THE SUBMARINE REVIEW

JANUARY 1986

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A QUARTERLY PUBLICATION OF THE NAVAL SUBMARINE LEAGUE

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FROM THE PRESIDENT

I am pleased to report several actions which demonstrate our intent to produce a responsive and dynamic Naval Submarine League. First, the Directors have approved a Submarine Service awards program for submarine-related personnel, but not to include senior officers of the rank of Commander or higher -- for whom there are seemingly adequate awards programs in existence. Recipients of the awards will be selected by the DCNO (SUBS) for approval by the Submarine League Directors. Each recipient of an award and spouse will be invited to the Annual Symposium for recognition. The Charles A. Lockwood Award for Submarine Professional Excellence will be given to a Junior Officer, a Chief Petty Officer, and an enlisted man (E-6 or below). The Levering Smith Award for Submarine Support Achievement will be given to a LCDR or below or a civilian. And the Frederick B. Warder Award for Outstanding Achievement -- for a specific action or continuing performance which had a favorable impact on the submarine service -- will be given to a LCDR or below or a civilian. These awards should fill a need for special recognition of deserving individuals and serve as a link between junior submarine personnel and the Submarine League. It should also be an avenue to unify and strengthen the League's membership.

Admiral Long, the Submarine League's Chairman, along with the Directors felt a great need to have new and broad inputs for the League's direction. Consequently, an Advisory Council of 12 distinguished submariners and 3 senior executives of industry has been established. Vice Admiral Phil Beshany was designated the Council President. This Council is designed to allow a group of dedicated individuals to make recommendations on critical issues vital to the continued growth of the Submarine League towards the accomplishment of its goals.

Finally, in response to the many comments of League members, the Directors of the Submarine League have decided to dispense with a classified briefing as part of the Annual Symposium, feeling that it could not be justified. The 1 1/2 day agenda will however be maintained, with the business meeting initiating the Symposium and with more time allocated for membership inputs at this session. This should be a useful and productive modification to our annual meeting's agenda. The Fourth Annual Symposium will be held on 9-10 July, 1986, at the Mark Radisson Hotel and Convention Center in Alexandria, Virginia. Please mark this date on your calendar.

The Holiday season is past, but I still want to wish all Submarine League members, "good health and success in the new year of 1986." The Submarine League is destined to play a vital role in this country's defense posture. It needs your support and participation in 1986.

Chuck

FROM THE EDITOR

A Senate Armed Services Committee staff study has provided the arguments for Senators Nunn and Goldwater in their campaign to have basic changes made in the defense organization. A major and suggested well publicized change, is to dis-establish the Joint Chiefs of Staff and establish a Joint Military Advisory Council of 4-star military officers on their last tour of duty -- to serve as the principal military advisors to the President, with the Chairman providing military advice in his own right.

Of lesser dramatic nature but probably of greater importance to our national security interests are the Study's recommendations relative to the military services' strategic planning process and the strategies being derived. In this regard, the status of strategic planning in the submarine service might be considered.

Is strategic planning an important activity of the submarine service? Mahan considered it to be "the essence of the military art." Yet, as the Study observes, because insufficient attention is being paid to strategic planning, there is "no clear articulation of the strategic goals and concepts necessary to establish resource priorities and to adapt readily to changing requirements and concepts."

Many of the articles in this present Submarine Review represent useful thoughts in the strategic planning process. Hence, a focussing on specific related ideas in individual articles herein should be useful in assessing the concerns expressed in the Study with regard to the strategies of the services. Specifically, these articles can help one reflect on the extent to which -- or even whether -- the submarine service is -- in the words of the Study -- guilty of developing a strategy which "is merely a convenient rationale to justify the weapons systems that the services want to buy" and as a result, "strategic plans are totally unrealistic and offer no guidelines for determining priorities in the actual allocation of resources."

KJM's "Not So Trivia a Pursuit" book review makes observations relative to the external characteristics of Soviet submarines which would belie the basic assumption of our present attack submarine strategy for war -- i.e. a quick forward decimation of Soviet submarines so as to ensure a control of vital sea areas which are critical to the support of U.S. overseas military forces and the U.S. economy, as outlined in VADM Thunman's "The Past is Prologue." Why certain design features are incompatible with the Soviet bastion strategy, and what they probably indicate as a more likely employment for many of the Soviet submarines, can be a necessary factor in the Submarine Service's strategic planning. The article on quiet MHD power in Soviet submarines alerts the strategic planner to the impact of this possible development on the present strategy.

Tony Wells' "Soviet Prospects" article provides changes in the threat which should be regarded in the strategic planning process in order to develop alternative strategies to meet such changes along with an evaluation of possible U.S. strategies and their priority. His thought that the Soviets are likely to carry some of their submarine war to the Continental Shelf areas of the United States needs to be evaluated and possibly factored into a modified U.S. submarine strategy. Also, Wells' recognition of the problems of finding enemy submarines in the Marginal Sea Ice Zone -- "like looking for a needle in a haystack" -- might belie U.S. optimism as to quickly destroying Soviet submarines. John Leonard's "The Melee," moreover, while recognizing the possibility of such engagements where mutual detection ranges are low, as in the sea-ice-zone, suggests a need for new kinds of weapons and approach to this mode of underseas fighting. The article on the Fuel Cell Submarine would also suggest the need for more and new kinds of submarine resources to fight the battles of a general war -- reinforcing Tony Wells' assumptions particularly as to more U.S. submarines being needed to protect the coasts of the U.S. from enemy submarine actions.

What this all adds up to is an appreciation of the problems facing the submarine strategic planner and the need for people trained in this discipline who can develop alternative strategies to meet changes in the threat as it develops. CAPT Linton Brooks in a previous SUBMARINE REVIEW article decried the loss of a critical number of submarine officers who were trained for strategic thinking about "nuclear" war and he saw the possibility that our submarine war plans for "nuclear" war would suffer.

Perhaps a general recognition of the need for a strong cadre of strategic thinkers and planners is lacking throughout all the services, and has been the root-cause of the Senators' indictment of present military strategy.

THE PAST IS PROLOGUE

[A digest of a talk by VADM Nils R. Thunman, USN, delivered 17 August, 1985 at the Submarine Veterans of World War II national convention.]

Shakespeare surely was thinking of us submariners when he penned King Henry's stirring words, "we few, we happy few, we band of brothers." Our brotherhood of the deep is truly unique and although we may be of different generations, it binds us through our common experience and undersea heritage.

In planning the future, we take lessons from the present and past -- from you, the submariners who won the war in the Pacific. You are the men of whom Admiral Nimitz wrote, "We shall never forget that it was our submarines that held the lines against an enemy while our fleets replaced losses and repaired wounds."

It is important for us to appreciate that the Submarine Force of today is founded upon the lessons of the past -- upon your successes as well as on your difficulties and how you overcame them. We are determined not to repeat the mistakes of the past. We respect Santayana's dictum, "Those who cannot remember the past are condemned to repeat it."

You gentlemen remember and understand far better than I the serious problems you encountered during the first two years of the war in the Pacific. I'd like to recall a few. Six months into the war more than 800 torpedoes had been fired in combat, with discouraging results. And not a single test had been run to investigate the skippers' complaints. It was easier to blame the skippers. It was not until June, 1942 that Charlie Lockwood and Jimmy Fife took matters into their own hands and ran the tests that confirmed what many of you had been trying to tell BUORD since Pearl Harbor -- that the Mark 14 torpedo ran 10 or 11 feet deeper than set! Also, the exploders often failed to work. Finally, in September, 1943, nearly two years into the war, you had a torpedo you could count on. Clay Blair summed it up correctly, "The torpedo scandal of the U.S. Submarine Force in World War II was the worst in the history of any kind of warfare."

We are not going to let that happen again. Our torpedoes and our missiles are going to work. The Mk-48 torpedo is the backbone of our arsenal. It is a good torpedo. Each year we fire about 1600 exercise torpedoes in various environments. We fire on instrumented tracking ranges where we can closely monitor the torpedoes' performance. We also fire in the open ocean and have tested the Mk-48 under ice. We try to stress the torpedo and the entire weapons system to its limit. However -- drawing on your experiences -- I remain skeptical about torpedo performance. In 1980 when I was COMSUBPAC, there were some disturbing trends in torpedo reliability. These trends revealed problems in both quality control and design -- which were fixed. The torpedoes were updated, and a rigorous warshot testing program ensued. Each year we select at random about 10 Mk-48 warshot torpedoes already loaded on submarines and fire them in a service weapons test, designed to test the entire system from launch to explosion. A Mk-48 warshot was also fired under ice to be certain it would work in that harsh environment. It did! Moreover, over the past year our success in these service weapons tests is approaching 100 percent. But I still remain skeptical. The Mk-48 is a good weapon but it won't meet the challenges of the next decade and beyond. So we are well along in the development of the advanced capability Mk-48, the ADCAP. It is being subjected to the most realistic and rigorous testing we can devise. Happily, the test results to date are most encouraging.

Peacetime training is another important area where we have profited from the lessons that you learned at great cost. You can remember well that months of hard fighting, bitter disappointment, and relieved skippers were required to overcome the cautious, stereotyped and unimaginative training practices of the pre-war days. The potential enemy was little known and peacetime operations were conducted in "home waters." Tactics were influenced by an ignorance of the capabilities of the enemy's ships and aircraft. These are lessons we cannot fail to heed. Today's training and operations take place literally in every ocean of the world. While, we strive to practice as we would fight, and to stress our skippers and crews to the greatest reasonable degree. We observe the Soviets' ships and study their tactics. There is no question that the Russians are good and getting better. So we are working harder to stay ahead.

In the vital area of tactics and training, you confirmed the importance of the periscope. In pre-WW II days, the periscope approach had fallen into disfavor. Doctrine then called for deep sonar approaches on the basis that "It is bad practice and it is contrary to submarine doctrine to attack at periscope depth when aircraft are known to be in the vicinity." Months passed after the war started before the fallacy of this doctrine was made evident. Yet, 20 years later, the THRESHER class SSN was built with only one scope. Belatedly this was recognized as a mistake and a second scope was installed in these subs. Today our SSNs all have two sophisticated periscopes with low radar cross-section, built-in cameras, infrared sensors and communications antennas. But in spite of the complex electronics packed into today's periscopes, the operational technique has changed little from your days. Short exposures, rapid target recognition, skillful use of the telemeter -- sometimes hampered by leaking hydraulic oil -- these skills are all with us today.

While we have profited from many of the lessons learned by your generation, it will not surprise you that, while developing a first-rate submarine force, we still face many of your problems. In the thirties there was a bitter battle over building the fleet boats. They said they were too big, too costly, and had unnecessary range and endurance for adequate defense. Fortunately, the submariners won and the fleet boat was built. With their speed, firepower, and room for growth, they proved vital to the ultimate victory. With smaller and less capable submarines, the war in the Pacific may well have gone much differently.

Today there is a similar debate over the submarine force of the future. Our maritime strategy is a quick-striking strategy which features the SSN as its leading edge. It calls for early offensive action in forward areas where only submarines can survive. This concept requires submarines with a clear-cut acoustic advantage that can reach the battle area quickly and bring great firepower to bear both on land and sea targets. As in the thirties, submarines with these capabilities are neither small nor low-cost. We have proposed to build the SSN-21, a fast, quiet and extremely capable submarine, designed to meet the threat of the next century. With the enthusiastic support of the Secretary of the Navy, the CNO and many in the Congress. I am confident we will get that submarine of the future.

I know that we would find that the life of the submariner's family has changed little over the years. The sacrifices made willingly by our submarine families year after year are both remarkable and praiseworthy. In Washington we work to give our submarine family all the support we can -- particularly in the areas of pay and allowances and in base and housing facilities. We'll never be able to give them all they deserve but we won't stop trying.

I started this talk with reference to the past and to our heritage and I'd like to return to that theme. In our libraries in Pearl Harbor and New London, we have collected the declassified patrol reports of the missions that you made. I urge our commanding officers to read them. I particularly remember reading Sandy McGregor's account of his second war patrol in USS REDFISH. After putting several torpedoes into a well escorted Japanese aircraft carrier, Sandy wrote, "Took a good sweep around. Unable to see aircraft carrier. He has sunk. Had many planes on deck." And then shortly after, "On passing 150 feet all hell broke loose when seven well-placed depth charges exploded alongside starboard bow." Sandy reported that the pressure hull was cracked in the forward torpedo room, that there were numerous air leaks throughout the boat, and a torpedo was making a hot run in #8 torpedo tube. Sandy brought that submarine safely back to Midway. Reading that patrol report gave me great confidence as I went to a command. And today, the accounts of REDFISH and those subs still on patrol like Mush Morton's WAHOO, continue to inspire the skippers of the nuclear era.

In some ways the commanding officers of your generation are different from the CO's of today's nuclear submarines. Today's skipper has never served on a surface ship. Few have been to sea on a diesel boat. They are more comfortable with digital sonar and fire control systems with star-wars-like video screens than analog machines and displays. But in truly important attributes, today's CO is little different from the skippers of your day. Our CO's are thoroughly professional, technically capable, fiercely independent, proud of his ship and crew and known occasionally to raise a little hell both at sea and ashore.

Modern technology hasn't changed the ingredients for a good CO -- good judgement, common sense, moral courage, and confidence in his ability, his ship and his crew. I'm pleased to report that we have men with these traits in abundance commanding our submarines at sea today. The future of our Submarine Force is bright. We are building four 688 class submarines a year, each more capable than the last. New TRIDENT submarines are being commissioned yearly. They are magnificent submarines. We are buying better submarine weapons than ever before. I have no doubt that the nuclear submarine is destined to be the capital ship of the future.

SOVIET SUBMARINE PROSPECTS 1985-2000

There was a time, until about 1980, when we believed that the Soviets had a poor grasp of applying noise reduction, acoustic processing, computer fabrication, and so on. What we did not always perceive was that the technical antecedents of their programs were based upon lengthy research and development with respectable pedigrees. The apparent surprises from 1980 to 1985 were the products of well-conceived research and development programs often begun ten or more years earlier. Linear extrapolation of Soviet naval systems can be misleading when consistent research and development programs indicate a potential for step changes in capabilities. This is as applicable to passive arrays and space-based radars as it is to heavyweight torpedoes and mines.

What do the next 10 to 15 years portend? Research and development programs in the current Five Year Plan will bear fruit in the 1995 to 2000 timeframe. The new construction of the last two years or so will become the staple units of the Northern Fleet out to the turn of the century. The SIERRA, MIKE, and AKULA classes will become the mainstays of the SSN Order of Battle for at least the next ten years, with modifications along the way. By 1995, the Northern Fleet will possess a majority of quieter and more capable submarines. The older, noisier boats will be coming to the end of their hull lives. The technical improvements in Soviet submarine capabilities present the Soviet high command with several options and could potentially change the nature of operations. Much will depend upon their perception of and reaction to U.S. policy in the Arctic. If U.S. operations prove to be ineffective or not sustainable for long periods, there may be a significant redress in the balance of Soviet SSN and SS forces within the Arctic bastions. The new, quiet SSBNs of the DELTA IV and TYPHOON classes may require less SSN support because of the Soviets' skillful use of the ice to mask SSBNs, thereby releasing some of the newer, quieter SSNs for operations further west and south.

Noise quieting itself makes submarine against submarine operations ever more precarious. Initial detection may become problematic for quiet Western submarines against quiet Soviet submarines. When contact is made, there are likely to be high speed melees with salvo attacks and counterattacks and a broader use of deception. Complex active sonars may acquire more significance. Stealth will remain important, but speed and weapon reliability may be equally important. However, will this type of submarine engagement become rare because of a significant reduction in the West's acoustic advantage? Under the ice cap and along the marginal ice zone, the West may find it extremely difficult to make an initial detection of a quiet, stealthy, well-handled Soviet SSBN. Full forward pressure by the West could conceivably become a "needle in a haystack" problem in a hostile environment.

