ESCAPE AND RESCUE FROM ROYAL NAVY SUBMARINES

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ABSTRACT

All Royal Navy submarines are fitted with systems which, after an accident that prevents the disabled submarine from surfacing, can be used by the survivors either to escape to the surface or, if circumstances permit, to remain in the submarine and await rescue by a submersible. This paper explains the philosophy underlying this policy, quantifies the risk to the submarines, and describes the escape and rescue system now in service. The physiological factors which constrain the design of the escape and rescue system are discussed. Also described are recent developments in indicator buoys, submarine decompression equipment, emergency life support systems and escape/survival suits, as well as research to identify ways to overcome the limitations of the system. Finally, the paper summarizes the R.N.'s escape and rescue organization which manages the complex task of coordinating the naval personnel, the civilian engineers, the scientists and the materials required to locate the disabled submarine and to deliver the survivors safely to shore.

Introduction

The probability of a submarine sinking in peacetime is extremely low, and, despite the increased demands for better operational performance, the world rate for accidental sinkings is less than 0.001 per submarine year, with collision between the submarine and surface ship being a significant element of the risk[1]. This low accident rate reflects the soundness of modern submarine design, combined with high standards of maintenance, and good operating and training procedures. However, total safety cannot be guaranteed and in the event of a submarine sinking it is R.N. policy to provide two methods to enable the survivors to evacuate the disabled submarine (DISSUB) safely: rescue, or escape. Rescue is the method by which the survivors are transferred from the DISSUB to the surface, or to a mother ship or submarine, by a rescue submersible. Escape is defined as any method by which a survivor leaves a DISSUB and makes his own way to the surface without direct assistance from external agencies. Rescue was developed in the U.S. as a consequence of the *Thresher* incident in 1963, whilst escape was extensively developed primarily in the U.K. during the 1950s and 1960s. Tabb[2] and Wilson[3] provide details of the historical and technical features that contribute to the present systems for escape and rescue.

The risks to a submarine are many, and to enable the escape and rescue policy to be aligned with the perceived risk, a major review is undertaken every 10 years by the Submarine Escape and Rescue Policy Review Committee (SEPRC). The last review reported in 1982 and examined the resources devoted to escape and to rescue, considering them against such factors as operating patterns, submarine design trends, developments in physiological research and survival medicine, and alertment and communication facilities. An important consideration of the SEPRC was whether escape, or rescue, alone could provide the required level of insurance at a reduced overall cost.

FIG. 1 shows that the European 180 m. continental shelf is extensive and encompasses those areas where the risk of a collision accident between a submarine and a surface ship is high due to traffic density. A significant proportion of submarine operating time is spent in these waters. Superimpose on this the increased risk whilst submarines are on trials, or undergoing work up, and the SEPRC concluded that the most likely accident is a collision in which the submarine is on the surface, or at periscope depth, and sinks in water with a depth of 180 m or less from which escape is possible. The proximity of the 600 m contour to the 180 m contour shows the rapidity with which depth increases beyond the continental shelf, until it becomes greater than the hull collapse depth of all submarines except specialized submersibles, and rescue is the only option until hull collapse depth is reached. The SEPRC report concluded that rescue was the preferred method for saving life, but that escape remained the more likely, so the capability must be retained. It recommended that future developments should be directed towards increasing the probability of survival of personnel awaiting rescue.

