Endurance, submerged:		
design	80 miles at 4 knots	80 miles at 4 knots
service	80 miles at 4 knots	80 miles at 4 knots
Armament	[3] 8 21-inch bow tubes (2 external) 2 21-inch amidship tubes (16 torpedoes carried) 1 4-inch gun [4] 3 0.303-inch machine-guns	8 21-inch bow tubes (2 external) 2 21-inch amidship tubes 1 21-inch stern tube (17 torpedoes carried) 1 4-inch gun 1 20mm Oerlikon cannon 3 0.303-inch machine-guns
Complement:		
design	56	61

[1] This was increased to 350 feet in the all-welded boats.

[2] T Class submarines serving in the Far East were modified to carry extra fuel, which increased endurance to 11 000 miles at 10 knots.

[3] As an alternative load, Group 1 submarines could carry 18 mines.

[4] These were later replaced by, or supplemented by, one 20mm Oerlikon cannon.

1930 - 1963 S CLASS SUBMARINES

The War Years

During the modernisation of the submarine force in the early 1930s, The Royal Navy became aware of the need for smaller boats, suitable for employment in the North Sea and restricted waters such as the Mediterranean. In response to this requirement, orders were placed for medium sized patrol submarines, from which the Swordfish and Shark Classes were evolved.

Based on the saddle tank construction of the L Class submarines, which they were designed to replace, the 12 vessels of these two classes proved so useful that an improved version was put into mass production during the Second World War. 217 feet long and displacing 872 tons (surfaced), the improved S boats gave outstanding war service under the most difficult conditions and there is some justification for describing them as the most important of the Royal Navy's submarines in the pre-missile era.

Improved S Class Submarines

Fifty Improved S Class submarines were launched between 1940 and 1945, making the S Class the largest group of submarines built for the Royal Navy: a total of 62 were constructed over a period of 15 years. In one respect the S Class was unique in that they were the only class to remain in production throughout the war period, which is a fair measure of their success.

As can be imagined, there were considerable variations in a design which spanned 15 years and modifications as a result of war experience could only be incorporated depending on the stage of construction reached. Although not, in themselves, above average, the combination of the S boat qualities, together with the reliability of their equipment and the great ease of operation and maintenance, made them very effective and safe.

No modifications were made to the first five vessels of the War Programme (Safari, Sahib, Saracen, Satyr and Sceptre), but an external stern torpedo tube was added to the group of boats that

followed, bringing the number of tubes up to seven and the number of available torpedoes to 13. This change was indicative of the varied armament of S Class submarines. Many boats were fitted with a 20mm Oerlikon cannon, mounted on a platform aft of the periscopes, which replaced or supplemented three portable 0.303-inch machine guns. 18 vessels built towards the end of the war and intended to operate in the Far East, had their standard 3-inch gun replaced by a 4-inch gun, mounted inside a low breastwork, forward of the conning tower. In addition, the boats fitted with a 4-inch gun had their stern torpedo tube removed, from weight considerations.

To extend their radius of action, submarines operating in the Far East during the war had some of their ballast tanks converted to fuel oil tanks, increasing the fuel load from 72 tons to 98 tons. All boats stationed in this theatre proceeded on patrol carrying as much additional stores as possible, particularly food and ammunition, stowed in all manner of unlikely spaces (an ammunition locker was placed under the wardroom table and shells were even stored in the engine room). Naturally this practice became a matter of some concern and although strict regulations were imposed on the stowage of ammunition (particularly regarding temperature requirements), the rules were never completely adhered to. By these measures, the S boats managed to achieve long patrol times in operational areas: the record of 49 days was set by Sirdar.

During 1941 and 1942 S Class submarines were fitted with the first radar sets for surface as well as air search and during the first stages of the war S boats were very active in the North Sea and Mediterranean. As a result losses were rather heavy and in the North Sea alone, six of the class were lost in 1940. As the war progressed however, the class became more adept and were particularly successful against other submarines. Of the 62 S Class submarines built, 17 were lost during the war, nine in the North Sea and Atlantic, six in the Mediterranean and two in the Pacific and Indian Oceans.

It is reputed that an S Class submarine, HMS Statesman, fired the last torpedo of the Second World War, when she sank a Japanese derelict.

The ability of the submarine to operate stealthily made the S Class ideal for secretive missions and the clandestine operations of the Vickers built Seraph provide one of the most fascinating stories of the Second World War and earned her the nickname HMS ‘Cloak and Dagger’. Commissioned in 1942 and under the command of Lieut. N L A ‘Jimmy’ Jewell, HMS Seraph’s first special operation was a surveillance of the North Africa coast as preparation for Operation Torch (code name for the invasion of North Africa). This was followed by the secretive landing and recovery of an American delegation who were to meet with Vichy French commanders near Algiers. A strong friendship and mutual respect grew between Seraph’s crew and the American passengers, which led to Seraph masquerading as a United States submarine under the nominal command of Captain Wright, USN.

Before the Allied invasion of North Africa, it was necessary to unite all the French forces in the various garrisons under the leadership of General Giraud. As the General did not trust the British and refused to co-operate with anyone but the Americans, Seraph sailed under the Stars and Stripes, with her crew adopting a much practised Anglo-American slang in order to appear as American as possible to her valuable passenger.

In the autumn of 1942, a decision was tentatively made to invade Sicily. As the Germans were bound to anticipate that Sicily would be a likely target, the question arose of how to fool them into deploying their forces elsewhere. As British officers were continually being flown around the coast of Spain to North Africa, a plan was devised to plant a body, carrying false papers, in the sea off Spain, as if coming from a crashed plane. In order to convince a post-mortem that the ‘officer’ had indeed drowned, the body of a man who had just died from pneumonia, in which form of death there is liquid in the lungs, was found.

On the understanding that his true identity would always remain secret, consent was obtained from the dead mans relatives and from that time forward, he became ‘Major William Martin, Royal Marines’ and his body was placed in cold storage as a plan was devised.

The body of ‘Major Martin’ was to carry two letters for delivery to Africa, one from Lieutenant-General Sir Archibald Nye, Vice Chief of the Imperial General Staff and one from Lord Louis Mountbatten, both of which intimated that Sardinia was the target of the assault. In addition to his identity card, the ‘Major’ was assumed to be a brilliant, but nevertheless extravagant man and in his pocket was a letter from Lloyds Bank Head Office, calling on him to pay off an overdraft of nearly £80. Assuming that every young officer had some romantic attachment, ‘Major Martin’ carried a photograph of and two letters from, his ‘girlfriend’ ‘Pam’. These letters were folded and unfolded continually to look as though they had been read and reread. Probably his engagement was the cause of his overdraft, for he also had in his pocket, a bill for £53 for an engagement ring. With the

addition of the usual paraphernalia, old bus tickets, keys, theatre tickets, scraps of paper, etc. 'Major Martin' was ready for his mission.

With the Prime Minister's approval, HMS Seraph sailed at 6 pm on 19th April 1943, with 'Major William Martin' safely stored in a six foot metal canister packed with dry ice. For ten days Seraph surfaced only at night. On the morning of 30th April, 1600 yards off Huelva, Spain, Seraph surfaced and 'Major Martin' was slid out of his canister into the sea. He was sighted by a Spanish fisherman later that morning and recovered by the authorities. A post-mortem revealed that death was caused by 'asphyxiation through immersion in the sea'. The German agent in Huelva 'played his part' and his superiors were alerted to the existence of the documents. To complete the plot, 'Pam' sent a wreath to the 'Major's' funeral in Spain, and his name was inserted in the casualty list which appeared in 'The Times' of 4th June 1943.

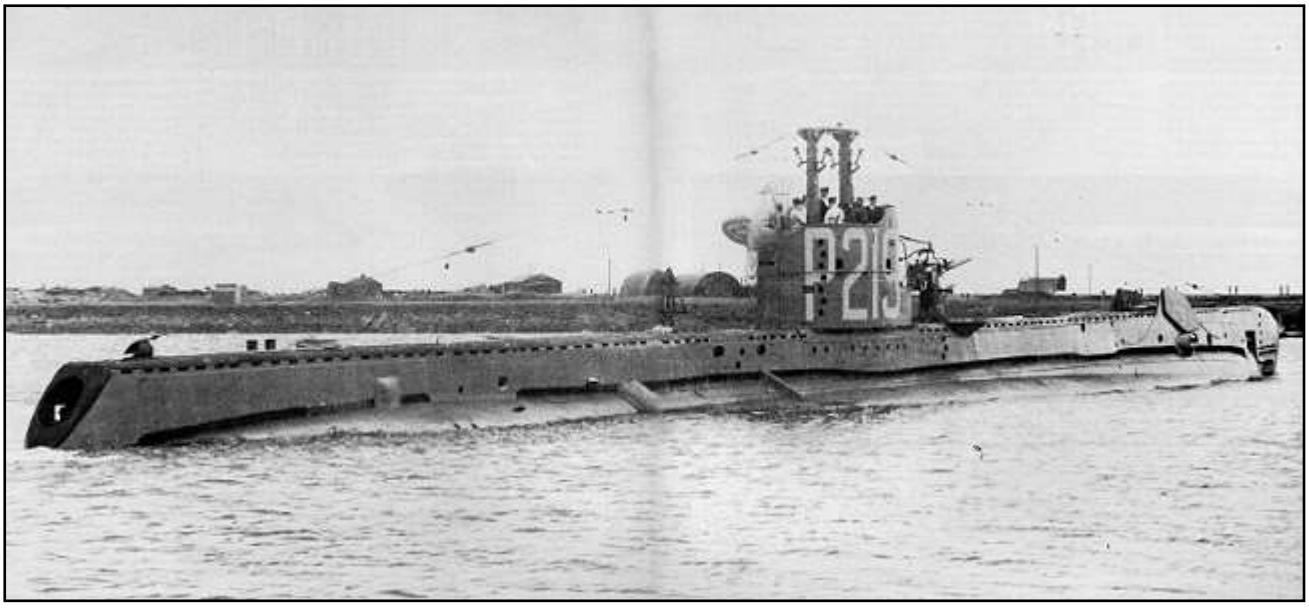
The success of 'Major Martin's' mission can be measured from remarks in Field-Marshall Rommel's personal papers, which revealed that when the Allies invaded Sicily the German defence was led astray, 'as a result of a diplomatic courier's body being washed up off Spain'.

These missions were vital to the Supreme Allied Commander, General Eisenhower and Seraph's exploits saved thousands of Allied lives. General Patton himself praised Seraph's conduct during the invasion of Sicily and Lieutenant Jewell subsequently received the Legion of Merit, the highest American honour that can be bestowed on a foreigner. When she was scrapped in 1963, a Seraph Memorial was erected in Citadel Campus at the Military College of South Carolina and includes Seraph's periscope, fore hatch, plane wheels and other items from the Barrow built submarine.