If the Soviets opt for a shift in emphasis to anti-surface operations and support of the shore through submarine-launched land-attack cruise missiles such as SS-N-21 and SS-NX-24, we may see asymmetries develop which could present the United States with several dilemmas. Submarine numbers count. If the United States configures primarily for ASW, with anti-ship and land attack as secondary roles, we may find that the Soviets have bought an advantage with a flexible mix of weapons for use in certain situations and a dedicated role in others. It is conceivable, for example, that the most capable new diesels could be SLCM armed to patrol in the shallow waters off the east coast of the United States, while a new class of SSGN could be a SLCM firer from within the Arctic circle with long-range, 3,000 km plus, weapons launched from special tubes. The SS-NX-24 may already pose such a threat. These could be targeted at sensitive objectives in the northern plains states. The older diesels could assume a more pedestrian but highly important role as mine layers. Conversely, as the Soviets gain experience in the flexible use of land attack cruise missiles in lieu of torpedoes, there may be SSBNs carrying a limited number of second-generation land attack cruise missiles in order to add diversity to their self-protection torpedo payload.

Whatever the eventual mix of weapons for the typical Soviet SSN, it is likely that there will be many permutations. Larger numbers of Northern Fleet submarines will be spared from the pro-SSBN mission for other operations. These can be grouped into several distinct categories in keeping with the historical development of the Atlantic and Arctic defense zones. Anti-surface warfare will be considerably strengthened with larger numbers of more versatile platforms in an expanded number of groups. Protective ASW will be provided in part by submarines. But the main ASW effort will be concentrated in specialist ASW groups in which coordinated ASW will be the dominant feature. It is unlikely that the Soviets will opt for independent ASW operations except for targets of opportunity and at choke points. When a detection is made, the Soviets are likely to use sledgehammer tactics instead of precise surgical attacks. A pattern of nuclear depth bombs may be the Soviet response to targets in inner zones or close to the ice edge. The new surface battle groups will be the keystone of surface operations. The first carrier battle groups will be available in the first half of the 1990s. With the CGNs and new destroyers, they will make NATO forays above 60 north less trouble free. The SSGNs and the Soviet Naval Air Force anti-surface carrier missile launches will be integrated more into coordinated strikes with these surface groups.

The Soviet aim is to form an Arctic defense zone above a line from southern Norway through the Shetlands to Cape Farewell into a Soviet lake. "Mare nostrum" is a term well-known to the Soviet Navy. Iceland and the whole of Norway could lie within this Soviet naval sphere of influence. This would be a natural and logical development of Soviet naval policy since they first perceived and articulated a serious threat to the Soviet homeland from nuclear armed carriers and POLARIS submarines.

It is unlikely that the Atlantic will see the extrusion of major surface forces from the

Norwegian Sea for wartime operations. Transits to Cuba and other surrogates in the south Atlantic will be commonplace, but they will not be part of any strategic deployment in the north Atlantic. Similarly, the Soviets will continue to use naval diplomacy as opportunities arise. The Soviet Northern Fleet Air Force may deploy to Cuba, Angola, and so on. But it is unlikely that overseas bases would be counted upon in wartime, except as expendable irritants to the West.

Although absolute numbers of submarines will decline, more are available for anti-SLOC in the northeastern and southwestern approaches, and off the coasts of the United States. In addition to the SLCM threat from nuclear submarines, the Soviets appreciate the value of diesel submarines in shallow water. If the United States seems to pressure the Soviet Union under the ice cap, the quid pro quo may be diesels in areas off the east coast where the U.S. Navy's deep ocean ASW configuration may have limited effect. The strategic significance of such deployments in terms of arms control leverage and the impact upon European cruise missile deployment may be exacerbated by the likely megatonnage of follow-on Soviet cruise missiles such as the SS-NX-24, but also larger successors to the SS-N-21 which could be fired from 65 cm torpedo cubes. Not only would this upset the strategic balance as currently conceived, based upon ICBM and SLBM numbers and throw weight, but also inject a new range of problems for the Strategic Defense Initiative (SDI). SDI will not be able to ignore the air breathing weapon, particularly if it can be carried in large numbers in 65 cm Soviet torpedo tubes in lieu of the larger-diameter torpedoes. The relatively small 53 cm diameter SS-N-21 may well have successors of a more troublesome complexion. However, the first practical problem for the U.S. Navy is to acquire a shallow water ASW capability and this may be at the expense of other systems.

The anti-SSBN mission in the Atlantic could become a more serious threat. More capable Soviet submarines released from pro-SSBN operations could be deployed in groups of two or three to destabilize Western SSBN operations. One can assume that current anti-SSBN operations have to be limited because of the low availability of front-line VICTOR III SSNs. There may therefore be an increasing requirement on Western SSBN operators to devise ever more rigorous deployment procedures, especially inside the 100 fathom line where Soviet barriers could possibly become effective.

The net effect of the above inroads by the Soviet Northern Fleet in SLCM deployments, anti-SSBN operations, pressure on the approaches from and to the SLOC terminals on both sides of the Atlantic, in addition to the strengthening of the Arctic area from the ice cap itself to the Skagerrak will be to stress U.S. Naval forces. The counter has to be measured and effective. A full forward strategy may well have a short term psychological impact upon the Soviets. But for the long term effect of keeping the Soviets tied down north of the North Cape, a thoroughly orchestrated program will be required. Piecemeal hardware programs will help, but are unlikely to provide a lasting solution. At the same time, under-ice operations may present insuperable environmental problems for the side which is locating, and ideal advantages for the side which is evading. In the high refraction environment of the Arctic, chance detections may become more commonplace as the acoustic advantage wanes. When range and bearing data become further distorted under the ice, a winning strike may have to be nuclear-tipped.

Anti-SSBN operations, tactics to support SSBNs, and the potential melees which are augured for under-ice patrols could lead to accidents, and therefore, possible crises. It may be on the anvil of experience that the U.S. Navy decides whether a full forward pressure strategy is viable.

Whether a breakthrough occurs in ASW technology remains to be seen. If the Soviets were to acquire a limited capability (for instance, in shallow water), the impact could be destabilizing since most of their Northern Fleet SSBNs could be under the ice and secure from the type of remote sensors described in open technical literature. There are no prizes for coming in second in naval warfare, and this is clearly the one major technical area in which the Soviets may concentrate considerable research efforts. The impact upon both pro and anti-SSBN operations in initial transit areas, not necessarily the deep ocean patrol areas, could be considerable. But this has to remain highly speculative for the time being.

CONCLUSIONS

Although there may not be any surges into the Atlantic by major surface units, the added confidence and capability attached to submarine operations may lead to a truly maritime strategy within the Arctic and Atlantic consistent with a combat option. This would assume that the Soviet high command believes that not only does the Northern Fleet adequately defend the homeland and fulfill its strategic mission, it also possesses reserves of capability that could be used to stress the West in a truly maritime rather than continental posture.

In the 1990s, the U.S. Navy's concept of "power projection" may be mirror-imaged by the Northern Fleet with simulated strikes against the Northern Flank, using cruise missiles, carrier support, and amphibious assault. Denmark and Iceland would be primary targets. Such operations would challenge the supremacy that NATO has enjoyed in the Norwegian and North Seas, thereby increasing pressure on the flanks of the NATO Central Front. Soviet strategy would be predicated upon gaining sea control. The essence of this would be the prevention of U.S. carrier battle groups and amphibious forces from penetrating the GIUK Gap, intense tactical ASW, and attacks upon NATO maritime air assets, command, control, and communications facilities, and extensive mining by aircraft and merchant ships. In other words, the Soviets' aim would be to maintain a line behind which they would have sea supremacy. The SSBN would be on station in the marginal ice zone and under the ice cap. A large proportion of SSNs currently employed on pro-SSBN duties would be used for sea control, operations against the shore, and anti-SSBN operations.

The land attack cruise missile adds a new dimension to Soviet maritime strategy in the Atlantic and Arctic. Furthermore, the Soviet SLCM presents complex arms control issues. The Soviets will acquire added flexibility to mix weapons in their 53 cm and 65 cm torpedo tubes, and to have multiple roles for their submarines. Soviet submarines deployed against crucial Western command, control, and communications and logistics sites may present a serious problem for ASW, especially in shallow waters. The quid pro quo for forward-deployed Western SSNs may be an increasing Soviet SLCM presence off the U.S. coast and harassment of deploying SSBNs.

Except for strategic ASW, the Soviet requirement for open ocean ASW is limited. They are likely to concentrate on transit and choke points, barriers, and protective ASW. Aggressive open ocean, anti-SSBN ASW has to be based upon a breakthrough in non-acoustic ASW. Should even a limited capability be possible, this might not only strengthen Soviet resolve to pursue a conventional option in its grand strategy, but also to pursue a new maritime strategy.

[This article is a digest of submarine-related sections of a paper authored by Anthony R. Wells and delivered at the CNA Sea Power Forum on November 14, 1985.]

THE MELEE

"Melee" is defined as a confused, general hand-to-hand fight, a rumble, a free-for-all, a dog fight, or a fire fight. Some tacticians and weapon system designers display little interest in the melee, since free-for-alls could be construed as tactical or technological failures. It is naive, however, to ignore the possibility of a melee in modern warfare. The history of conflict provides little basis for assuming that set-piece exchanges are more frequent or decisive than melees. Submarine warfare is not likely to provide the exception. New technology will not go uncountered in such a way as to permit our submarines to consistently detect, close, and attack an enemy submarine at secure ranges.

Naval weapon development in general, and submarine weapon development in particular, must address two, not necessarily complementary, conflict environments. The first to be considered is that of active military combat wherein the ability of the submarine to damage an opponent and survive is measured against the capabilities of the opponent. This environment will be understood by members of the Submarine League who served in World War II. The second conflict environment is characteristic of the post-World War II period; the ability of the submarine to fight and survive is measured not only against the abilities of the opponent, but also against the capabilities of other forces which compete for a share of the defense budget. This battleground lies in computer simulations; victories and defeats are judged in terms of cost effectiveness. While success in the battle for development and acquisition dollars is essential to sustain submarine force levels, the force should never lose sight of the realities of combat. Actual combat has the nasty habit of uncovering weaknesses not identified in the structured deliberations of weapon system analysts and developers.

Nuclear submarines have faired well in the competition for development and acquisition dollars. Their fighting platforms have an acknowledged capacity to survive, relative to surface and air platforms. This attribute has allowed the submarine force to concentrate on the development of weapons which will hurt the enemy rather than on weapons essential to self protection. The high point in this phase of development was the emergence of a new class of submarine, the Fleet Ballistic Missile Submarine. The nuclear attack submarine has exploited this same avenue, but not without complications. During the early post World War II years, prior to the emergence of the Soviet Union as a balanced naval power, the attack submarine was designed with emphasis on ASW. In support of this specialization, the attack submarine became a two-weapon ship: the MK 48 torpedo and the SUBROC missile for a standoff capability. Since the MK 48 had an anti-ship capability, the anti-surface mission was preserved. With the new emphasis on anti-submarine warfare, weapon storage capacity, launch rate and fire power were deemphasized, a pattern which has been carried forward through the SSN 688 class and haunts the submarine today.

New weapon technologies have lead the attack submarine force to add to its offensive weapon inventory. This new dimension has been realized primarily through the development of the compact, submerged-launch, cruise missile. The HARPOON anti-ship missile and the TOMAHAWK anti-ship and land attack missiles have been added to the submarine weapon options. The new weapons create not only an opportunity for submarines, but also a substantial weapon traffic jam. The effective use of these weapons requires a reemphasis on fire power which the evolutionary fire control system, the MK 117, and ASW oriented storage/launcher system have difficulty supporting. Current U.S. attack submarine development efforts are concentrating on getting the attack submarine out of the firepower bind. This focus is antagonistic to serious consideration of survivability in combat. If one or more new weapons might be considered essential to platform survival in combat, they may be rejected simply because they would further aggravate the firepower bind. Yet it is not in the long term interest of submarines to discount new possibilities.

Continued emphasis on offensive weapons may be justified in those cases where the attacker is considerably less vulnerable than its targets. Our submarines have been in that position relative to shore targets, surface targets, and even submarine targets for several decades. Our ability to sustain a significant edge over opposing submarines is strictly dependent upon technology and tactics. An intelligent opponent, one that acknowledges an initial technical disadvantage, say in platform quieting, will utilize every trick available to neutralize the other's advantage. Such an opponent is likely to work the problem backwards; for example, defeat the incoming weapon first, the supporting fire control system second, and then defeat the attacking platform.

The task of defeating an incoming weapon would also be worked backwards. In the case of an acoustic homing torpedo the logic would go as follows: defeat the warhead (tough hull), defeat the exploder, defeat the acoustic sensor (anti-reflective coatings), defeat the homing system (acoustic counter measures), defeat the delivery vehicle (speed and maneuver). Such measures may be effective singly or in combination. We should remember that during the early months of World War II many of our relatively unsophisticated torpedoes were self-defeating.

The technically disadvantaged opponent may also choose to operate two or more submarines in close tactical coordination. Such a measure was used by U.S. Navy fighters in actions against the Japanese Zero. Through such a step, the tactical options available to the disadvantaged players increase, while the options available to the initially advantaged player are decreased.

The objective of the disadvantaged player in working the attack problem backwards is to reduce combat to the level of a melee. When this goal appears to be gained, he will move on to select sensors and weapons that may be employed effectively within the melee environment. This logic parallels that of a street gang, typically composed of disadvantaged individuals. Such gangs thrive on rumbles and select their tactics and weapons accordingly. It should be noted that their weapons are simple, reliable, and close range. There are strong indications that our potential submarine opponent has addressed the submarine-versus-submarine combat problem in street gang fashion.

There is more than one route which would lead our submarines to engagement in a melee: the acoustic advantage enjoyed by one player might be wiped out by environmental anomalies; detection and counter-detection could take place within minutes at very short ranges; fast reaction would be required. Perhaps the most direct route to a submarine melee engagement lies in one of our "early generation" submarines meeting an opponent's "later generation" submarine. In such a case, neither vessel might enjoy an initial detection advantage. The ultimate advantage should fall to that submarine which had best prepared to handle a melee action.

There is an urgent requirement to provide our submarines, existing and new construction, with capabilities which will permit our forces to terminate a melee action with a victory. Any pretense that the present MK 117 fire control system and the MK 48 torpedo are sufficient to meet this objective is absurd. While it has never been the intention of the submarine weapon system developer or the tactician to place our submarines in a disadvantaged position, it is time to face that possibility, so that an initial disadvantage is not reduced to a permanent disadvantage. Now is the time for a Tactical Defense Initiative, a parallel to the present Strategic Defense Initiative.

As potentially disadvantaged players, our attack submarines must begin to work the attack problem backwards. They must learn to thrive upon and win in a melee. Can we defeat the warhead or exploder carried by an inbound torpedo? Not likely with our present hull configurations. Can we reduce the effectiveness of its active acoustic homing system? Perhaps. We can undoubtedly do better. Can we maneuver to a position outside the attack envelope of the torpedo? Our own maneuvering envelope is constrained. Quickening our responses would help. Our basic tactical objective must be to survive the first weapon salvo and then move to deliver a fast, crippling attack on the opponents engaged in the melee. It is in support of this objective that a new melee weapon is required.

An acoustic homing torpedo should only be considered in melee actions as a measure of last resort. Such weapons are relatively slow, can be countermeasured, and may represent an equal threat to the launching submarine when used at close range with rapidly changing attack geometries.

Ideally, a melee weapon would have the properties of a gun; simply aim and fire, fire, fire ... Fortunately, or unfortunately, underwater bullets, rockets, or lasers have a very limited range. The direct fire gun is not likely to serve as a useful option. An indirect fire scheme, however, might fulfill the melee function quite well. The indirect fire concept might utilize a short-range, SUBROC type rocket carrying a payload of distributed munitions. The munitions would be deployed in a pattern above the predicted position of the target submarine prior to water reentry. The technological key to this concept is a small munition capable of a vertical sink rate in excess of 100 knots to cripple the target submarine upon contact. The smaller the munition, the bigger the rocket's numerical payload; the larger the attack pattern, the higher the probability of hit. The choice of indirect fire has the advantage that the vertically running munitions will always be presented with the maximum target, the full length and breadth of a horizontally running submarine. Such a weapon would have no problem with mutual interference and could not be counter measured.

