THE ARCTIC SNORT PATROL OF H.M. S/M. "AMBUSH"

by

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H.M. Submarine "Ambush" left the Clyde on February 12th, 1948, to carry out a prolonged snort cruise between Jan Mayen and Bear Island. She returned to the Firth of Forth on March 18th. This was the third in a series of long snort patrols, the first having been carried out by H.M. Submarine "Taciturn" in temperate waters, and the second by H.M. Submarine "Alliance" under tropical conditions, an account of which was included in the Journal of Naval Engineering, Vol. 2, No. 3.

Objects

The objects of the patrol were :—

(i) to gain further information on the physiological problems associated with snort propulsion, in particular under conditions of cold and rough weather, and

(ii) to obtain further data on speeds, fuel consumptions, engine loading, etc., in order to deduce the most suitable and most economical methods of snorting for long periods.

The readings required to achieve the first object were taken by a medical officer, whose main consideration was the effect which vacuum fluctuations have on the ears of personnel. These fluctuations are caused by the fact that the supply of air to the engines is interrupted in rough weather by the closing and opening of the ball float valve at the top of the snort mast.

The readings required to achieve the second object, which included maximum pressure cards, exhaust temperatures, vacuums, back pressure records, fuel consumptions, spray valve running lifts, engine settings, etc., at varying speeds and electrical loads, were taken by the ship's staff.

During the patrol, both icing conditions and exceptionally rough weather

were experienced. It was therefore possible to assess the limiting effect which these factors impose on a submarine fitted with the existing snort equipment.

An Early Defect

On February 15th an attempt was made to start snorting in a position just inside the Arctic Circle and due north of the Faroe Islands. It was found to be impossible to drain the water out of the air intake trunk of the snort mast, however, because the bridge induction master valve was leaking. This valve, which is of the rubber seated, quadrant operated, flap type, is normally open on the surface. It allows air to be drawn from a splash-tight cowl in the bridge structure direct to the engine room, thus reducing the considerable draught which otherwise comes down the conning tower when running at high speed. It also allows the engines to be run when the conning tower hatch is shut in rough weather. The bridge induction and snort induction trunks marry outside the pressure hull, and the same telemotor-operated hull valve is used for both systems.

As the bridge induction master valve is situated close to the water-line, it is only possible to get at it in a flat calm weather. It was, therefore, decided to return to the Faroe Islands in order to carry out an investigation.

The cause of the trouble was found to be a stray bolt which appeared to have been in the trunking since building, had got carried down to the valve during rough weather, and was securely lodged under the valve. The bolt was removed, the section of trunking which had been moved to carry out the investigation replaced, and after a test dive, *Ambush* returned to her diving position in the Arctic.

It is interesting to note that the morale, which was very high throughout the patrol, was lowered more by thoughts of having to return due to this defect, than it was by the exceptionally heavy weather which was encountered a few days later.

The Effect of Cold and Rough Weather

Snorting was started on the 19th of February and a northerly course was maintained until Jan Mayen Island and the ice barrier were sighted. Course was then altered towards Bear Island, and pack ice and brash ice were met several times during the next few days.

A rapid fall in sea temperature below 37° F. invariably indicated approaching ice and on one occasion it dropped from 39° F. to 31° F. in less than one hour. These low temperatures did not adversely affect the running of the engines and the jacket cooling water and lubricating oil were always sufficiently warm.

Air temperatures inside the submarine while dived were not so low as had been expected and the special warm clothing which was carried was a convenience rather than a necessity. External air temperatures, however, had a considerable effect while snorting, and freezing-up took place inside the submarine while on the surface.

When the wind was blowing from a northerly direction, ice was deposited on the head of the snort mast and on the radar mast and periscopes if these were raised. The ball float-valve became completely frozen-up on several occasions. Final freezing was preceded by an erratic " build-up " of vacuum, which indicated that ice was being formed inside the valve box and restricting the air flow. It was always possible to thaw out the valve by dipping it below the surface for several minutes, but on attempting to restart snorting it froze up again in a very short time. The submarine was thus forced to dive deep until conditions improved.

Another factor which precluded snorting was rough weather. If the sea and swell were excessive it was impossible to control the submarine at periscope depth, particularly in a following sea. This also necessitated a deep dive until the weather moderated. If the duration of icing conditions or rough weather exceeded the endurance of the batteries, the submarine was forced to surface in order to re-charge.

