HISTORICAL DEVELOPMENT OF THE SUBMARINE

FROM THE HAND-DRIVEN TO THE DIESEL

This article is an extract from the brochure prepared by Vickers-Armstrongs (Shipbuilders) Limited, to commemorate the launching of H.M.S. Dreadnought *at their Barrow Shipyard, and permission to reprint this extract is acknowledged.*

In 1907, during H.M.S. *Dreadnought's* first commission as flagship of the Home Fleet, King Edward VII visited her at Portsmouth. While on board, Admiral Fisher pointed out to the King some of the earliest of the Navy's submarines lying alongside Fort Blockhouse and told him they were the warships of the future. That was a far-sighted prediction which illustrated the outstanding ability of Admiral Fisher to appreciate the capabilities of a new development.

At that time submarines were in their infancy. The idea was not new but the earliest attempts at submarine construction were not successful. The first designer to achieve any success was David Bushnell, a young American, whose first boat was used during the war of American Independence. This boat had an iron hull, with a lead keel for ballast, part of which could be jettisoned in an emergency. There were two tanks in the bottom of the boat, into which sea water could be admitted through a valve so as almost to submerge the boat. Two hand pumps were used to force the water out again in order to surface.

Unlike his predecessors, Bushnell appreciated that the pressure of water increases with its depth, and also that gunpowder can explode under water. He used two propellers, one in the vertical plane for forcing the boat under water, and one for moving the boat horizontally. These were rotated by hand from inside the boat. A detachable charge of gunpowder, controlled by a clockwork fuze, was carried externally on a wooden screw which was forced into the hull of the enemy ship, using a handle inside the submarine.

The attack was made by towing the boat near to its target with its tanks flooded. The operator then manœuvred close to the target with his horizontal propeller and dived with the vertical propeller to fix the charge under the bottom of the ship, where the submarine was held trapped by its slight positive buoyancy. The fuze gave a delay period of thirty minutes to enable the submarine to escape. This boat was used to attack the British fleet lying off Governor's Island, New York, in 1776. The attack, made in darkness, failed only because the screw for the charge could not penetrate the copper sheathing on the ship's bottom. The boat was sighted during its escape, and two further attacks were also unsuccessful because of the good look-out established in the British ships.

A second boat of this type was used in the war of 1812, in an attack against H.M.S. *Ramillies*, commanded by Captain Sir Thomas Hardy, who had been captain of the *Victory* at Trafalgar. This attack was nearly a success, as a hole had been bored through the copper sheathing and the charge was being attached when the screw broke.

' Too Dreadful a Weapon '

Another American, Robert Fulton, devised a submarine in 1797 and offered his design to various European governments in turn. Eventually Napoleon gave Fulton a grant in 1800 and his boat, *Nautilus*, was launched in 1801. She

submerged completely by taking water ballast into internal tanks and had a force pump to eject this water when required. Driven by a hand-operated propeller, she was the first boat to have a horizontal rudder, or hydroplane, to control her depth. The explosive charge was attached to a spike on top of the submarine.

The first submerging trials, in the Seine at Paris, were successful, and were followed by a trial attack on an old schooner at Brest, which was also a success. But the French government could not agree with Fulton over his belligerent rights in the event of capture, and eventually Fulton crossed the Channel to offer his invention to England. A demonstration was arranged, which was again a success ; so much so that the Commission appointed to assess the submarine rejected it as being too dreadful a weapon to use. The dejected Fulton returned to America and in 1810 was awarded a grant by Congress to build a larger submarine. But he died during the trials and the project was abandoned.

Orchestra under the Sea

William Bauer, a Bavarian army officer, was the next submarine inventor. His first boat was lost in 1851 when it got out of control and went to the bottom in sixty feet of water off Kiel. Bauer and the two seamen with him escaped because of Bauer's ingenuity. He realized that their only chance was to admit water into the boat so that the air inside would be compressed to the water pressure outside, permitting them to open a hatch and rise to the surface in a bubble of air. Bauer eventually persuaded the two men to co-operate and they escaped successfully after five hours under water.