IMPROVED S CLASS SUBMARINES MAIN PARTICULARS

Length overall	217ft	**Endurance, surface:**	
Beam	23ft 6in	**design**	6000 miles at 10 knots
Depth	11ft	**Endurance, submerged:**	
Displacement,		**design**	Details unknown
surface	872 tons	**Armament***	6 21-inch bow tubes
submerged	990 tons		1 21-inch stern tube
Diving depth	350 feet		(13 torpedoes carried)
No. of shafts	2		1 3-inch gun
Speed, surface:			3 0.303-inch machine-guns
design	15 knots		1 20mm Oerlikon cannon
service	14.75 knots	**Complement:**	
Speed, submerged:		**design**	48
design	10 knots		
service	9 knots		

** The armament of submarines of this class varied considerably. For example: 23 boats were fitted with the six bow tubes only; 18 vessels, intended to operate in the Far East, had their 3-inch guns replaced by 4-inch guns; whilst, in some boats, the Oerlikon cannon replaced, rather than supplemented, the three machine-guns.*



S Class submarine HMS Seraph

1936 - 1958 U AND V CLASS SUBMARINES

U Class

The first three U Class submarines were ordered in 1936 to serve as unarmed targets for anti-submarine vessels. But in a change of policy (perhaps with a foreboding of war) Undine, Unity and Ursula were laid down at Vickers in February 1937, were modified during construction to accommodate six bow tubes (four internal and two external) so that they could undertake short offensive missions. To allow the installation of a small deck gun, the hull forward of the conning tower was reinforced.

From their first sea trials the three boats demonstrated excellent handling and manoeuvrability, which combined with ease of production and low cost, made the design particularly successful.

In 1939, a realisation of the inevitability of war and the small size of the U boats made them particularly suitable for North Sea and Mediterranean operations, prompted the Admiralty to put the class into quantity production. Twelve identical vessels were ordered, but of these only four were fitted with six bow tubes. The two external tubes and the bulbous bow they formed were removed from the remaining boats because the notable bow wave the bulge created when running at periscope depth made it difficult to keep the boat trimmed longitudinally.

Under the 1940 and 1941 War Programmes, a further 41 U boats were ordered, but only 34 were completed. This second group of U Class submarines did not differ substantially from the first, but an approximate increase of 5 feet in the stern gave them a more streamlined shape aft and improved the flow of water over the propellers.

In addition to their four 21-inch stern tubes and three 0.303-inch portable machine guns, the U boats were fitted with a 3-inch gun forward of the conning tower. However as this was an afterthought to the original design, no separate hatch was fitted for the gun crew or ammunition. This resulted in the conning tower becoming extremely crowded before and after gun action and if the gun crews were employed, rapid crash diving was impossible.

The limited offensive potential of individual U boats was compensated for by the considerable number that were commissioned in a short period of time and these small and nimble vessels became one of the most important operational classes in the Second World War, with a record that can be fairly described as heroic.

The wartime submarine fleet relied almost entirely on the S, T and U Classes. This policy was very different to that of the First World War (when some 12 new classes were developed), and was pursued so as to cause minimum interference with the shipbuilders' production programme.

The majority of the 49 commissioned U boats (all but two of which were built by Vickers) served with the Second Flotilla based at Malta and achieved notable successes against warships and merchantmen. Two U boats stationed in the Sicilian Channel, sank several Italian major merchant ships which were transporting troops and supplies to Africa. Like other British boats, the U Class were particularly successful against submarines, in the Mediterranean alone, five Barrow boats (Upholder, Ultimatum, Unbeaten, Unruly and United) sank a total of eight: six Italian and two German.

During the war 19 boats of the class were lost on active service, 13 in the Mediterranean and 6 in the North Sea and Atlantic. Another submarine, Untamed, sank in May 1943, but was salvaged two months later and returned to service as HMS Vitality. From 1941 numerous boats were ceded to Poland, USSR, Holland, Norway and Free France and several of these were also lost in action.

One U Class submarine that is famous for the part it played in the Second World War is the Vickers' built Upholder, which probably had the finest fighting record of any Allied submarine of the period.

HMS Upholder

Commissioned in August 1940 and under the command of Lieutenant-Commander Malcolm David Wanklyn VC, HMS Upholder sailed to her Maltese base on 10th December. During this passage, Lieut.-Com. Wanklyn demonstrated that he was a man of many talents when a bulkhead door almost severed the tops of three fingers of Chief Engine Room Artificer Baker. With infinite patience and a very delicate touch, Wanklyn sorted out the mangled fingers and strapped them up. For the next four days Wanklyn painstakingly dressed the injured fingers of his patient until he could be transferred to a Military hospital in Gibraltar. Due to Wanklyn's skill and patience Baker regained the full use of his hand. Upholder eventually arrived at Malta on 10th January 1941.

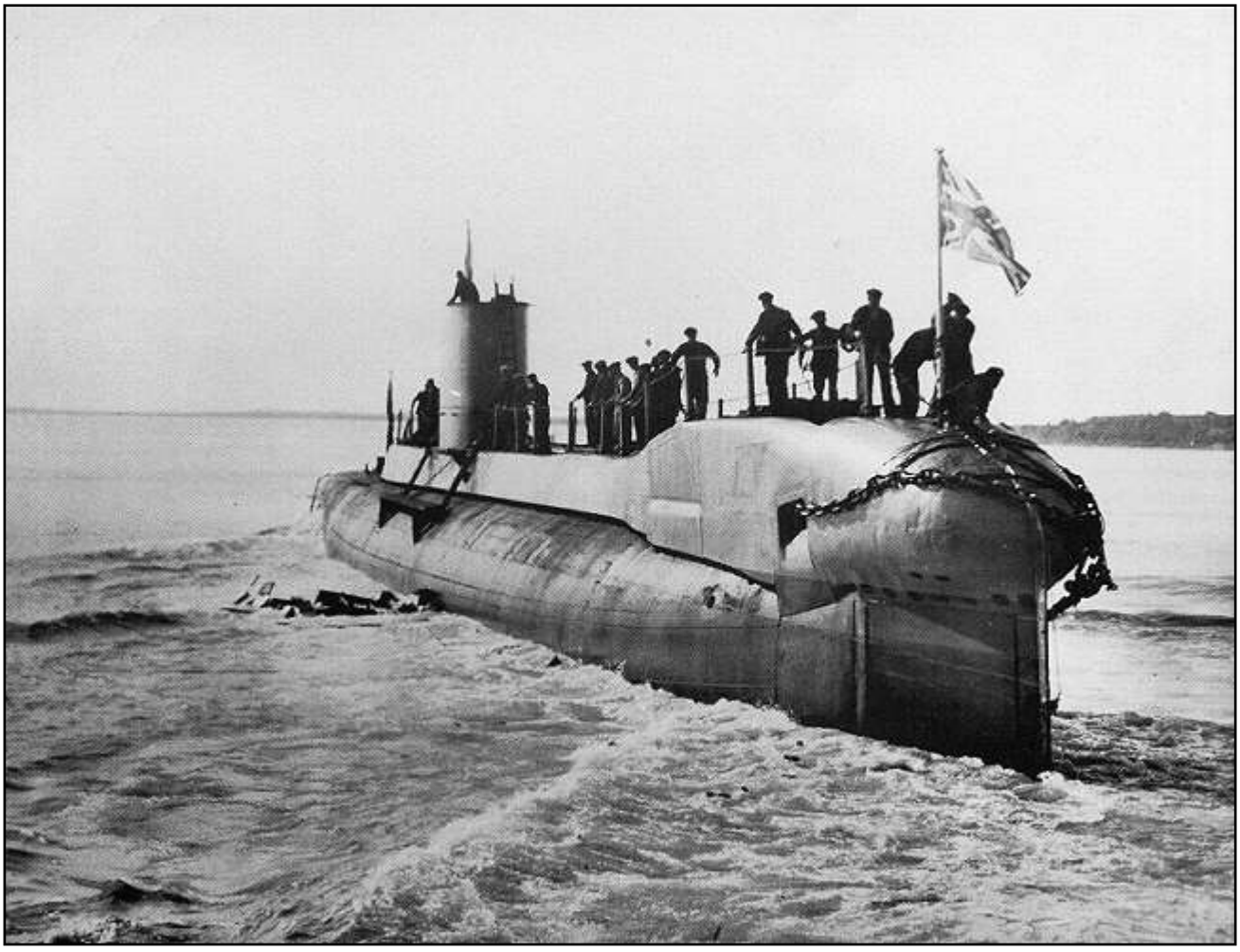
Upholder's first four patrols yielded no successes and doubts were raised as to Wanklyn's competence. However on her fifth patrol off Cape Bon, Upholder compensated for her earlier misses with a vengeance, sinking three enemy convoy vessels and 'finishing off' an abandoned supply ship.

Following Upholder's seventh patrol, her commander was awarded the Victoria Cross. The failure of Upholder's asdic set had robbed Wanklyn not only of a means of detecting the enemy but also of a valuable aid in taking avoiding action during a counter attack. Despite this handicap, Upholder continued to destroy enemy shipping and it was the sinking, on 25th May 1941, of the heavily escorted troopship Conte Rosse with over 12000 members of the Afrika Corps on board, that earned Wanklyn his VC. Following this daring success, enemy destroyers counter attacked and during the next twenty minutes, dropped 37 depth charges near Upholder. The citation for Wanklyn's VC stated, 'The failure of his listening device made it much harder for him to get away, but with the greatest courage, coolness and skill he brought Upholder clear of the enemy and safe back to harbour'.

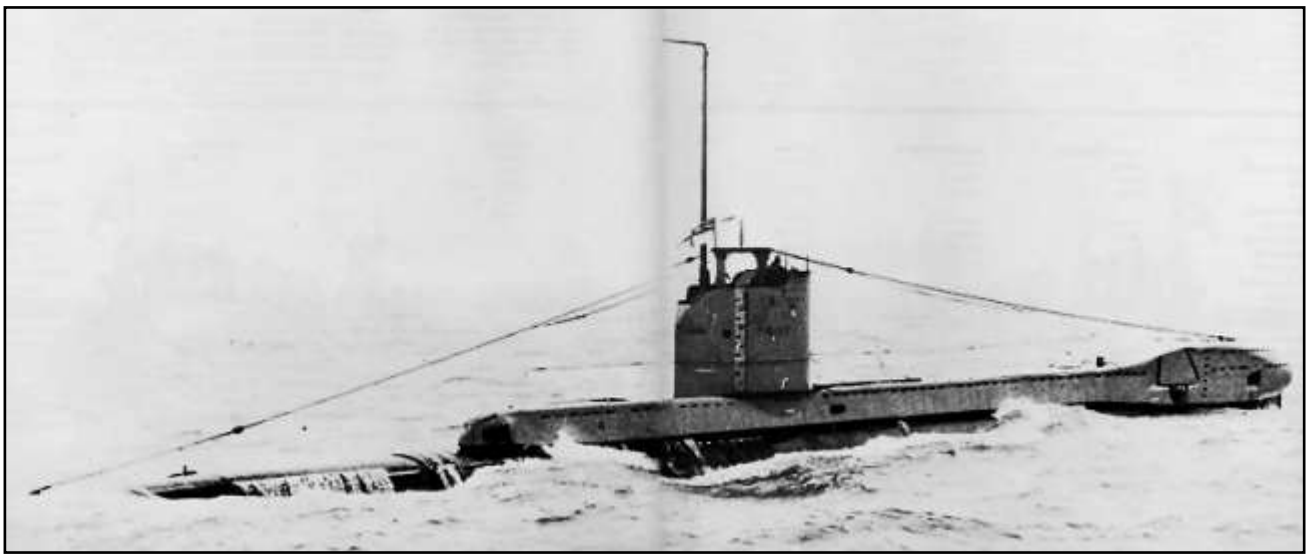
During the 16 months that Upholder operated in the Mediterranean, she completed 24 patrols and sank 119000 tons of German and Italian shipping, three U-Boats, one destroyer, one armed trawler, 15 transport and supply ships and probably another cruiser and another destroyer, before she herself failed to return from a patrol in April 1942.

