HISTORY OF THE SUBMARINE.

(From a Bulletin, May, 1918, of the Naval Consulting Board)

The first recorded experiment in submarine operation was made by a Hollander, Dr. Cornelius Van Drebbel, who in 1624 constructed a one-man submarine operated by feathering oars, which made a successful underwater trip from Westminster to Greenwich on the Thames. Dr. David Bushnell, an American inventor and graduate of Yale in the class of 1775, nearly sank the "Eagle" in New York harbor during the Revolutionary War by the use of his little one-man-powered submarine the "American Turtle." In England, the American inventor, Robert Fulton, in the presence of William Pitt, then chancellor, and a large number of spectators, blew up a brig by exploding a mine which he had placed under her bottom by the use of his submarine boat. Both of these inventors were discouraged and were refused the necessary assistance to enable them to develop further their ideas regarding submarines, although they had undoubtedly shown that there were great possibilities in the underwater type of vessel. Various unsuccessful attempts were made to utilize submarines during the Civil War, but at that time their only means of offense was a torpedo at the end of a long war, and the solitary recorded hit was as disastrous to both the warship and the submarine. Just as the breech-loading rifle, a very ancient device, failed to come into its own until the invention of the metallic cartridge, the submarine had to await the invention of the automotive torpedo before it became a really efficient means of offense.

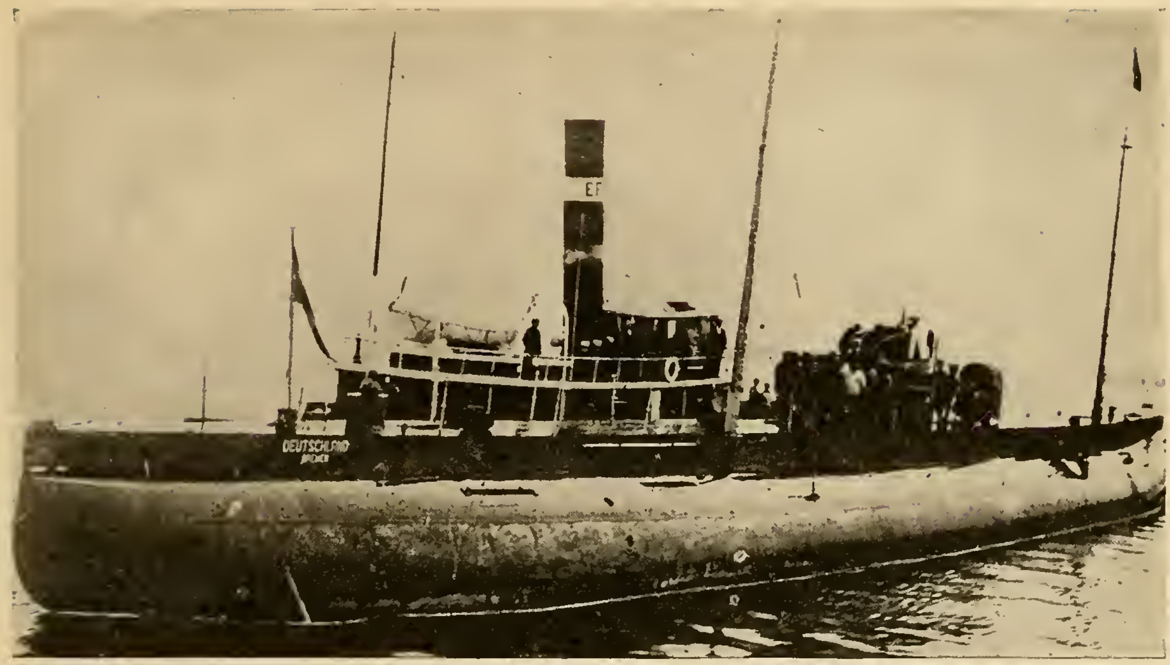
Modern submarines are divided into two general classes: The Coast Defense type of from 300 to 700 tons surface displacement, and the Cruising type of from 800 to 2,500 tons displacement, having a radius of action of from 3,000 to 8,000 miles, and capable of operating along the Atlantic coast of the United States from European bases. The smallest type of modern coast defense submarines, which can hold the necessary apparatus to have a useful range of action, weighs about 300 tons; the handling of such a weight from the deck of a vessel at sea cannot be accomplished with any degree of safety. Generally, the German U boat—which is the designation for the enemy sea-going submarines—is made with a double hull. The bottom space between the inner and outer hulls is used for water ballast; the top space is used for carrying fuel oil. Water ballast displaces the fuel oil as it is consumed by the internal combustion engine. The frequent statements that oil has been seen on the sea, after a U boat has been attacked, may have merely indicated that the submarine's outer hull had been punctured. However, there is some oil slick on the surface when the exhaust mufflers are flooded.