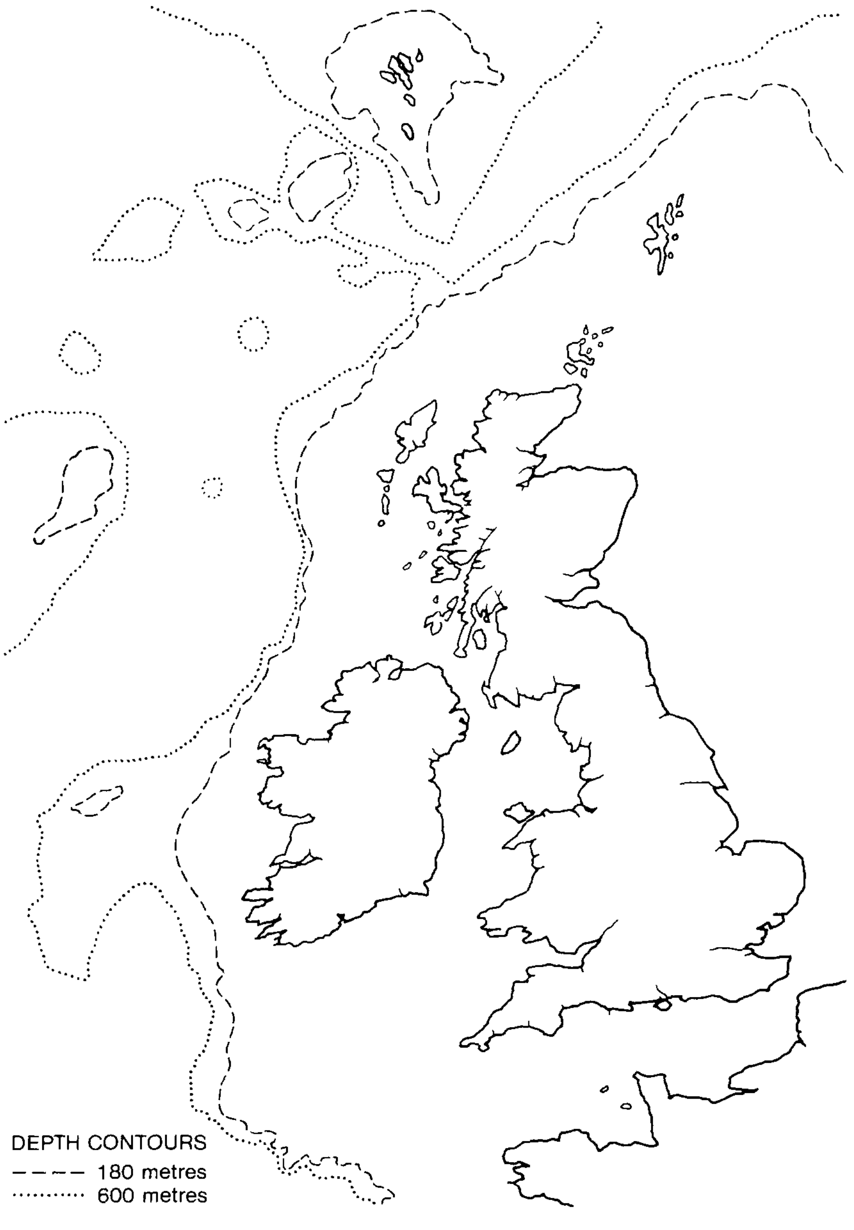

FIG. 1—THE EUROPEAN CONTINENTAL SHELF, SHOWING THE 180 M AND 600 M DEPTH CONTOURS

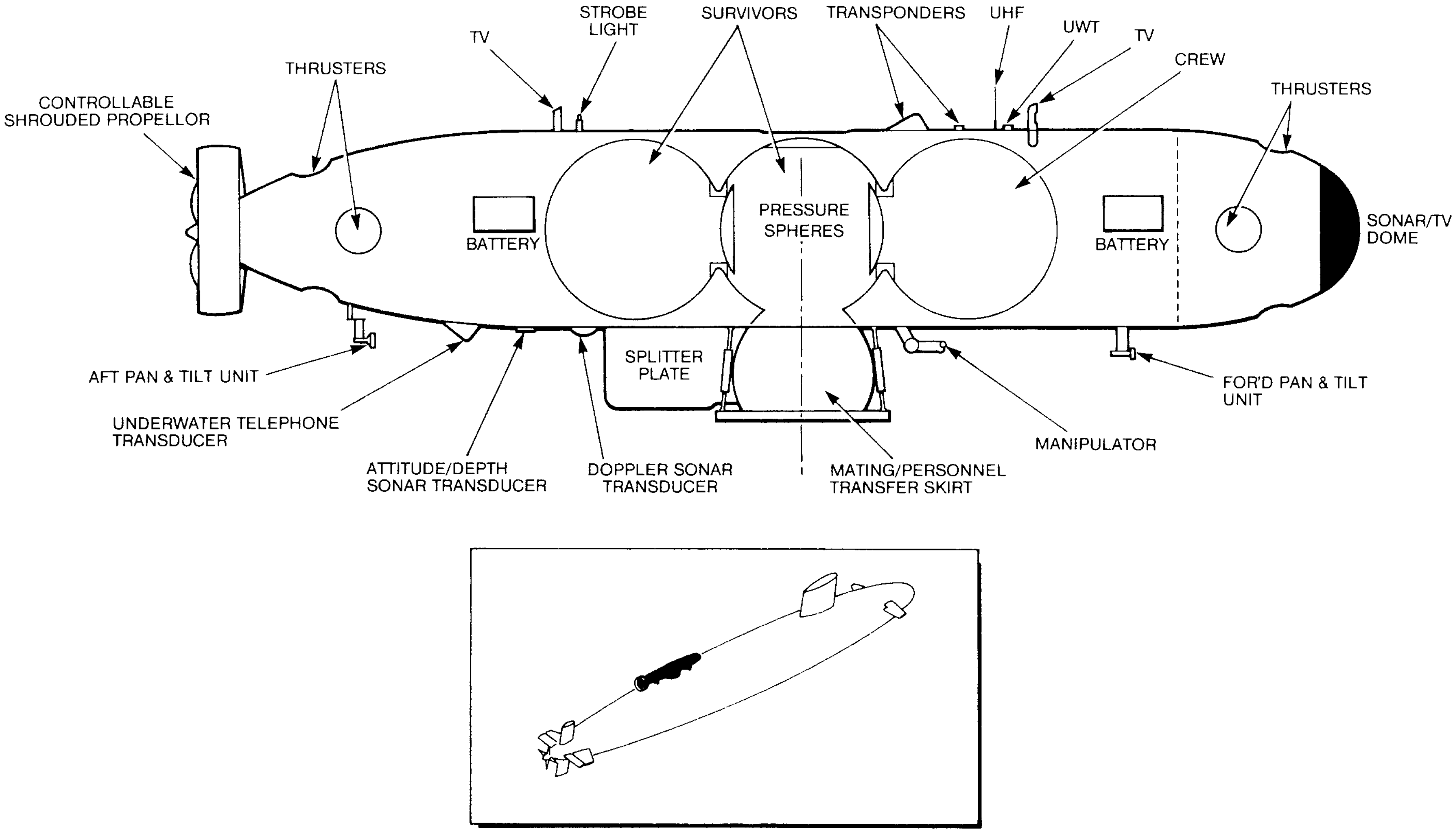

FIG. 2—THE DEEP SUBMERGENCE RESCUE VEHICLE (DSRV); INSET, THE DSRV MATED ON TO THE MOTHER SUBMARINE (MOSUB)

Rescue

Rescue involves mating a submersible onto a DISSUB escape tower hatch so that the survivors can transfer into the submersible and then be transported dry to the submersible's mother submarine (MOSUB), or to a surface ship. At all depths rescue involves minimum risk to the survivors and is the only way to recover those survivors trapped in a DISSUB between the maximum escape depth (180 m) and hull collapse depth, or at depths less than 180 m where internal pressure in the DISSUB is too high to allow safe escape. Under a Memorandum of Understanding between the U.K. and U.S.A. the R.N. can call on the services of the U.S.N. Deep Submergence Rescue Vehicle (DSRV), which has been specifically designed to rescue survivors from a DISSUB (FIG. 2). The DSRV is carried to within 200 m of the scene of the DISSUB mated to the after escape tower of an R.N. missile submarine (SSBN) MOSUB. On arrival, the DSRV detaches from the MOSUB, and transits to and mates with the DISSUB escape tower hatch. 24 survivors then transfer from the DISSUB into DSRV and are shuttled back to the MOSUB where they are disembarked into the after escape compartment, unless they require decompression in which case they are transferred into the forward escape compartment. The DSRV then continues the rescue until it has to return to the MOSUB for battery charging. When all survivors have been rescued the DSRV remates with the MOSUB which then heads for port, continuing to decompress the last wave of survivors, if necessary whilst underway. All R.N. submarines now have a DSRV—compatible rescue system on both forward and after escape compartments. FIG. 3 shows a DSRV rescue scenario.