Remembering that the Navy lost not only an outstanding submarine commander but also a very highly trained and experienced team of officers and ratings, the Admiralty took the unprecedented step of publishing a special communiqué, praising Upholder and all her crew for their long and arduous duty in the Mediterranean, which ended with the words, 'The ship and her company are gone, but the example and the inspiration remain'.

After the war, many of the surviving U Class submarines were put into reserve or lent or sold to other countries. Some boats were later returned by foreign navies to be scrapped and the last of the Royal Navy U boats were broken up in 1950.



Undine entering Walney Channel in October 1937



The Vickers built Unity which served her short career in the hostile environment of the North Sea.

V Class

In 1941 modifications were made to the design of the U Class submarines in order to obtain a type of boat which, while retaining the same characteristics, would be stronger but simpler and less expensive. The resultant V Class were slightly longer than the U boats and because of a partly welded pressure hull, had a greater operational depth, 300feet as opposed to 200 feet. The electric welding of hull assemblies also gave a quicker building time.

The class were built exclusively at Barrow and the first eight submarines were ordered in 1941. Large numbers were planned and 42 V boats were ordered between 1941 and 1943. However, with the capitulation of Italy in 1943 the need for coastal submarines in the Mediterranean decreased and 20 of the class were subsequently cancelled when the end to hostilities in Europe seemed imminent.

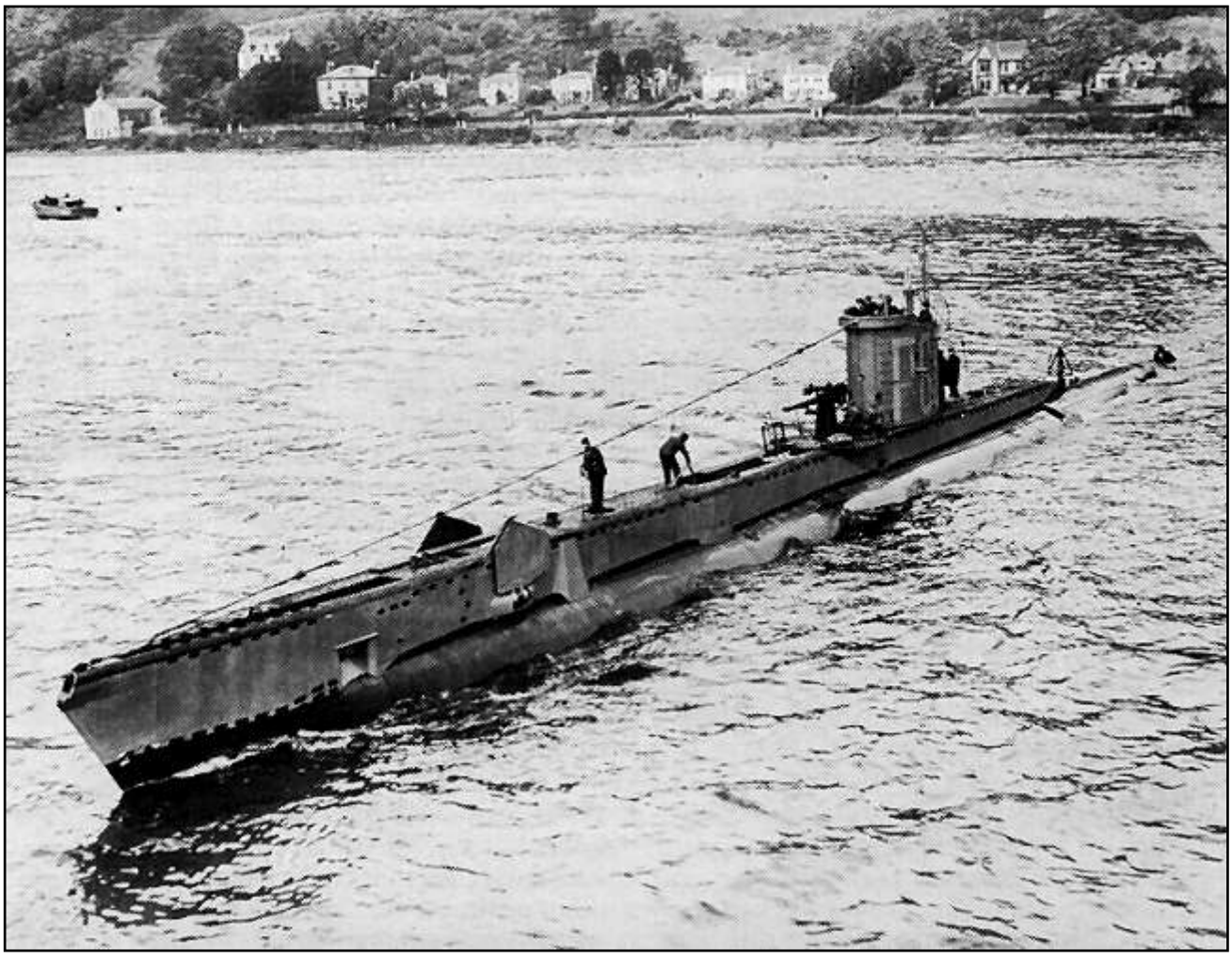
MAIN PARTICULARS

	U Class (Group 1)	U Class (Group 2)	V Class
Length overall	190ft 7in	195ft 6in	203ft 5in
Beam	15ft 9in	15ft 9in	15ft 9in
Depth	15ft 9in	15ft 10in	15ft 9in
Displacement,			
surface	630 tons	648 tons	660 tons
submerged	730 tons	735 tons	740 tons
Diving depth	200 feet	200 feet	300 feet
No. of shafts	2	2	2
Speed, surface:			
design	11.5 knots	11.5 knots	12.5 knots
Speed, submerged:			
design	9 knots	9 knots	9 knots
Endurance, surface:			
design	4050 miles at 10 knots	4050 miles at 10 knots	4700 miles at 10 knots
Endurance, submerged:			
design	23 miles at 8 knots 170 miles at 2.5 knots	23 miles at 8 knots 170 miles at 2.5 knots	30 miles at 9 knots
Armament	[1] 4 21-inch bow tubes (8 torpedoes carried) [2] 1 3-inch gun 3 0.303-inch machine-guns	4 21-inch bow tubes (8 torpedoes carried) 1 3-inch gun 3 0.303-inch machine-guns	4 21-inch bow tubes (8 torpedoes carried) 1 3-inch gun 3 0.303-inch machine-guns
Complement:			
design	[2] 33	33	37

[1] *The first seven U Class submarines had two additional external bow tubes installed and carried 10 torpedoes.*

[2] *Undine and Unity, which were not fitted with the 3-inch gun, had 27-man complements.*

None of the 22 V Class submarines built were lost in the war and the lead ship, HMS Venturer distinguished herself by sinking two German submarines, one in November 1944, the other in February 1945. Venturer was transferred to the Royal Netherlands Navy following the war and many other V Class vessels served with Allied navies (particularly Greece, Norway and Free France) during and after the conflict. The last of the class in service with the Royal Navy was scrapped in 1958.



Launched in May 1943, HMS Venturer was transferred to the Royal Netherlands Navy in 1946 and renamed Utstein.

1939 - 1952 MIDGET SUBMARINES

The War Years: Midget Submarines

No history of Barrow built submersibles would be complete without reference to the Royal Navy's midget submarines and it is true to say that Britain, although one of the last countries to be involved with midget submarine construction, made the most impressive use of this type of vessel.

The first boats, called 'Chariots', were copies of the Italian Maiale Class, or 'Pigs' and were followed by a range of midget submarines designed to penetrate Norwegian anchorages which were sheltering German battleships.

Human Torpedoes - 'Chariots'

Intended for clandestine attacks on vessels at anchor and copied from Italian 'Pigs', which successfully attacked Alexandria in 1941, the Chariot was not a torpedo but an electric vehicle manned by a crew of two equipped with breathing tanks, who sat externally and attempted to attach their bow warhead onto the hull of an enemy vessel. The freezing Norwegian waters incapacitated the operators because they were so exposed and the most decisive results were achieved in the warmer waters of the Mediterranean.

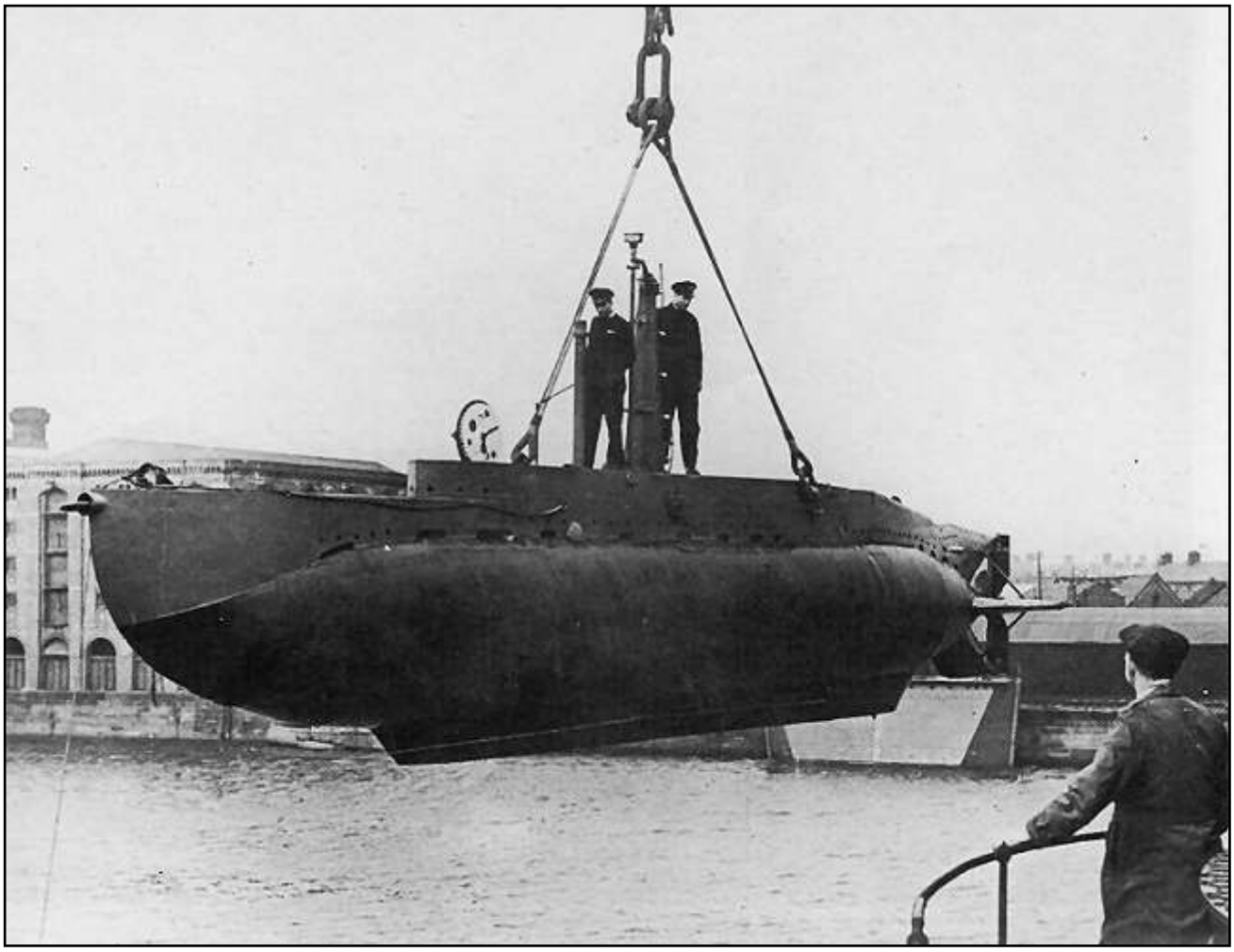
The most notable successes of the Chariots were the sinkings of three Italian cruisers: Ulpio Traiano at Palermo on 3rd January 1943, Bolzano at La Spezia on 21st June 1944 and Gorizia at La Spezia on 26th June 1944.