The submarine when submerged so that its periscope does not project above the water, is blind but not deaf, for it is provided with sound detectors or microphones that will indicate the approach and direction of a ship, if its own machinery is at rest or moving slowly, with noise so slight as not to interfere with the listening. The propagation of sound through water is more rapid and efficient than through air, because water does not have so great a cushioning effect upon the sound waves. While we speak of sound waves, and can measure their amplitude in some cases, there is no bodily displacement of the medium through which they travel. In general the harder, denser and more incompressible the medium, the more efficient the transmission of the sound waves. The underwater listening devices which are so frequently availed of in submarines and patrol boats and destroyers used to attack them, consist primarily of a large diaphragm or its equivalent in some other physical form.

DETAILS OF THE LIBERTY ENGINE.

In May, 1918, the war department authorized the following description of the Liberty engine, generally accepted as one of the few really remarkable inventions brought out in the course of the war:

Cylinders—The designers of the cylinders for the Liberty engine followed the practice used in the German Mercedes, English Rolls-Royce, French Lorraine-Dietrich and Italian Isotta Fraschini before the war



Supersubmarine Deutschland which arrived at Baltimore after a trip across the Atlantic.

and during the war. The cylinders are made of steel inner shell surrounded by pressed steel water jackets. The Packard Company by long experiment had developed a method of applying these steel water jackets.

The valve cages are drop forgings welded into the cylinder head. The principal departure from European practice is in the location of the holding down flange, which is several inches above the mouth of the cylinder, and the unique method of manufacture evolved by the Ford Company.

Cam Shaft and Valve Mechanism Above Cylinder Heads—The design of the above is based on the Mercedes, but was improved for automatic lubrication without wasting oil by the Packard Motor Car Company.

Cam Shaft Drive—The cam shaft drive was copied almost entirely from the Hall-Scott motor; in fact, several of the gears used in the first sample engines were supplied by the Hall-Scott Motor Car Company. This type of drive is used by Mercedes, Hispano-Suiza and others.

Angle Between Cylinders—In the Liberty the included angle between the cylinders is 45 degrees; in all other existing twelve cylinder engines it is 60 degrees. This feature is new with the Liberty engine, and was adopted for the purpose of bringing each row of cylinders nearer the vertical and closer together, so as to save width and head resistance. By the narrow angle greater strength is given to the crank base and vibration is reduced.

Electric Generator and Ignition—A Delco ignition system is used. It was especially designed for the Liberty engine to save weight and to meet the special conditions due to firing twelve cylinders with an included angle of 45 degress.

Pistons—The pistons of the Liberty engine are of Hall-Scott design.

Connecting Rods—Forked or straddle type connecting rods, first used on the French De Dion car, and on the Cadillac motor car in this country, are used.

Crank Shaft—Crank shaft design followed the standard twelve cylinder practice, except as to oiling. Crank case follows standard practice. The 45 degree angle and the flange location on the cylinders made possible a very strong box section.

Lubrication—The first system of lubrication followed the German practice of using one pump to keep the crank case empty, delivering into an outside reservoir, and another pump to force oil under pressure to the main crank shaft bearings. This lubrication system also followed the German practice in allowing the overflow in the main bearings to travel out the face of the crank cheeks to a scupper which collected this excess for crank pin lubrication. This is very economical in the use of oil and is still the standard German practice.

The present system is similar to the first practice, except that the oil while under pressure is not only fed to the main bearings but through holes inside of crank cheeks to crank pins, instead of feeding these crank pins through scuppers. The difference between the two oiling systems consists of carrying oil for the crank pins through a hole inside the crank cheek instead of up the outside face of the crank cheek.

Propeller Hub—The Hall-Scott propellor hub design was adapted to the power of the Liberty engine.

Water Pump—The Packard type of water pump was adapted to the Liberty.

Carburetor—A carburetor was developed by the Zenith Company for the Liberty engine.

Bore and Stroke—The bore and stroke of the Liberty engine is 5x7 inches, the same as the Hall-Scott A-5 and A-7 engines and as in the Hall-Scott twelve cylinder engine.

Remarks—The idea of developing Liberty engines of four, six, eight and twelve cylinders with the above characteristics was first thought of about May 25, 1917. The idea was developed in conference with representatives of the British and French missions, May 28 to June 1, and was submitted in the form of sketches at a joint meeting of the aircraft (production) board and the joint army and navy technical board, June 4. The first sample was an eight cylinder model delivered to the bureau of standards July 3, 1917. The eight cylinder model, however, was never put into production, as advices from France indicated that demands for increased power would make the eight cylinder model obsolete before it could be produced.