One concept does not provide a solid foundation for a viable melee weapon system. There are many issues and trade-offs to be considered. For example, can current sensor and fire control technology provide an accurate target position in a melee environment? What is the trade-off between weapon range, munitions payload, and probability of crippling the target? In short, the hard work remains to be done. It is, however, important that we get on with it.

John Leonard

SUBMARINE RESISTANCE TO NON-CONTACT EXPLOSIONS

A question of great interest to submariners is the degree of protection the Russian double-hull design provides against underwater explosions. It is certainly true that the farther one is from an explosion, the more likely one is to survive it. Yet it is not correct to impute a large degree of invulnerability to the fact that a torpedo warhead explodes a few feet away from a pressure hull, rather than in direct contact. This article offers some simple proofs of that statement.

In order to appreciate the problem, some knowledge of the explosion process is useful. High-explosives (HE) are oxygen-rich chemical compounds characterized by extremely rapid decomposition when suitably ignited. From the point of ignition, a detonation wave proceeds outward through the body of the material. It travels at a velocity greater than the speed of sound in the explosive. The significance of this fact is that since intelligence cannot be transmitted at a speed greater than sound in a solid, the unexploded material ahead of the detonation wave can have no knowledge of its approach, so to speak. (If it did, it would break up.) Behind the detonation wave, then, we have a mass of incandescent gas at high temperature and pressure; ahead of it, undisturbed explosive; and outside the explosive, undisturbed water.

At the explosive/water boundary, an enormous amount of energy just ... well, just "appears." "Enormous" is used advisedly. Temperatures are in the tens of thousands of degrees Kelvin, and pressures in the hundreds of thousands of psi. A shock wave is formed. This is a true shock -- with a rise time from zero to maximum pressure of less than a micro-second. For our purposes, we may safely ignore the physical chemistry that describes very high pressures in water, and just use the acoustical approximations. It happens that this is a conservative approach -- i.e., any conclusions we may draw will always be on the safe side.

Empirically, we know that the peak shock wave pressure is a product of pounds of equivalent-TNT (modern HE's have a TNT equivalence of about 1.5; i.e., 100# of modern HE = 150# of TNT) and standoff distance in feet. This product is adequately correct for charges ranging in weight from a few ounces to kilotons.

As a function of time, the peak pressure decays exponentially as shown in Figure 1.

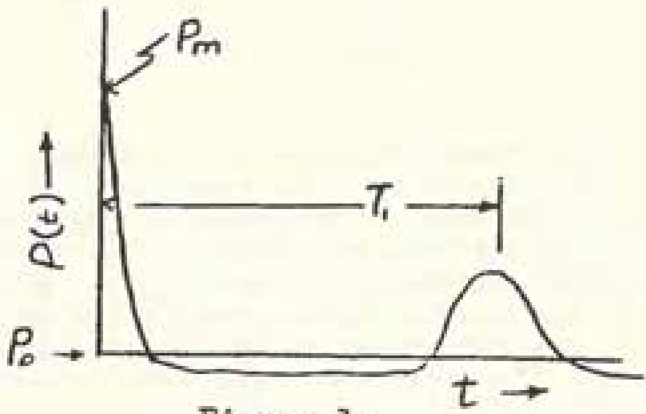


Figure 1.

The "tail" of the curve will be discussed later.

Po is hydrostatic pressure
Pm is peak pressure
T1 is time of first bubble pulse

The actual pressure experienced by a submerged target from a reasonably-distant non-contact explosion (from a mine, a depth charge, an atomic depth bomb, etc.) is modified by the presence of the ocean surface. Figure 2 shows the geometry:

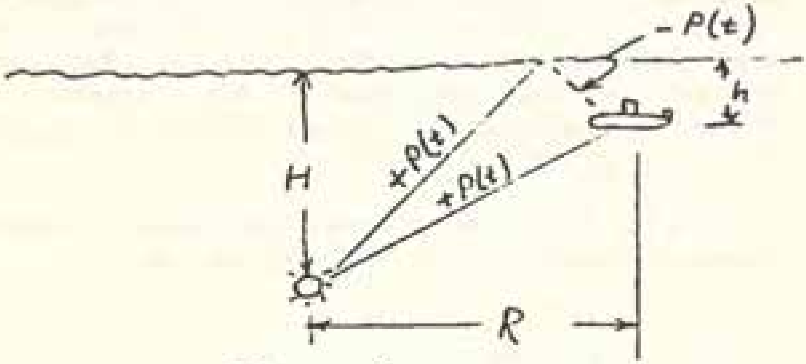


Figure 2

The target "sees" the incident shock wave, P(t), shown in Figure 2. The shock that hits the surface, however, is reflected as a rarefaction, -P(t), which effectively cancels +P(t) after what is called the "cut-off time, t_{co}", which is simply the interval between the arrival of +P(t) and -P(t) at the target and is measured in micro-seconds. The resultant shock wave history looks like this:

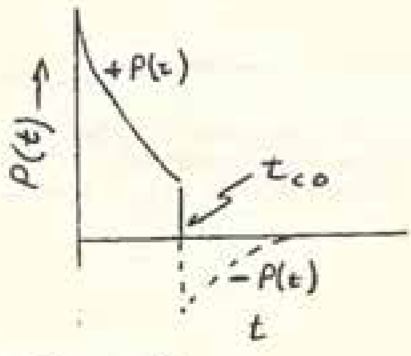


Figure 3

This shows that a submarine is better off shallow than deep since cut-off time increases directly with depth. Barring other disadvantages, surfaced is best. We must note, however, that for the geometry we are considering here (explosion against an outer skin), the cut-off phenomenon is of only academic interest.

Now to the tail of Figure 1. The departure of the shock wave leaves behind a sphere of hot gas at very high pressure. It expands rapidly; so rapidly, in fact, that its momentum carries it past the point where its internal pressure equals the hydrostatic pressure. Naturally, it contracts; and again overshoots the hydrostatic pressure, P_o, emitting a pressure pulse -- not a shock -- at time T_1. This is called the "first bubble pulse," and while its maximum pressure is typically 25% of P_m, it is significant that the area under the curve, the "impulse," may exceed the area under the shock wave itself. Except at very shallow charge depth, there is more than one bubble pulsation.

Finally, we know that the bubble migrates upward between pulsations a distance roughly equal to its maximum radius. This fact leads one immediately to the speculation that it should be possible to "tune" an under-keel warhead to a specific target. Specifically, one should be able to size the weight and to establish the charge's depth below the keel in such a way that the first bubble pulse will be emitted practically at the target keel; and further, T_1 could be synchronous with the fundamental period of hull flexure. This is an absolutely devastating form af attack, against which no defense is known. Indeed, the notion has intrigued weapons designers for most of this century. It is quite possible to tune warheads in this way, and you might enjoy the exercise of doing it for a target with a draft of, say, 30 feet, and a fundamental period of 0.75 seconds. As a practical matter, of course, it would be unwise to carry a shipload of torpedoes, each tuned to a specific class of ship.

We come back now to the relative vulnerability of the double-hulled submarine. It is true that a torpedo warhead exploding a few feet from the pressure hull may not blow a hole in the hull. My statement, however, is that any respectable warhead a few feet away will leave the interior of the boat (including ship's force) in a shambles.

To justify this statement, we present the term called "Shock Factor (SF)." SF is an interesting parameter. One way to regard it is as a measure of the energy density per square foot of pressure hull; specifically, SF = Constant $(Energy)^{1/2}$; but a more useful and informative way is to look at it as a measure of the velocity of the pressure hull due to the impact of the shock wave. This quantity is known as the "take-off velocity" or the "Taylor Plate Velocity," after Sir Geoffrey Taylor, who published it a few decades ago. Calculation of this velocity, V_m, is too tedious for this article, but it involves all the right things: the peak pressure; charge weight; standoff range; a time constant; and the mass per square foot of the hull. It is not surprising that this velocity is equal (very nearly) to some constant times the "shock factor" for a given hull thickness. For instance, for a 3" hull, V_m = 90 x SF; for a 2" hull, V_m = 108 x SF; and for a 1" hull, V_m = 138 x SF, the same for mild steel and HY-80. For a titanium hull of the same thickness, V_m is greater than it is for steel. Put another way, for a given charge geometry, there will be more shock damage inside a titanium hull than there will be inside a HY-80 hull of the same geometry. For two such 3" hulls, V_m (or the effective Shock Factor) will be 28% higher for the titanium hull.

The next step in examining explosive damage to double-hulled subs is to propose and describe two different modes of material behavior. The first of these I will call "plastic" behavior, and HY-80 typifies it. If your boat has a test depth of, say, 1000 feet, and circumstances force you to 1300 feet, you are not in real danger. The second type of behavior I choose to call "brittle," and a piece of blackboard chalk demonstrates what this is. If you bend a piece of chalk between your thumbs and forefingers, nothing happens until you get to a certain point. Then the chalk snaps; suddenly, completely, and without warning. Shock behavior is like that. Everything we know about equipment undergoing shock loading says that most of it is "brittle;" everything is fine up to a certain point. Just a little past that point, and things snap.

The Shock Factors to which we design submarine fittings and equipment are classified, but that need not deter us. Shock acceptance testing is controlled by a Navy MIL-Spec. It requires that equipment weighing over about 6000# be explosively tested in a floating shock test vehicle, the most severe test being the explosion of a 60# charge, depth 24', standoff range 20'. The MIL-Spec does not specify the material of the explosive. To be conservative, I have assumed it to be the modern 60# high-explosive to be the equivalent of 90# of TNT. For this explosive the Shock Factor is .47. If you accept shock loading as leading to "brittle" behavior, you will agree that at Shock Factors not very much higher than 0.47, undesirable things will happen.

The Table below needs some explanation. To get back from the theoretical to the real world, I have chosen two charges of nominal warhead size: 100# (150# TNT equivalent), and 500# (750# TNT), and two stand-off distances -- 6 feet and 12 feet. These latter were picked because "Jane's," 1984, gives the separation between the inner and outer hulls as "possibly six feet" for the TYPHOON class, and as "ten or more feet" for the OSCAR class. The first two targets as tested, have a Shock Factor of 0.47. The next four targets represent two different warheads at two different stand-off distances.

TABLE 1

Target	#s of TNT	Standoff range in feet	Max Pressure psi	Hull Velocity	Shock Factor
1	150	26	3591	41.3	0.47
2	750	58	2659	39.4	0.47
3	150	12	8603	91.0	1.02
4	150	6	18828	184.1	2.04
5	750	12	15773	202.9	2.28
6	750	6	34521	415.0	4.56

Now, it would be nice to be able to say that Targets 1 and 2 above, are "safe," and Targets 3 - 6 are not; but nothing is that neat in the underwater explosion business. For one thing, only about 1% of the volume of Target #4 actually experiences a test Shock Factor as low as 0.47. For Targets 4-6, somewhere between 5 and 10% of the target volume experiences a Shock Factor greater than .47. These facts lend emphasis to the intuitive feeling that it is better to attack the Engine Room than the Crew's Mess.

As a generalization, however, it is reasonable to say that Target #3 is going to need several minutes (at least) before that target is in any shape to return torpedo fire. Targets #4 and 5 are going to have trouble making it to the surface, and are very likely to be in need of a tow -- if they get there. Target #6 can be written off.

To sum up, it is correct that an outer hull affords some degree of protection; but it can be nullified by large warheads. In any event, it ought not to be exaggerated.

VADM Robert Gooding, USN(Ret.)

THE LAW OF THE SEA AND SUBMARINES

The United Nations Convention on the Law of the Sea was completed in December 1982 and is now ready for ratification. This Treaty may not ultimately enter into force. But, since it was arrived at by consensus, the Treaty is bound to influence or indeed come to represent customary international law. In fact, the Treaty is already cited by the International Court of Justice. Thus, how it will affect U.S. submarine operations should be understood, even though the United States (along with a very few other states) elected not to be a party to the Treaty. And, by reviewing the history of the law of the sea, it can be speculated as to the effect of the new Treaty on U.S. submarines.

Necessarily, what follows is a simplification -- a layman's perspective -- and should not be regarded as authoritative.

Prior to World War II there were, essentially, two legally defined parts of the seas: the High Seas and the Territorial Sea. Because of the Truman Proclamations of 1945, the 1958 Conventions on the seas included two other sea areas -- the Continental Shelf and what is now termed the exclusive "Economic Zone," which involves fishing and conservation of the living resources in this sea area. The 1982 Convention then added two more spheres of interest, one for Straits and the other for the "Area" of the seabed beyond the limits of national jurisdiction, i.e., the floor of the High Seas. For submariners, only the High Seas, the Territorial Sea, and the Straits areas are of particular concern.

The High Seas

The High Seas are all parts of the seas outside of the Territorial Sea or bodies of waters within states. There is no sovereignty over any part of the High Seas, but vessels using the High Seas are sovereign territory of the flag they fly. Among the traditional high seas freedoms are the freedoms of navigation and overflight. "Freedom of navigation" has historically included the right of submerged movement of submarines.

The creation of an "exclusive" Economic Zone out to 200 nautical miles from a coastal state -- by the 1982 Treaty -- involves about one-third of the high seas but does not affect the freedom of navigation. It remains to be seen, however, whether some coastal states will attempt to encroach on freedom of navigation by expanding, or attempting to expand, their jurisdiction in this exclusive economic zone.

The Territorial Sea

In the Territorial Sea the coastal state has all but absolute sovereignty. It is in effect an extension of the land itself. The right of passage of foreign vessels within another state's territorial sea is restricted to "innocent passage," which, for submarines, means that when in another's territorial sea they must travel on the surface and display their own flag.

Sovereignty over a territorial sea is universally accepted in international law. However, the breadth of the territorial sea has resisted legal definition. The earliest limits used the range of an 18th Century cannon to measure the breadth of the territorial sea. This was gradually equated to one marine league or 3 nautical miles. On November 8, 1793, the United States adopted the 3-mile limit. It is fair to say that the 3-mile limit was generally, though not universally, accepted up to about World War II.

The 1958 Convention on the Territorial Sea did not set a limit on the Territorial Sea. But it did recognize a "Contiguous Zone," not to extend beyond 12 miles from the coast. In this zone, a coastal state could take measures to prevent or punish infringements of its customs, fiscal, immigration or sanitary laws and regulations within the territorial sea. Thus it is a type of "hot pursuit" zone or buffer zone, into which a nation's jurisdiction extends for these purposes.

In 1960 the Soviet Union set the breadth of its territorial sea at 12 miles. By 1979, 76 nations claimed or accepted 12 miles, and 25 more recognized limits beyond 12 miles. Only 23 states, including the United States, recognized 3 miles.

In any event, the 1982 Treaty set the breadth of the territorial sea as 12 nautical miles, and continued the requirement for surface navigation of submarines while in the territorial sea. The Treaty also extended the contiguous/hot pursuit zone to 24 nautical miles, or 12 miles beyond the territorial sea.

But what of passage in straits? With a 12-mile limit, reportedly some 116 straits may lawfully be territorialized and available to foreign submarines only under the limited right of innocent passage -- i.e., transit on the surface.

The present treaty, however, purports to take care of that with a new straits regime and its concept of "transit passage."

Straits Used in International Navigation

Prior to 1982 there was a general recognition in international law that transit through straits connecting portions of the high seas was a right of any nation. Special treaties, of course, governed the passage through certain straits, e.g. the Turkish strait, the Danish strait, the Strait of Magellan. Significantly, no treaty covers the Strait of Gibraltar. The United States -- for straits greater than 6 miles in breadth -- could always claim a "high seas" component in the strait with its attendant "freedom of navigation," i.e., submerged right of transit. The 1982 Treaty, to compensate for a 12-mile territorial sea limit at the same time preserved the right of passage through straits used in international navigation by establishing a new regime defined as "transit passage."

The 1982 Treaty recognizes four types of straits:

1. Straits whose passage has been regulated by long-standing international conventions in force, like the Turkish, Danish and Magellan straits, where it was deemed better to continue the existing legal agreements than to apply new rules.