While on the surface a considerable amount of ice formed on the superstructure. This inevitably affected the trim on diving but did not appear to cause any serious reduction of surface stability. More than ten degrees of frost was experienced in the control room and several salt water systems including the trimming pump, depth gauges, and sanitary water supply became frozen. These thawed out, however, after about half an hour dived.

Main Engines

The effect of snorting on the running of a submarine engine is too complex a subject to be fully covered in this article. The following points may, however, be of interest.

As no torsionmeters are fitted in submarines, the torque loading of the engine is limited by placing a restriction on the amount of fuel which may be burned per revolution. This quantity is usually expressed in terms of lb of fuel/hour/r.p.m. or more simply lb/revolution. The exact figure, which is determined on bench trials, gives an engine loading equivalent to the maximum allowable b.m.e.p. The power available is thus proportional to the r.p.m. A limit is also imposed on the exhaust temperature at which the engine may be run.

While snorting, the engines draw air down the induction trunk of the snort mast, and in so doing a partial vacuum is created in the submarine. In order to safeguard personnel, the maximum vacuum allowed for continuous running is six inches of mercury. The restriction to the flow of exhaust gases caused by the length and diameter of the snort mast results in the engines being run at high back pressure, sometimes as much as 8 lb/sq. in. If the sea is rough or depth-keeping is difficult, the vacuum and back pressure will fluctuate.

These factors, if considered together, form themselves into something in the nature of a vicious circle. To start with, the resistance to motion of a submarine is considerably greater while dived than when it is on the surface, because the superstructure is submerged. The power required for propulsion at a given speed is, therefore, greater and this necessitates a higher fuel consumption with resultant increase in exhaust temperature. On increasing this speed, the effect on engine loading is as follows :—

(i) More power is required, therefore more fuel must be supplied

(ii) Increased fuel consumption raises the exhaust temperature

(iii) The increase in speed results in a lower induction pressure and a higher exhaust back pressure, both of which reduce scavenging and combustion efficiency

(iv) Loss of power due to inefficient combustion has to be made up by a further increase in fuel supply, which raises the exhaust temperature still higher.

It is obvious from the above, that while snorting the limiting conditions for running the engines are approached much more rapidly than they are when the submarine is on the surface, and the available range of r.p.m. is much reduced.

Even the use of a supercharger is not an unmixed blessing because as it

increases the induction pressure, so it increases the air throughput of the engine, which in turn leads to a higher vacuum in the submarine and higher exhaust back pressure.

Other factors which increase the wear and tear on engines using snort are :—

(i) The necessity for running at high loading and low revolutions in order to re-charge batteries while propelling.

(ii) Increased carbon deposits in exhaust systems due to bad combustion and reduction of excess air.

(iii) High circulating water pressure which is made necessary because the system has to discharge against the dived sea pressure. This increases the likelihood of leaking joints in exhaust boxes and jacket cooling systems.

The proof of the pudding is in the eating, however, and the fact that no major defects were developed on *Ambush's* snort cruise shows that the existing machinery will stand up to such conditions for long periods.

Auxiliary Machinery

The behaviour of most of the auxiliary machinery is not greatly affected by snorting, one notable exception being the distilling plant.

Two distillers with electrically-heated evaporators are fitted in *A* Class submarines. Condensation is effected by a vapour compression pump. Large changes of the vacuum in the submarine, caused by starting the engines, rough weather, or bad depth-control, alter the back pressure on the vapour pump and so cause priming.

Apart from a small number of enforced stops due to defects, both distillers were run continuously during the Arctic patrol, the hours for one plant being 620 and the other 560. More than 4,000 gallons of fresh water were produced with the result that it was never necessary to ration water for any purposes.

Automatic Depth-keeping Gear

An automatic depth-keeping gear of German origin was fitted in *Ambush* to test its endurance.

The device was affectionately nicknamed " George " and, in the words of the nursery rhyme, " when he was good he was very good, but when he was naughty he was horrid."

Conclusion

So far as is known, the objects of the patrol were achieved, and a considerable amount of useful information was obtained. H.M.S. *Ambush* was fortunate in that the results of the two previous patrols were available and a repetition of some difficulties was eliminated.

Finally, no report on the cruise would be complete without reference to the food, the abundance and excellence of which were quite outstanding. It is considered that this was a most important factor in maintaining a very high morale, without which the results might well have proved to be less satisfactory.