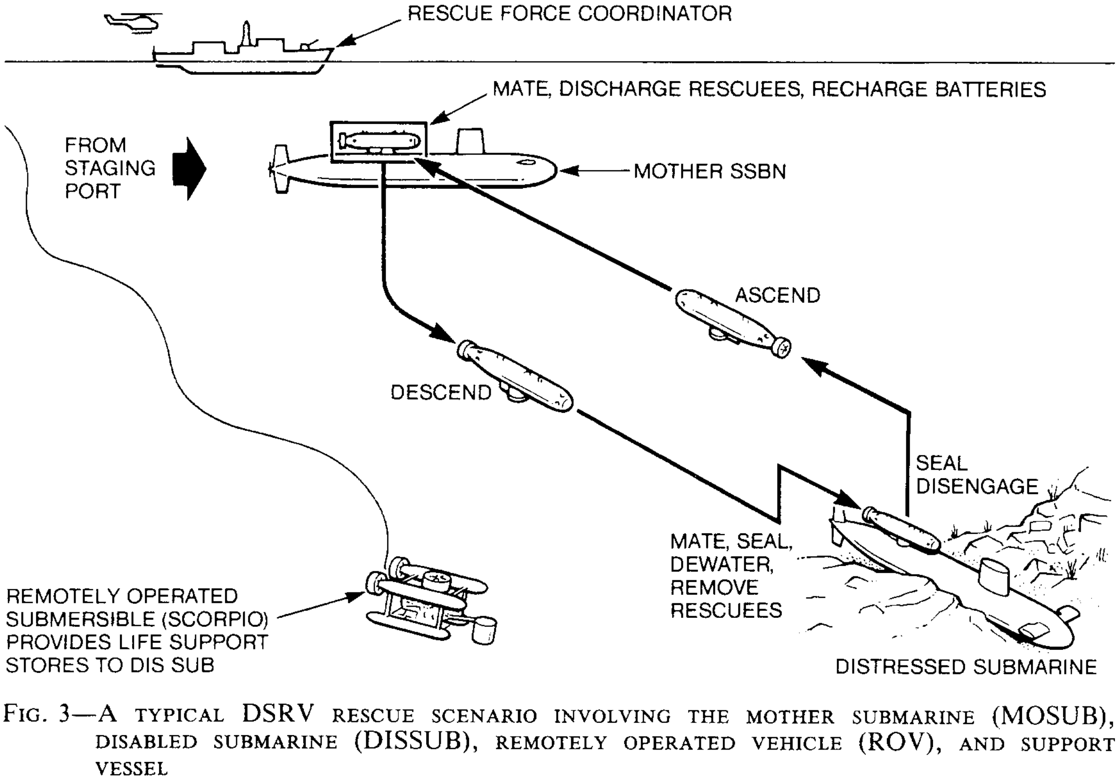

FIG. 3—A TYPICAL DSRV RESCUE SCENARIO INVOLVING THE MOTHER SUBMARINE (MOSUB), DISABLED SUBMARINE (DISSUB), REMOTELY OPERATED VEHICLE (ROV), AND SUPPORT VESSEL

The DSRV is based in San Diego, and is required to be embarked on the MOSUB and ready for passage within 48 hours. During the time from initial call-out to arrival at the DISSUB which may be four days, it is necessary to ensure that conditions in the DISSUB do not force the survivors into an escape situation. The body can tolerate only small variations in the partial pressures of oxygen and carbon dioxide, so even minor changes in the atmospheric conditions may affect the survivors' choice to await rescue, or to escape. The atmospheric conditions are therefore monitored and controlled by the use of chlorate candles to generate oxygen, and soda lime canisters to remove carbon dioxide. More reliable and rugged gas monitoring instruments are required. Work is in hand to develop oxygen generation and carbon dioxide removal equipment. Additional supplies of emergency life support stores (ELSS) can be provided by using pressure-tight pods carried to the DISSUB and 'posted' into the escape tower by divers, remotely operated vehicle (ROV), or manned submersible. In order to control ambient pressure in the DISSUB, a decompression system is under development to allow the controlled depressurization of an escape compartment at depths down to 180 m. The DSRV is not the only rescue submersible available to the R.N. A U.K. 9-man LR5 submersible is maintained at notice for instant call-out. LR5 can be transported to the accident zone using H.M.S. *Challenger*, British Telecom's Cable Ship *Alert*, or an RMAS vessel of the R.M.A.S. SALMOOR Class.

The first exercise of a U.S.N. DSRV with an R.N. MOSUB took place in 1979 in Scotland. From call-out in San Diego to sailing on H.M.S. *Repulse* took 47 hours; now that the system has been tested, that time would probably be reduced in an emergency. A continuous series of exchanges and exercises has since been undertaken to refine the procedures.