2. Straits which can be transited by remaining in the High Seas area at all times. In such corridors, high seas freedom of navigation persists.

3. Straits which are used for international navigation between one part of the high sea or an exclusive economic zone and another part of the high seas or an exclusive economic zone. These "straits" compose a great bulk of straits used in international navigation. For such straits "transit passage" implies the rights of freedom of navigation and overflight, solely for the purpose of continuous and expeditious passage. Any

reference to surface navigation by submarines are omitted while a carefully worded subsection of the Treaty only calls upon ships in "transit passage" to refrain from activities other than those incident to their normal modes of expeditious transit.

The use of the words "freedom of navigation" in the definition of "transit passage," and a "normal mode" provision, form the basis for the right of submerged transit by submarines of straits used for international navigation.

The carrying out of any research or survey activities during transit passage is prohibited without the prior authorization of the States bordering straits. Strait states may designate sea lanes and traffic separation schemes where necessary and may adopt laws and regulations relating to transit passage in respect to pollution control, fishing, etc.. Such regulations must not however hamper or suspend the right of transit passage. Strait states must give appropriate publicity to any danger to navigation or overflight within or over the strait.

4. The fourth category of straits have no right of "transit passage." Submarines have only the right of "non-suspendable innocent passage," i.e., surface transit. Such straits are the "island exception" straits, where the waters of the strait lie between the mainland and an island of a single state, and an equally convenient route exists seaward of the island. An example is the Strait of Messina, between the Italian mainland and Sicily. Since ships can easily go around Sicily in high seas waters, the conference felt that there was no need to preserve more than a right of non-suspendable innocent passage through such a strait. Similarly, only innocent passage applies to straits connecting the high seas to a territorial sea.

In the development of the 1982 Treaty, Spain and a group of strait States tried to amend the text to require surface transit of submarines -- evidence that opposing states understood that the text permits submerged transit. It seems clear that the 12-mile limit and the transit passage provisions go hand in hand and that the United States, the Soviet Union, or the other maritime nations would never have agreed to one without the other.

It is this author's view that the present Law of the Sea Treaty compensates for the expansion of territorial sea limits by providing special rules for straits that preserve the traditional high seas freedom of navigation for most straits that connect the high seas.

So What?

While this writer personally regrets the U.S. decision not to sign the Treaty, the fact is, that it does not seem that dire consequences will follow. The 12-mile limit is now customary international law and in practice the U.S. observes it. Since the rights of "transit passage" are given to "all states," the U.S. benefits from the Treaty's rules despite not being a party to the Treaty. In addition, the rights and duties of innocent passage are probably an improvement over previous conventions. With the Soviet Union and other maritime nations insisting on adherence to the new straits regime, the U.S. will benefit. In the event of selective discrimination by littoral states against the U.S., the U.S. can still argue for the right of freedom of navigation based on traditional practice. Practically, most of the strait states either lack the capability to detect submerged submarines, or, if friendly, tend to ignore such transits -- in contrast to overflights.

What the United States does give up is the availability of a forum in which to vindicate its rights. The Treaty's dispute-resolution mechanisms include compulsory third party adjudication, conciliation procedures, etc., available only to, and between, States who are parties to the Treaty. So what happens if Spain or Morocco, who acceded to the straits rules as defined in the Treaty, now say to the U.S., "Why should I let you transit what are now my territorial waters when you, the United States, have not accepted the other obligations of the Treaty?" For such a case, the U.S. may have to resort to the use of the threat of force to insure passage of its ships or aircraft.

In summary, while there is likely to be only limited immediate effect from U.S. nonparticipation in the Treaty -- as a matter of law -- the U.S. has traded certainty for continuing uncertainty, and has excluded itself from the mechanisms available to resolve the uncertainties.

L.T.U.

NEW SUBMARINE POWER PLANTS

[Ed note. In the Foreword to Jane's Fighting Ships, 1985-1986, the editor, Captain John Moore, indicates that the Soviets have a new form of submarine propulsion in recently launched new types: "In some cases, those with MHD (magnetohydrodynamic) or EMT (electromagnetic) propulsion, there will be no need for propellers or pump jet, both of which are liable to damage particularly under ice, and both of which emit radiated noise. As well as increased speed, these developments would decrease the sonic signature and could have an effect on the magnetic signature." Later in his Foreward, Captain Moore discusses "the nine-metre pod" which rises above the stern of several new types of Soviet submarines. He suggests that the pod might contain "a form of auxiliary silent propulsion of the MHD variety," (which uses superconducting magnets). He also states that; "There is evidence that the 'ALFA' class and 'OSCAR' class use a form of superconductivity and it is unlikely that this is for anything other than propulsion." In order to understand Captain Moore's assumptions, as noted above, a search was made for past Soviet articles which might relate to such propulsion systems. The article which follows sheds some light on this subject. Later articles in the Soviet press also expanded on the themes of this article, with one showing an electromagnetic propulsion system which resembled, somewhat, the present pods as observed on the new submarines.]

THE ARTICLE

Since the first submarine was built, designers have continually endeavored to increase the cruising speed and the depth of dive, and to reduce the level of noise of the power plants... . The problem, of course, is a considerable one. Experts of a number of countries consider its solution to lie in development of power plants which are new in principle. Particular attention is directed to electromagnetic ram jet engines, which operate on the principle of creation of a jet stream generated by electromagnetic forces.

Such a power plant is interesting in that, as noted by foreign experts, it has substantial advantages. It is significantly more powerful, which in turn permits higher speeds and greater displacement for submarines. The level of vibration is reduced; there is a substantial decrease in the noise of operation of the power plant because of the absence of the traditional bladed propeller; and there is a reduction in the number of moving parts of the mechanical and electrical systems.

But the main advantage is that in the new power plant there are combined to a certain degree a motor (a machine which converts some type of energy into mechanical work, for example a rotating shaft) and a propelling agent (a device for converting the energy of the motor into work expended in overcoming the resistance to motion of the submarine.)

The idea, as may be seen, is intriguing. But how realistic is it?

In 1962, accounts were published in the foreign press of an electromagnetic engine designed by American expert Wayne M. Philips; adaptable to a submarine 200 meters in length and capable of variable speeds.

In 1964 P.A. Dorakh published the accounts of research in which he asserted that knowledge in the field of magnetism and phenomena of superconductivity makes it possible to improve the tactical-technical capabilities of electromagnetic engines to the extent that they can be used as a propelling agent for submarines. Dorakh illustrated his demonstration with a diagram of an electromagnetic motor developed by Engineer S. Bey.

Later the first practical strides were made in this direction. In 1966 the mechanical engineering department of the University of California built and tested a model submarine (3.05 meters in length, 0.45 meters in diameter, and weighing 408 kg) with an EMS-1 electromagnetic motor. As an electrical source a lead-acid storage battery is used (with a weight of 150 kg). In tests the model achieved speeds of more than 1 knot.

It should be noted, however, that the idea of a ram jet engine is not all that new. As early as 1661 the English inventors Tolgood and Hayes patented a vessel design in which the "pusher" was a pump device. It was the forerunner of modern water drive engines. In 1738 the Russian academician Daniel Bernoulli wrote his work "Hydrodynamics," in which he expounded the theoretical basis of reaction of a jet of water for propelling a vessel. Utilization of hydrojet engines for submarines was first proposed in Russia in 1880 by long range navigator Captain I. S. Lostevich and a mechanic of the Izhorskiy Plant, F. Ye. Korichia.

There are several projects underway abroad to develop electromagnetic ram jet engines for submarines.

One of the more simple planned designs is a model with a bi-polar system of direct current with an external pole. In it a magnetic pole is created by the coils of an electromagnet. The threads of the coil are placed inside the hull of the submarine in a horizontal position. On them, along the right and left sides, are placed conducting electrodes, which are in direct contact with sea water. As a result, on each of the elementary volumes of water surrounding the boat there are resultant magnetic forces and electrical fields (Lorenz fields). They seek to drive the water to the rear along the longitudinal axis of the boat's hull, which forces it to move forward. But the efficiency of the work of such an engine depends on the magnetic field and the electric conductivity of the sea water, which is many times less than that of metallic conductors.

This deficiency, it is noted by foreign experts, is not present in the induction electromagnetic ram jet propelling device of the initial type. In the latter, an electric current is induced not in sea water, but rather in an intermediate highly conductive liquid (a liquid metal). Here great force is generated, which is used in creating a jet of sea water. The role of converter is played by a flexible membrane. Such a propelling device could be called an electromagnetic water jet. However, its design is technically complex because of the necessity to transmit great force from a layer of liquid metal to the sea water by means of the flexible membrane.

An attempt was made to avoid these shortcomings in the electromagnetic ram jet propeller in a project conducted by H. Albert and E. Zhako (of Michigan University). The authors created a self-propelled model of a noiseless submarine, without bladed propellers or a rudder .

The model is set in motion by forces generated as a result of fluctuations in the external casing of the hull. In other words, the biotechnical principle is used to create motive power. A similar method of movement through water is used by some marine animals, particularly by skates. Their motive power is generated by pulsations and a unique displacement of wave profiles along their elastic fins.

As applied to submarines, this principle of motion is called a "skin motor." It consists of the fact that movement and control of the model are accomplished by means of a special external flexible casing, which creates fluctuations in the form of progressive waves, which run along the hull on the side of the stern extremity of the model. The fluctuations are generated by means of a series of electromagnetic rings placed along the flexible casing of the hull on its internal side.

Upon a change of direction of the electric current around the electromagnetic rings, the external casing is subjected to the influence at first of radial forces from their center, and then to opposite pulling forces. This process is so distributed in time that it creates a progressive running wave, which insures the necessary stresses for movement of the boat.

A propellant device of this type can serve simultaneously as a means of control; that is, to change the course of the submarine vessel and to accomplish dives and surfacing.

In the opinion of foreign specialists, the application of electromagnetic ram jet propellant systems of various types of submarines and on large-tonnage submarine transport vessels will result in overcoming a number of technical problems, which according to them are deterring further developments and improvements in the tactical-technical characteristics of submarine vessels.

[This article by CAPT-Lt (Res) A. Popov, SUBMARINES and.....SEA SKATES was published in KRASNAYA ZVEZDA in Russian, 11 August, 1974.]

VIEWING A SUBMARINE MISSILE-LAUNCH

The countdown for the GEORGE WASHINGTON CARVER's qualification test firing of a ballistic missile began at 2200 on Friday, August 9, 1985. As noted in an earlier Submarine Review, such firings can be viewed from the range ship which monitors these missile demonstrations. Consequently, two hundred and forty invited guests were on hand next morning to board the USNS RANGE SENTINEL for the viewing at sea, of a POSEIDON C-3 missile launch from the SSBN 656 -- the GEORGE WASHINGTON CARVER -- in its shakedown operations.

At 0815 -- T-240:00 and counting -- the GEORGE WASHINGTON CARVER was hauled from her pier and out into midchannel by two tugs. From there a harbor pilot guided her exit to the open ocean. The RANGE SENTINEL, 15 minutes behind, followed the CARVER towards a 300 fathom spot in the ocean, 55 miles off Cape Canaveral.

The SSBN was in the fourth phase of her qualification-handling and firing of a ballistic missile. In Phase I, the missile with a non-nuclear warhead was loaded aboard. In Phase II, the "prep" sequence was begun. This gave the crew 10 days to refit and effect preventive maintenance on the missile and its allied equipment. Then Phase III was begun -- first with two days in port then with five at sea. During this period 80 "faults" within four to six countdowns per day, were pumped into the system to test the crew's readiness to handle virtually every imaginable emergency. A "fault" might be: a missile hatch which fails to open; a loss of "spin up" power on the missile's navigation system; a shut down of a computer; loss of ship control due to a trim pump failure; etc. With the successful handling of these "faults" the SSBN moved into Phase IV, the Launch Phase. This is the certification phase -- that proves the submarines' capability to verify the quality and performance of the missile through preliminary tests and then to get it away and flying to its full range to a specific target position.

At T-30:00 and counting, the RANGE SENTINEL is gliding into gentle swells, two miles off the starboard quarter of the GEORGE WASHINGTON CARVER. A blistering-hot sun and masses of white cumulus clouds overhead promise ideal conditions for the missile launch. But launch must be made in all-weather conditions once the countdown has started. Sea conditions cannot be a major factor for scrubbing the mission. So, the spectators expectantly line the port-side rail of the range ship to observe the GEORGE WASHINGTON CARVER easing under the sea, first to get a good trim, then to remain motionless and balanced under the surface of the ocean. But the sub's telemetry mast remains out of the water.

The man "conning" the submarine is not its skipper, but rather is the Assistant for FBM

Operations, Test and Evaluation of the Navy's Strategic Systems Program Office in Washington. His presence for all such ballistic missile tests during the 10-day countdown is mandatory.

Helicopters from nearby Patrick Air Force Base scour the area around the submerged submarine to spot and chase away any boats close to the launch position. Missing from the scene are the usually present Soviet trawlers that constantly try to monitor our submarine operations. When word comes from the two helo crews that the area is all clear, they head westward back to Patrick.

At T-10:00 and counting, way down range, two planes high above the test area are ready to track the POSEIDON missile when it is airborne. Eastern Test Range transmits their "Clear to launch" directive. With two minutes to launch all systems are "go." At T-1:30 a "Permission to fire" is given by the "man from Washington." Aboard the range ship cameras and binoculars are at the ready. The loudspeaker on the RANGE SENTINEL breaks the silence: "Ten . . . nine . . . eight." The launch is certain. "Four ...three ... two ... one ... IGNITION." With that a huge 34-foot, 65,000 pound POSEIDON C-3 breaks the water -- gas ejected from its launch tube. Once clear of the water's surface, the missile's first stage rocket motor ignites into a maze of orange, white and red. The missile's data system is now functioning.

Shortly, the only evidence of the C-3 in flight is the trail of white smoke rising miles above the submerged submarine. Within 15 seconds, a shock wave of sound generated by the light-off of the booster hits our ears. The sea around the telemetry mast -- still jutting above the water -- is sea-green mixed with white disturbed foam, the product of the gasses ejected from the submarine's missile tube.

About ten minutes later we hear the announcement over the public address system that, "The missile is running hot, straight and normal" -- as though we're still in the age of straight running steam torpedoes. After a few more minutes, the GEORGE WASHINGTON CARVER slowly surfaces, then heads back to base. RANGE SENTINEL takes up position one mile astern of the submarine and follows her home. At 1715 the evolution is completed as both ships are docked. Final word is that the missile launch was perfect and the missile hit its mark down range.

This is the best proof of the deterrence value of our strategic nuclear weapons. They work, and they're ready to be launched by a weapon system that can't be destroyed before firing. And that's why an enemy isn't likely to use his missiles first, and why "nuclear war deterrence" should become a dinosaur in the English language.

Larry Blair

[Ed note: U.S. citizens may witness such a submarine ballistic missile launch by contacting Ms. Pat Hicks, Public Relations Director, COMSUBGRU 6, NOTU Cape Canaveral, Florida 32920. Phone (305) 853-7971.]

NUCLEAR SUBMARINE OFFICER PROGRAM MANAGEMENT

1985 marked a change in direction in the management of the nuclear submarine officer community. New measures were called for to effect the improvements in accession and retention necessary to support the growing nuclear submarine force. In particular, the program had to address the shortages of experienced (O-4 to O-6) nuclear officers and post-command submarine officers.

It was determined that an innovative approach had to be taken to permanently fix these problems.

This solution would encompass the following:

- A more effective submarine officer career development path.
- A new approach in management of existing personnel assets.
- Enhancements to Nuclear Officer Incentive Pay.

Refinement of the career development path resulted in the "split department head" concept. Under this plan most officers will serve two department head tours, each about two years in duration. For example, an officer might be Engineer Officer on an SSBN for two years and then become Navigator/Operations Officer on an SSN. This program is in effect and promises to vastly improve the experience level across the full spectrum of submarine warfare of our officers before their XO and CO assignments. The enthusiastic response to this plan from our officers is a clear indicator of the positive effect that this will have on our community health.