X5 Class

Laid down in 1939, the prototype X-craft was built by one of the leading advocates of midget submarines, a First World War submariner, Commander Varley and following successful trails off Scotland in October 1942, was commissioned as X3 (X1 was an experimental fleet submarine built in 1925 and X2 was a captured Italian submarine). A second prototype vessel, X4, was constructed and based on these two boats, operational craft were quickly developed.

In December 1942, Vickers began to build six X-craft (X5 to X10) for employment in European waters. Their obvious primary operation was to attack the German battleship Tirpitz, which was holed up in Alten Fjord, Norway. By September 1943, the six X Class midget submarines and their hand picked, highly trained crews were ready to undertake a mission that was to write a chapter in the history of submarine warfare.

With engines that generated 42 hp (surfaced) and only 32 hp (submerged), the X-craft were too small to undertake long passages and were therefore always towed to their target areas by sizes submarines at maximum speeds of 10.5 knots (surfaced) and 12 knots (submerged). As can be expected, towing midgets reduced the endurance of submarines, the S Class for example had a 30 per cent reduction in endurance and the comparable figure for the larger T Class was 5.5 per cent.



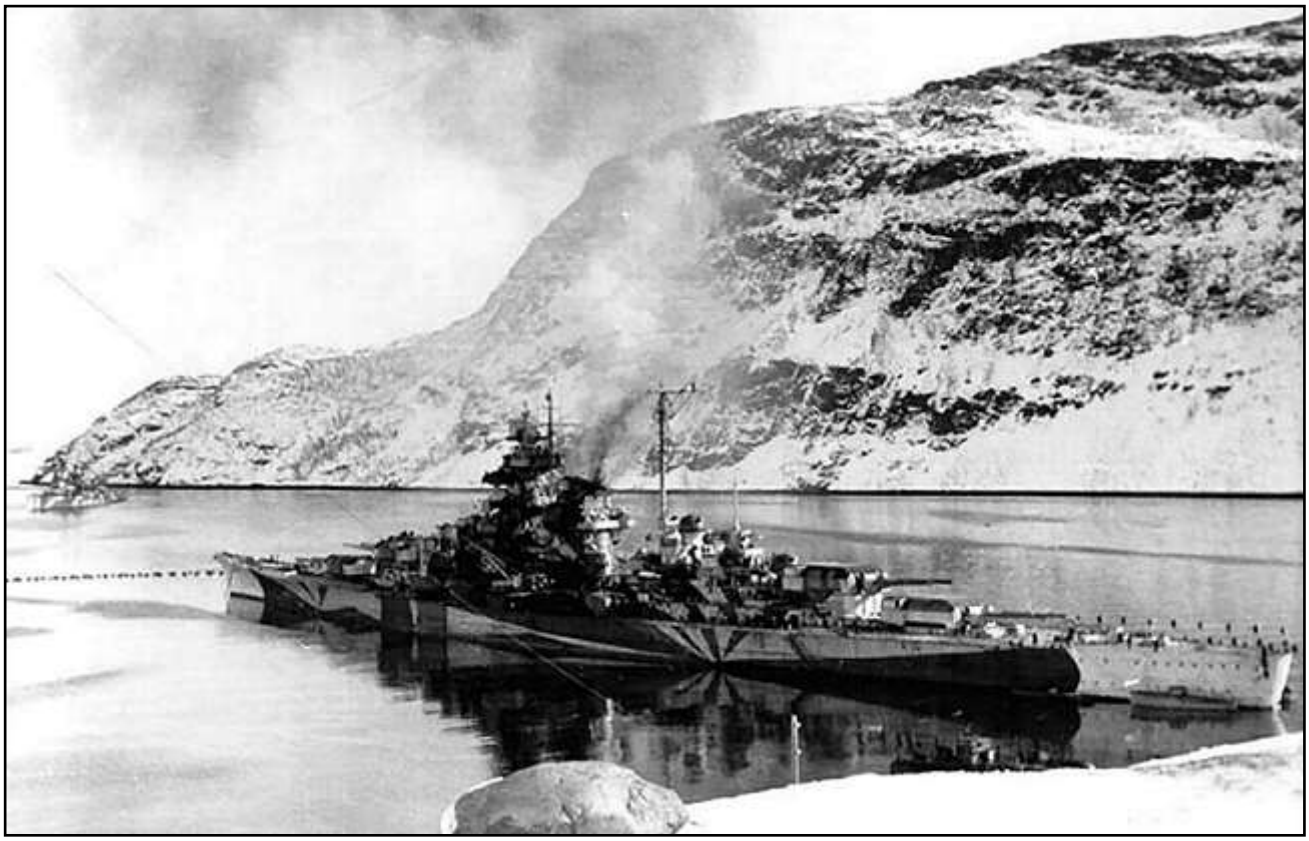
An X5 Class midget submarine being 'launched' into Buccleuch Dock

The Tirpitz mission began in an undistinguished manner when on the outward passage to Norway (which was an eight day journey covering over 1000 mile), X9 sank and X8 had to be scuttled. Fifty miles from their target the four remaining X-craft were cast loose to proceed under their own power, through winding, shallow fjords, mine fields and anti-submarine nets to the anchorage of Tirpitz. X10 penetrated the inner fjord but had to abandon her attack because of mechanical defects. Harassed by vigorous enemy patrols, her captain valiantly stayed hidden with his small boat for five days until, finally, he could return to the towing ship. X10 was scuttled on the return journey to England.

On 22nd September 1943, X6 (Lieut. Donald Cameron, RNR) and X7 (Lieut. Basil Place) followed an old freighter through the final set of nets and arrived at their objective within minutes of each other. An alert guard spotted one of the craft, raised the alarm, but under a heavy counter

attack, X6 managed to get beneath the massive ship and drop two separate explosives (carried as saddle tanks), following which she became entangled in the underwater torpedo nets and had to surrender. X7 also released two charges beneath Tirpitz but before she could fully escape, the first of the explosives from X6 detonated and she too was soon forced to surface and surrender. A third submarine was sighted and brought under heavy fire. This was probably X5 which was never seen again (in 2009 divers found, within the torpedo net area, an unexploded saddle charge thought to have belonged to X5).

The attack on Tirpitz was a great success, for although the charges did not sink her, the damage they inflicted resulted in the vessel being towed south for repairs. Here Tirpitz was at last within the range of British bombers which finally eliminated her a little more than a year later. For the part they played in preventing Tirpitz sailing from Norway, Lieutenants Place and Cameron were awarded the Victoria Cross.



Tirpitz anchored in a Norwegian fjord

Six further X-craft, X20 to X25, were built in 1945, five of which were scrapped at the end of the war. The sixth, X22, was lost in a collision with HM Submarine Syrtis in the Pentland Firth.

XT Class

During 1943 and 1944 Vickers built six XT-craft submarines for training purposes. Having an endurance of only 500 miles at 4 knots, the XT-boats were a simplified X5 Class submarine without the side cargo release gear, night periscope or automatic helmsman. In addition, their day periscope, projector compass and air induction trunk were fixed in the ‘up’ position.

Twelve more vessels ordered in 1943 from Broadbents of Huddersfield were cancelled before completion. The six Barrow boats were scrapped at the end of the war.

XE Class

The XE Class, with air conditioning and extra stowage space, were designed for employment in the Far East. Spring loaded legs made it easier for these midget submarines to rest on the seabed and an air lock allowed a diver to leave the submarine and place limpet mines on the hulls of enemy ships.

Vickers built the first six vessels of the class, the most famous and successful of which was HM Midget Submarine XE3, commanded by Lieut. Ian Fraser RNR, which attacked the Japanese heavy cruiser Takao on 31st July 1945.

After being released from the towing submarine, XE3 spent more than 24 hours getting into a position to attack the Takao, which was moored in the Johore Strait, Singapore. After his first attempt failed, Fraser circled the target and put his boat under the great ship's hull. Despite being hampered by weed and barnacles and a leak in his diving equipment, the boats diver, Leading Seaman James Magennis, swam along the cruiser's hull placing limpet mines. Exhausted he re-entered the submarine and XE3 pulled clear.

During the next stage of the attack, a jammed empty limpet container prevented the jettisoning of the side cargoes of explosives, which gave the submarine an uncontrollable list. Magennis volunteered to go back outside and spent 15 minutes freeing the load. All this time the submarine and diver were vulnerable, lying in the crystal clear water. XE3 eventually made her escape and whilst returning to base unscathed, the charges detonated sinking the 11000 ton vessel. Lieutenant Fraser and Leading Seaman Magennis were both awarded the Victoria Cross for their bravery in performing this operation.

Five additional XE-craft were built, four were scrapped in 1952 and XE11 was lost in a collision with the boom defence vessel Loch Striven in March 1945.

The design of X-craft midget submarine classes varied considerably, but for an indication of their details the main particulars of the prototype (X3) and the X5 Class are shown below.

