WELCOMING ADDRESS BY FLAG OFFICER, SUBMARINES, TO PRESS REPRESENTATIVES TO BE AN INTRODUCTION TO A FULL SUBMARINE ESCAPE TRAINING COURSE.

Gentlemen,

I welcome you to Fort Blockhouse and am grateful for your attendance at this explanation of the problems both physiological and practical inherent in escape from a sunken submarine.

2. The first half of the twentieth century has seen a steady trend towards naval fighting extending with growing impetus to below and above the sea surface whilst overseas trade which is vital to our existence persists almost exclusively upon it.

3. Undoubtedly for an island power like Britain the abolition of the submarine would be much in our favour and it was advocated by Britain in the inter-war period. Since there is no probability of such international agreement it is necessary for Britain to maintain an adequate submarine force in balance with the rest of the Navy.

4. The need for Britain to possess submarines is imperative for two reasons:

Firstly, in peace to train surface forces, harbour defences Fleet Air Arm and R.A.F. Coastal Command to fight the U-Boat and to assist the Scientist in practical experiment to this end,

Secondly in war to fight the enemy, more especially off his ports and coasts where operations can only be undertaken unsupported; our submarines in war have paid a high dividend as I will show you.

5. Although submarines are very expensive to build and maintain, they have achieved a high return in war.

The manpower devoted by the Navy to submarines in peace and war remains at about 2% yet in World War II the following enemy vessels were sunk by British submarine action:-

35 U-Boats.

7 Cruisers.

17 Destroyers.

131 Minor War Vessels.

/The .....

WELCOMING ADDRESS BY FLAG OFFICER, SUBMARINES, TO PRESS REPRESENTATIVES. (Continued).

The enemy merchant tonnage sunk very nearly topped the two million ton mark. In addition a great deal of shipping was heavily damaged notably the Warships TIRPITZ, SCHARNHORST and LUTZOW and 7 cruisers.

6. This is a high score for one fiftieth of our naval forces, but I must point out that the submarine in war is only effective when used offensively; it assists in the vital role of protecting our trade as its operations reduce the enemy's naval power.

7. To take another outstanding example. The Submarine Branch of the United States Navy also comprises about 2% of their naval manpower Finding themselves opposed to a maritime power who had thoroughly neglected anti-submarine warfare and in addition had diverted the major effort of their submarine fleet to military supply of outlying island fortresses, the United States submarines made the most of it and were responsible for sinking nearly a ⅓rd of the Japanese warship casualties and nearly 2/3rds of their Merchant Marine Casualties, a total of over 5 million tons.

8. I have made this digression to explain emphatically why submarines are likely to stay and why we must have them. The advent of increasing air power and atomic weapons supports rather than conflicts with their usefulness.

9. If I have made my point that the Submarine Branch is vital to Britain I will now pass to the specific reasons why I asked the Admiralty's permission for your visit. It is because of the power of the press to conflict with or to assist our endeavours in building and maintaining an efficient submarine service, and this particular moment is an important milestone in our development.

10. You will know better than I what constitutes news, but it seems to me that a submarine disaster for certain morbid reasons may be news for weeks and I imagine that it is always likely to remain so just as long as the circumstances and cause of disaster are unknown. The inevitable result

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WELCOMING ADDRESS BY FLAG OFFICER, SUBMARINES, TO PRESS REPRESENTATIVES. (Continued).

is that the occasional submarine disaster obtains a disproportionate amount of publicity compared with the overall endeavours of the Submarine Branch and the generally happy conditions of service obtaining.

11. For the past 25 years, with the introduction of Davis Submerged Escape Apparatus, efforts towards improving the chances of escape in disaster have been vigorously pursued, not only by escape training but by two High power Admiralty Committees in 1939 and 1946 convened to report on the subject.

Concurrently the problem has been subject to continual study by the Naval Physiological Establishment at Alverstoke.

12. The story and conclusions of this research is in itself an interesting study. Unfortunately it shows clearly that there are certain definite and very restricted limits to chances of survival. As a broad illustration, should men be entrapped at a depth equivalent only to the length of a submarine and if conditions are ideal both for escape and rescue reception on the surface, their chance of survival is no better than even.

13. Another point I wish to emphasise is that Britain has had on an average 50 submarines in commission in peacetime for the past 29 years of peace since 1920. In this period there have been 10 submarine disasters.