Bauer's second boat was built for the Russian government at St. Petersburgh in 1855 and made over a hundred successful dives. During the coronation of Tzar Alexander II in 1856 Bauer submerged the boat with an orchestra aboard in Cronstadt Harbour, where they played the national anthem, which was heard on board all the ships in the harbour and caused quite a sensation.

The next development occurred during the Civil War in America from 1862 to 1864. The Southern ports were blockaded by Northern monitors, cutting off the South from all commerce. To counter this, a few small submarines called ' Davids ' were built, carrying a gunpowder charge with chemical fuzes at the end of a spar projecting forward from the hull. These boats attacked when almost submerged, and rammed the spar against the victim to detonate the explosive. There were two types, one with a hand-driven mechanism for turning the propeller, operated by eight men, and the other having a small steam engine for this purpose.

The first ' David ' attack was made on the Ironsides in October 1863 and caused considerable damage, but the submarine was swamped and only the officer in command escaped. The second attack was made against *Housatonic*. This was more successful and the *Housatonic* was sunk. But the explosion also sank the submarine and all her crew was lost. This courageous exploit demonstrated to the maritime powers the possibilities of the submarine, although the ' David ' boats were still hardly a practical proposition because a successful attack resulted in the loss of the boat and her crew.

Enter — the Torpedo

The feasibility of manœuvring a submarine had now been proved but no further progress could be made until an underwater weapon was available which could be exploded at the target without damaging the submarine. The first torpedo was invented by Captain Luppis of the Austrian Navy in 1865. His torpedo was self-propelled, but steered remotely by lines attached to the rudder. The propulsive power was provided by a steam engine, or by clockwork, neither of which worked satisfactorily, and the steering arrangement was crude. Luppis took his invention to Robert Whitehead, who modified the

design and produced a torpedo driven by compressed air, with a range of 700 ft and a speed of 6 knots. The Admiralty heard of this development in 1869 and officers of the Mediterranean Fleet were sent to witness trials. As a result, further successful demonstrations were carried out in England and a contract was agreed. The Whitehead torpedo was first used in surface ships, but it was in submarines that the torpedo was destined to make its most important contribution to sea power.

Towards the end of the nineteenth century two American inventors, Lake and Holland, competed for submarine contracts with the U.S. Navy. Lake's boats had four hydroplanes, two forward and two aft, and could maintain a constant depth. However, they were fitted with large wheels for running along the sea bed. This was not acceptable to the U.S. Navy and the Holland design was adopted.

The Curate's Idea

In Europe, Nordenfeldt, the Swedish gun designer, built several boats for European navies. His design was developed from the ideas of a curate in Liverpool called Garrett, and two of his boats were constructed at Barrow. The first, prefabricated at Barrow and shipped to Turkey in sections for assembly in 1886, was 96 ft long with a displacement of 160 tons. She was driven by a coal-fired boiler and steam engine, and had a funnel which was unshipped in preparation for submerging and replaced by a watertight cover. The boiler retained a head of steam sufficient for cruising some twelve or fourteen miles. The boat was designed to have slight positive buoyancy and was submerged by a vertical propeller at each end of the hull. She was bought by the Turkish Government but very little was done with her because of difficulties in training her crew.

The second Nordenfeldt, 123 ft 6 in. long with a displacement of 220 tons submerged, was completed at Barrow in 1887 and, after trials, was bought by the Imperial Russian Government, but was lost on her way to Russia.

These boats were good sea boats on the surface, but when submerged the trim had to be carefully watched to maintain fore-and-aft stability. The principle of submerging them was unsound, though it did ensure that the submarine would surface if the mechanism failed or power was lost. They were eventually superseded by the Holland type from America.

Hollands for Britain

By the end of the century the submarine was being adopted by most maritime powers, with the notable exception of Great Britain, where the official view at that time was that the submarine was a defensive weapon only, perhaps useful to a small navy, but not necessary in the powerful Royal Navy. However, public criticism was so strong that in 1900 the Admiralty ordered five boats from Holland and it was stated that these boats would be used for experiments to assist the Admiralty in assessing their true value. Holland's boats were being built in America for the U.S. Navy, and were clearly the most reliable type which had yet been produced. Vickers, Sons & Maxim at Barrow had obtained the sole European agency for building the boats patented by Holland, who sublet this contract with the Admiralty to Vickers.

