committee where the greatest need for assistance lies and that we encourage the organization to realize that by joining the Foundation that they have acquired staff varying in skills from executive director to office junior, and to develop a relationship with the secretariat accordingly.

For example, in 1988 the SCF created an award which recognizes that many members put an enormous amount of effort into the development of their organization. Since the development of professional and scientific organizations is the main reason for the Foundation's existence, the board of Governors resolved to mark the bicentenary year with the establishment of the Science Centre Foundation award. This was such a success that it was decided to make this award an annual event.

The award is presented to the elected officer, member or official of an organization which is a member of the SCF, in recognition of dedication and outstanding service to that organization and to the fostering of cooperative relations between organization and the Foundation.

If SPUMS decided to join the Foundation and establish a secretariat the following might happen:

1 We can provide a registered office with mail address and telephone. Routine matters can be handled by the staff while the rest is sent on to the Secretary. Files and records can be maintained at the office.
2 We can provide assistance with the preparation and attendance at committee meetings.
3 We can create a data base and keep it up-to-date.
4 We can send out subscription notices, record payments, and send out reminders. We can bank, prepare monthly financial statements, leaving the Treasurer responsible for budgeting and forward planning.
5 We can assist the Editors at the word-processing stage, then return the disc for editing and lay-out. We could undertake the sales and advertising tasks.

The tasks I have outlined are basic administrative procedures. However, it is perhaps in helping the Society to look at its objectives and translate these into programmes that we could be most helpful. Relieving executive members of most of their clerical chores will allow available time to be spent on developmental projects. From discussions and reading background material provided, it would appear that a number of areas could be explored:

1 An expansion of educational activities such as providing more scientific meetings including those catering for members other than doctors.
2 Establish hyperbaric medicine as a recognized part of medical education.
3 Establish contact with other medical organizations such as the Postgraduate Federation in Medicine.
4 Develop projects in developing countries such as making a video suitable for a teaching aid.

To give some idea as to how to implement for example the first suggestion of educational activities it might be possible to select a small group to put material together for a two-day seminar, then take this to each State and appropriate centres. This would enable wider participation by both members and associates, thus helping them to become more involved with the Society.

My talk to-day has been an attempt to demonstrate how the SCF functions and what we could achieve together. I hope that the opportunity you have given me to-day is not the last time I shall be talking to members of this Society.

Mrs Ruth Inall is the Executive Director of the Science Centre Foundation, the address of which is Private Bag No 1 Darlinghurst, New South Wales 2010, Australia.

SUBMARINE ESCAPE AND RESCUE

Greg Adkisson

Submarine escape and rescue of the 1990's is a complex evolution involving a variety of different craft, both surface and submersible, and often the co-ordinated efforts of many nations. To appreciate what we are able to accomplish today, it is worth looking back through time to appreciate the work of those that passed before us.

History

The first successful submarine escape on record occurred in 1851. The *Brandtaucher* or *Sea Devil* was a German vessel commanded by Wilhelm Bauer, a corporal in the Bavarian artillery. She was a stubby, narrow beamed vessel of some 35 tons with a very deep draft and motored by a hand turned propeller. She was first sent into action against the Danish fleet which was blockading the harbour at Kiel. The Danish fleet stayed at sea and Bauer's first day consisted of moving about the harbour without seeing enemy action.

Not one to give up easily, Wilhelm set out to sea on the second day determined to sink a ship. Unfortunately, his determination would prove successful but not in the way he imagined. The *Brandtaucher*, on its second submergence, ran out of control and sank in 18 metres of water. Unsure of quite how to handle the situation he discussed it with his shipmates. They were all for staying put, having no idea of how to leave. Wilhelm, however, felt that it was time to return to the artillery and came up with the idea that, by pumping water into the vessel, pressure could be equalized, the hatch opened, and they could all swim to the surface. It

took five hours and a large hammer to convince his men but the plan succeeded and the first successful escape became a reality.