14. In view of this figure of 50 in commission for 20 years the losses have not been unexpectedly heavy. The submarine is extremely vulnerable to collision or errors in drill and the causes of mishap have been:-

Collision on surface	3 (H.47, POSEIDON, TRUCULENT)
Collision with surface vessel with submarine at periscope depth.	3 (H.42, L.24, M.1).

/Failure ....

WELCOMING ADDRESS BY FLAG OFFICER SUBMARINES, TO PRESS REPRESENTATIVES. (Continued).

Failure of either drill or material or a combination of both. 4 (K.5., M.2., THETIS, AFFRAY).

15. Although escapes were made in 3 cases (POSEIDON, THETIS and TRUCULENT) with and without the aid of Davis Escape Apparatus, these survivors were disappointingly few. There is good reason to suppose that in the case of THETIS where 4 men escaped out of a total of 103 many more escapes could have been made had there been more confidence amongst personnel in the potentialities of escape equipment.

16. In the case of TRUCULENT, 64 men, that is all who had a chance to escape, did in fact leave the submarine, they died subsequently due to exposure and weather conditions.

17. I wish here to emphasise that 10 misfortunes in 29 years with some 50 submarines in commission shows that the man's career is a reasonably safe one; the point is that when an accident occurs involving the pressure hull being holed and buoyancy being lost the chances of escape are slender except in shallow water.

18. I wish to give you the whole picture as accurately as I can so we must examine the case more closely. The adverse point is that when an accident does occur and the submarine is sunk the chances of survival have proved no better than one in ten. It is this chance of survival that

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WELCOMING ADDRESS BY FLAG OFFICER, SUBMARINES, TO PRESS REPRESENTATIVES. (Continued).

it has been the Admiralty's particular aim to improve both in peace and in war.

19. When a disaster occurs the Admiralty and this Headquarters in particular are inundated with ideas suggestions and inventions to make submarines safer. Some of them are practicable but what is invariably ignored is the fact that a submarine is primarily a weapon of war and that it is NOT practicable to make it 100% safe. It therefore seems to me logical to invite the press here, show and tell the Press everything to do with escape and hope that interest and full knowledge may remove any misunderstandings. The addition of escape equipment to a submarine is bound to detract from its capabilities as a war vessel, either by taking up room that would otherwise be used for military equipment or by making the overall size of the submarine greater. It must be remembered that we have lost over 100 submarines in 10 years of war and only 10 submarines in the years of peace since 1920. The main protection against disaster in war is that the submarine should have good military characteristics. By detracting from these to provide escape gear which I have shown is not even always useable in a peacetime accident, it likely to increase casualties in war. The chances of most types of escape gear being of use in war are more slender than in peace time and although some provision equivalent to the airman's parachute must be provided, a most careful balance must be struck between escape gear and military characteristics.

20. The lectures and demonstrations which you will be given are not Confidential, they are for you to use if and when you think fit, if any subject is raised that is "off the record" you will be told so.

21. You will hear of the physiological problems and learn that the Ruck Keene Committee in 1946 noted that in analysing all successful

/escapes ....

WELCOMING ADDRESS BY FLAG OFFICER, SUBMARINES, TO PRESS REPRESENTATIVE.
(Contined).

escapes it was found that more had been made without D.S.E.A. than with it.

22. You will hear of research into this interesting fact and the new techniques developed. You will study the very real difficulties of actual escape in darkness and cold water. The problems that face men whilst in the submarine, in getting out of it and on arrival at the surface. It might be noted here that salvage is not attempted as a means of rescue as the time required in preparing for and carrying out a major salvage operation of this nature would preclude any chances of the survival of entrapped persons.

23. You will understand why I have chosen this particular time to invite you. It is because escape training in the new 100 feet tower is now underway. This is the latest effort to minimise fatalities. Whilst studying the problem, however, please bear in mind that, although a considerable advance, the 100 foot tower is not going to prevent submarine accidents in the future or ensure that everyone escapes. Provided that there are survivors after an accident, it will under certain conditions give them a better chance.

Gentlemen,

The first British submarine accident occurred just over fifty years ago in March 1904 when A1 was rammed while submerged by the S.S. "Berwick Castle" off the Nab and sank with the loss of all hands. Between this date and the beginning of the first World War a further five accidents occurred. Two of these accidents were caused by the submarine being run down by a ship while submerged; two collided with ships while on the surface and were holed and sank, and two were what might be called "submarine" accidents in which some failure of men or material let in the sea. All subsequent submarine accidents have also been attributable to one of these three causes. In all six of these pre-World War I accidents practically the whole crew were drowned instantly, the only survivors being those who floated off before the submarine sank.