The order was placed in December 1900 and the first boat was launched on 2nd October 1901. These boats, 63 ft 10 in. long, with a submerged displacement of 122 tons, were driven by a petrol engine at 7·5 knots on the surface, and by a battery-powered electric motor giving 5 knots when submerged. They carried a crew of seven and had one torpedo tube in the bow, with three Whitehead torpedoes. The trials were successful, the boats proving easy to handle under water. However, their design was not well suited to surface work in rough weather and an order had been placed with Vickers, at the same time as the Hollands were ordered, to design and build a larger submarine based on

the Holland type. This was the A1 which was completed in July 1903, five months after the completion of Holland V.

Now that the Royal Navy had, if somewhat reluctantly, adopted the submarine, progress was rapid. Twelve more A class were ordered in 1902 and 1903 and all except A13 were completed by September 1905. A13 was an experimental boat, fitted with a Diesel engine instead of the petrol engines used in the remainder of the class, and she was not finally handed over until 1908. The A class was followed by eleven B class and thirty-eight C class, again designed by Vickers, and all but six were built at Barrow and commissioned between April 1905 and March 1910, the remainder being built at Chatham Dockyard. The B and C classes were almost identical, and were a larger version of the A class, with petrol engines for surface propulsion and small batteries of accumulators for electrical propulsion when submerged.

Diesel Development

These early boats, which were referred to in more conservative naval circles as ' Fisher's toys ', were designed for coastal defensive work, and had a limited range. It was soon realized that the submarine could be used in other more ambitious roles, if the radius of action could be increased. The petrol engine was not suitable for this, because of the dangers of carrying petrol on long-range operations. The development of the Diesel engine solved this problem, as its heavy oil fuel had a high flash point and the danger of explosion was negligible. The experimental work on A13 bore fruit and D1 was ordered from Vickers in 1907. She was the prototype of the first class of Diesel submarines, and was 160 ft long with a submerged displacement of 590 tons, nearly twice that of the B and C classes. For the first time the initial design work was carried out by the Admiralty, bringing submarine design into line with the usual procedure for other Admiralty ships. Eight of the D class were built, six at Barrow and two at Chatham.

The experience gained with D1 was incorporated in the design of the famous E class submarines, which did such outstanding work during the first World War. The E-boats were larger than the D class and were armed with two bow torpedo tubes, one at the stern and one on each side for broadside firing. A 12-pounder gun was mounted on the casing, a development which had been tried out in D4. The Diesels developed 1,600 horse-power, giving a surface speed of 15 knots, and the submerged speed was 10 knots, produced by 840 horse-power electric motors. Both the D and E classes had twin screws instead of the single screw used in the earlier boats and this became general practice for the subsequent designs. The radius of action of the E class was 3,800 miles on the surface at 10 knots, and between 15 and 120 miles submerged, depending on the speed. Fifty-six of the E class were built. The first twenty-six were divided between Chatham and Barrow, twenty being built at Barrow and completed between January 1913 and January 1916, including two boats launched at Beardmore's and fitted out at Barrow. The remaining boats of the class were built at 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 type, AE1 and AE2, were built at Barrow for the Royal Australian Navy and handed over in 1914.

TWO WARS—AND BEYOND

In 1914 there were seventy-six submarines in the Royal Navy and a further twenty under construction. Although one of the last naval powers to adopt the submarine, Great Britain now had the largest submarine fleet in the world. There were also sixty-eight battleships and battle-cruisers, 110 cruisers and 218 destroyers at that time in the Royal Navy—a larger fleet than the total

of any two other navies in the world. The rebuilding of the Royal Navy in the ten years before this had gone on apace under the impetus given by Sir John Fisher and those associated with him in this work, including Sir Philip Watts.

Of the submarines in commission at the start of the first World War, the majority were the B, C and D class boats. The Hollands and the A class had been scrapped and nine of the new E class had been delivered.

