GERMAN HYDROGEN PEROXIDE U-BOAT ENGINE

by

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A very brief note on the development by the Germans during the last war of a new system of submarine propulsion may be of general interest.

The problem

Although high underwater speed has generally been the goal of designers of submarines, it is not practicable with conventional submarine machinery to achieve this without a serious reduction in other qualities such as submerged and surface endurance, habitability and surface fighting qualities. Necessity is the mother of invention however, and our A/S tactics compelled the Germans to concentrate on high submerged speed or else to fail in their U-Boat campaign. Once committed they spent enormous sums to this end.

In particular, Doctor Walter of the firm of that name at Kiel had always believed in high underwater speed and developed a promising engine cycle from 1938 onwards ; but although a successful prototype submarine of 87 tons was completed in 1940, it was not until 1943 that serious efforts were made to develop an operational version. By then it was just too late to bring these " Walter boats " into operational use before the German surrender.

From the technical aspect the Walter boat was a success, submerged speeds of about 20 knots being obtained in experimental boats. Such U-Boats would undoubtedly have proved a difficult target for our A/S ships.

Possible solutions

To attain the high submerged speeds required, the Germans tried several different methods, including :—

(i) *Conventional electrical propulsion with greatly increased battery and motor powers.*

In conjunction with a specially designed hull form (also developed by Doctor Walter) this method was used in the Type 21 U-Boats which, it was hoped, would attain submerged speeds of 17 knots. They were not very successful however, and in any case the maximum speed obtained was not up to expectations.

(ii) *Surface Diesel engines running, when submerged, on stored oxygen.*

Part of the exhaust is cooled and re-circulated to the engine inlet, with the oxygen.

Some success was obtained with this " closed cycle " but mainly for the midget U-Boats. The method was not considered attractive for very large powers and even the small units were still in the experimental stage. The method promised a greater endurance at moderate speeds than any other method considered.

(iii) *The Walter engine running on stored oxygen.*

This was the system finally decided upon. Dr. Walter favoured a turbine as the best method of developing the very high powers required and, when concentrated hydrogen peroxide became available, realised its possibilities as an oxygen carrier for his purpose. His own hull form for high submerged speeds was, of course, used in these boats.

It must be emphasized that the success of the Walter boats depended largely on overcoming the difficulties connected with production, storage, handling and decomposing concentrated hydrogen peroxide—a substance which had never before been used, or indeed been available, on a commercial scale.

The Walter U-Boat engine

Hydrogen peroxide is fed at high pressure to a catalyst chamber where it decomposes into steam and oxygen which pass to a combustion chamber. Here fuel oil is injected and burnt with the oxygen, thus further raising the temperature of the mixture.

Feed water is also sprayed in, cooling down the gases and generating more steam. The " gas " (about 83% steam, 17% CO_2) passes to a turbine where power is developed and then to a condenser. The condensate and CO_2 then pass to a separator. Here the CO_2 is discharged overboard by excess pressure and the water passes on to the feed tank. An extraction pump takes suction from this tank and discharges to a sea-water cooler outside the submarine's hull.

Water is formed in the system due to decomposition of peroxide and combustion of the fuel and the surplus is discharged overboard with the exhaust gases.

Design features

It is essential to supply the peroxide to the catalyst chamber and fuel and water to the combustion chamber, in the correct proportions. This was achieved by fluid regulators working on a flowmeter principle. A triple feed pump driven by one motor is also used to simplify speed control.

The turbine glands needed special attention to prevent CO_2 leaking into the turbine room. A gland vapour pump and associated condenser system was used to draw gas and some air from the glands, condense the steam from the gas and discharge the air and CO_2 overboard with the main exhaust gases.

Starting was effected by grouping the control valves and operating them by a cam mechanism to ensure the correct sequence. A small amount of peroxide was injected into the catalyst chamber first and passed to the combustion chamber ; fuel was then injected into the combustion chamber and ignited by a spark. Larger amounts of peroxide, fuel and water were then introduced.

The catalyst was in the form of small stones or porcelain rings impregnated with the active chemical and enclosed in stainless steel mesh.

Many problems were presented by the high temperatures employed in catalyst and combustion chambers, by the turbine blading and by the dangers involved in leaks from the peroxide storage containers and piping.

Some of these problems were only partly solved and components exposed to the highest temperatures needed frequent renewal.

Hydrogen peroxide

Since the Walter plant was based on the use of hydrogen peroxide as an oxygen carrier, some remarks on this substance are given here.

The peroxide used for submarine propulsion was 80% (approx.) solution of hydrogen peroxide (H_2O_2) in water. The Germans called it T-Stoff, Ingolin or Aurol.

It is a powerful oxidant and furthermore will decompose into steam and oxygen in the presence of dirt, rust, most metals, woollen clothing—in fact the majority of materials. Since the reaction releases sufficient heat to ignite most inflammable materials it can be realised that careful handling is required.

If allowed to heat up to a high temperature, concentrated hydrogen peroxide will explode.

Safety precautions may be summed up as measures to prevent contamination ; to keep the temperature down and to provide adequate venting of the gases generated. Large quantities of water should be available on the spot for diluting spills of peroxide and, in emergency, for diluting peroxide in storage.

Pure aluminium, stainless steel, glass and certain synthetic " rubbers " are non-catalysts and can be used for peroxide systems.

Production of concentrated hydrogen peroxide is expensive. The Germans' main plant produced about 1,200 tons per month at a cost of nearly £120 per ton.

The Walter engines used about 9 tons of peroxide for each ton of oil fuel.