MAIN PARTICULARS	X3	X5 Class
Length overall	43ft 6in	51ft 7in
Beam:		
with charges	8ft	8ft 6in
without charges	5ft 6in	5ft 9½in
Displacement, with charges:		
surface	30 tons	Unknown
submerged	32¼ tons	Unknown
Displacement, without charges:		
surface	22 tons	27 tons
submerged	24 tons	29½ tons
Diving depth	200 feet	300 feet
No. of shafts	1	1
Speed, surface:		
with charges	5.5 knots	6.5 knots
without charges	6 knots	Unknown
Speed, submerged:		
with charges	Unknown	5 knots
without charges	Unknown	Unknown
Endurance, surface:		
with charges	1100 miles at 4.5 knots	1320 miles at 4 knots
without charges	1400 miles at 4.5 knots	1860 miles at 4 knots
Endurance, submerged:		
with charges	85 miles at 2 knots	80 miles at 2 knots
without charges	85 miles at 2 knots	Unknown
Armament	2 2-ton side charges Limpet mines	2 2-ton side charges Limpet mines
Complement:		
design	3	4

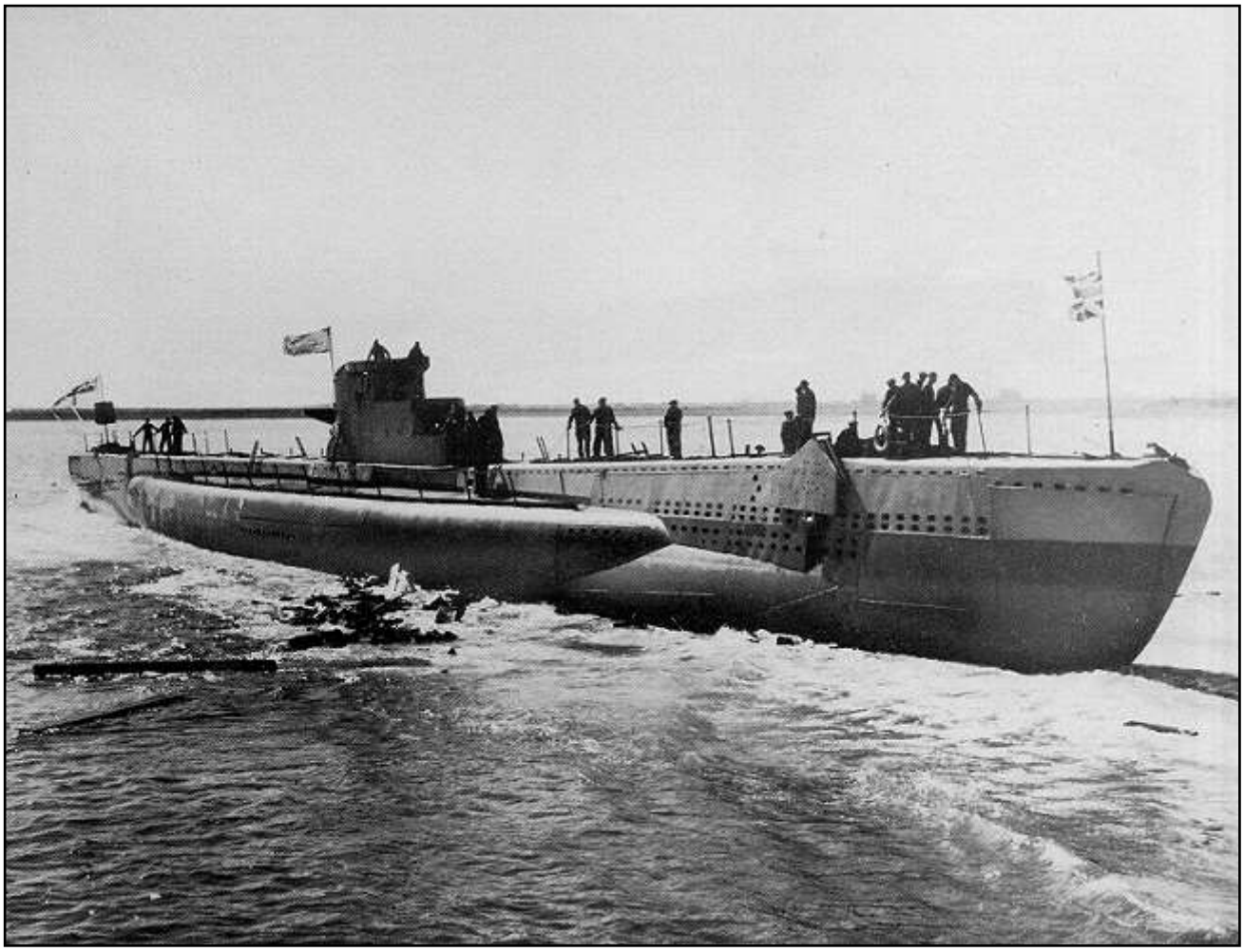
'Welman'-Type Midget

The 'Welman'-type midget was a Royal Navy built submarine that was never particularly successful and never saw action. It is not known how many Welmans were produced, but the prototype was built at Welwyn Garden City. A one man submarine it had no periscope and vision was through armoured glass segments in the small 'conning tower'. Designed to fix a 560 pound charge to its target by means of magnetic clips, the Welman could never be made to work properly and was finally abandoned.

Other underwater craft were tested towards the end of the war, including submersible canoes and supply craft for clandestine operations. An X-craft with a conning tower was designed but never built.

Midget submarines were used to reconnoitre landing beaches prior to the Normandy invasion in June 1944 and on D-Day itself several acted as navigation beacons well inshore to guide the first assault waves. In the Far East they were used to cut submarine cables and sabotage telephone lines. At best, the secretive operations of midget submarines were hazardous, but many feats of skill and bravery were performed by their crews.

1943 - 1977 A CLASS SUBMARINES



31st August 1944, the launch of the first of class Amphion

On the morning of 7th December 1941 the US Fleet suffered more damage in one hour than during the whole of the First World War when Japanese aircraft bombed Pearl Harbour, the United States' largest naval base and the airfields which were an essential part of its defences. The attack lasted from 7.55 am to 9.15 am and initiated the Pacific Ocean as one of the wars' major battlegrounds.

This distant theatre of war heralded a change in British submarine policy. As none of the existing submarines had adequate range, a new class representing the only new design produced by the Royal Navy during the Second World War, was adopted, which had greater range and increased speed. The opportunity was also taken to introduce new major technical advances, of which the most important was an all welded hull.

These new A Class submarines were basically an enlargement of the T Class, with a construction that was simple, fast and so arranged to utilise many of the materials set aside for the T boats. The A Class, perhaps the most successful of all 'traditional' types of pre-nuclear submarines, were fitted with an effective air conditioning system, air warning radar which could function at periscope depth, a high flared bow for excellent sea performance, formidable armament of ten 21-inch torpedo tubes and had an appreciably reduced underwater noise level.

Forty six A boats were ordered Under the 1943 Programme and the first of class, Amphion, was laid down at Vickers on 14th November 1943 and launched on 31st August 1944. Only Amphion and Astute, also Barrow built, were completed before the end of the war, but neither were involved in any hostilities. With the conclusion of the war imminent, 30 of the 46 boats ordered boats were cancelled, of the 16 that remained, Vickers constructed ten.

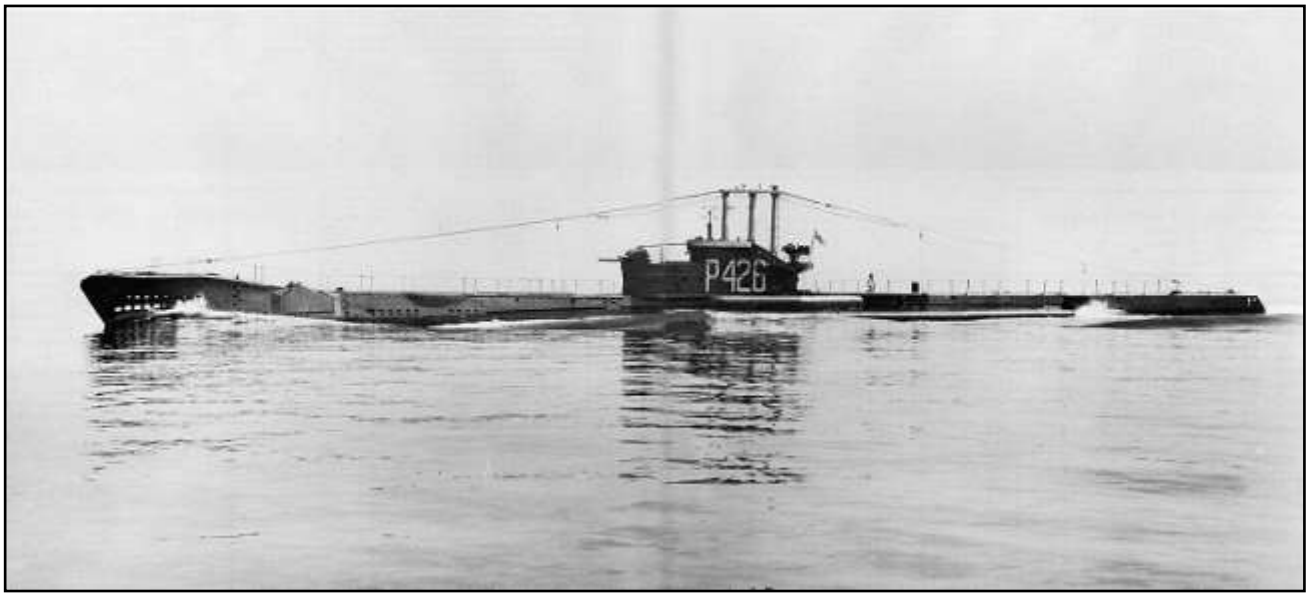
A Class submarines were over 280 feet long and displaced 1385 tons (surfaced). Their two Admiralty diesels developed 4300 hp which gave a surface speed of 18.5 knots. The submerged speed was 8 knots, produced by two English Electric motors generating 1250 hp. The radius of action of the A Class was 10500 miles on the surface at 11 knots and up to 90 miles submerged at 3.5 knots.

The heavy armament consisted of six 21-inch bow tubes (two external) and four 21-inch stern tubes (two external), with 20 torpedoes carried. The class were also fitted with one 4-inch gun forward of the conning tower, one 20mm Oerlikon cannon and three portable 0.303-inch machine guns.

As the final act was being played in the theatre of war, it is interesting to recall the words of Sir Winton Churchill used to express to the submarine branch of the Royal Navy the nation's gratitude for the difficulties and dangers it faced in the Second World War, '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'.

After the war, A Class and other submarines were fitted with a 'Snort' (Schnorkel) mast, which was a device by which air could be taken into a submarine so that it could continue to use its diesel engines when submerged. To demonstrate the effectiveness of the system, the Vickers built HMS Andrew completed a record 15 day, 2500 mile submerged passage from Bermuda to England. She surfaced in the English Channel on the eve of the Coronation in 1953, just in time for the feat to be reported in the same news bulletin as the first ascent of Mount Everest.

In the spring of 1951, as if to remind submariners of the hazardous nature of their profession, disaster again struck the Royal Navy Submarine Service. Leaving Portsmouth on a training cruise on 16th April, HMS Affray dived at 9 pm in the extreme western part of the English Channel. She vanished with all her crew plus 23 submarine officers under training and some Royal Marine Commandos, a total of 75 men. The importance of effecting a quick rescue was hampered by the fact that the Commander's brief was very wide ranging.