Physiology of Rescue

If the DISSUB is pressurized above 1 bar, some form of controlled decompression will be required to return the survivors to the surface conditions. The maximum DISSUB pressure from which rescue is feasible is 5 bar, because this is the maximum working pressure of the DSRV, and approaching the limits within which survival is expected. However, the forward end decompression compartment of an R.N. MOSUB can operate at pressures only up to 2 bar, so there is a need to understand the limits of safe decompression from 5 bar to 2 bar, and subsequently to 1 bar.

Research at the Admiralty Research Establishment has concentrated so far on two particular operational problems; determining the maximum pressure from which it is safe to decompress survivors rapidly to 1 bar; and determining the maximum pressure from which it is safe to decompress rapidly to 2 bar. FIG. 4 shows the form of decompression profiles used in these studies, and FIG. 5 gives a summary of results of these and other unpublished studies carried out in the U.S.A. and France. Further experiments are planned for 1989. The role of hyperoxic gases on the decompression limits will be

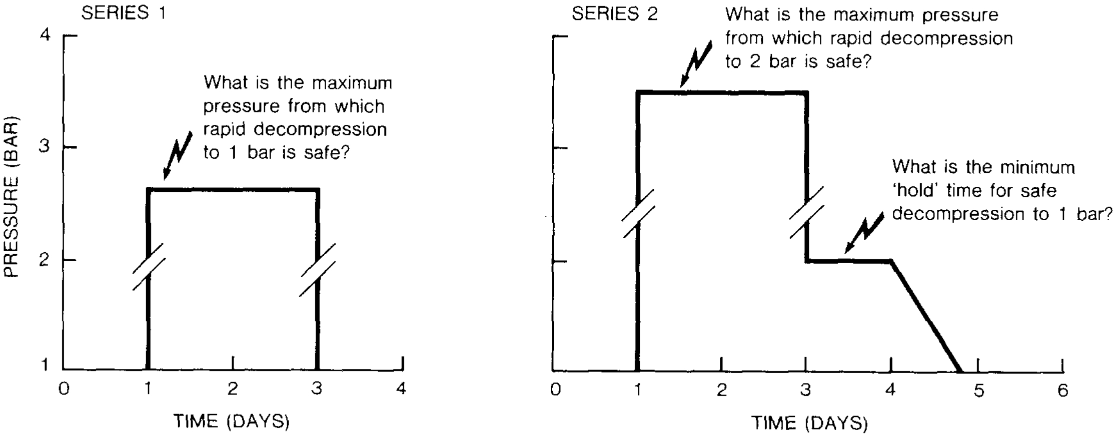

FIG. 4—THE DECOMPRESSION PROFILES USED IN THE EXPERIMENTS TO DEFINE THE MAXIMUM RAPID DECOMPRESSION STEP WHICH SURVIVORS FROM A PRESSURIZED DISABLED SUBMARINE CAN TOLERATE DURING A RESCUE. SOME OF THE SPECIFIC QUESTIONS INVESTIGATED ARE SHOWN. THE RESULTS FROM THESE EXPERIMENTS ARE INCORPORATED IN FIG. 5.

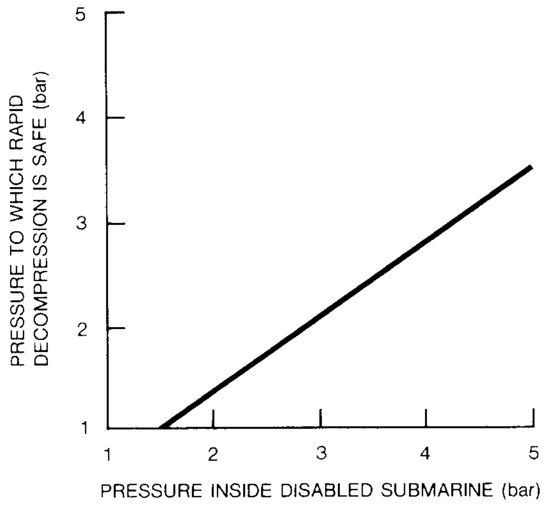

FIG. 5—THE PRESSURE TO WHICH SURVIVORS CAN BE RAPIDLY DECOMPRESSED DEPENDS ON THE PRESSURE TO WHICH THEY HAVE BEEN EXPOSED IN THE DISABLED SUBMARINE. THIS GRAPH, BASED ON STUDIES CARRIED OUT IN THE U.K., U.S.A. AND FRANCE, SHOWS THE PRESENT U.K. ESTIMATE OF THE RAPID DECOMPRESSION LIMIT IMPOSED BY A PRESSURIZED DISSUB. IT HAS BEEN TESTED IN U.K. FOR SIMULATED DISSUB PRESSURES UP TO ABOUT 3 BAR

explored, as will the relative importance of other conditions in the DISSUB, e.g. the level of carbon dioxide, the temperature, and the state of hydration of the survivors (who will have experienced a restricted food and water intake for some time).

Escape

When a submarine has an accident that results in sinking, escape is likely to be necessary if there is an unsecured flood, atmospheric contamination, or increasing ambient pressure. Any of these situations, singly, or in combination, could prevent the survivors remaining in the submarine to await rescue. In 1946 the Ruck-Keene committee analysed successful and unsuccessful escapes in many submarine accidents and concluded that whilst waiting to escape survivors should be subjected to pressure for the minimum time possible. This led in the 1950s and 1960s to the development of the dedicated tower escape system to replace the compartment method of escape. The latter required the complete escape compartment to be flooded deliberately in order to equalize the compartment and sea pressures so that the escape hatch could be opened. The escapers were thus exposed to raised pressures for a considerable period of time.