The larger accessions during the 1980s will allow virtually every junior officer assignment ashore after his first sea tour. The opportunities for personal and professional development at postgraduate school, instructor duty at Nuclear Power School, prototype, and submarine training facilities, as well as Washington and staff duty will reinforce the overall capability and experience level of our officer corps.

Nuclear Officer incentive pay which was last raised in 1981, had proven its value in retaining junior officers. But this incentive pay had eroded in value and did relatively little to address the severe shortages of experienced and post-command officers. A program was therefore developed that not only increases the value of the incentive pay (with built-in provisions for further increases should that be necessary), but addresses the entire nuclear officer community from new accessions to the critically needed post-command officers. Highlights of the new Nuclear Officer Incentive Pay program are:

- Multiple Continuation Pay Contracts (3, 4, or 5 yrs) to 26 years. Such pay to be raised from $7000 to $9000 per year.

- Annual Incentive Bonus to be raised from $6000 to $7200 per year ($3600 for LDO/WO) and no longer billet dependent.

- Accession Bonus is paid with $4000 upon acceptance, and $2000 upon completion of training (vice the previous split of $3000 and $3000).

Additionally, Submarine Pay has been improved such that it does not decrease after 18 years of service.

This program, which has been included in the FY-86 Defense Authorization Act, will provide us the tools to help solve our officer inventory problems today as well as the flexibility to prevent recurrence of these problems in the future.

I am convinced that this course will mitigate some of the problems in officer inventory management that we have faced for so long. We can build on the positive effects of an exciting career development path coupled with improved compensation to develop a more capable and experienced submarine force officer corps to serve the United States for many decades to come.

CAPT H. C. McKinney, USN

THE FUEL CELL SUBMARINE

Many will argue that the U.S. needs 130 or more attack submarines to meet the present Soviet naval threat -- and Secretary Lehman stated this need recently before a Congressional committee. Today, 96 U.S. SSNs are confronted by a Soviet force of nearly 300 attack submarines, so additional numbers of U.S. attack boats is certainly logical. The low-cost way to acquire efficient subs, in addition to the 100 SSNs programmed by the U.S. Navy, seems better directed towards fuel cell powered submarines than modern diesels. At one-fourth the cost of a new SSN, the fuel cell submarine offers a far more practical, expendable, quiet, and long submerged endurance -- yet limited capability -- approach to meeting the Soviet threat, particularly: under the ice, in shallow waters, in defense of homeland waters and offensively in sea areas where a concentration of several submarines tend to be more effective than a single high-quality nuclear submarine.

In effect, fuel cell power either drives the submarine directly through a d.c. motor or it stores electrical energy in a battery system which can augment the fuel cell's electrical output -- for high speed submerged operations. It's like a diesel-electric submarine, but it is far better adapted for today's naval threats.

Why this power system is practical today, how it works, and what its potential is for future operations are the ingredients of this article. That a fuel cell submarine can't compete with a nuclear-powered SSN for most of the submarine jobs, is understood. But as a solution to greatly increased numbers of useful attack submarines in an environment of belt-tightened budgets, it appears attractive.

Background

Fuel cells have been, and are being, used extensively in the NASA manned space flight programs. The United States Army employs fuel cells as portable field power units. American power companies such as Consolidated Edison are operating fuel cell plants which can generate 4.8 megawatts of power -- or enough electricity for 2,000 customers. Telephone companies use smaller, 40-kilowat fuel cell plants which generate power for their telephone electric switching equipment. And, many East coast utility industries have invested over $200 million since 1980 on 50 fuel cell units to power apartment buildings, offices, and factories in order to lessen the dependence on centrally situated power plants.

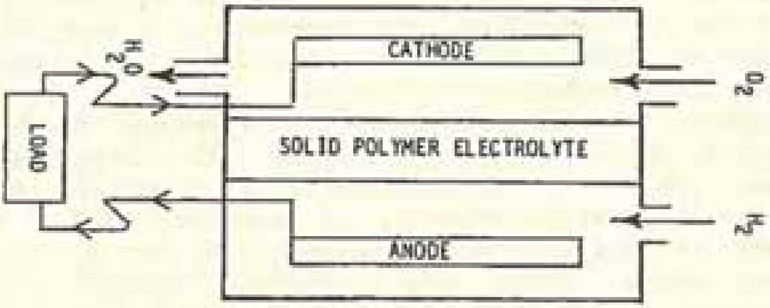
<u>How the Fuel Cell Power System Works</u>

A fuel cell power system generates hydrogen and oxygen in a "reformer," from stored hydrogen peroxide and JP-5 aviation fuel. The hydrogen and oxygen produced then passes through fuel cells which power a d-c propulsion motor. There are three types of hydrogen and oxygen generating systems which the Western nations see as feasible for use in submarines. One operates on a chemical reaction that utilizes boron hydride. A second uses the principle of hydrolysis. While a third operates on the principle of reforming hydrocarbons into hydrogen and oxygen. The latter has been used in a 1981 Massachusetts Institute of Technology design study and is described here as a feasible and safe way of producing H_2 and O_2 for fuel cells. This uses a reformer system that utilizes hydrogen peroxide (H_2O_2) and marine JP-5 distillate fuel. The important feature of this fuel cell system is the emphasis on the safe handling feature of the H_2O_2 solution.

The important reason for an H_2 and O_2 "reformer" generator is that it does not require noisy internal combustion to produce power. Pollutants are not emitted nor is there a requirement for moving parts. Collectively, these characteristics produce a very low acoustic signature -- highly desired in a submarine propulsion system which is estimated to provide power conversion at efficiencies of 40 to 70 percent.

The fuel cell resembles a large battery that can be constantly recharged. A simplified diagram of one of these "batteries" is shown. During operation, the anode side of the fuel cell is bathed with hydrogen-rich gas or pure hydrogen, while oxygen bathes the cathode side. The electro-chemical reactions as the two gases pass by a solid polymer electrolyte are shown. The useful product of the chemical reaction is a very high direct current flow of electrons between the electrodes and through the dc propulsion motor circuits of the submarine or to the sub's batteries. The reaction product in a fuel cell is pure water.

FUEL CELL



Anode.. $2H_2 \rightarrow 4H^+ + 4e^-$

Cathode.....$4e^- + 4H^+ + O_2 \rightarrow 2H_2O$

Over All....$2H_2 + O_2 \rightarrow 2H_2O$

Several fuel cells can be physically arranged into modular stacks. The stacked fuel cells are connected to the propulsion motor circuits in series to provide the desired voltage output levels. They can also be parallel-connected to obtain the required current or power levels. Computer controlled switchers and rheostat circuits are then used to make the series-parallel electrical connections and to control the speed of the propulsion motor. These circuits and fuel cell stacks, in essence, form an efficient power-generation matrix.

The "reformer" part of the fuel cell propulsion system generates the hydrogen and oxygen gases for the fuel cells. Figure 1 is a simplified diagram of the reformer used in the MIT study. The hydrogen peroxide solution is fed to a "decomposer." The "decomposer" is a catalytic device made of a silver palladium screen pack. This device decomposes the H_2O_2 solution to make steam and oxygen. These products are "cooled" and then the oxygen is extracted from the water by a "separator" unit. The water is sent to holding ballast tanks or pumped overboard, while the oxygen is directed to the fuel cells or to the internal atmosphere control system of the submarine for life support. The heat from the steam being cooled by the oxygen "cooler" unit is used to "heat" the JP-5 distillate prior to its injection into a "converter." The "converter" is another catalytic device which causes the JP-5 to decompose in the presence of oxygen and sufficient heat -- increased by the reaction of JP-5, O_2, and steam in a "combustion chamber" -- to form CO, CO_2, and hydrogen. The heat, oxygen, and steam are supplied to the "converter" from the H_2O_2 "decomposer" via the combustion chamber. A concurrent reaction occurs when the steam is introduced into the "converter:" $H_2O + CO + \text{Heat} = CO, CO_2 + H_2$.

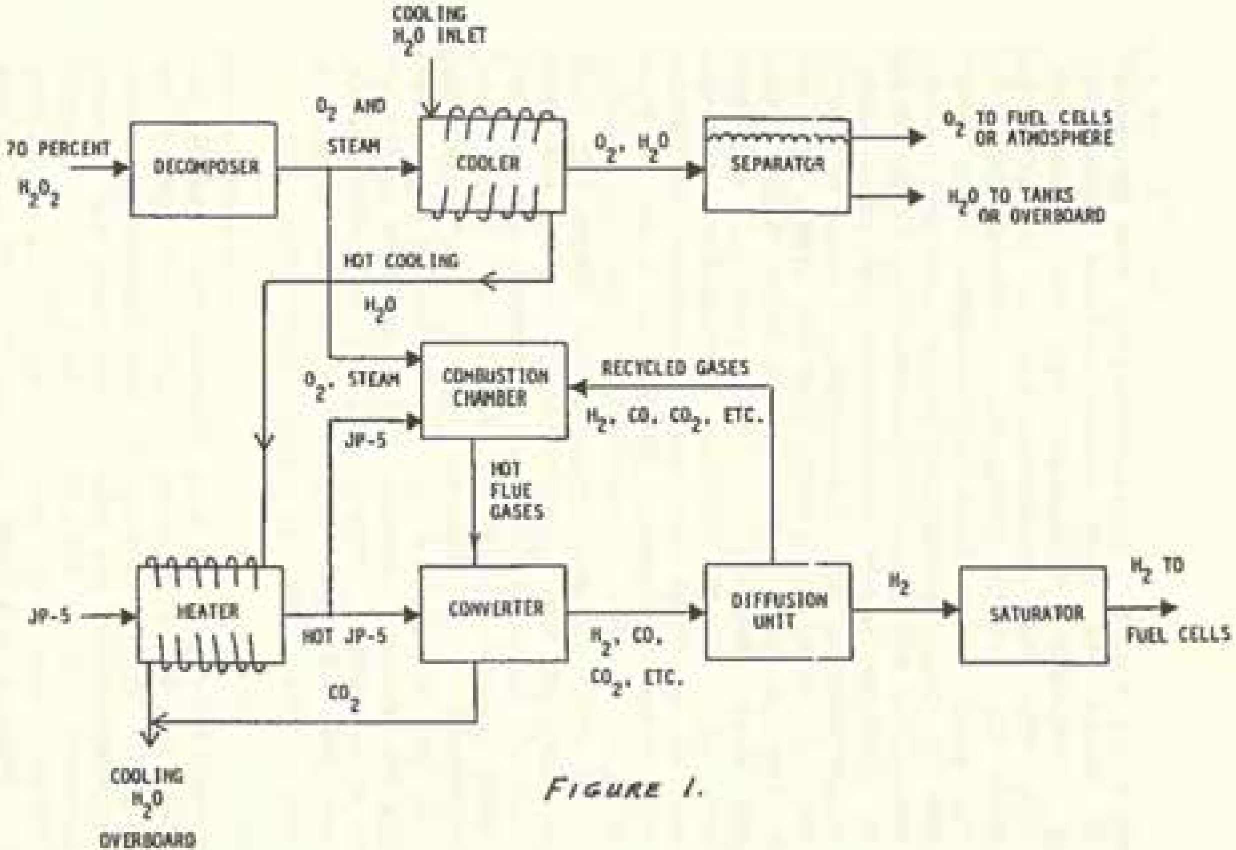

COOLING
H_2O INLET
70 PERCENT
H_2O_2
DECOMPOSER
O_2 AND
STEAM
COOLER
O_2, H_2O
SEPARATOR
O_2 TO FUEL CELLS
OR ATMOSPHERE
H_2O TO TANKS
OR OVERBOARD
HOT COOLING
H_2O
COMBUSTION
CHAMBER
O_2, STEAM
RECYCLED GASES
H_2, CO, CO_2, ETC.
JP-5
HOT
FLUE
GASES
JP-5
HEATER
HOT JP-5
CONVERTER
H_2, CO,
CO_2, ETC.
DIFFUSION
UNIT
H_2
SATURATOR
H_2 TO
FUEL CELLS
CO_2
COOLING
H_2O
OVERBOARD

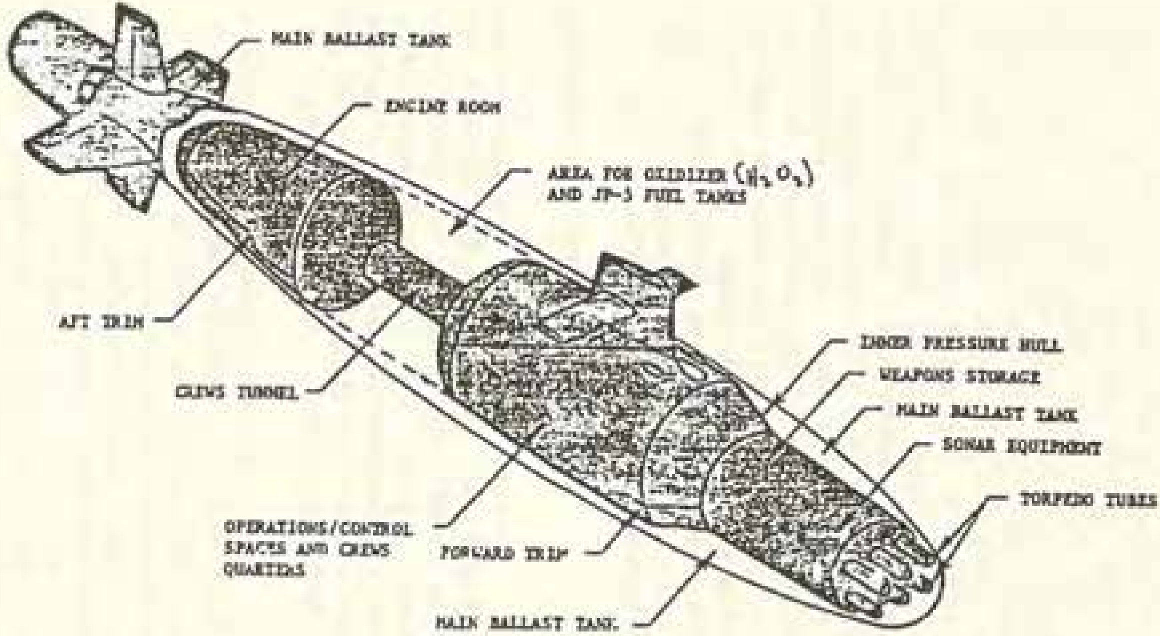
FIGURE 1.

The converter system removes the heavier CO_2 gas and discharges it overboard with the cooling water. The remaining lighter gases are sent to a "diffusion" unit, where hydrogen is separated from the other gases with a silver palladium membrane device. The H_2 gases are then sent via a "saturator," to the fuel cells for consumption. Because many light gases, including hydrogen, are sent through the "diffusion" unit, a constant recirculation of these gases from the "diffusion" unit, to the combustion chamber must be maintained to prevent the diffusion unit from becoming saturated with unwanted gases.

The problem of corrosion from using the hydrogen peroxide solution can be substantially reduced with plastics and teflon. These materials line feeder-lines and fuel tanks. The modularization of fuel cell stacks also promotes the control of corrosion by providing better maintainability through modularity.

<u>The Fuel Cell Submarine</u>

The propulsion system configuration for a fuel cell submarine is similar to that used in a 1981 design-study presented at the Massachusetts Institute of Technology. It is comprised of two reformer systems and ninety 42-kilowatt fuel cells that are packaged into stacks to form a power generation matrix. The fuel cell stacks and the two reformer systems are readily sound-quieted by using equipment containment vessels, sound suppression deck mounts for the containment vessels, and sound reduction of auxilary systems. The only moving parts for the fuel cell sub's propulsion system are the machine-controlled gas distribution valves, the electrical rheostats, the solid-state switching circuits in the fuel cell matrix, and the bearings in the electrical drive motor. The end product is extremely quiet. It will be less complex with less moving parts and more efficient than nuclear reactor-steam



The Fuel cell Submarine Configuration

propulsion systems or diesel-electric systems. The 400° F nominal operating temperature of the "reformer" and "combustion chambers" produce another desirable feature that is paramount in future attack submarines -- i.e. a very low infrared (IR) signature.