Salvage was practicable with such small vessels and indeed four out of the six submarines were salved in periods varying from 4 days to five weeks. After the loss of "A.1", therefore, the official escape policy was to try and salvage the submarine and save the crew. In no case was anybody saved by salvage, and, indeed the chance of saving anyone was remote, as the submarines had no bulkheads and were generally flooded throughout as soon as the accident occurred. The most important contributions to submarine safety lay in the material and other lessons learnt which made accidents in the future less likely. For instance after "A.1", a lower hatch was fitted at the bottom of the conning tower. In a subsequent similar collision in which "A.9" was involved, the submarine was undoubtedly saved by this modification. This lesson has not been lost sight of and all present day submarines have a lower conning tower hatch and whenever any valve or service passes through the hull, its integrity is always ensured by a valve. A no less important contribution to submarine safety was the knowledge that the only hope of survival was not to have an accident. The submarine service thus built up its reputation for meticlous care in everything to do with the operation of a submarine and for the methodical checking and maintenance of all equipment. Such a tradition is likely to save far more lives than any number of interlocks and escape equipment.

In 1912 or thereabouts, the first practical steps to save life after a submarine disaster was taken in the design of the "E" Class. Her bulkheads were fitted for the first time to divide the submarine into several watertight compartments. After an accident only one compartment was expected to be flooded and it was hoped that some survivors would still be alive in the unflooded compartments. There would then be some point in attempting to salvage them to save them. Two years later, in 1914, the first ideas that it might be possible for survivors to make an escape from a submarine as opposed to the submarine being salved to save them took practical form in the issue of the Hall Rees apparatus. This was a bulky self-contained breathing set, with a helmet the size of a diver's suit. Only one was carried in each submarine and it was to be used to escape from the conning tower. This apparatus was landed after two years as being too cumbersome and complicated and dangerous to use. It is of interest however as it was the ancestor of the Davis Submarine Escape Apparatus.

Bulkheads saved their first man in August, 1916, when "E.4" and "E.41" collided during exercises and both sank. In "E.41" most of the crew escaped up the conning tower before she sank but a Stoker Petty Officer Brown was trapped in the engine room. He had no escape gear and his main problem was to get the hatch open and hope to float to the surface. It is not perhaps generally appreciated that even at the shallow depth of 30 feet at which "E.41" lay, the sea pressure exerts a force of some seven tons on a hatch holding it tight shut. There is never the remotest possibility of opening it by brute strength. The only way is to let the sea into the compartment and flood it up so that the pressure is the same on both sides of the hatch. It can then be opened quite easily. Stoker Petty Officer Brown did this and succeeded in opening the hatch. Every time he did so however, a bubble of air went out, the pressure in the compartment dropped and the hatch slammed down again, on one occasion on his hand. He then had to flood up again to balance the pressure. After the third try the compartment was completely flooded but the hatch stayed open and, by taking a deep breath, he floated to the surface. This was the first escape in the Royal Navy from a submerged submarine. It was only from 30 feet or so but nevertheless was a landmark.

Five months later "K.13", on trials in the Gareloch, dived with an engine induction valve open. 29 men in the after part of the submarine were drowned at once, but 48 in the forward compartments were saved by the bulkheads. Two men in the after compartments who attempted to emulate Stoker P.O. Brown were drowned. Two officers attempted to reach the surface through the conning tower to summon help, one was drowned but the other succeeded in getting the hatch open and ascending in a bubble of air. In the sheltered waters of the Gareloch in a depth of only 38 feet divers were able to connect an air supply through an ammunition hoist to keep the survivors alive. The whole resources of the Clyde were then applied to salvage and after two days, one end of "K.13" was raised to the surface and 46 men were rescued.

Salvage as a method of submarine rescue therefore gained immensely in prestige, and after the war it remained the primary method of rescuing survivors from a submarine accident. In the six years immediately following World War I, there were four submarine accidents. In none of these four accidents was salvage effective, in two cases because the water was far too deep for salavge even to be attempted and in the others because the whole crew were drowned at once after a collision. In any case, all four submarines were sunk in water deep enough to collapse the bulkheads. In these four accidents from which there was not a single survivor, collision while submerged was responsible for three of them (H.42, L.24. M.1) and the fourth was a submarine accident (K.5).