The *Brandtaucher* was salvaged in 1887 and placed at the Naval College at Kiel. In 1906 she was taken to the Naval Museum in Berlin but deteriorated over time and is no longer in existence.

During the war between the North and the South in the United States, the need for submarine escape became all too painfully apparent. The Confederate States of the South began building a series of semi-submersibles, not true submarines but of a similar design and concept. The year was 1861 and these small hand powered submersibles, called "Davids", were designed to do battle against the overwhelmingly superior Northern fleet. It was billed as the battle between David and Goliath. In 1863, one of the first of these was constructed in Mobile, Alabama. 50 feet long with a 9 foot diameter, it was powered with steam and was capable of 7 knots. It was equipped with a single spar torpedo in front and reverted to hand power when submerged. Lieutenant Glassell commanded but the engineer was a man named Tombs.

She was sent to sea against the northern vessel *New Ironsides*. She rammed the *New Ironsides* but caused only superficial damage. The crew expected the David to sink and abandoned the submersible. Mr Tombs, however, belying his name, stayed aboard and escaped with the vessel into the night.

The next vessel in the line became somewhat more infamous. Designed by Hunley and McClintock, she was 60 feet long, hand powered by a crew of 8, with an additional man on board as the pilot, and was equipped with a spar torpedo. In her initial trials off Charleston, a paddle-wheeler came along, flooded the boat and sent her to the bottom. Lieutenant Paine was the sole survivor, managing to escape through an open hatch. She was raised and refurbished, only to be sunk during her second trial by a storm. On this occasion Lieutenant Paine and 2 of the crank turners escaped. She was salvaged and refitted. Proving herself to be a true submarine, she promptly sank a third time. Lieutenant Paine and 3 others escaped setting, by Lieutenant Paine, what appears to be a world record of 3 actual escapes from a sunken submarine.

She was raised again and given a new crew. Lieutenant Paine was no longer in command, a bad omen perhaps, for she sank this time taking all nine men aboard to their deaths. She was salvaged again and sank again. This time 7 men died. She was raised again and was finally to do battle. She damaged a frigate but the frigate was repaired while the sub sank again with all but the pilot being drowned.

She was raised a final time and dried out. She was sent into battle again against a selected target, the Northern corvette *Housatonic*. A call for volunteers had gone out but was promptly ignored. The South finally managed to put a partial crew on board with Lt Dixon in command from the 21st infantry. On the 17th of February, 1864, she set to sea. The *Housatonic* expected the attack and was keeping a sharp eye towards land. The valiant vessel, however, went around and approached from seaward. She was sighted about 100 yards off and the *Housatonic* attempted to manoeuvre. The attempt was unsuccessful and the *Housatonic* was struck just forward of the mainmast at the magazine. The sub earned a place in history as the first to sink an enemy vessel but, unfortunately, she sank with the *Housatonic* and the entire crew perished with her. There were no further attempts to use submersibles by the South but the North continued building a series of semi-submersibles, similar in design to the Davids, known as Cigar boats.

Of the ill-fated Davids, one man was quoted as saying the "David lost so many Confederate lives it must have been designed by a Yank". 35 men lost their lives before even going into battle.

Other submarines and other crews were lost in the following years.

In 1916 HMS E-41 collided with another submarine and sank in 30 feet of water. Stoker Petty Officer Brown made British history as the first man to successfully escape from a British submarine and survive to tell the tale. With the development of the Davis Escape Lung, Britain began to move towards the concept of escape as the primary method of leaving a disabled submarine. In 1933 the advent of modern submarine rescue occurred when the USS Squalus sank in 234 feet of water and the entire crew was rescued using a relatively new device called the McCann Bell. The McCann Bell was a submersible rescue chamber designed to go to 250 m and attach to the hatch of a disabled submarine. It was capable of doing this only if the submarine remained at 1 atmosphere of pressure.