The escape tower is a small volume, floodable airlock which allows each escaper to be under pressure for only a short time. At the current maximum design depth of 180 m pressurization from 1 to 19 bar is achieved in 20 to 22 seconds. The escaper wears the Submarine Escape Immersion Suit (SEIS) with a built-in life jacket and a hood over his head. A Hood Inflation System (HIS) provides clean breathing air which inflates the life jacket and relieves into the hood allowing the escaper to breathe normally during tower flooding, and pressurization. FIG. 6 shows the arrangement of a typical escape tower. Once pressure equalization between the tower and the sea has been achieved, the upper hatch opens automatically and buoyancy in the SEIS carries the escaper to the surface, breathing normally all the way using air that expands from the SEIS life jacket into the hood. A typical tower escape cycle takes 3 to 4 minutes from the escaper entering the tower, flooding, pressurizing and equalization with sea pressure, and finally evacuating the tower and then draining down ready for the next escaper. In the 30 m submarine escape training tank (SETT) at H.M.S. *Dolphin* submariners are taught the procedures of tower escape. Procedures for an escape following the uncontrollable flooding of the escape compartment may require the escaper to forcibly exhale all the way to the surface. Whilst this is considered to be an extreme situation, these procedures are also taught at the escape tank. Peacock[4] describes the arrangement of the SETT.

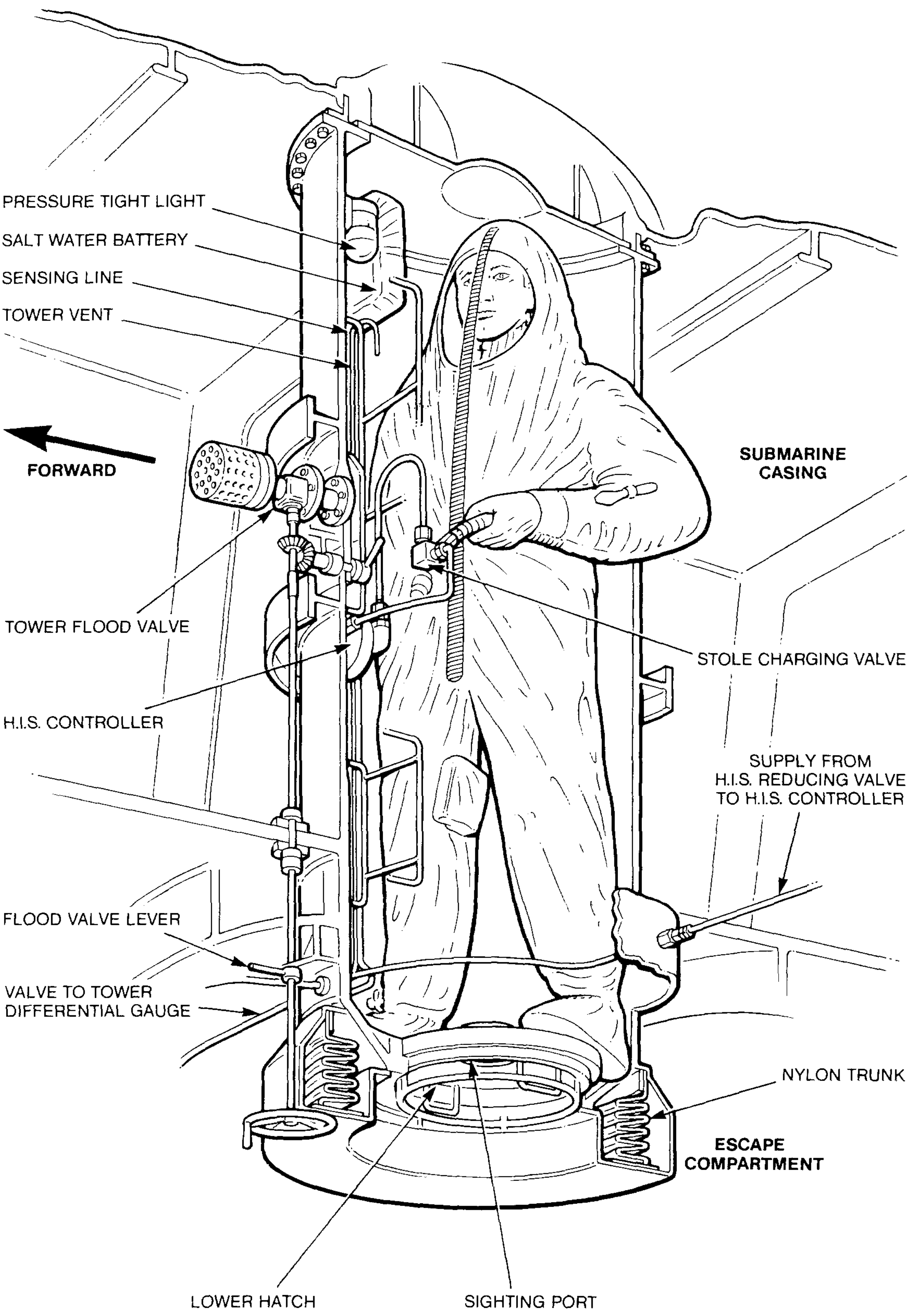

FIG. 6—AN ESCAPER WEARING THE SUBMARINE ESCAPE IMMERSION SUIT (SEIS) STANDING IN THE ESCAPE TOWER BEFORE IT IS FLOODED. THE ESCAPER IS CONNECTED TO THE SUBMARINE'S HOOD INFLATION SYSTEM (HIS) AIR SUPPLY WHICH PRESSURIZES THE SEIS HOOD AND ALLOWS HIM TO BREATH NORMALLY

Physiology of Escape

During the escape the survivor experiences the very rapid change of pressure shown in FIG. 7. This shows the pressure-time history of a member of the team which took part in the R.N.'s escape exercise 'Deepex 87' in July 1987. The ideal pressure profile was established by work at the then Royal Naval Physiological Laboratory (now the Environmental Science Division of the Admiralty Research Establishment) during the 1950s and 1960s. Animal and human studies showed that safe escape was possible from depths to about 180 m of sea water—a limit set by the occurrence of decompression sickness (the bends), which is caused by a 'gas phase' (colloquially known as bubbles) being set up in the tissues of someone who undergoes a sudden decompression.