Although the salvage policy was singularly ineffective in saving anyone, it is true to say that it is unlikely that there would have been any survivors even if Davis Submarine Escape Apparatus had been fitted. However, after the M.1 disaster in 1925, much attention was given to methods of individual escape as an alternative to salvage. The U.S. had already produced the Momsen Lung for this purpose and the Germans had had the Draeger gear as early as World War I. There was always the possibility of reviving the old Hall Rees gear.

At the ame time efforts were redoubled to try and make salvage effective and, taking a lesson from "K.13", it was directed to raising one end of a submarine and providing air connections to keep the crew alive while this was being done. All ideas of salvage in water deeper than 20 fathoms at which the bulkheads would go was given up.

In 1929 trials were carried out with various types of breathing apparatus and the Davis Submarine Esaope Apparatus was adjudged to be far superior to the other competitors and so it was decided to adopt it and issue it to submarines. Trials to find the best way to open the submarine hatch in order to escape were also instituted. In 1930 the installation of the D.S.E.A. on a scale of one per man to all submarines was begun.

In this interim period three more accidents occurred, "H.47", POSEIDON and "M.2". Two collisions on the surface and one submarine accident. Two of these accidents had a very decided influence on escape policy.

POSEIDON collided while on the surface, with the Chinese steamer "Yuta" on 9th June, 1931 and sank in about 20 fathoms. 27 men escaped by the conning tower before she sank but twenty-six men were trapped in the submarine. Eight of these in the fore ends were saved by the bulkheads, but 18 in the after ends were drowned.

POSEIDON was however the first submarine accident in which men escaped using D.S.E.A. and it was concluded that it was perfectly efficient if used correctly. The need for better training was obvious and D.S.E.A. training tanks were ordered to be built at Malta and Hong Kong as well as that already existing at Fort Blockhouse. To reduce the chance of "Bends" it was necessary to make provision to flood up more rapidly so that the men would be under pressure in the submarine for a shorter time before escaping. Special flood valves were therefore fitted to submarines. It was clear that the arrangements for opening the hatch were most unsatisfactory and it was decided to fit twill trunks and special escape hatches. You will see the twill trunk in operation in the demonstration. The twill trunk has the effect of making it possible to equalize the pressure and open the hatch without a large bubble going out, letting it slam down again. Men can stand with their heads in air while waiting to escape and can then dip under the twill trunk and escape through the hatch. As one man in the fore ends of POSEIDON had had no D.S.E.A. set, the scale of issue was increased to $1\frac{1}{3}$ times the crew, dispersed throughout the submarine.

"M.2" sank while carrying out submerged exercises in West Bay. The exact cause of loss is unknown but she was equipped to carry a small sea-plane and is believed to have flooded through the hangar door. "M.2" was fitted with D.S.E.A. but no escapes were made. The submarine was not found for some days. Obviously it is essential to be able to find a lost submarine as quickly as possible and so indicator buoys, one at each end, were fitted to all submarines. These buoys could be released by the crew to mark the submarine's position.

Salvage operations were put in hand on "M.2" mainly with the object of finding out what had gone wrong. After ten months of hard work the stern was raised above the surface. It slipped back almost at once and salvage was then abandoned.

It was therefore abundantly clear from the lessons of "M.2" that salvage for the purpose of saving lives was hopeless and the POSEIDON accident showed that individual escape by D.S.E.A. gave a far better chance. In 1932/33 the whole business of submarine escape was most carefully reconsidered and salvage as a method of rescue was finally abandoned. D.S.E.A. was now to be relied on entirely to save life after an accident and as I have already indicated, measures were taken to improve its chances of success as a result of experience gained in POSEIDON.

For new construction submarines it was decided to strengthen the bulkheads to make escape possible down to 200 feet or so and to fit two-man escape chambers at each end of the submarine which were considered to give a better chance of escape than the twill trunk. In the two-man escape chamber men could escape in pairs with a very short flooding time and would not be subjected to pressure and flooding until their turn came to escape.

In the early thirties, then, salvage was finally abandoned as a method of escape and all submarines were fitted with D.S.E.A. on a scale of $1\frac{1}{3}$ times the size of the crew. A twill trunk escape hatch was fitted at each end, as were indicator buoys. That has been, with many improvements, the escape equipment in use in our submarines right up to the present day.