Developing 4300 hp, two Admiralty diesel engines propel HMS Aurochs through a calm sea.

Alas, Affray lay undiscovered until late June, when an underwater television camera searching north of Guernsey found her in 278 feet of water. Pictures revealed her snort mast snapped off, but

no explanation was given as to why she had sunk, why nobody escaped or why she was never salvaged. HMS Affray has the unfortunate honour of being the last Royal Navy submarine to be lost.

Between 1955 and 1960, A boats were modernised on the same lines as the T Class, with a complete rebuilding of the forward and after hull sections, lengthening and streamlining. The two external torpedo tubes forward and aft were also removed, leaving a total of six.

From 1967 on these fine submarines were progressively scrapped. In 1972, HMS Aeneas was hired by Vickers for successful trials of SLAM (Submarine Launched Anti aircraft Missile), a four barrel cluster of guided missiles having high lethality against low flying aircraft.

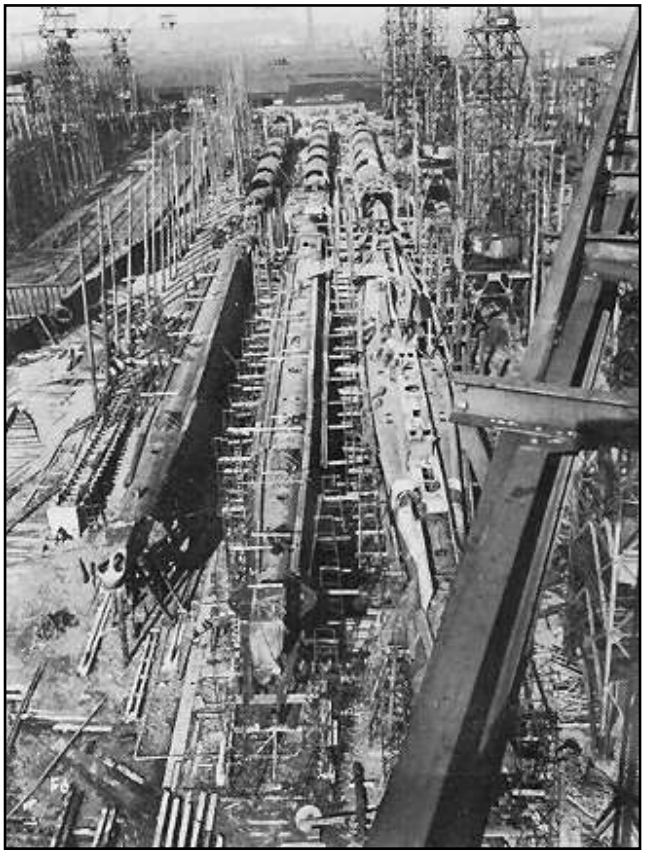
As the Barrow built HMS Andrew awaited disposal in 1977, the end of an era was signalled, she was the oldest submarine in service, the last to carry a deck gun and the last submarine designed during the Second World War to be still at sea.

During the war, in addition to vessels built for the Admiralty, Vickers also constructed four submarines for the Turkish Navy. The 687 ton boats were however acquired by the Royal Navy and temporarily commissioned as P611, P612, P614 and P615. Similar to the S Class but with a weaker armament, they were a sensible addition to the Fleet and served mainly in the Atlantic, where P615 was torpedoed by a U-Boat in 1943. After the war the three survivors were returned to Turkey and remained in service until 1957.

As the world moved into a new era of peace, Barrow's contribution to the national war effort makes a fascinating catalogue. To quote from 'A Century of Shipbuilding' by Tom Clark, 'A cursory check has made it four aircraft carriers, three cruisers, ten destroyers, ten cargo ships, eleven landing craft and ninety nine submarines'. An amazing total of 137 vessels built in under six years. The majority of the submarines were handed over in the four years of 1941 to 1944 and the peak rate of production was reached in 1942 when an average of over two boats per month was achieved.

A Class submarines at various stages of fitting out.

MAIN PARTICULARS	A CLASS SUBMARINES
Length overall	280ft 6in
Beam	22ft 4in
Depth	16ft 9in
Displacement,	
surface	1385 tons
submerged	1620 tons
Diving depth	350 feet
No. of shafts	2
Speed, surface:	
design	18.5 knots
Speed, submerged:	
design	8 knots
Endurance, surface:	
design	10 500 miles at 11 knots
Endurance, submerged:	
design	16 miles at 8 knots
	90 miles at 3 knots
Armament	6 21-inch bow tubes (2 external)
	4 21-inch stern tubes (2 external)
	(20 torpedoes carried)
	1 4-inch gun
	1 20mm Oerlikon cannon
	3 0.303-inch machine-guns
Complement,	
design	61



Particulars and A Class submarines under construction

POST WAR SUBMARINES

Experimental and E Class 1955

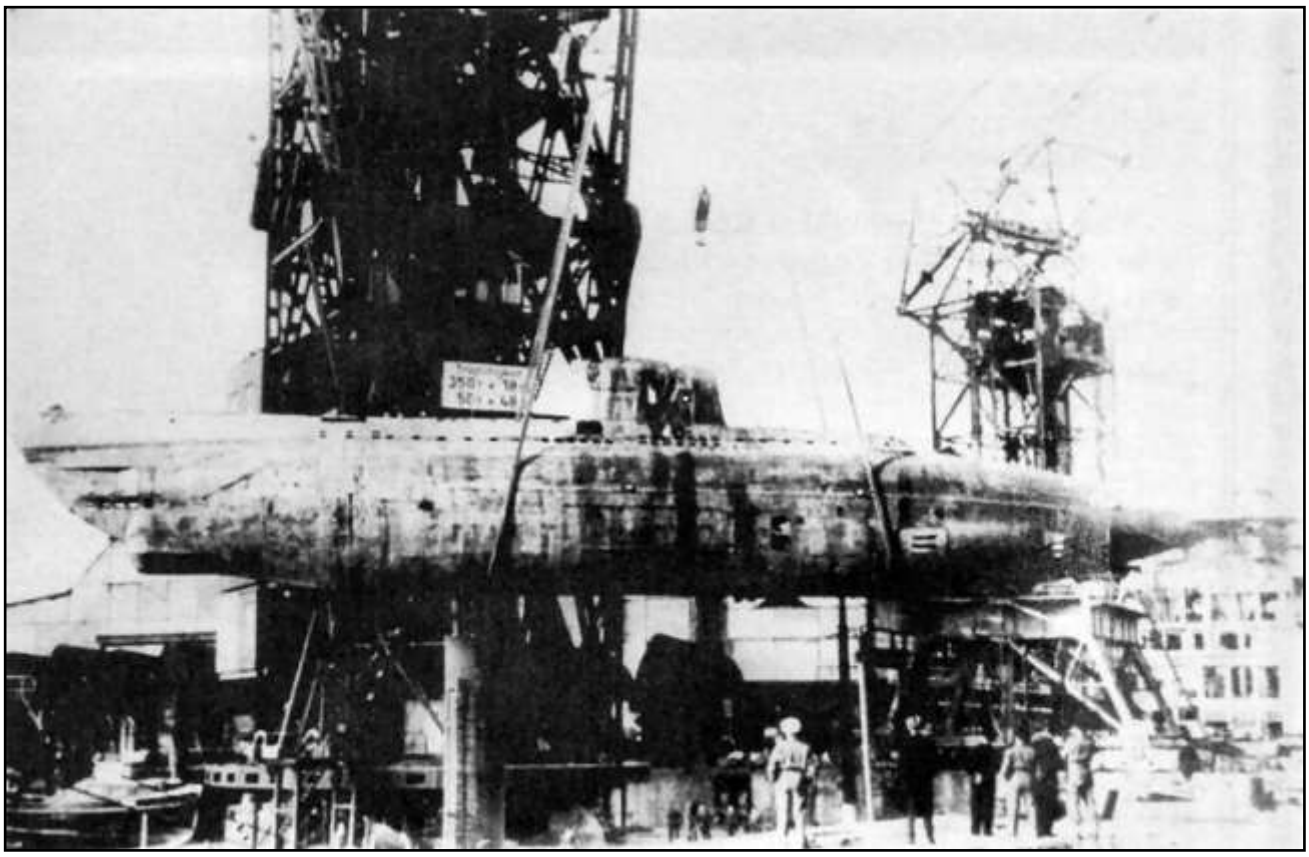
As early as 1911 Germany was conducting laboratory experiments with closed-cycle propulsion systems that did not breathe air, hoping that it would be possible to build a true submarine, one that was designed to stay submerged, as opposed to a submersible boat. By the start of the Second World War research had gathered momentum and in 1940, following the trials of a prototype hydrogen peroxide driven submarine, the odd little V80, a number of experimental boats were built.

In 1946 one such experimental boat, U-1407, which had been scuttled at the German collapse, was salvaged and after a long delay was commissioned into the Royal Navy as HMS Meteorite. Her recovery led to a British development programme which resulted in two 1120 ton submarines, Explorer and Excalibur, being constructed at Barrow. Built for speed trials only, they were purely experimental, unarmed submarines. Their high-test hydrogen peroxide engines were basically steam turbines, with the steam being supplied from the heat generated by the interaction of high-test hydrogen peroxide (HTP), a catalyst and diesel oil.

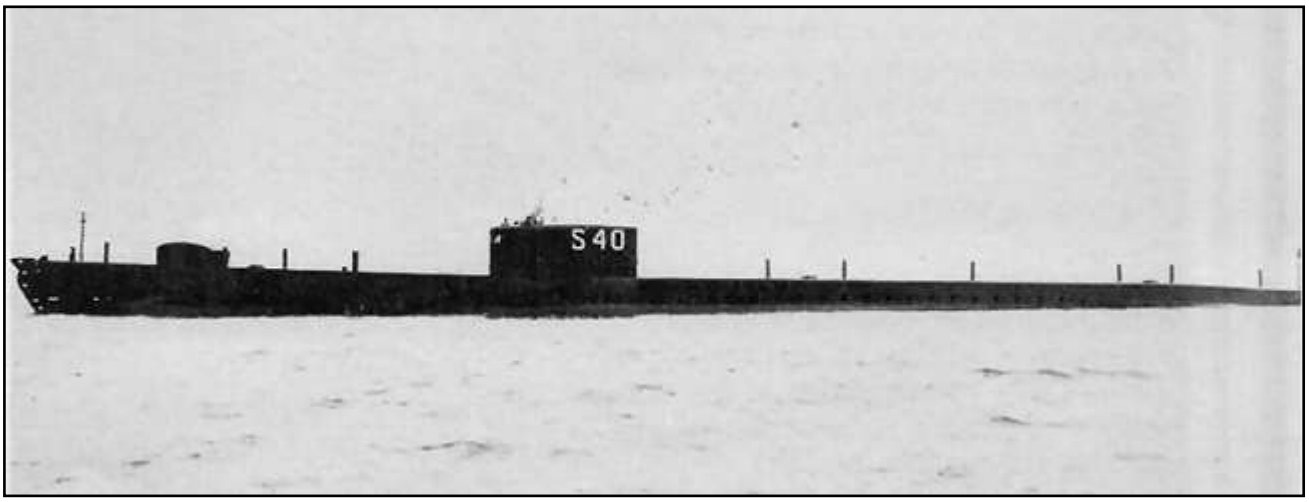
HMS Explorer had so many teething troubles that her first captain never took her to sea. However when she finally made an appearance in 1958, she was impressively fast, submerged speeds of 25 knots were achieved, with retractable superstructure fittings aiding the streamlined hull form.