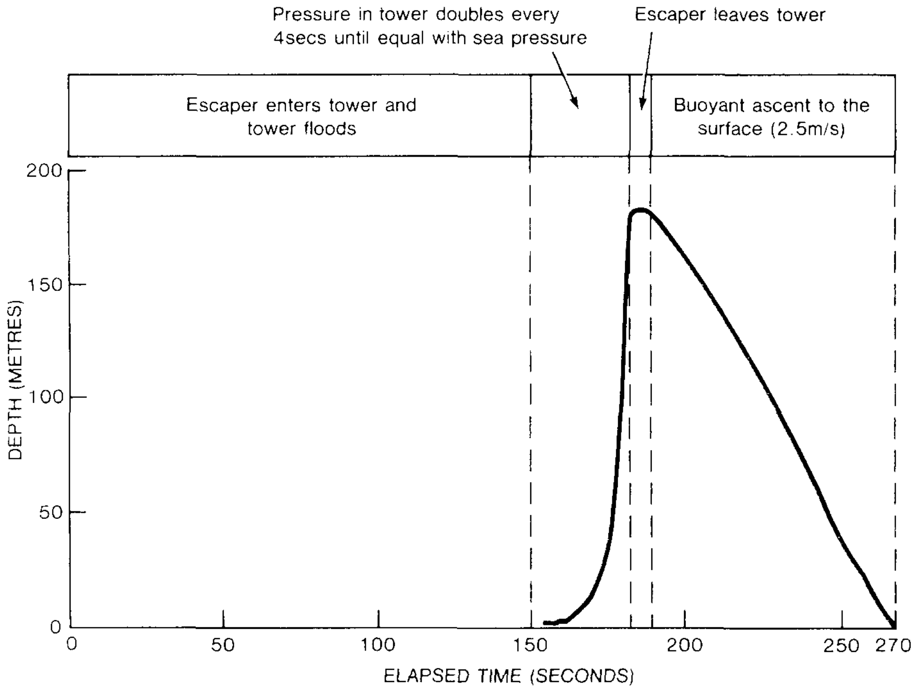

FIG. 7—THE RAPID PRESSURE CHANGES EXPERIENCED BY A SURVIVOR DURING A TOWER ESCAPE RECORDED DURING AN R.N. EXERCISE IN JULY 1987. AT THE TOP IS SHOWN THE SEQUENCE OF EVENTS THAT OCCUR DURING ONE 'CYCLE' OF THE ESCAPE TOWER. AFTER THE ESCAPER HAS LEFT, THE TOWER IS DRAINED OF WATER IN READINESS FOR THE NEXT ESCAPER

During the time the escaper spends under raised pressure air diffuses into his tissues to establish a new equilibrium. The oxygen is used up by the normal metabolic processes of the cells. However, nitrogen is an inert gas, so when the pressure decreases (during ascent to the surface) this nitrogen is released from the tissues into the blood, in which it is transported to the lungs and breathed out. If the amount of nitrogen coming out of the tissues is greater then the amount which can diffuse into the blood and to be transported to the lungs then bubbles of gas will form. These usually appear in joints where they cause pain, but can also form in nerves where they lead to loss of neuro-muscular function which can lead to permanent injury or even death.

We expect that the pressure within a DISSUB will be greater than the normal 1 bar, so the limits to safe escape already established need reconsideration. If the pressure has been raised for more than about 12 hours the tissues of the survivors will be saturated with gas at this raised pressure. So, when they undergo the escape sequence they will have to eliminate not only the gas they absorb during the escape, but also the extra gas they acquired during the period they were waiting to escape. As stated above, the safe escape depth is determined by how effectively the nitrogen is eliminated from the body. Therefore because the escaper has a greater nitrogen load than normal the amount he can safely take up during an escape sequence is limited—i.e. the depth from which safe escape is possible is reduced. Studies carried out at the Physiological Laboratory have given some indications of the nature of this limit (see FIG. 8) which is based on data published by Bell *et al.*[5]

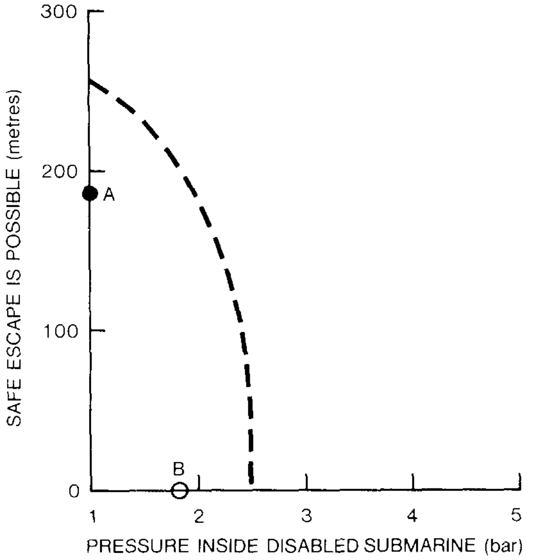

FIG. 8—THE DEPTH FROM WHICH IT IS SAFE TO ESCAPE DEPENDS ON THE PRESSURE TO WHICH THE SURVIVORS HAVE BEEN EXPOSED IN THE DISSABLED SUBMARINE. THE CURVE IS THE 'SAFE-TO-ESCAPE' LINE FOR GOATS. POINT A IS THE PROVEN DEPTH FOR ESCAPE AT 1 BAR, BASED ON R.N. EXERCISES. POINT B IS THE ESTIMATED PRESSURE FROM WHICH SAFE HUMAN ESCAPE WOULD NOT BE POSSIBLE. EVEN MINOR CHANGES IN DISSUB PRESSURE HAVE A MAJOR EFFECT ON THE 'SAFE-TO-ESCAPE' DEPTH

From data presented by Bell *et al.*[5]

To overcome the limits to safe escape imposed by the pressurized DISSUB, it is necessary to find ways of reducing the amount of nitrogen in the tissues of the survivors—either before they escape, or during the escape sequence. In principle this could be done by making the escape sequence faster. However, the rate of tower pressurization is probably already the fastest possible without causing mechanical damage to the body; the hold time is limited by the time needed for the escaper to leave the tower, and the ascent rate is constrained by the design and buoyancy of the SEIS.