Maintenance requirements are significantly reduced and a modest crew of about half the number of an SSN is required for wartime scenarios.

With only short piping runs between the adjacently located fuel and oxidizer tanks and the reformer systems, -- as shown in the fuel cell submarine picture -- safety problems are minimized. The pipes will be of double-wall design, the inner pipes carrying the JP-5 and H_2O_2 to the "reformer" systems. The outer pipes will contain any leaks that might occur. By implanting monitoring devices in the outer pipes, leakage from the inner pipes can be detected and corrective action taken to prevent leakage to the internal atmosphere of the submarine.

A typical getting-underway scenario involves bringing five to six fuel cells on line fifteen to twenty minutes after the reformer system has started generating oxygen and hydrogen gases. During the fifteen minute interval, half of the submarine battery system would be used to drive the electrical propulsion motor until the fuel cell electrical output was great enough to be brought on-line. After the fuel cell electrical current is sufficient to propel the submarine at about six knots, the fuel cell output can be connected to the dc propulsion motor. At the same time, the fuel cells would recharge the battery system to replace the electricity lost by the initial steaming surge and carry the necessary hotel load. The same technique would be used for sudden emergency flank-speed requirements -- but using most of the fuel cell units. A lesser number of fuel cells would be used for speeds of less than its top speed of 32 knots.

Conclusions

The small dimensions (about 2000T) of a fuel cell submarine helps to make it approach an SSN's 60-day under-ice capability -- with fuel for about 6 knots submerged endurance over the 60 days. A larger submarine fleet composed of a high-low mix of SSNs and fuel cell submarines would allow the nuclear attack submarines to be more readily available for operations where they are needed the most; particularly for remote ocean operations which require highspeed long range transit capabilities.

The fuel cell subs could be forward based in Allied countries to eliminate long ocean transits to their patrol areas. They would be well suited for Mediterranean operations, and be very good for mine laying operations. And, remember that with the towed linear array, the wire-guided MK 48 torpedo and the TOMAHAWK missile, they are far more effective than the diesel boats of the past.

The fuel cell sub can be the key to a rapid and effective expansion of the United States submarine fleet when war is imminent, or after the start of a general war.

Michael D. Fulgham

THE ADMIRAL H. G. RICKOVER FOUNDATION

The Admiral H. G. Rickover Foundation was formed in 1982 when Admiral Rickover retired after having served his country for 64 years in the U.S. Navy. The Foundation's primary concern is to continue Admiral Rickover's years of dedication to excellence in education. Former Presidents Nixon, Ford, and Carter serve as honorary members of the Board of Directors. Admiral Bobby Inman is Vice Chairman. The office of the Foundation is located at 7710 Old Springhouse Road, McLean, VA 22101.

The Rickover Foundation sponsors the Rickover Science Institute (RSI) which is held at the Xerox International Training Center in Leesburg, VA. RSI is a six-week residential summer science program designed to nurture the intellectual and practical skills of America's teachers of the gifted and talented. The program, which is taught between the students' junior and senior years of high school, combines intensive classroom lectures and tutoring with off-campus internships in scientific research. It is the only program of its kind in this country which is designed to equip students with theoretical background as well as practical experience in scientific research.

As an innovative model program, the Rickover Science Institute is meeting the expectations of Admiral Rickover when he said, "The impact of the Rickover Science Institute is expected to go beyond the student and faculty participants. They will return to their home schools as role models for this type of program which I hope can be emulated." Funds for the Institute are donated by private individuals and corporations as well as by the National Science Foundation and the National Endowment for the Humanities. All contributions are tax deductible.

The Foundation also sponsors international student exchanges in which students from other countries attend the Rickover Science Institute and American students attend sessions in math and science, go to research facilities, and visit cultural sites in the host country. Funds for this project are provided by the United States Information Agency.

NEW IDEAS

SUBMARINE LAUNCHED CRUISE MISSILE ATTACKS ON SHIPS IN PORT

Now that U.S. submarines are being equipped with TOMAHAWK cruise missiles, a new capability and therefore responsibility devolves upon the Submarine Force. Most of the thinking about use of such missiles has included use of nuclear warheads in a theater bombardment role, with conventional warheads used against ships at sea.

The greatest concentrations of ships -- even in the middle of a war -- are apt to be found in port. Moreover, most ports are poorly defended against a missile like TOMAHAWK, while most ships in port are in reduced states of readiness. It seems only sensible then to plan now for saturation non-nuclear attacks against those ships which may be in the main naval and commercial ports of the enemy.

If security of intent and submarine movements be maintained, surprise might be achieved -- while Russian sea forces are intent upon tracking Carrier Battle Groups in far-removed areas. Saturation might be enhanced by combining submarine attacks with an attack by B-52s launching Air Launched Cruise Missiles at port targets.

In the Falkland Islands War, the Royal Navy nuclear submarines would have been orders of magnitude more effective if equipped to attack the Argentine warships in their port areas.

Recent developments of standoff air-to-surface missiles for use against tanks which do not necessitate a lock-on under pilot control, lend credence to the concept that a TOMAHAWK with the proper homing system could attack individually targetted ships in a port area. Should this prove impractical, provision of satellite relay of terminal homing commands to the missile and feedback from the missile might be provided. Should satellites prove too vulnerable, provision of a high altitude drone aircraft, launched from a forward positioned submarine, might suffice.

To increase the volume of fire, the conversion of a Polaris submarine to carry hundreds of TOMAHAWKS, rather than a few dozen, would make sense.

Strategically, the need for missile attack against ships in port is driven by the continued Russian buildup of conventional forces -- as though nuclear deterrence was an accepted condition. Should this be the case, the speed with which U.S. forces could annihilate Russian sea forces will be critical to the even more critical battles being fought on land. In an age where through modern reconnaissance two large navies know where each unit of the other is at least part of the time, naval war is being converted from the opportunistic winning of sea encounters to the almost perted-out process of destruction of ships wherever they may be. Speed of the process will be the critical factor. Naval war must be won in months instead of years -- everything else will happen too fast. The implications of this are profound in terms of weapons, tactics, weapon supplies and defensive planning.

In a previous SUBMARINE REVIEW I recommended development of fleets of very large aircraft carrying large numbers of RPVs and missiles, as a way to fight and win this new kind of naval war. Pending such a development, it is inevitable that too few carrier battle groups will have too many missions and that submarines must take on the fight as described here. Should war break out along a central front, it follows that U.S. strategy should provide for attacking peripheral interests of the enemy in order to stress his overall system. All enemy holdings in South East Asia and North East Asia should, for example, be wiped out.

It is predictable that submarine launched cruise missiles will place U.S. and allied port facilities in jeopardy as well as ships in port and at sea. The loss of industrial products on the scale experienced in World War II would bankrupt the world. The war must thus be won fast; and by the U.S.

R. B. Laning

A DRAG REDUCTION COATING FOR SUBMARINES?

Is a polymer base coating, developed to reduce aerodynamic drag, applicable for use on the hulls of submarines?

In 1983, a fluorocarbon-base liquid, developed by Fluorocarbon Technologies Inc., was sprayed on the aerodynamic surfaces of the Hawker Sea Fury and the F-51 Mustang aircraft competing in the National Air Races in Nevada. The Sea Fury's maximum airspeed was increased 25 mph over its normal maximum speed of 320 mph. The Mustang's airspeed improved 11 mph from a top speed of 383 mph. The Sea Fury set a new course record as did the Mustang, but the Mustang also won the Gold Unlimited prize. The drag reduction noted in these aircraft was substantial.

The coating used on these aircraft was essentially hydrophobic and resistant to foreign debris attachment. And, the sub-surface penetration of the fluorocarbon material significantly prevented corrosion and oxidation.

A next step, using this polymer paint on marine craft, then followed. A wide variety of power and sailing craft were coated below their waterlines. Their drag reduction was even more dramatic. A Bristol 42 Trawler got an increase of 2 knots of speed over the trawler's normal speed of 8.5 knots at 1200 rpm. A Hatteras 47 reduced its normal fuel consumption by 9% during a 7000 n.m. cruise. And, a one-ton yacht increased its powered speed from 6.1 to 6.7 knots over a measured course.

Several smallcraft were observed for their marine growth. The yacht JUVENTUS, a Gulfstar 50, was in the water for 27 months without appreciable fouling and this included no barnacle growth. Other yachts, so coated, were rapidly cleaned on their marine railways by merely a hosing down. It was thus evident that the anti-fouling qualities of this paint were good, while there was a minimum loss of coating over a period of more than a year, resulting in no appreciable increase in fuel consumption.

Several types of metal-hulled craft showed a good anti-corrosion effect. Coated stainless steel, cold roll steel, aluminum and copper all proved corrosion free in a 4 week test of this coating.

When its applicability to submarines was questioned, an attempt was made to acquire towing-tank drag resistance empirical data on coated models. However, no U.S. tanks appeared willing to conduct such tests. They feared that the anti-fouling nature of such paints would be likely to foul the water of their test tanks -- just like the environmentalists who protest the use of toxic marine paints. Hence, eventually, a towing tank was found which would conduct tests on fluorocarbon impregnated surfaces -- at the University of Canton in the People's Republic of China. Tests were made on a flat plate, towed submerged. The plate was bare metal in the initial test runs and then it was coated with the fluorocarbon paint.

The data taken showed the polymer-coated 2-meter plate to have its drag reduced by about 10.8% at a towing speed of about 4 knots. A 2-meter merchant hull shape was also towed in the Canton tank. Initial test runs were with this small hull covered with a commercial polyurethane type of anti-fouling paint. Then, with the fluorocarbon paint sprayed on top of the standard paint, the runs were repeated. Of interest is the fact that this polymer paint is about half the cost per gallon of the commercial paints in use -- at about $80. The results were even more startling. At a towing speed of about 4 knots (about the maximum for the Canton tank) the reduction in drag for the combined paint job approached 25%. This reduction is achieved relative to a normal "rough" anti-fouling covering -- and justifies the 25% reductions in fuel consumption observed in other tests.

At the completion of the tests, the Chinese Navy was so impressed by the results that they initiated a program for the hull painting of their new-construction "Sub Chasers," the equivalent of our small DEs. The Chinese have also programmed for the painting of one of their Whiskey submarines -- the polymer paint to be applied over a standard zinc chromate type of preservative coating.

A few more characteristics of this polymer paint -- in order to understand the paint's practicality -- are: it can be applied at as low as -60°F and has a thermal envelope of -100°F through 750°F; it is a very slick type of lubricant; it is non-flammable; it doesn't tend to wash off; it makes a very hard coating, resistant to abrasion; it is non-toxic; there is no noticeable leaching over a long period of time and hence the danger of this coating polluting harbor waters is minimal; the polymer liquid mechanically bonds to and penetrates treated surfaces; and fluorocarbons are chemically benign.

But what does not show up in tests so far, is the probability that, in reducing drag, it would also significantly reduce the self-noise of a submarine -- so important to passive detection.

Bill Orr

APTITUDE SCORES FOR FIRE CONTROL JOB SELECTION

Would an idea derived from some old piece of research be useful for attacking a present day problem and be considered "a new idea"?

One such intriguing piece of submarine officer research done in 1954 -- which is here resurrected -- may or may not apply in the changed circumstances of our submarine Navy, a Navy which is now heavily computerized, nuclear power oriented and with a fundamentally different major mission -- ASW. Still, human problems which seem more difficult to get a handle on than technical ones, appear to be repetitive enough to suggest that what seemed reasonable in a 1954 submarine Navy of diesel boats might still have some application to today's fire-control jobs -- changed as they've been over a thirty-year period.

The 1954 study used the scores of an officer's five aptitudes to determine his efficiency in five fire-control jobs. The aptitude marks were, at that time, filed in every officer's record and were readily available to evaluate the performance of Submarine School officers in their tactical course.

The Sub School test-population was chosen because of the consistently high motivation of each officer throughout his 26-week course, thus reducing the overall effect of motivation on the marks achieved in doing any of the five fire-control jobs. As shown on a Form 318, the five self-descriptive aptitudes in battery were Verbal

Reasoning, Mathematical Reasoning, Mechanical Reasoning, Spatial Relations and Relative Movement. In other similar aptitudes-for-job studies (as in the famous Harvard experiments) it was recognized that the motivation of particular individuals had played a greater part in job success than the inherent capabilities of the individual.

The five fire-control jobs examined were: Torpedo Data Computer (TDC), Dive, Sonar, Manual Plot and Assistant TDC. Why it might be valuable to derive an aptitude profile for each job made good sense in 1954. Then, another war was believed to involve the rapid construction of large numbers of submarines. Their consequent manning by a high percentage of inexperienced submarine officers might thus involve insufficient training time to master any or all of these jobs before exposure to torpedo attacks against an enemy. The placement of inexperienced officers in the fire-control team, using their aptitude scores, promised a more efficient way to maximize team effectiveness.

Two successive Submarine School (Officers) classes, (170 officers in two classes), were evaluated, with the fire-control job ratings of each student matched to his aptitudes. The correlations derived are shown:

TABLE 1
Correlations Between Fire-Control Jobs and Aptitudes of Submarine School Officers
Combined Classes

	TDC	Dive	Sonar	Plot	Ass. TDC
Verbal	.15	.23	.02	.24	.17
Mechanical	.25	.20	.24	.28	.19
Mathematical	.27	.18	.22	.13	.16
Relative Movement	.44	.35	.07	.39	.32
Spatial Relations	.18	.08	.17	.29	.38

These correlations appeared to be very good compared to other attempts to provide a job description, based on aptitudes alone. The dominating importance of Relative Movement in four out of the five jobs, suggested that officers with a high score in Relative Movement might excel in the Sub School tactical courses.

Significantly, the average aptitude marks of the students in the two classes evaluated were quite high -- with Relative Movement closest to being "average." These scores are shown in the following table:

TABLE II
The Student Mean Aptitude Scores (Bell Curve)

Verbal	57.9
Mechanical	60.6
Mathematical	61.2
Relative Movement	51.8
Spatial Relations	58.3

These students were the result of a screening process -- with more than double the number of volunteers to those actually selected for Submarine School. The candidates had had at least two years of service -- mainly in the fleet -- had been recommended by their Commanding Officers, and were for the most part qualified Officers of the Deck. This latter factor could have had a significant impact on the Relative Movement scores of the two classes tested -- since low Relative Movement scores seem likely to have influenced OOD qualification.

Shortly after the above results were made known, the selection for the next officer's class at Sub School, of those candidates "in the gray area" -- those without outstanding fitness reports or recommendations, but not easily rejected -- was made on the basis of having high Relative Movement scores. At the conclusion of that Sub School class, the Commander of the Submarine School reported that "they were the stars of their class in the Attack Teacher." The same selection process was used for the next Sub School class and a similar report of success in the Attack Teacher was recorded, for those officers specially selected because of their high Relative Movement aptitude.

Had the U.S. gone to war in 1954, a quick differential-placing of submarine officers at the five fire control positions could have been made, using the "weighting factors" (Table III) applied to an officer's aptitudes to derive an overall score.

TABLE III
Weighting Factors for Selection for Fire-Control Positions

	Verbal	Mech	Math	Rel. Mov.	Spatial
TDC	-.02	.06	.09	.41	-.07
Dive	.14	.06	.00	.35	-.16
Sonar	-.20	.25	.25	-.11	.08
Plot	.12	.07	-.10	.33	.08
Ass't. TDC	.06	-.13	.03	.18	.35

Although today's nuclear submarine fire-control team has little semblance to the 1954 diesel-boat team, there might be wartime situations which could benefit from a recognition of an officer's aptitude profile. A sabotaging of a submarine's computer system, a temporary loss of auxiliary electrical power, war damage to the fire control system, or a rapid construction of some less sophisticated type of submarine for replacement of losses, might reintroduce aptitudes into the "war-fighting" equation. Best placement of officers for prior training in these emergencies might be done this way.

Breaking off a war patrol because of outages of the fire-control system is not an acceptable solution -- particularly in light of the great dependence placed on submarines to achieve decisive results early in a conflict.