On 3rd January, 1939, the THETIS sank on trials after flooding through a torpedo tube in Liverpool Bay. The THETIS had a two-man escape chamber at each end of the submarine and no twill trunks. The two forward compartments were flooded, but the whole of the crew and passengers numbering 103 escaped immediate drowning and retreated into the after compartments. It had been laid down that escapes should not be started until it was known that ships were there to pick up survivors. The THETIS was not found and therefore no ships arrived for 17 hours and during this time the survivors did their best to surface the submarine. Eventually they succeeded in bringing the stern above water. By this time with the large number of men on board and the hard work they had been doing, the air was very foul. As an example one officer stated that by the time he had climbed up the steep incline to the stern of the submarine he was so exhausted that he had to rest for 10 - 15 minutes before he had the energy to put on a D.S.E.A. set. Two men then escaped without difficulty from the after escape chamber using D.S.E.A. It must have appeared now to the survivors that unless they got a move on they would die first, so they made the fatal mistake of trying to get <u>four</u> men into the two-man chamber. After a quarter of an hour, three were dead and one nearly so. The discouraging effect of this accident can be imagined. However two more men escaped with D.S.E.A. but no-one else ever came out and the stern sank again shortly afterwards.

There is little doubt that the rest of the crew succumbed to C.O.2. poisoning and died. From this it was obvious that in future, escapes must begin much sooner and on no account should matters be left so late. This drew attention to the great importance of finding the submarine quickly so that escapes could start. The THETIS disaster shook everyone's confidence in the D.S.E.A. Here was a submarine sunk in only 150 feet of water and fitted with the latest two-man escape chambers but from which there were fewer survivors than in the POSEIDON eight years before. Furthermore, the appearance of the stern above water made the Admiralty wonder whether they had been right to abandon salavge. The Admiralty therefore appointed a high-power committee under Admiral Nasmith to review the whole question of submarine escape and whether we had been right to abandon any idea of salvage.

The Nasmith Committee confirmed that salvage was rightly abandoned and that, had the crew really understood the physiology of escape they should all have been saved without difficulty; it was the delay that had been fatal.

The Nasmith Committee therefore stressed the need for more training and recommended the construction of a 100 foot training tank. They also recommended that the two-man escape chamber should be abandoned and that the twill trunk should be fitted in all future submarines. They admitted that the two-man escape chamber gave a better chance of escape under certain conditions but considered that it was too complicated and took too long to get the whole crew out. The twill trunk method on the other hand was simple and the men were under leadership for much longer. The Nasmith Committee also set in train a very important series of physiological experiments; a Sub-Committee being appointed for this purpose.

Their first discovery was that C.O.2 poisoning set in much sooner under pressure. A concentration of C.O.2 that was just permissible at atmospheric pressure was likely to be leathal when the air was compressed ready to escape. This emphasized the need for still faster flooding and the Nasmith Committee advocated releasing any compressed air left in the submarine while flooding up, to speed up the process and freshen the air. The need to escape early was made more important than ever by these experiments as the atmosphere in a submarine after ten hours dived was found to be sufficiently foul to be lethal on flooding in 150 feet. Most of the recommendations of the Nasmith Committee were implemented although World War II had started and effort was concentrated on winning the war.

During World War II more valuable physiological experiment was carried out, much of it being required for operational use in X-Craft and Chariots. It revealed not only the C.O.2 poisoning effect already mentioned, but that the risk of oxygen poisoning was very much greater than had at first been believed. Oxygen poisoning varies enormously between individuals, but it may set in after 5 minutes breathing oxygen under pressure at 100 feet, and in any case for the average man is about 20 minutes at 100 feet. The wearing of D.S.E.A. while flooding up to try and avoid C.O.2 poisoning and the "Bends" is likely therefore to lead to oxygen poisoning and so push escapes out of the frying pan into the fire.

During World War II, among the 77 submarines lost in all, were four that could be classified as accidents. In 1940 the UNITY was lost after colliding with a merchant vessel in a fog while on the surface. Most of the crew escaped before she sank, but two were carried down with her and two were drowned before they could be rescued. In 1941 the UMPIRE was also lost after collision on the surface. Some escaped before the submarine sank but 21 were taken down inside the unflooded compartments. All 21 made successful escapes from the twill trunk or the conning tower with only 14 D.S.E.A. sets between them - of these, six were subequently drowned before they were picked up.