First Successes

At the beginning of the war the D and E class boats were used in the Heligoland Bight, first for reconnaissance patrols only and subsequently with a free hand. The first offensive success was scored by E9, commanded by Lieutenant-Commander Max Horton, who had stood by this boat during her construction at Barrow. On 13th September, 1914, Horton sighted the German cruiser *Hela* near Heligoland, closed to 600 yards and fired two torpedoes, one of which struck amidships. *Hela* sank and E9 was hunted for the remainder of the day. During his next patrol in the Bight, Horton sank the destroyer S116.

These first successes by a British submarine were followed by many courageous exploits. Particularly important were the operations carried out in the Baltic and in the Sea of Marmora, enemy waters which were closed to surface ships but where our submarines were able to operate with devastating effect during the first two or three years of the war.

Meanwhile new classes of submarine were being developed and built. Most of them were patrol submarines, improving on the successful E class, but there were a number of interesting freak designs which were not entirely suitable for submarine operation. Experience had shown up the dangers of using submarines for joint operations with surface ships, because of the difficulties of distinguishing between friendly and hostile submarines. However, this was ignored and it was thought that there was a use for a submarine which could keep up with the fleet on the surface and submerge for attack when contact with the enemy had been made. Since this required a surface speed of 24 knots, which was beyond the capabilities of Diesel engines at that time, steam turbine machinery had to be used.

K Class Tragedy

A new design was developed, the K class ; large boats with a submerged displacement of 2,500 tons. These boats began to come into service in 1916 but were never used successfully in the role for which they were designed. This was disastrously illustrated in January 1918 when ten K boats put to sea with the Grand Fleet. During the night the helm in K22 jammed to starboard and she swung round and collided with K14. The two boats locked together and a series of collisions occurred in which K17 and K4 sank with all hands and four other submarines were damaged. This disaster finally sealed the fate of the fleet submarine and the K-boats were scrapped at the end of the war. One more experimental boat, K26, was built after the war but was never used as a fleet submarine.

The M class were originally to be K-boats but were redesigned as submarine monitors immediately after laying the keels. They carried a 12 in. gun and had Diesel engines for surface propulsion. The attack procedure was to cruise at periscope depth until the target was lined up. The gun was fired at about 45 degrees elevation, with the boat brought up so that about 6 ft of the barrel showed above water. After firing, the boat submerged again to reload. Four of these boats were ordered, but only M1 was commissioned before the end of the war, and the fourth was never completed.

Max Horton, who later became famous as Admiral Commanding Western Approaches in the second World War, came to Barrow again to take command of M1, which left in April 1918 and was sent to the Mediterranean. She was

eventually lost without survivors in a collision with a collier in 1925. M2 was later rebuilt as a submarine aircraft carrier, with a hangar and catapult in place of the gun mounting, and carried a two-seater scout biplane, but was subsequently lost in the English Channel during exercises. M3 was converted to a minelayer in 1927 and was scrapped in 1931.

High Underwater Speed

The R class are also interesting, in view of modern developments. They were designed for anti-submarine operation, with an exceptionally high speed under water, which was obtained with high powered electric motors and single-screw propulsion, and by particular attention to streamlining the hull. They could make 15 knots submerged and 10 knots on the surface, and had six bow torpedo tubes.

By the 'cease fire' in November, 1918, a total of 124 submarines had been completed at Barrow for the Royal Navy ; fifty-two of these, of nine different classes, had been handed over since the outbreak of war in August 1914. After the war eleven more submarines of the war-time programme were completed, the last one being handed over in 1921, and four more were transferred to Admiralty Dockyards for completion after launching. There followed an interval of over four years before submarine construction began again.

Between the two world wars warship design was confined by the provisions of the various naval treaties, starting with the Washington Naval Treaty in 1921. So far as submarine construction was concerned, this was a period of consolidation, used to improve on the war-time designs and to incorporate better equipment.

The development of anti-submarine measures had a significant effect on submarine design in this period. During the first World War submarines were detected by visual spotting, or by hydrophones, which picked up and gave the direction of the noise from the boat's propellers or machinery. Many suggestions were received at that time for anti-submarine weapons, the most curious being a scheme to lay barrels of fruit salts on the sea bed, controlled from ashore. When it was suspected that a submarine was in the area, the barrels were to be opened remotely by the shore control, and the resulting stream of bubbles effervescing from the fruit salts would carry the boat to the surface, where it could be sunk by gunfire. Needless to say, this idea was never tried out !