LETTERS

RUSSIAN SUBMARINES IN WORLD WAR II

I feel duty bound to take issue with the review of RUSSIAN SUBMARINES IN ARCTIC WATERS (October, 1985) because it could lead to some very wrong beliefs about the ability of Soviet submariners - at least in the past.

The reviewer says that ..."the Russian submarines played what appeared to be quite an important role in World War II." But thorough research into the records and post-war analysis of all navies involved (admittedly hampered by Soviet falsehoods and concealments) has led me to a very different finding which was summarised in the Soviet section of my UNDERWATER WAR 1939-1945: "the other Allies were forced to conclude with regret that Soviet submarines in all areas contributed very little to winning the Great Patriotic War. The crews were smart, keen and did their best with old-fashioned equipment, poor training facilities and a superabundance of political control; but the sum of their achievements was not impressive." That was putting it very kindly -- kindly because, like any submariner, I sympathised with the dreadful conditions and political constraints under which Soviet crews worked.

The reasons for reaching this conclusion are too numerous to give here but there are plenty of examples in THE UNDERWATER WAR if anybody cares to follow them up. Double-checked sources -- mainly

German and British -- will confirm them. Soviet boats boasted much but achieved very, very little.

Kolyshkin's book was first printed in English by Progress Publishers (Moscow) in 1966 shortly after a translation of Admiral Golovko's WITH THE RED FLEET appeared. Both publications are straight PR/Propaganda efforts; they are thoroughly unreliable, misleading and stocked with gross exaggerations of successes which can be disproved with certainty. In fact, the Soviets now have a problem: should they tell their present officers under training that these accounts were lies or should they allow them to get a totally false impression?

Much of what the reviewer says is simply taken from Kolyshkin's book; and without unwarranted effort he could hardly have written anything else. But I believe it is important that SUBMARINE REVIEW readers are not persuaded to think that Soviet submarines had a good, or even a fair, record in World War II: by any standards -- and shed of niceties -- it was appalling. Indeed, their shortcomings, when brought to light by the real facts, suggest certain weaknesses which may well become apparent in any future shooting war.

Unfortunately, apart from taking Kolyshkin's account at face value, your reviewer himself has misread at least one incident and been misled by another. Stolbov did not sink U-402, which went down to aircraft from USS CARD off the Azores; nor did he sink any other U-boat. The only U-boats sunk by Soviet submarines were U-639 and U-144. And no 'midgets' attacked the TIRPITZ: the large K-21 (LUNIN) claimed to have scored two hits in the open sea (hence the Order of the Red Banner) but the Germans never even noticed an attack had taken place. Moreover, the 'midgets' were not midgets in the accepted sense but small M-class boats which were often called 'babies'; and none of them approached the TIRPITZ in a Norwegian fjord.

Commander P. R. Compton-Hall

THE MERCHANT SHIP TORPEDO

The Submarine Force is interested in getting a new torpedo -- an anti-merchant ship weapon. What an opportunity to demonstrate to the public that the Navy can produce a simple, low-cost torpedo that can actually do-the-job; and produce the torpedo in a short period of time -- in stockpiled numbers which would represent a significant war-fighting capability.

What a publicity coup this would represent for the Navy!

The ingredients of the design problem don't require lengthy study. It's to be a single-purpose torpedo, used against a well-defined target -- the relatively slow, big, noisy, little maneuverable and not easily protected merchant ship of today. Most importantly, this torpedo is to be used by the highly mobile and covert nuclear submarine which can readily gain optimum attack positions against such a target -- to launch a "surprise" attack.

The Mk 18 electric torpedo of WW II -- a quiet, $9 K, wakeless, "straight runner" -- could do the job well for a majority of today's probable scenarios. But after 40 years, we should be able to rapidly produce a far better torpedo -- still within the Mk 18's envelope, still at relatively low-cost compared to the Mk 48, and one which could do-the-job for virtually all scenarios, even those in shallow waters or where the merchant ship has ASW protection, -- which can't spot the firing sub's location.

But the hitch in this program -- if British torpedo experience is valid -- will come from the demands to use Navy Lab technology, bad advice to the contractor from the Navy customer, over-complicating the weapon, misdirecting the effort and having no clear-cut individual responsibility for the outcome. What seems to make sense is a "fly off" competition between two contractors -- like the F-16/F-17 competition -- the contractor to develop a "best weapon" within some fixed dollar constraint ($200K.?), and with little interference from "the customer."

It worked for the F-16 and it will work even better for the "merchant ship" torpedo!

D. E. K.

THE ICE CAP

Recent articles in the SUBMARINE REVIEW refer to the permanent ice cover in the Arctic Ocean as an "ice cap." This strikes a nerve-end in the intellectual sinews of this writer.

"Ice cap" is a land ice-term, defined in NWP 79-1, the Arctic Reference Manual, as "a dome shaped glacier usually covering a highland." Submariners should take the lead in calling the ice cover over the Arctic Ocean "the Arctic Ice Pack,"...."the multifarious mantle of floating ice of more than 1/10 (1/8) concentration that covers the Arctic Ocean and adjacent seas to varying extents the year round."

Dick Boyle

[Ed note: The Oxford Universal Dictionary defines for "ice-cap,"...."a permanent cap or covering of ice over a tract of country, as e.g. at either pole." So take your pick?]

RELIEF FOR ATTACK SUBMARINE OFFICERS

Admiral Thunman's "Submarine Force Today," published in the July, 1985 issue of THE SUBMARINE REVIEW, and his admitting to "a sharp increase in resignations in the first third of this year" struck a nerve end with regard to officer retention.

This submarine rider has been able to keep his finger on the pulse of officer morale during more than 20 deployments in the past 24 years. He has participated in many wardroom discussions regarding retention.

Quickly distilled, two problems cry out for attention:

(1) The pressure of events during the first two weeks in port after deployment, "Stand Down" notwithstanding.
(2) The lack of telephone lines aboard submarines.

First, when a ship returns from patrol, there is little letup in pressure, even if "Stand Down" is in effect. Many material and administrative actions, some that have been festering for months, need attention.

During World War II, the Relief Crew concept worked well. Why don't we try to work out some way to get the officers off their boat for the first two weeks after deployment? Relief crews could be part of the parent squadron staff. Official turnover could be carried out within hours of return to port.

Second, telephone problems are terribly frustrating to busy young officers. There simply aren't enough lines into complex machines worth hundreds of millions of dollars. There are normally three lines on a 637 class SSN -- CO/XO, Wardroom and Control Room. A busy pre-deployment upkeep demands much more support than this. The only easy way to get through is to call the submarine in late evening.

Dramatic improvement is required. Four banks of phones are suggested: (Example is 637 class SSN).

(1) CO -- Dedicated line.
XO) Two lines, ringing in
Ships Office) rotation.

(2) Wardroom)
Stateroom 1) Three lines, ringing in
Stateroom 3) rotation.

(3) Chief's Quarters)
Control Room) Three lines, ringing
Crew's Activity Space) in rotation.

(4) Engineer's Stateroom -- Dedicated line.
(Assumed to be Stateroom 2)
AMR-2) Two lines, ringing in
Engine Room) rotation.

The relief crew idea will require billet creation; this will take time. But let's not hesitate to get started with improvement. Remember the J. O. sentiment: "we need a break in the pressure."

The telephone problem could be solved within a month. Let's get on with it and improve communications aboard our submarines.

TPR

HM SUBMARINE No 1 (HOLLAND 1)

While browsing through the October, 1985 edition of THE SUBMARINE REVIEW, I came across some inaccuracies in the following two sentences of the report by Hugh Latham on the 23rd Reunion of International Submariners:

> "Next day they visited HMS HOLLAND #2, recently raised from the harbor and restored. (It was one of four Holland boats operated by the British before the U.S. began submarining.)."

A brochure issued by the Royal Navy Submarine Memorial Museum at Gosport where this historic submarine is now undergoing restoration identifies it as HM Submarine No 1 (Holland 1). The lead ship in a class of five, it was built by Vickers at Barrow, launched in October, 1901 and completed the following year. Obviously it did not antedate USS HOLLAND (SS 1) which was delivered to the U.S. Navy on 11 April, 1900 and placed in commission 12 October of the same year. HM Submarine No 1 (Holland 1) sank in a storm off Land's End while under tow to the shipbreakers, and was recovered in 1982.

A possible clue to the cause of these inaccuracies can be found in the preceding sentence, which reads:

> "Latham's first stop to the 'reunion' was at the Sub Base in Portsmouth, England, where he and two other American submariners were royally entertained by 'a number of British submariners'."

Those of us who have experienced the British Navy's delightful, devastating hospitality -- particularly when the hosts outnumber the guests -- can quite appreciate Mr. Latham's situation, and can feel both sympathy and envy.

Harry Caldwell

THE LAST U-BOAT SUNK IN WW II

Some eight hours before the unconditional surrender of Germany on 7 May, 1945, a friend of mine, Squadron Comdr. K. M. Murray, RAF(Ret.) sank the last U-boat to be sunk in combat action in World War II. Ken once served on the SACLANT staff under our mutual submarine friend, RADM Jim Davis, but is now retired and lives in Dornoch, Scotland, where he is Secretary of the Royal Dornoch Golf Club.

Why this is being dredged up is due to some letters I recently received concerning the sinking of the U-320 and the locating of the Catalina pilot who was responsible for it. A letter from a Herr Karl-Heinz Weber -- the navigator of the U-320 which was attacked by a flying boat near Bergen, Norway, on 7 May -- initiated the correspondence. Herr Weber's letter was written to locate the pilot so that the survivors of the U-320 could include him in their next reunion in 1986 -- "our former adversary responsible for the sinking of our submarine." Herr Weber further explained that there were still about twenty U-boat survivors of the original 49 and that their next biannual reunion would be in 1986 at Schledehausen, Germany.

Historical records show that after the U-320 had taken "a series of aerial depth charges" which badly damaged the submarine, the crew had tried to save their boat for 2 1/2 "terrible days." The U-320 however was finally abandoned and the crew escaped with their lives -- late on 9 May, well after the European War was over.

The letters were successful in locating the pilot who did the fatal damage, Ken Murray, and he is accepting the invitation of his former adversaries.

Admiral Pete Galantin

NAUTILUS

NAUTILUS will be open for visitors after a gala opening ceremony on Sunday, 20 April, 1986. The new Submarine Force Library and Museum will share the honors with NAUTILUS at the Submarine Base in Groton, Connecticut. The opening has been scheduled to coincide with the reunion of NAUTILUS alumni at the Submarine Base that weekend. Look for more news as final plans become firm.

Bill Purdum

SUB VETS OF WW II

I am fond of the section: IN THE NEWS. Keeps us all up to date as to what is happening in the active submarine Navy, change of command, launchings, and other happenings.

I was particularly drawn to the note from Hugh Lathan, a member of Sub Vets of WW II, concerning his attendance at the reunion of the International submariners held in France. I would ask that you publish a note to all readers that our Sub Vets of WW II organization would like to have those who are eligible, join our organization. Ours is an organization of submariners who served in submarines and relief crews during World War II from 7 December, 1941, to 31 December, 1946. We have in excess of 7500 members and hold an annual reunion. Our purpose: "To perpetuate the memory of those shipmates who gave their lives in submarine warfare," and to this end we have an established scholarship program and we support 55 scholarships at $750.00 each. We are more than a bunch of "old Vets who wear colorful vests and hats and still raise hell."

Joe McGrievy
Past President of Sub Vets of WW II.

IN THE NEWS

o A lately retired British Admiral, Sir Lindsay Bryson, is reported by Navy News & Underseas Technology, Oct. 25, 1985, to have commented adversely on Britain's post-war history of torpedo developments -- "which totals 25 projects with only three successful so far." He is quoted as saying that often the projects "reflected a lack of clear policy by the customer and the need to control the enthusiasms of government scientists not subjected to commercial financial constraints." Admiral Bryson further noted that even when industry was brought in on torpedo projects, the resources allocated for development were tiny compared with those devoted to air-flight guided weapons. "Britain," he said, "tripped up with torpedoes because no one at the right level of management was in charge of the total weapon system. Worse still," he continued, "government research establishments clung to responsibility for the torpedo." The lessons from all this, according to Bryson, should be, "it is essential to separate research from development," and, "it is vital that defense research establishments not be allowed to do the development."

o The Financial Times of England, Oct. 9 edition, has an article by Alan Cane telling of the Swedish Navy's plan to install a closed-cycle Stirling engine in one of their conventional submarines. This new engine, "is expected to extend the submerged operational capability of non-nuclear submarines from three days to three weeks, while eliminating the need for frequent 'snorkeling'." The new system has been developed by Kockums and is being considered by the Australian Navy for their next generation submarine. The engine's cost of "some 100,000 pounds for an output of 75 kilowatts is bloody expensive, but it solves a problem which can't be solved any other way for the time being," according to a former Royal Swedish Navy submariner. It is also noted that this new system utilizes huge oxygen tanks "to carry their air requirement on board."

o An AP story, Sept. 16, 1985, tells of photographing the submarine SCORPION 17 years after it was lost. A new deep-diving submersible, the ARGO, took a large range of photos of the bottomed SCORPION, but reportedly there was no immediate indication from the photographs as to what caused the SCORPION's sinking.

o The Submarine Launched Mobile Mine, according to Steven Eisenstadt in the Defense News, has been delayed in delivery by about two years. This was due, according to the article, to a small New Jersey snow-making equipment manufacturer taking the job and "botching" it. A modified version of the Mk 37 torpedo, it was designed to be launched into shallow-water harbors by submarines standing well offshore in safe, deep-water positions. The Navy had hoped to have about 300 of the mines in its inventory by this year, and about 900 by the end of the decade.

o A Sept. 27, 1985 story in Navy News & Undersea Technology, tells of the failure of the UK's TIGERFISH heavyweight torpedo to perform reliably -- since its service acceptance in 1979. Two of these torpedoes were fired in the Falklands war in 1982, "and failed each time." The TIGERFISH should have entered service as early as 1967.

o An article by Paul Bedard in Navy News & Technology, 27 Sept., 1985, tells of Navy plans to meet a White House ordered cut in the 5-year Defense budget, of nearly $300 billion. This cut would involve one TRIDENT ballistic missile submarine and one SSN-688.

o *The Washington Post* of Nov. 27th, carried a Walter Pincus story which told of the possibility of two SSBNs being dismantled next year "if President Reagan continues his policy of not undercutting SALT II agreement limits." The NATHAN HALE and ANDREW JACKSON would be decommissioned when the USS NEVADA, a new TRIDENT submarine, became operational. The SALT II agreement which set a limit of 650 ballistic missile submarine launch tubes -- for all SSBNs -- expires on Dec. 31st. But if President Reagan decides to continue to stay within the SALT II limits, as has been suggested during the summit meeting with the Soviet leader, Mikhail Gorbachev, then this dismantling should proceed as indicated.

o *Sea Power* of Sept. 1985, reports that the Navy's Extremely Low Frequency (ELF) transmitting station in the upper Michigan peninsula, was activated on August 1st. This station is tied in with one in Northern Wisconsin and has the capability to send ELF messages to deeply submerged submarines -- around the world and at anytime. The speaker at the inauguration of this facility, VADM Kirksey, said "This new facility is a vital key to maintaining communication links between the National Command Authority and the Navy's missile submarines .... and is a vital part of our deterrent posture."

o As a result of Congressional action in early November, there will no longer be "Commodores" in the U.S. Navy. From hence forward they become One-star Admirals or Rear Admirals, lower half -- like the one-star Brigadier Generals of the Army.

o *Sub Notes* of October, 1985, reports on a new, small diesel-electric submarine, PIRANHA -- a Vickers Shipbuilding & Engineering Ltd. product. With a length of 26.6 meters, a displacement of 134 tons and manned by a crew of 7, she can also carry 10 combat swimmers. She can make 9 knots submerged, operate over 800 miles from a base and patrol for 12 days at a time. PIRANHA is designed to penetrate coastal defenses. Her armament is 6 bottom-laid mines, two 2-man Scuba diver chariots, and inflatable assault craft. She has a diver lockout means which allows 2 men at a time to exit from the sub and gain access to the chariots or become part of a frogman assault crew.

o RADM Virgil Hill, Jr., became the Director of the Attack Submarine Division (OP-22) in OPNAV in October, 1985. Also in October RADM James G. Reynolds became Director of the Submarine Combat System Project (PMS-409) in the Naval Sea Systems Command. (This Project is the revised SUBACS project.)

o RADM Bruce DeMars was appointed to the grade of Vice Admiral on December 6 and has taken over the job of Deputy Chief of Naval Operations (Submarine Warfare), OP-02, Office of the Chief of Naval Operations, relieving VADM Nils Thunman who has been assigned as Director of Naval Training at Pensacola.

o A news item in the Washington Times of Nov. 1, 1985, tells of a Swedish surveillance ship, the ORION, which, while observing a new type of Soviet submarine -- a "KILO" class non-nuclear submarine -- in the Baltic, was rammed by a Soviet minesweeper which had positioned itself between the ORION and the Soviet submarine. It seemed to be trying to stop the surveillance. The damage to the ORION was only minor and may have been unintentional. KILOS have been previously reported only in the Pacific.

o A news item in the Chicago Tribune of Oct. 22, reported that the Chinese had successfully launched a surface to surface cruise missile from a land-based site. It landed in the East China Sea. It is believed to be the first cruise missile to be tested by China, and that it was for use by submarines. Most of its flight path was over land to apparently facilitate checks on its flight.