Early in 1943, the VANDAL disappeared while on independent exercises in Inchmarnock water with all hands. The cause of this loss is unknown and the wreck has never been found.

A few months later the UNTAMED sank while exercising submerged off Campbeltown due to flooding through the patent log sluice which had been dismantled in error to effect repairs. The whole crew retreated to the engine room and shut the watertight door. They prepared to escape by twill trunk to flood the engine room. Unfortunately the flood valve was defective and so thay had to flood through the engines. Valves were, however, open to the after compartment as well which slowed up the rate of flooding still further and this, coupled with the depth of 153 feet killed the whole crew by C.O.2 poisoning b fore they could escape, confirming the physiological predictions of the Nasmith Committee.

At the end of the war, the Admiralty appointed another committee under Rear Admiral Ruck Keene to enquire anew into the whole question of submarine escape and rescue. This committee interviewed a considerable number of men of various nationalities who had escaped from submarines during World War II. Their findings were of the greatest importance and were: -

(a) That the main hazard is not the ascent from the sunken submarine, but the period inside the submarine before escaping, especially during flooding up. Three quarters of the casualties in an accident occur during this time.

(b) That as many men escaped during the war making "free ascents" without any apparatus at all as with any form of breathing apparatus.

They, in their turn recommended that twill trunks should be abolished and that a special one-man escape chamber be used instead and that "free ascent" should replace ascent by D.S.E.A. Free ascent will be demonstrated to you in the tank shortly and I will merely remark that, provided you take a deep breath before leaving the submarine, it will last you all the way up to the surface. To ensure that you do go up to the surface a life-jacket is worn. Indeed, the volume of air in your lungs at 100 feet is three times or so what it is on the surface, all the way up it is therefore essential to breathe out hard to get rid of the surplus. Free ascent is far simpler than any kind of breathing apparatus and training has now started in earnest. You will be able to interview both instructors and trainees if you wish.

The One-Man Escape Chamber is also installed in the 100 foot tank and you will see it shortly The theory is that it is possible to flood it up very quickly with purified air and so give the best chance of survival against bends or C.O.2 poisoning without introducing the danger of oxygen poisoning. To overcome the objection to the "Thetis" type of chamber it is operated from inside the submarine and the escaper has nothing to do except breathe out when the hatch opens (which it does by sea-pressure). In the last resort, the escaper can be pushed out with a piston. The One-Man Escape Chamber gives a better chance of escape than any other method of individual escape. It is hoped that it will be satisfactory down to 300 feet but the chance of survival at this depth is probably no better than even. The One-Man Escape Chamber is now proved as far as possible in the tank and a second One-Man Escape Chamber is now being fitted in H.M.S. SOLENT in Portsmouth Dockyard for further trials at sea. All new construction submarines will have one at each end.

In 1949 F.O.S/M pointed out that, as no individual escapes even with the One-Man Escape Chamber would be effective over 300 feet, there was a strong case to adopt the U.S. Rescue Bell, and to strengthen new construction bulkheads up to the same strength as the pressure hull. Escapes would then be possible down to the full diving depth of the submarine.

A U.S. Rescue Bell was therfore obtained from the U.S.N. under the Mutual Defence Aid Pact and trials have demonstrated it to be suitable for use in British waters where tides and weather are formidable. The ocean salvage vessel KINGSALVOR has been altered to take the bell and the complicated gear that is necessary for mooring over a sunken submarine in deep water and has been renamed KINGFISHER. The final trials are about to begin in the Clyde.

Since the Ruck Keene Report there have been two more submarine disasters and a careful review of escape measures by F.O.S/M. and the Admiralty.

The loss of TRUCULENT on 12th January, 1950, in collision with the S.S. DVINA, trapped some fifty to sixty men in the engine room. No doubt remembering the THETIS the decision was made to escape at once and both the after ends and the engine room were flooded up and evryone escaped by the twill trunk method, half using D.S.E.A. and half with no sets. Only ten men were, however, rescued and the rest were swept out to sea by the strong ebb tide and drowned. Thus is demonstrated the great difficulty of issuing instructions which are simple and yet applicable to all occasions. The TRUCULENT disaster confirmed that in shallow water (68 feet) and with the air fresh, the twill trunk escape, with or without the Davis Submarine Escape Apparatus, is quite efficient. It also showed the need for 100% escape gear at each end as it is quite possible for the whole crew to retreat to one end or the other. It drew attention to the need to provide some measures to keep men alive in the water after they have escaped. Some of the TRUCULENT survivors probably drowned because because they had no D.S.E.A. set to act as a lifebelt, but others undoubtedly died of exposure. Immersion suits to keep men alive in the water are now in service in all submarines and you will see them in the demonstration.