Because it is not possible to reduce the amount of gas taken up during the escape it is necessary to seek ways of reducing the nitrogen load before the escape. This could be achieved if the survivors breathed an oxygen-rich (hyperoxic) gas before they begin to escape (and perhaps during the escape as well). However, apart from the mechanical and logistic problems of handling high pressure oxygen-rich gases in a submarine, there is an important physiological constraint which may limit this approach—oxygen rich gases can be toxic to humans. The most important aspect of oxygen toxicity likely to be relevant to submarine escape is the toxic properties of the gas on nervous tissue, particularly the brain (so-called, CNS or central nervous system toxicity), which results in involuntary movements, spasms or convulsions and unconsciousness. Obviously the risk of this happening cannot be accepted as a normal part of submarine escape.

A research programme has therefore begun at the Admiralty Research Establishment to determine the limits to safe escape from a pressurized DISSUB, and to explore the role of hyperoxic gases in overcoming these limitations. The work will progress through a variety of preliminary studies, and when there is sufficient background knowledge, experiments using human volunteers will be undertaken. To enable the pressure profiles to be simulated accurately, repeatedly and safely, a new hyperbaric chamber is being installed (the Submarine Escape Simulator or SES). The SES (FIG. 9) is designed to reproduce the physiological aspects of a submarine escape rather than the form and function of an escape tower. It comprises two spheres, of internal diameters 3 m and 2 m respectively, connected by a large-bore pipe fitted with a pressure control valve. The chamber has been constructed to simulate pressures equivalent to 1500 m sea water. The SES is used as follows: a subject is placed in the 2 m sphere (which, if required, can be flooded to simulate the flooding of the escape tower). The pressure in the 3 m sphere is raised to a pre-determined level such that when the pressure control valve is opened the pressure in the 2 m sphere rises until it equilibrates at a final pressure equivalent to the depth from which the simulated escape is taking place. The rate of change of pressure is determined by hand, or computer-control of the movement of the pressure control valve. The composition of the gases breathed by the subject before and during the simulated escape can be accurately monitored and controlled. The chamber is expected to become operational in 1989.

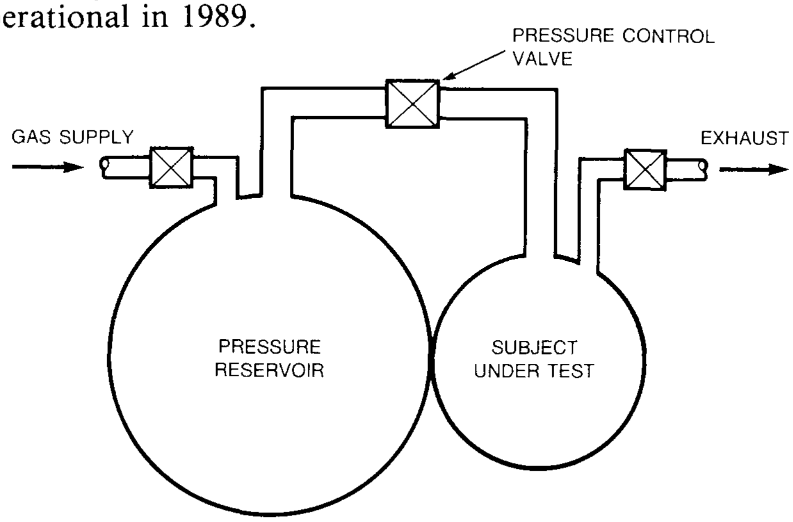

FIG. 9—DIAGRAM OF THE SUBMARINE ESCAPE SIMULATOR THAT IS BEING INSTALLED AT ARE ALVERSTOKE. IT IS DESIGNED TO SIMULATE, ACCURATELY AND SAFELY, THE PRESSURE CHANGES ENCOUNTERED DURING SUBMARINE ESCAPE, AND WILL BE USED IN EXPERIMENTS TO DEFINE THE LIMITS TO SAFE ESCAPE FROM A DISSABLED SUBMARINE IN WHICH PRESSURE IS GREATER THAN 1 BAR

Surface Survival

Having successfully reached the surface, the escaper's SEIS provides a survival capability which is designed for use in the North Atlantic in winter conditions. The immediate action of the survivor when reaching the surface is to inflate the SEIS using carbon dioxide from pressurized bottles.

Two key factors in ensuring the long-term survival of the escaper are the need to prevent hypothermia, or drowning induced by wave splash. The latest SEIS, the 'development Mk. 9' (FIG. 10) has been designed to improve the thermal insulation characteristics significantly as compared to the in-service Mk. 8 SEIS. The Mk. 9 has internal sections that compartmentalize the gas volume and maintain an insulating gas layer whilst the survivor is floating horizontally. The suit has also been fitted with additional insulation to the feet and lower torso sections, and a novel method of urine disposal has been incorporated. This latter feature ensures that the inside of the suit remains dry, otherwise the pool of urine which collects in the lumbar region acts as a heat sink, and removes valuable body heat. The Mk. 9 SEIS is also provided with a facial wave splash visor. This reduces the amount of sea water which hits the survivor's face and which can lead to splash-induced drowning, or reduced capability to survive.