Provisionally accepted from Vickers in March 1958, Excalibur was built at a cost of £1,142,000. Both Explorer and Excalibur were fitted with the latest submarine escape arrangements, including the one man escape chamber and equipped with the most modern escape breathing apparatus for use by the ship's company in the event of an emergency.

Explorer and Excalibur were, not unnaturally, known as the 'blonde' submarines, because of their hydrogen peroxide fuel and they served a useful purpose inasmuch as they gave the Royal Navy's ant-submarine forces some valuable practice against fast targets. Their main use however, was to prove finally that the HTP system was only a stopgap. HTP proved difficult to the point of being dangerous and there was more than on contemporary report of explosions in the two submarines and at least one instance when the crew was forced to stand on the casing to avoid the noxious fumes which had suddenly filled the boat. 'I think the best thing we can do with peroxide is to try to get it adopted by potential enemies', said one RN submariner.



The German U-Boat 1407 which was commissioned into the Royal Navy as HMS Meteorite.



The experimental submarine HMS Excalibur.

HMS Explorer at sea.

NUCLEAR FLEET SUBMARINES

Fleet submarines are the nuclear powered capital ships of the modern Navy. They are the main striking power of the Fleet and are themselves the single most effective anti-submarine weapon available. Fitted with complex computer assisted sensors and the latest torpedoes, they can silently shadow a target for long periods at high speed while hundreds of feet below the surface, ready to attack with deadly effectiveness when required.

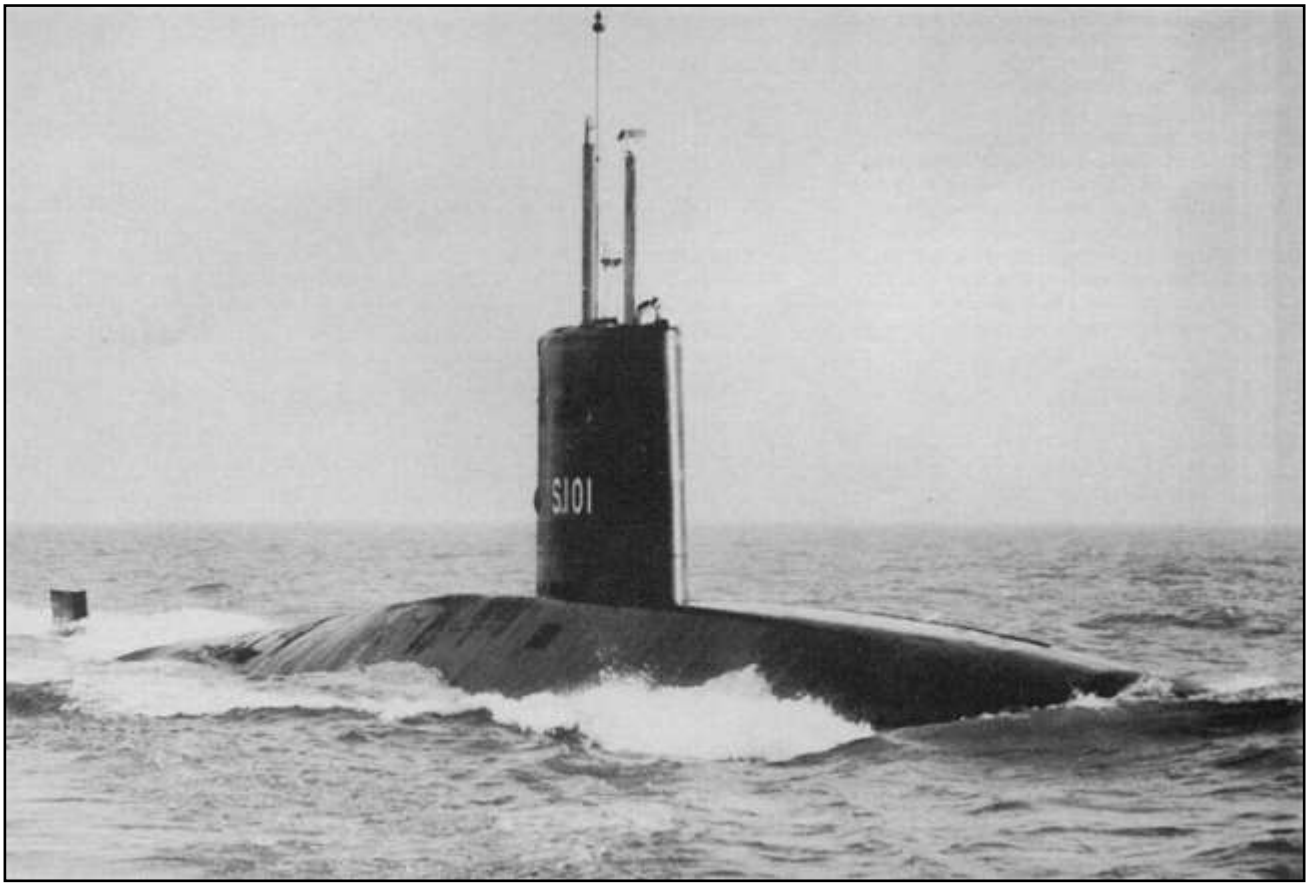
Following the progress made by the United States in the revolutionary field of nuclear powered submarine propulsion, a mid 1950s policy decision announced that, instead of developing an all British nuclear submarine, much time and money would be saved by accepting the American lead and taking advantage of US nuclear technology. Therefore, the first British nuclear powered Fleet submarine, HMS Dreadnought, comprised an American 'kit of parts' in a Vickers hull.

HMS Dreadnought

Specially designed to hunt and destroy enemy underwater craft, Dreadnought was laid down on 12th June 1959 and launched by Her Majesty the Queen on Trafalgar Day (21st October) 1960. Dreadnought's preliminary trials, which began early in 1962, progressed very satisfactorily, considering that Britain had not built a nuclear powered submarine before and she made her first dive, in Ramsden Dock on 10th January 1963. At the time of her completion, April 1963, she was one of the most formidable attack submarines in the world.

Dreadnought is handled by means of telemotor controls, using a type of joystick and elaborate instrument panel similar to those in the cockpit of a modern aircraft. At high underwater speed she also behaves and handles like an aircraft and can be set on course and depth by an 'automatic pilot'. She is also capable of performing 'aquabatics'.

Comprehensive air-conditioning and purification equipment maintains safe and comfortable atmosphere control and enables Dreadnought to operate for more than two months without recourse to air from the surface, a pint of distilled seawater an hour, passed through electrolysers, provides enough oxygen for a 100 man crew. Food supplies are the only factor which limits submerged endurance.



HMS Dreadnought, Britain's first nuclear powered submarine launched on Trafalgar Day 1960.

HMS Dreadnought surfacing.

In the after end of Dreadnought, which is almost totally American and is known as the 'American Sector,' electricity is produced for less than 1p a kilowatt hour; water produced on the same basis costs about 7.5p a gallon.

Accommodation is of an unprecedented standard, even in surface vessels and the crew appreciate shower baths, laundry and washing facilities; amenities that weren't installed in earlier submarines. Separate mess spaces are provided for senior and junior rates, arranged on either side of a large galley, equipped for serving meals on the cafeteria system. Particular attention was paid to the decorating and furnishing of living quarters and recreational spaces, which include cinema equipment, an extensive library and tape recordings; features which help to offset the monotony associated with prolonged underwater voyages.

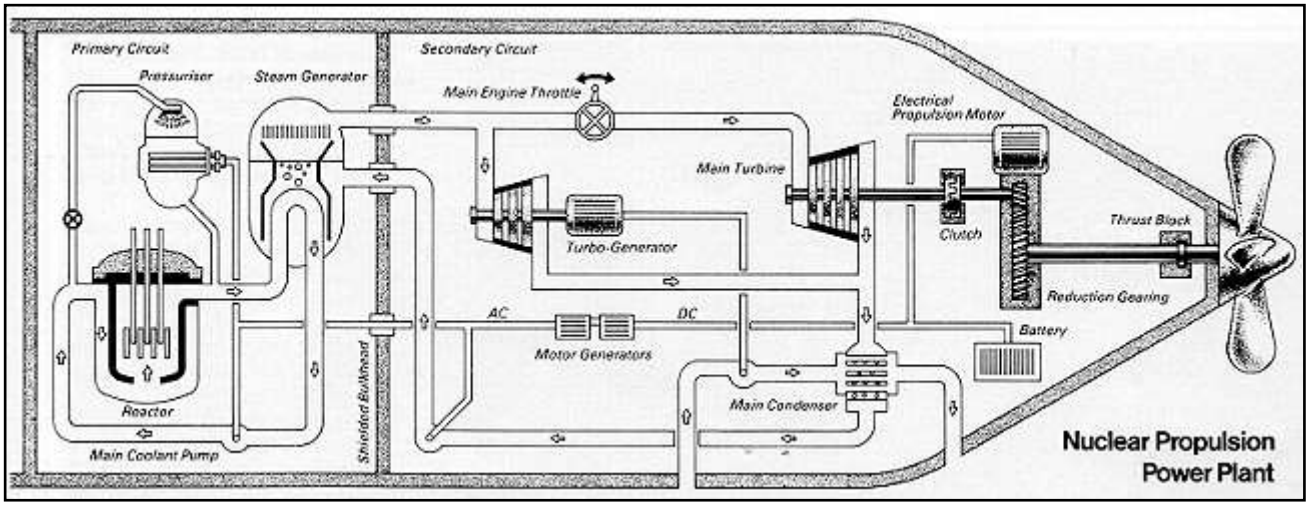
During her career, Dreadnought has been on many varied patrols. On 24th June 1967 she was ordered to sink the wrecked and drifting German ship Essberger Chemist. Three torpedoes hit along the length of the target: the gunners of HMS Salisbury finished the job by piercing the tanks that were keeping the Essberger Chemist just afloat.

In the mid-60s, Dreadnought's visits included trips to Norfolk Va, Bermuda, Rotterdam and Kiel. She was at Gibraltar in 1965, 1966 and 1967 and on 19th September 1967 she left Rosyth for Singapore on a sustained high speed run. The round trip finished as 4,640 miles surfaced and 26,545 miles submerged.

Apart from minor hull cracking problems, Dreadnought proved to be a reliable vessel, popular with her crews. In 1970 she completed a major refit at Rosyth, in the course of which her nuclear core was refuelled and her ballast tank valves were changed to reduce noise. She was re-commissioned on 10th September 1970 and she has a commemorative postal cover to prove it. On 3rd March 1971 she became the first British submarine to surface at the North Pole.