Work was then concentrated on the twelve cylinder engine and one of the experimental engines passed the fifty hour test Aug. 25, 1917.

After the preliminary drawings were made, engineers from the leading engine builders were brought to the bureau of standards, where they inspected the new designs and made suggestions, most of which were incorporated in the final design. At the same time expert production men were making suggestions that would facilitate production.

The Liberty twelve cylinder engine passed the fifty hour test showing, as the official report of Aug. 25, 1917, records, "that the fundamental construction is such that very satisfactory service with a long life and high order of efficiency will be given by this power plant and that the design has passed from the experimental stage into the field of proved engines."

An engine committee was organized informally, consisting of the engineers and production managers of the Packard, Ford, Cadillac, Lincoln, Marmon and Trego companies. This committee met at frequent intervals and it is to this group of men that the final development of the Liberty engine is largely due.

THE WORLD'S LARGEST SEAPLANE.

At the Naval Air Station, Rockaway, Long Island, on November 27, 1918, some wonderful feats were performed with seaplanes. The principal achievement was the breaking of all records for the number of passengers carried in any type of airplane. This was accomplished when the newest type of the American navy's seaplane, the monster NC-1, the largest seaplane in existence, made a most perfect flight with fifty men on board. The pilot was Lieut. David H. McCullough of the naval reserve flying corps, and the flight was made to demonstrate the enormous lifting power of the latest model of bomb carrying seaplanes. No special modifications were made for this test flight, most of the fifty men being accommodated in the large boat body.

The design and construction of the NC-1, with its triple motors, huge size, and other distinctive features, was carried out by the navy in co-operation with the Curtiss Engineering Corporation. It was not specifically a flying boat nor was it of the pontoon variety of seaplane, but combined the most valuable advantages of both, its size and purpose being considered. While it was entirely new and original in type, the NC-1 incorporated proved essentials in aircraft construction and even before it was tested was regarded in naval circles as a preinsured success rather than as an experiment.

This was the first American trimotored seaplane, being propelled by three Liberty motors that develop a maximum of 1,200 horsepower, giving it a cruising speed of eighty miles an hour. The flying weight of the machine was 22,000 pounds, while the weight of the seaplane itself, unloaded and without a crew, was 13,000 pounds.

An idea of the size of the big seaplane is shown by the fact that the wing spread is 126 feet, the breadth of wing 12 feet and the gap between wings 12 feet.

Late in 1918 the NC-1 made the trip from Rockaway to Washington, about 350 miles, in 5 hours and 20 minutes. The flight from Washington to Hampton Roads, 150 miles, was covered in 2 hours and 15 minutes, and the trip from Hampton Roads to New York, 300 miles, took 4 hours and 20 minutes.

MATERIALS USED IN THE CONSTRUCTION OF AN AIRPLANE.

The United States Signal Corps has compiled figures showing the materials necessary for the construction of an airplane of the ordinary type. This does not include the materials used in the construction of the engine:

Nails		4,326
Screws		3,377
Steel stampings		921
Forgings		798
Turnbuckles		276
Veneer	square feet	57
Wire	feet	3,262
Varnish	gallons	11
Dope	gallons	59
Aluminum	pounds	65
Rubber	feet	34
Linen	square yards	201
Spruce	feet	244
Pine	feet	58
Ash	feet	31
Hickory	feet	1½

KING DECORATES AMERICAN YOUTH.

Flying Cross Awarded to Lieut. Luff.

Lieut. Frederick Luff, son of Mr. and Mrs. H. J. Luff, 3046 Lincoln boulevard, Cleveland, who gained the distinction of being Cleveland's ace by downing nearly a dozen German airplanes, has been awarded the distinguished flying cross by King George.

Recommendation for awarding the cross was made by Gen. Sir Herbert Plumer, commander of the Second British Army, after Lieut. Luff had gone five miles behind the German lines and shot down an observation balloon. Other aviators who tried the feat had been shot down.

Luff is the only living American who has the cross. Four others on whom the honor had been bestowed fell to their deaths. He has sent his parents a certificate of the bestowal of the cross.

"When I got within 200 yards of the balloon," Luff wrote, "machine gun bullets came thickly at me. I was nervous. Flaming 'onions' also were shot at me. They are projectiles that are shot at planes to set them afire. I finally hit the balloon and saw it fall in flames, while the observer went out in his parachute."—Cleveland Plain Dealer.

CANADIAN ACE OF ACES HAS 72 PLANES TO HIS CREDIT.

Col. William A. Bishop, Canadian ace, talks of "thrills" and he's amply qualified to speak. His official record tells how he downed 72 German airplanes. He has been decorated by almost every one