Asdic and Depth Charges

The depth charge was introduced during the first World War but the lack of effective detection equipment reduced its value. After the war, the Asdic device was produced under the auspices of the Allied Submarine Detection Investigation Committee, considerably improving the detection and location ability of anti-submarine vessels, but equally useful to the submarine itself. However, as these devices improved, the importance of greater diving depth and resistance to shock from explosions increased, and influenced the hull design and methods of supporting equipment.

Most of the boats built in the late 'twenties and early 'thirties were patrol types, the O, P and second R classes. There were two further attempts at producing boats with fleet speed on the surface, this time with Diesel power, in the X1 completed at Chatham in 1925, and later in the three River Class boats completed at Barrow in the 1930s. X1 was notable in that she was a large boat carrying four 5·2 in. guns in two turrets. However, apart from the patrol boats, the most successful special purpose designs were the submarine minelayers of the *Porpoise* Class, which gave good service in the second World War.

Submarine building at Barrow began again, but at a slower pace than before, in 1925 with an order for two O class boats for the Royal Australian Navy. These were followed by ten boats of the O, P and R classes, the three River Class

and three *Porpoise* boats for the Royal Navy, completed between 1929 and 1937. During the 1930s, three more classes came into service. The S class were first built in the early thirties at Chatham and were comparatively small boats of about 800 tons surface displacement, intended for use in confined waters. The T class were larger boats with a corresponding displacement of 1,320 tons, replacing the older types as the standard patrol submarine, and the first three were completed at Barrow in 1938 and 1939. The U class were smaller than the S-boats and intended for training purposes as replacements for the old H-boats of first World War design and also for short range patrol work. They were used to good effect in the Mediterranean during the war. The first three of these were completed at Barrow in 1938.

At the beginning of the second World War in September 1939 there were fifty-seven submarines in commission ; twelve S class, three of each of the T, U, and River classes, six *Porpoise* class, and eighteen of the O, P and R class boats. The remainder were first World War boats of the H and L classes. The policy at the beginning of the war was to produce the T and U classes only, but the S class were introduced into the programme in 1940 because they had proved most suitable for North Sea work.

Prefabricated Hulls

The war-time building programme concentrated on these three types, which were modified as time went on, both to introduce new equipment and also to use welded construction instead of riveting. The latter change increased the diving depth, 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. It was not until near the end of the war that a new design, the A Class, was introduced, principally because the series of modifications on the existing designs had led to acute congestion. However, the war ended soon after the first A-boat was delivered, and the war-time submarine fleet relied almost entirely on the S, T and U-boats. This policy was very different from that of the first World War, when some twelve new classes were developed, and was pursued so as to cause the minimum interference with the shipbuilders' production programme.

Between September 1939 and the end of the war in Europe in May 1945, a total of eighty-seven submarines, mostly T and U class boats, were built at Barrow for the Royal Navy and our allies, and a further eighteen boats of the X-craft midget type were also built. The bulk of these were handed over in the four years 1941 to 1944, and the peak rate of production was reached in 1942 when an average of over two boats per month was achieved.

At the end of the war, production had changed over to the A class boats, and ten of these were completed between 1945 and 1948. Since the war the new designs have been the *Porpoise* and *Oberon* classes, which are deep-diving anti-submarine boats with conventional propulsion, and the two high-speed experimental boats, *Explorer* and *Excalibur*, which used concentrated hydrogen peroxide in their propulsion, a development of a German invention during the war. Another four of the famous X-craft of a new design have also been built at Barrow.

Another German war-time device has been incorporated in the post-war British boats. This is the Schnorkel, or snort, which permits air to be drawn in from the atmosphere to enable the Diesels to run while the boat is submerged at periscope depth. This idea had been used first by the Dutch Navy between the two World Wars, but it was decided during the last war not to fit it in the British boats because other equipment would have to be sacrificed and our boats were still comparatively safe to recharge their batteries on the surface. The Germans introduced Schnorkel when our anti-submarine forces made surface charging a distinctly unhealthy operation.