In the years to follow, the United States, while maintaining an escape capability in the form on the Momsen lung, and later the Steinke Hood, would move towards rescue, bringing men out of a submarine by means of a rescue chamber or rescue vehicle, as the primary means of saving lives in a submarine accident. The United Kingdom would continue to concentrate on escape, maximizing a man's ability to exit from a disabled submarine and get back to the surface. Today, the United Kingdom has combined these methods to maximize success.

General Considerations

Should a submarine become disabled and sink, several variables come into play. There are four general scenarios. The submarine may be dry and unpressurized, wet (partially flooded) and unpressurized, dry and pressur-

ized or wet and pressurized. The optimum state for survival is dry and unpressurized. Each scenario presents unique challenges to would be rescuers.

There are two methods of leaving a disabled submarine. Escape is when the survivors make their own way to the surface. Rescue is when the survivors are transferred by means of some type of submersible.

Methods of escape

Generally, survivors are encouraged to wait until surface forces are on hand to assist with recovery. If escape is forced due to deteriorating conditions, the Submarine Parachute Assistance Group (SPAG) may be air dropped in to assist. Two methods are available:

Tower escape, with hooded ascent, is the primary means of escape with one or two survivors being pressurized and exiting at a time.

Rush escape is a secondary method when the entire compartment is flooded and all escapees are pressurized together. As they can only escape from the compartment singly the majority are exposed to raised pressures for some time, increasing the risk of decompression sickness.

Methods of rescue

Rescue is the preferred method of recovering survivors and should be utilized unless conditions are optimum for escape or if deteriorating conditions force escape. Several methods are available.

The US Navy maintains two Deep Submergence Rescue Vessels (DSRV) for world-wide assistance in submarine disasters. They are capable of mating to any submarine with standardized mating hatches with a maximum depth capability of 1500 metres. They can rescue survivors from boats pressurized up to 5 ATA.

The LR5 is a civilian submersible under contract to the Ministry of Defence. Like the DSRV, it can mate to compatible submarines at pressures greater than 1 ATA.

The USN McCann Bell is surface deployed and is capable of rescuing men from a non-pressurized submarine at depths up to 250 m.

Other nations have developed rescue capabilities and NATO is investigating the possibility of a European DSRV.

Medical Concerns

Men escaping from a disabled submarine are faced with a wide variety of potential problems. These are compounded in the submarine is at an increased pressure to before the escape. Various conditions that may present include:

Pulmonary barotrauma.
Other barotrauma, especially ears.
Decompression sickness.
Exposure, including hypothermia or sunburn.
Drowning and near drowning.
Traumatic injury.
Exposure to toxic gases, oxygen, carbon monoxide, chlorine, carbon dioxide.
Radiation injury.
Dehydration from limited water supplies.

Recent Highlights

Exercise Sedgemoor was a joint US-UK submarine escape and rescue exercise designed to test all phases of a rescue operation. Of particular note was the fact that it was the first time that submariners were taken from one pressurized submarine to another pressurized submarine in a simulation, start to finish, of a pressurized rescue scenario. This proved the pressurized rescue capabilities of the DSRV, the LR5 and the British Mother Submarine (MOSUB) system.

Summary

Submarine accidents can and do occur. A high standard of readiness and training on the part of rescue forces is necessary to insure optimum success in rescuing survivors of such disasters. Once the sinking occurs, tremendous problems face the survivors and their would be rescuers. Proper planning and preparation can optimise the possibility of a smooth, co-ordinated rescue.

Reference Publications

1 Adkisson GH and Raffaelli P. *Subsunk. Notes for Medical Officers. INM Report 15-88.* Alverstoke, Hampshire: Institute of Naval Medicine, July 1988;
2 Mole DM. *Submarine Escape and Rescue Capabilities in 1989 Submarine Medical Officer Qualification Thesis.* Groton, Connecticut: Naval Undersea Medical Institute, 1989

Greg H Adkisson MD is a Commander in the Medical Corps of the United States Navy. He was serving as exchange medical officer with the Royal Navy when this paper was prepared.

His address is Department of Anesthesiology, Naval Hospital San Diego, San Diego, California 92134, U.S.A.