In his SEIS the survivor floats on the surface until retrieved by rescue forces. Despite the SEIS performance, it is best to minimize the time a survivor spends in the water. Escape and rescue instructions advise the survivors to delay making escapes until either they know that surface forces have arrived, or until they are forced to escape by deteriorating conditions in the DISSUB.

FIG. 10—THE LATEST DEVELOPMENT ESCAPE SUIT—SEIS MK. 9. ON THE LEFT IS THE UNINFLATED SUIT SHOWING THE HOOD CLOSED. ON THE RIGHT THE SUIT IS INFLATED AS IT WOULD BE ONCE THE SURVIVOR REACHES THE SURFACE. THE HOOD HAS BEEN UNZIPPED AND PUSHED OVER THE HEAD, AND THE WAVE-SPLASH VISOR PULLED DOWN OVER THE FACE

The SUBMISS/SUBSUNK Organization

The R.N. has a comprehensive organization to cope with a submarine disaster. This can be best described under its individual phases.

Alertment

Shore authorities can be alerted by negative alertment, i.e. non-receipt of an expected signal, or more usually by receipt of a distress message. This may be transmitted by the submarine as it sinks, but more likely will come from one of the two indicator buoys which every R.N. submarine carries. These contain the Type 639 radio which transmits on international UHF/HF (243MHz/8364kHz) distress frequencies. Submarines carry the Type 680 Emergency Communications Buoy (ECB) which can be fired from the submarine's submerged signal ejector in each escape compartment. Three Personal Locator Beacons (PLB) are carried in each escape compartment and these are worn by escapers. Both ECB and PLB transmit on 243MHz, with ECB being accessed into the SARSAT search and rescue satellite.

The Search and Assembly of Rescue Forces

Once the alarm has been raised, a designated Submarine Search and Rescue Authority (SSRA) assumes overall command, assisted by a co-located Rescue Co-ordination Centre (RCC). Ships, submarines and aircraft in the vicinity are immediately ordered to start a search, and a Senior Officer Search Force (SOSF) is detailed from among the ships. Meanwhile the SSRA calls out and assembles the resources needed to recover escapers, re-supply ELSS to survivors awaiting rescue, and to rescue those survivors. The Submarine Escape and Rescue Assistance Team, based at H.M.S. *Dolphin*, incorporates a SUBSUNK Parachute Assistance Group (SPAG) with equipment and liferafts for 200. The material resources are categorized to ensure they arrive at the scene of the accident as required. In summary these comprise:

(*a*) First Reaction Stores: compression chambers, inflatable boats, medical and victualling stores, underwater communications.
(b) Second Reaction Stores: ELSS, delivery pods, ROV *Scorpio*, divers, and the Atmospheric Diving System "JIM".
(*c*) Third Reaction Stores: salvage items, decompression system (when commissioned).
(*d*) Rescue Assets: DSRV, SSBN MOSUB, LR5, a platform for LR5, e.g. H.M.S. *Challenger* or C.S. *Alert*, and R.M.A.S. SALMOOR Class salvage vessels.

The SPAG team are trained as water-entry parachutists and are permanently on 6 hours notice for take off from R.A.F. Lyneham in order to get to the scene of the accident rapidly. First and second reaction stores are embarked in a ship of opportunity for quickest delivery to the search datum. Many of these stores are containerized for helicopter airlift.

The Recovery

Escapers who are on the surface are recovered and taken to an Escape Gear Ship (EGS) with at least one compression chamber and medical support personnel to treat the survivors for possible decompression sickness, embolisms or physical injuries.

The Rescue

This phase may overlap with or completely replace the Recovery Phase. It may also take a long time and it comprises three main parts:

(*a*) Resupply of ELSS to maintain the survivors who are awaiting rescue. Resupply continues throughout the rescue.
(*b*) Rescue of a limited number of men by LR5 whilst awaiting the arrival of DSRV and continuing after the arrival of DSRV.
(*c*) Rescue by DSRV.

Conclusion

The organization needed to effect a successful recovery of survivors involves military personnel of all three U.K. services, together with the U.S.N. and U.S.A.F. Essential support is provided by RMAS ships and civilian specialists in the MOD(PE). The value of the assets committed by the R.N. to submarine escape and rescue show the premium that the R.N. is prepared to pay for its insurance. However, in order to achieve good value for money there is an on-going programme to seek cost-effective improvements. With current procurement policy aligned towards a closer co-operation with industry, and seeking utilization of commercial technology it is hoped that ideas for improvements can be identified. Areas where attention can be usefully concentrated are:

(*a*) Equipment and consumables for maintaining oxygen and carbon dioxide levels in the DISSUB.
(*b*) Reducing the volume of escape/rescue stores on the submarine.
(*c*) Presentation of instructions to survivors on the DISSUB.
(*d*) Rugged, reliable atmosphere monitoring instruments for use in the DISSUB.
(*e*) An increase in the escape or rescue capability from a pressurized DISSUB.
(*f*) Increasing the surface survival capability.
(*g*) Improved thermal insulation materials for survivors.
(*h*) Reduced cost Personal Locator Beacons.
(*i*) Underwater communication/location/station-keeping systems for ROVs, LR5, DSRV.
(*j*) Drugs for reducing pressure effects or sea sickness.
(*k*) New generation rescue submersibles.

This article has covered the major topics of escape and rescue, but it must be appreciated that each in its own right is an extensive subject. It is hoped that sufficient information has been provided to illustrate the magnitude of the committment required to support a modern submarine fleet. In 1987 the complete system was tested in a SMASHEX. This used H.M.S. *Sealion* as the DISSUB and the organization and systems were exercised 'for real', except that DSRV was not actually called out. The exercise was successful with escapes and rescues both being effected. This gives encouragement that in the event of a submarine accident the R.N. has a capability to recover the survivors successfully.

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