In response to an invitation for proposals for submarines, made by the U.S. government in 1887, designs by Holland and Nordenfeldt were submitted After much consideration the proposals of the former designer were accepted, and formed the basis of the designs for the “ Plunger,” the “ Holland ” and the six vessels of the “ Adder ” class. From what has been already stated, the criticism of Admiral Hichborn (chief con­structor of the U.S. navy) will be understood when he char­acterizes Holland’s method as a “ steering-under ” or “ diving ” device, and Nordenfeldt’s as a “ down-haul ” or “ sinking ” design. The great majority of modem boats are worked by the Holland method. The “ Plunger ” was authorized in 1903; she has a length of 85 ft., diameter 11½ ft., light displacement 154 tons and load displacement 168 tons; she is of sufficient strength for a submergence of 75 ft., and when wholly submerged has a margin of buoyancy of ¼ ton. In addition to her horizontal rudders for diving, she has two down-haul screws, fitted in opposition to Mr Holland’s recommendations; she may there- fore be said to be a combination, for diving purposes, of both the Holland and the Nordenfeldt designs. The “ Plunger’s ” main engines are used for propulsion when she is navigated at the surface of the water. As originally designed they were triple-expansion steam engines, driving triple screws, but have since been altered to gasolene internal-combustion engines driving a single screw. These engines are also used for charging electric accumulators, from which alone motive-power can be obtained when the boat is submerged. The current for charging the accumulators is obtained from a dynamo of 70 H.P., which can always be run in the awash condition to keep the accumulators fully charged. In the awash condition, when the boat is otherwise air- and water-tight, communication is kept up with the outer air by means of ducts and a smoke-pipe, the former bringing in air for combustion and respiration, and the latter carrying off deleterious products of all kinds. For submergence special fittings are used to close these ducts and pipes, and to stop the gasolene generator. The main engine is then no longer available, and for propulsion power is drawn from the accumulators, the dynamo thus becoming a motor which derives current from the accumulators and itself drives the screw-shaft. As was the case with Mr Holland’s earlier boats, great attention is given to automatic control of weights, and water-ballast is admitted to compensate for any change, such as would be produced by the discharge of a torpedo. With her original machinery the “ Plunger ” was to have had a surface speed of 15 knots; her anticipated speed awash or submerged is now 8 knots. To assist in determining the boat’s direction a *camera lucida* is ordinarily provided, but for correcting this Mr Holland prefers trusting to observations made during occasional rises to the surface; for this purpose the boat is provided with a conning tower 4 ft. high, protected with 4-in. steel. The “ Plunger ” is armed with Whitehead torpedoes, and has two tubes for discharging them. After many trials it was at last decided to build a repeat of the “ Adder ” to take her place, and this second “ Plunger ” was completed in 1903. The “ Holland ” is a smaller boat, having a length of about 54 ft., and was purchased in 1900. The official report on this vessel is that “ she has shown herself capable of such perfect control in the vertical plane that she may be kept whilst moving within a few inches of any desired depth, and that she may be brought to the surface and submerged again in a very short time.” A good idea of the general form of the “ Holland ” may be obtained from figs. 122, 123, 124 and 125 (Plate XXVII.), the last three of which represent this vessel when undergoing trials to test her driving qualities.

The design of the six submersibles of the “ Adder ” class is shown in fig. 126. They are of the following dimensions: length 63 ft. 4 in., diameter 11 ft. 9 in.; displacement for surface running 104 tons; submerged displacement 120 tons. The main features of this class are the same as for the “ Plunger.” The shell-plating is 7/16 in. in thickness, and the frames 3½ in. by 3 in., with a spacing of 18 in. The main machinery is a four-cylinder single-acting balanced Otto gasolene engine, which at 360 revolutions will develop 160 H.P. and give the boat a speed of about 8 knots. For propulsion in the submerged condition an electric motor is used, working at 800 revolutions, and giving a speed of 7 knots, a single left-handed propeller being employed. The current for the motor is provided by storage batteries capable of supplying 70 H.P. for four hours; and these batteries are charged by the main engine. The requisite air supply is obtained when the vessel is at the surface, and is stored under a pressure of 2000 lb by a pump driven by gearing off the main engine or main motor. Air at a pressure of 50 lb is used for the expulsion of torpedoes, and the same agent, at various degrees of pressure, works the trimming and ballast tanks and some parts of the machinery; while the exhaust air from the latter subserves the purpose of ventilation. The vessel is fitted with power and hand- steering gear, and there are automatic devices for securing a con­stant depth during submergence. Five Whitehead torpedoes, 45 cm. (about 18 in.) in diameter and 11 ft. 8 in. long, are provided, and there is one expulsion tube placed forward about 2 ft. below the light water-line.

The French submarine boat “ Plongeur ” has already been mentioned. A further advance in this direction was made in France in 1881, when a small submarine was completed by Μ. Goubet at Paris. An inspection of this vessel led to an order for the mechanism of a number of boats from this engineer for the Russian government, and several sets were built and delivered early in 1883. The length of a boat constructed by M. Goubet in 1885 was 16 ft. 5 in.; it had an oval section 5 ft. 9 in. in depth and 3 ft. 3 in. in breadth, and tapered to a point at each end. A longitudinal section of the boat is represented by fig. 127. The main portion of the hull was of bronze, cast in one piece, and at the centre of its length it was surmounted by a large dome having seven glazed openings. There was just sufficient room for an officer and a man seated back to back within it, their eyes in this position being level with the glass windows of the dome. All valves and other mechanism requiring regulation were brought within reach of these occupants, so that no movement on their part was required which might affect the trim; a reservoir of compressed air supplied the means of respiration, and an air-pump removed the vitiated atmosphere. The motive-power was furnished by accumulators, the electric energy stored therein driving a screw propeller by means of a motor. No means of recharging these accumulators when exhausted was provided on board. Submersion was effected by admitting water into tanks divided by transverse bulkheads at sufficient intervals to prevent the surging of the water in the fore and aft direction. A pump expelled this water again when desired, and a safety weight attached to the bottom of the boat was ready for detachment in the presence of danger. A pressure gauge indicated the depth of water reached, and the officer could regulate the opening of the inlet valves or the action of the pumps to maintain or vary this depth as desired. For controlling the boat in a horizontal direction a specially devised pendulum was employed, by means of which a clutch was moved, and a constantly running shaft was thrown into gear with a pump as soon as the boat departed appreciably from the horizontal plane. The action of the pump was reversible,