Very little is known about how AFFRAY was lost, but the indications are that the crew were overcome very quickly. No indicator buoys were released and it is clear that no attempt was made to escape. The loss of AFFRAY did, however, draw attention again to the problem of finding a submarine after an accident. Although it would not have helped AFFRAY, indicator buoys are now of an improved pattern and have flashing lights and an indicator buoy with a wireless set with which to summon assistance is now undergoing trial.

The Ruck Keene committee recommended a mixture breathing set to replace the D.S.E.A. in existing submarines for use with twill trunks during the flooding-up period, as existing submarines have no room for the One Man Escape Chamber. This would protect the survivors against C.O.2 poisoning while flooding-up with much less chance of giving them oxygen poisoning than when breathing the pure oxygen in the D.S.E.A. or giving them the "bends" if an apparatus using fresh ordinary air were to be used. Such a set, the Submarine Escape Breathing Apparatus (which you will be shown) has been developed. It has, however, been found impossible to stow 100% of these sets at each end of the submarine, and so a new system known as the Built In Breathing System has been designed instead. You will also be shown this in the demonstration. It consists of large bottles of "mixture" gas (40% oxygen 60% nitrogen) built into the submarine and a tube and mouthpiece for each man at each end of the submarine. The men will breathe from this system while flooding-up, the time of which has been still further cut down by extra flood valves, and then make a "free ascent" through hatches fitted with twill trunks.

The Built In Breathing System has passed tests in the 100 foot tank and is now fitted for sea trials in H.M.S. SLEUTH. Other submarines are being fitted as they come in hand for refit. They will, however, retain D.S.E.A. until the Built In Breathing System has passed its final tests in H.M.S. SLEUTH.

To summarise, therefore, the policy for escape gear in New Construction submarines is to fit strong bulkheads to stand the full diving pressure of the submarine and to fit them to take the rescue bell at either end. They will also be fitted with air supply and exhaust connections at both ends to enable the air to be refreshed while the rescue bell is arriving and in case operations have to be suspended due to the weather. This will give a chance to escape down to the full diving depth of the submarine. It will, however, only be of use in peacetime.

They will also be fitted with a One Man Escape Chamber at each end of the submarine which will enable escapes to be made down to 300 feet without outside assistance. As I have said before, however, a considerable proportion of casualties are likely at this depth. Once the One-Man Escape Chamber has been accepted for service, only Immersion Suits will be carried and there will be no need for the Built In Breathing System, the Submarine Escape Breathing Apparatus or the Davis Submarine Escape Apparatus.

They will also be fitted with radio indicator buoys, underwater telephones and underwater signal ejectors for firing smoke candles from each end of the submarine, and many other devices, <u>all</u> duplicated at each end of the submarine.

In existing submarines it has been decided that the fitting of the rescue bell is not justified as the bulkheads will not stand much more than 200 feet at which depth individual escape is practicable and should be successful. Twill trunks, but with more rapid flood valves and the Built In Breathing System, will be used by "free ascent" in immersion suits. Once the Built In Breathing System is accepted for service the Davis Submarine Escape Apparatus will be landed. Underwater telephones, radio indicator buoys etc. will be fitted.

Well, Gentlemen, you will see that very substantial changes are about to take place in Submarine Escape Policy and much new equipment and methods are about to come into service. The price in complexity and weight in the submarine is very large and the inroads into the military characteristics are serious. However the One-Man Escape Chamber and the Built In Breathing System will also be of use in war, unfortunately the Rescue Bell, except during trials etc., will not.

Before closing this lecture I would like to add a note of warning. No submarine accident, as I hope this lecture has shown, is like the last and it is extremely difficult to forsee every contingency. A submarine equipped with these new systems may well be flooded throughout when the accident occurrs or be in deep water where no escape equipment will avail. The best escape policy for submarines in the future is still the same as fifty years ago - good drill, good maintenance and attention to sound submarine practice.