Dreadnought is now at Rosyth Naval Dockyard, laid up indefinitely while her radioactive contamination decays. Her nuclear fuel has been removed and she has been stripped of useful equipment. She will eventually be sunk deep in the Atlantic or broken up for disposal in some other way.

During Dreadnoughts build, Rolls Royce and Associates, in collaboration with the United Kingdom Atomic Energy Authority, were developing a completely new nuclear propulsion system. On 31st August 1960 Britain's second nuclear powered submarine was ordered from Vickers and fitted with Rolls Royce's nuclear steam raising plant, Valiant was the first all British nuclear submarine.



Schematic drawing of a nuclear power plant.

Valiant, Swiftsure, Churchill and Trafalgar Classes

Although the name originally chosen for her was Inflexible, Britain's second nuclear submarine was commissioned as HMS Valiant on 18th July 1966. Derived directly from HMS Dreadnought, Valiant's near perfect streamlining gives maximum underwater efficiency, whilst her fin like conning tower is intended to reduce drag to a minimum.

As early as April 1967 Valiant set a record submerged passage for a British submarine when she completed the 12,000 mile homeward voyage from Singapore in 28 days. Month long submerged voyages have since become routine.

Vickers' third 'nuke', Warspite was launched on 25th September 1965 and commissioned on 18th April 1967. Unfortunately, completion of the Valiant Class was held back to speed up work on the Resolution Class Polaris submarines. However, as soon as Resolution was launched, no time was lost in completing the Valiant Class and starting work on a Repeat Valiant Class, the Vickers built Churchill and Courageous, together with Cammell Laird's Conqueror, the only British nuclear Fleet submarine to be built outside Barrow.*HMS Warspite*

On 15th March 1983, HMS Warspite returned to her base at Faslane, after a 111 day patrol off the Falklands, the longest ever made in peacetime by a British submarine. With a 110 man crew, her Commanding Officer, Cdr. J G F Cooke, said the only things left in the submarine's deep freeze 'are three herrings and two lemons'.

During the past nine years, Vickers have built six Swiftsure Class submarines (Swiftsure, Sovereign, Superb, Sceptre, Spartan and Splendid) which incorporate improvements and bring the total nuclear powered Fleet submarines in the Royal Navy to 12. Two even more sophisticated Trafalgar Class submarines, Trafalgar, which is nearing completion and Turbulent which was launched on 1st December 1982, are under construction.*HMS Turbulent*

HMS Turbulent

Life on Board

Most of a nuclear powered submarine's crew are watch keepers whose working hours are taken up at regular watch keeping positions and with the continuous training task. 'Off duty' time is not entirely

free as everyone has some further task to perform, such as routine maintenance, paper work or ‘housekeeping’ and ‘domestic’ chores.

To maintain peak efficiency, proper relaxation is very necessary and entertainment during patrols is provided by a wide selection of modern films, a large popular paperback library and by personal cassette recorders which cater for individual tastes.

Accommodation is of a high standard, despite obvious limitations in space. The mess, recreation and sleeping spaces have been made as pleasant and comfortable as possible within the confines of a submarine hull and a modern, well equipped galley, which maintains a high standard of catering, offers a choice of several hot or cold dishes at all meals and times.

Although capable of keeping up with a surface fleet, it is unlikely that the high performance Fleet submarines will ever be seen in close formation with surface ships in normal exercises or in actual operations. With the fearsome title of ‘Hunter-Killers’, their task is to hunt down their prey alone, to reduce the risk of being attacked by friendly forces.

The nuclear powered submarine represents a terrible threat to surface warships, for her speed allows her to close in, attack with a variety of weapons, such as guided torpedoes or even missiles and then withdraw at high speed.

As Admiral Sir John Fisher wrote prophetically in 1904, ‘It’s astounding to me how the very best amongst us fail to realise the vast impending revolution in naval warfare and naval strategy that the submarine will accomplish!’

FLEET SUBMARINES MAIN PARTICULARS	DREADNOUGHT	VALIANT AND CHURCHILL CLASSES	SWIFTSURE CLASS
Length overall	265ft 9in	285ft	272ft
Beam	32ft 3in	32ft 3in	32ft 3in
Displacement,			
surface	3500 tons	3500 tons	3500 tons
submerged	4000 tons	4500 tons	4500 tons
Diving depth	In excess of 1000ft	In excess of 1000ft	In excess of 1000ft
Speed,			
surface	In excess of 25 knots	In excess of 25 knots	In excess of 25 knots
submerged	30 knots	30 knots	30 knots
Armament	Six 21-inch bow tubes	Six 21-inch bow tubes	Five 21-inch bow tubes
Complement,			
design	88	103	97

HMS Trafalgar.

HMS Turbulent surfaces alongside HMS Invincible.

POLARIS SUBMARINES

The mid 1950s development of the submarine launched Polaris ballistic missile by Lockheed and the US Navy led eventually, to the signing of the Polaris Sales Agreement between Prime Minister Harold Macmillan and President John F Kennedy.

It was decided that the United Kingdom would have four Polaris submarines to carry the latest A-3 missiles, that the submarines would be British designed and built, that the whole weapon system and equipment, except warheads, would be purchased from the United States and that the warheads would be British. The Government directive was explicit, the four SSBNs (Ship Submersible Ballistic Nuclear) were to be deployed at the earliest possible date and the programme executed within the allotted budget. 'A challenge had been issued and a challenge was going to be met'.

The Build Programme

The programme was authorised in February 1963, the submarines were to be built in pairs, with maximum speed, by Vickers (Lead Yard) and Cammell Laird. The order for a fifth SSBN was announced in 1964, but was cancelled by a new Government the following year. The keel of the first of class, HMS Resolution, was laid down at Barrow on 26th February 1964 and represented for Vickers the sternest test the yard had had for many a year.

The planning and design effort which went into the Polaris submarine programme was colossal: 500,000 man-hours of planning, preparation of more than 10,000 carefully detailed drawings, all to be translated into the physical business of construction. Additionally a full-scale wooden 'mock up' was built. Not only did this allow the exact positioning of any piece of equipment to be planned and the routes for cables, pipes and trunking to be decided, but when the crew arrived to stand by their ship, they were able to train on the mock up and become familiar with their new charge before they even set foot aboard her.

In constructing Resolution, the hull was assembled on the berth from sections prefabricated in the Assembly Shop. The fore and aft parts of the ship were built up simultaneously and into the space between were placed the prefabricated missile sections, complete with missile tubes. Thirty months

was the time occupied from keel laying to launch, which was carried out by Her Majesty Queen Elizabeth the Queen Mother on 15th September 1966.

The autumn of 1967 was an important on in the history of Vickers. Resolution having successfully completed her Contractors' Sea Trials was accepted into the Fleet on 2nd October.

To provide an operational submarine of completely new design, with a complete weapons system from the United States and with adequate support facilities, within 4.5 years of ordering the vessel, was a truly remarkable performance. 'Vickers work force had met their challenge!'

Hard on the heels of Resolution's delivery to the Fleet came the launch of Repulse, on 4th November. This launch was not accomplished without one of those heart pounding incidents which sometimes accompany these occasions. Repulse decided to elude the waiting tugs and remain on display in the Walney Channel until the next high tide.

Repulse was fitted out in Devonshire Dock and joined the Fleet, ahead of time, on 28th September 1968. Her sister ships, Renown and Revenge, built at Cammell Laird, were commissioned in November 1968 and December 1969, respectively.

A US Air Force photograph showing the firing of HMS Resolution's second Polaris A-3 missile on 3rd April 1968.

Barrow's second Polaris submarine – HMS Repulse.

All on Target

One of the most important events in the work-up of a Polaris submarine is the Demonstration and Shakedown Operation (DASO), which is conducted off Cape Kennedy in Florida. This operation culminates in the firing of a Polaris missile down the US Air Force Eastern Test Range to a target up to 2,500 nautical miles away. The Ministry of Defence planned in 1963, to fire Britain's first Polaris missile at 11.15 Eastern Standard Time on 15th February 1968, HMS Resolution failed to achieve this by 15 milliseconds, but the firing was otherwise successful!

Polaris armed nuclear submarine HMS Resolution.

Vigilance Maintained

POLARIS SUBMARINES

MAIN PARTICULARS

Length overall	425 feet
Beam	33 feet
Displacement,	
surface	7500 tons
submerged	8400 tons
Diving depth	In excess of 1000 feet
Speed,	
surface	20 knots
submerged	25 knots
Armament	Six 21-inch bow tubes
	16 Polaris A-3 tubes
Complement, design	143 (two crews)

Being the United Kingdom's contribution to NATOs strategic nuclear deterrent, at least one Polaris submarine is constantly on patrol, sailing submerged 'one knows not where', but always carrying her deadly cargo of two stage ballistic missiles. 'Sherwood Forest' is the nickname given to the compartment housing these 16 missiles, which are 31 feet long, 4.5 feet in diameter and weigh 28,000 pounds. Fired from the submerged submarine, the multiple nuclear warheads can soar into the stratosphere and devastate a target 2,500 nautical miles away. One Polaris submarine carries more destructive potential than the total amount of explosives expended by all sides in the Second World War.

When a Polaris submarine heads out to sea, the crew settles down to a life of routine, where days pass relatively quickly, but time seems to stand still. Their main activities are devoted entirely to ensuring that the secrecy of their position is preserved and that the deadly missiles are always ready to fulfil their ultimate purpose. To make

the fullest use of Polaris submarines, each has two crews, known as Port and Starboard, which take turn and turn about in the two month patrol cycle.

Food assumes an importance beyond its intrinsic value and plays a large part in influencing the morale of those onboard. From the small galley of a Polaris submarine, three cooked meals a day are prepared for the 143 officers and men, in an eight week patrol, the equivalent of feeding a family of four for five years.

The primary source of power for Polaris submarines is a pressurised water nuclear reactor which provides steam for the propulsion turbines and turbo generators. Systems for every day running range from high and low voltage electrical power, steam, hydraulic, pneumatic lubricating oil and water for essential ship's services, to freshwater, air-conditioning and refrigeration for domestic purposes. A network of communications and control systems is used for the transmission of information, for direction of remote services and for round the clock monitoring of conditions throughout the ship.

The Cost of Peace

Polaris submarines are designed to carry, and maintain in a state of readiness to fire, 16 Type A-3 Polaris missiles in addition to their conventional torpedo armament. The Admiralty believe that if the missiles are ever employed they will have failed in their purpose of preventing war. But to quote Vice-Admiral Hugh Mackenzie (ex Chief Polaris Executive): 'It is no use pretending to be able to do the job. The stakes are too high to rely on bluff'.

Such is the fearsome capability of HMSs Resolution, Renown, Repulse and Revenge that, even in peacetime, the 'opposition' is unlikely to subscribe to that proverbial saying 'Out of sight, out of mind'.

Footnote: This article has been copied and edited from a series of Vickers leaflets kindly lent to me by fellow club member Peter Waller, whose father once worked at Vickers. They were published in 1984 so some of the information, especially on nuclear submarines and weapons systems, will be out of date. The colour and a couple of black and white plates have been added and are from my collection of photos downloaded from the internet.