IN REMEMBRANCE

CAPTAIN J. GORDON McGARRY, USN(Ret.)

- Co-Chairman NSL Speakers Package
- First Contributor to NSL
  (one year prior to incorporation)
- A PROFESSIONAL OFFICER AND GENTLEMAN

GOVERNMENT AFFAIRS

SUBMARINE R & D CONGRESSIONAL ISSUES

The last Government Affairs report gave the status of the Authorization Bill for FY86 at about $302.5 Billion after joint House and Senate Armed Services Committee action. Of that, $35.5B was allocated for all of the Defense Research and Development programs. The DoD Appropriations Bill contained a recommended $282.5B, vice the $302.5B in the Authorization Committee version. Almost $36B was for RDT & E. The following is a comparison of R&D funding for the three services:

(in $ billions)

	Army	Navy	Air Force
1985 Appropriation	4.35	9.17	13.42
1986 Budget Estimate	5.29	11.26	15.58
House Allowance	4.44	9.46	13.22
Committee Recommendation	4.84	10.10	13.86

($7 B is recommended for Defense Agencies)

The Under Secretary of Defense Research and Engineering supplied to the Congress his estimate that the real growth in RDT & E had increased from the 12.3% of FY 81 to a requested 20.1% for FY 86. However House action is expected to cut the requested $11.2B to about $10B, reducing the real growth factor considerably.

The submarine-related programs which can be identified in the budget before the House Appropriations Committee are:

Programs ($ M)	FY 86 Request	House App. Comm
TRIDENT II	2165.6	2130.6
Sub ASW Standoff Weap	75.3	75.3
Sub Sonar Devel (Adv)	22.4	12.5
Sub Arctic War Support Eq	9.7	9.7
Sub Hull Array Devel (Adv)	13.2	8.2
Adv Sub Sys Devel	180.6	180.6
Sub Tact Warfare Sys (Adv)	23.2	23.2
Attack Sub Devel	33.1	33.1
Adv Nuc React Comp Sys Devel	120.1	120.1
ASW Surveillance	19.5	17.5
Sub Communications	4.4	4.4
Sub Sonar Devel (Eng)	40.3	40.3
SUBACS (Eng)	205.2	0.0
SSN-21 Combat Sys (vice SUBACS)	-	200.0
Sub Tact Warfare Sys (Eng)	49.8	37.8
Op Reactor Devel	12.7	12.7
HY 130 Steel	-	5.0
Naval Oceanography	-	5.9

The Navy's R & D request is organized into three major groupings:

(a) Basic Research and Exploratory Development, at about 7.5% of the total R & D budget;

(b) Development with the bulk of the R & D account of about 87%; and

(c) Management Support.

The programs listed above are all in the Development sector.

For Basic Research and Exploratory Development, $853.2 M was requested. Of that, the submarine programs are:

Technologies ($ M)	FY 86 Request	House App. Comm.	Senate App. Comm
Nuclear Propulsion	49.0	49.0	49.0
Ship and Submarine	25.3	25.3	25.3
UnderSea War Weapons	44.2	44.2	37.0

There were three comments made during the course of Congressional action on the Navy's R & D request that are worthy of special note.

In presenting the Navy's R & D program requests to the Senate Appropriation Committee, the Assistant Secretary of the Navy (Research, Engineering and Systems) cited the "...markedly greater quieting, strengthened double hulls, higher speed, higher reserve bouyancy, and deeper operations" provided the Soviets by their submarine technology. He went on to state that the largest share of the $853 million requested for Basic Research and Exploratory Development is aimed at surmounting that threat.

When acting on this program, the Senate Appropriations Committee noted that the budget request for UnderSea Warfare Weapon Technology was more than 46% over FY 85. They also noted that an emphasis was given to warhead, fuzing, and torpedo propulsion research and development. In addition, they cited the Navy's plan to expand the effort to $50 million in FY 87. The Committee claimed support for research in the underwater weapons field but concluded that the proposed research effort was far too broad and lacking in specific goals and objectives. They therefore recommended a reduction of more than $7 million and suggested that at least $5 million of that cut be for torpedo components.

A second major action by the Committee in the Strategic R & D program was a recommendation for a reduction of $35 million, from the $2.165 B request. The Committee also came out strongly for penetration aids and proposed to OSD that Navy and Air Force programs be merged. The important point, however, is not the 1.6% cut but what the Committee said about the program.

> "The Committee strongly supports development of the TRIDENT II SLBM as an integral part of the Strategic Force Modernization Program. The TRIDENT II is a three-stage, 83 inch diameter missile weighing close to 130,000 pounds. It will be capable of carrying a wide range of both high and low-yield warheads, providing optimal targeting flexibility. The TRIDENT II will use stellar-inertial guidance, requiring in-flight updates, making it a markedly different kind of ballistic missile system than Air Force ICBMs. The high yield of the MK 5 re-entry body will give the TRIDENT II a high kill probability against the full spectrum of hardened Soviet targets.
>
> "In the view of the Committee, the TRIDENT II SLBM provides a much needed complement to the MX Peacekeeper and small ICBM programs. The introduction of the TRIDENT II into the ballistic missile inventory will be at a critical time -- midway between initial deployment of the MX in late 1986 and the small ICBM in late 1992. Moreover, with the deployment of the TRIDENT II, the Navy is provided the opportunity to exploit the full payload and range capabilities of the TRIDENT Submarine."

The third major point made during these proceedings concerned the new design SSN or SSN-21. The Committee increased one tactical system development program element by $31.5 million and directed that $40 million be applied to fully fund the competitive SSN-21 contract design program. They stated their support for the new Attack Boat as follows:

"The Committee recommends full funding for the new design SSN (SSN-21) at the authorized level. The Navy has initiated a very ambitious SSN-21 program. The new-design SSN would achieve significant improvement in such areas as speed, quieting, and firepower over current SSN-688-class submarines. The Committee supports, in principle, the requirement for a new design SSN -- particularly given the fact that the Soviets are now producing or testing nine different classes of submarines with capabilities spanning the entire range of undersea warfare applications." "However, the Committee continues to be interested in the cost and program management of the SSN-21 program. Testimony before the Committee indicated that the new design SSN will cost at least $1,000,000,000 per copy, which raises serious questions as to affordability and maintenance of the Navy's force level objectives of a 100-level attack submarine fleet into the 21st century. The Senate Armed Services Committee has expressed similar concerns regarding the SSN-21 program. This Committee supports Navy efforts to reduce the unit costs of the new design SSN, while maintaining its improved capabilities over the SSN-688."

The Senate Appropriations Sub Committee for Defense also added $5 million for procurement of long lead material for an HY-130 hull section and selection of a design agent. That effort is to lead design of the HY-130 section and manage its integration into a test ship. By this action, the Committee expressed the hope that HY-130 could be introduced into a fiscal year 1993 authorized boat of the SSN-21 class. That would be a full year earlier than now programmed.

The Senate Appropriations Sub Committee also confirmed the joint House-Senate Conference action regarding SUBACS development. In summary, the Navy originally requested $305 M for a three phase development and deployment program. The first phase was to integrate detection, a digital data bus, UYK 44 computers and new weapons launch, navigation and communications systems and make this integrated system backfittable into the 688s. The follow-on phases were planned to introduce advanced sonar arrays and large scale functional software improvements. But House action deleted that entire line item and substituted instead a new $200 million item for SSN-21 combat systems.

The effort of the U.S. Navy in submarine Research and Development was summed up by the Assistant Secretary of the Navy (RE and S) in his statement to the Senate Appropriations Committee as follows:

> "In our Advanced Submarine Technology Program we are developing systems and concepts for future attack submarine classes. As required by the FY 1985 budget authorization, our R & D program has approximately $30 M available to advance the state of submarine technology, which can be exploited by the SSN-21 well into the next century. The R & D program also includes a vigorous program to ensure that a follow-on to the new design attack submarine can be implemented as the threat dictates."
>
> "The key attributes of our future submarines can be defined in terms of their combat control and weapons, quieting, sensors, firepower, speed, depth, survivability, and affordability. Major thrusts in the technology base for combat control and weapons include advances in combat information management, development of concepts for quieter, faster, and more potent torpedoes, and development of concepts for Arctic warfare. In the area of quieting, we are concentrating on reducing the noise generated by ducted propulsors, machinery, and weapon launching

systems. Reductions in the weight and volume of hull, mechanical and electrical systems will allow our submarines to carry more weapons."

CAPT Jim Hay, USN(Ret.)

BOOK REVIEWS

NOT SO TRIVIAL A PURSUIT

The Soviet Submarine Fleet: A Photographic Survey by John Berg with an introduction and preface by John Moore is intended to be a recognition guide for the "non-naval public." However, even a quick glance suggests it is far more valuable. The book is based on a format Berg designed as a guide for Scandinavian spotters and has been expanded into a text that presents photographs of almost every contemporary "full-size" Soviet submarine class. The photographs are generally of superior quality, and thereby reveal features that are not usually apparent in pictures published in newspapers and magazines.

The preface presents a brief but sufficient overview of submarines, their operations, and some pointers on reporting submarine sightings. A few brief paragraphs on the Soviet Navy and a rough distribution of submarines between the four Soviet Fleets are included. But a separate and more interesting summary is presented on the cover flaps.

The text is arranged into six chapters or groups. The groups are conventional attack, conventional attack equipped with cruise missiles, nuclear attack, nuclear attack equipped with cruise missiles, conventional and nuclear equipped with ballistic missiles, and specialized or auxiliary submarines. Within each group, at least one photograph of individual submarines is presented with a short description of its identifying features, its order-of-battle by fleet, its surface displacement, and its length in meters. At the end of Group 2 and Group 4, there is an additional collection which points out the similarities and differences among conventional attack units as well as nuclear attack units.

Photographs are included for all submarine classes discussed, except for the MIKE SSN (a drawing "based on satellite photographs" is presented), the DELTA IV SSBN, the LIMA SS, and the UNIFORM SSN. Except for a few units, the photographs are of sufficient quality to make this a collection that will be of interest to submariners, as well as the "non-naval public." Indeed, the quality and completeness of the photography reveal a great deal more about Soviet submarines than is available in any text to date -- and therein lies the value of this book. Since the author has included photographs of class variants and old as well as new photography of standard units, changes over time become more obvious. In fact, The Soviet Submarine Fleet: A Photographic Survey reveals that Soviet submarines differ from U.S. submarines in many ways and that some of the observable features of these hulls aren't readily identifiable and are subject to discussion as to their function. To make a best evaluation about the implications and functions of these features is certainly "not so trivial a pursuit."

Looking at the photographs Berg and Moore have assembled and making educated guesses as to the purpose and implication of certain features can be a fun and worthwhile pursuit for the submariner. Having a limited knowledge of contemporary Western submarine design might not be a handicap, since the Soviets appear to have moved in directions not identical to the United States. Indeed, knowing U.S. design practices may be misleading particularly when the photos are not examined with great care. What is needed is an experienced eye, practical sense, and the insatiable curiosity that is characteristic of the submariner. Being curious as to how submarines are being improved and as to the nature of the latest developments, I would start a sort of Trivia Pursuit game -- using photos from this book or ones from other publications, The Proceedings, Jane's Fighting Ships, Soviet Military Power, etc. And, start with the biggest and possibly most radical submarine of modern time, the TYPHOON. My first thoughts are to its great size: about 170 meters long, 25 meters in beam, and 16 or so meters high with a very long parallel mid-body. This envelope produces a submerged displacement of only 25,000 tons? My submariner's instinct sends up a red flag on that value. With a cross-sectional area of over 300 square meters the outer envelope of the sub must contain over 45,000 tons. The small surface displacement of 20,000 tons described in the book would require a free-flood volume of 20 to 25 thousand tons. It would be an unprecedented folly in ship design to tote around 25,000 tons of sea water unless there is a way of making some clever use of it.

The high freeboard suggests a healthy reserve buoyancy, probably more than 25%. The lack of limberholes, which total over 500 on previous SSBNs such as the DELTA-III Class, further suggest that there is not a great deal of free-flood volume that must be drained from the superstructure as the ship surfaces.

Now the difficult questions; or, as the gamesman says, the next level of difficulty. For what purpose is all the volume? Reloads, extra weapons? Twenty tubes forward is only four more than the DELTA submarines, which are about 1/3 the size of TYPHOON. More design folly? What is the vapor on the missile deck and along the flanks? Air to reduce boundary layer density? The photos in DoD's Soviet Military Power also show that vapor, although much less intense. Since the freeboard remains constant in all these photos, it doesn't appear to be the result of ballast tank venting. Why are there such large, almost square holes on the deck, on the trailing edge of the "lower sail," around the base of the sail, and along the after deck? It is hard to believe that these holes are ballast tank vents in that they appear both atop and outboard the sail in clusters and in the same transverse plane. Their location seems to alternate port to starboard between the "tracks" and wanders closer together as they progress aft to the plane of the two large trapeziodal structures, then the holes are continued aft, but outboard of the "tracks." These similar holes also appear on the OSCAR (page 4 and 58) and the DELTA-III (page 70).

Next level of difficulty. What are the trapezoidal structures that rise from the after deck? Their shape may be an effort to reduce submarine drag through equal area rule design (i.e., that cross-sectional area is nearly constant along the direction of flow). Independent of shape, these structures are likely to have a marked effect on the flow over the after deck. They appear to be in line behind a pair of unusually large hatches with openings of about 4 meters by 7 meters. Although they are of different sizes, similar hatches are on the VICTOR-III, the DELTAs (Two in tandem on D-III), and the OSCAR. There may, of course, be others. But more trivia. Why the white paint along the door edges? The only other white paint seems to be for locating things, such as air salvage fittings, plimsoll marks, and escape hatches. Are these stowages for communication buoys? If so, why so many size variations on different submarines, and why the white edges, and why so big? Whatever is inside is over 3 meters wide and 6 meters long -- big enough to carry men!

Same level of difficulty. Why is the sail so big? Why two levels of sail? Why are there sponsons around the sail? Their multi-meter width suggests more than a convenient walking deck. The whole sail design suggests some other function than housing masts. And why are the crew access hatches centerline and, except for the standard pair of air salvage fittings at the forwardmost and aftermost bulkheads, only single centerline fittings are observed on TYPHOON. Neither the salvage fittings nor the hatch locations are suggestive of the twin hull configuration reported in the literature.

Now that you've showed your prowess in making guesses to these "not so trivial" questions, you might relax with some easier, "first-level" questions. What is the purpose of the winglets aft of the trapeziodal structure? Are they like the flow directors on aircraft, or are they vortex generators to counter the disturbances created further forward?

Now even easier. What is the function of the pair of "tracks" on the walking deck? Up to now you might have kept your U.S. design concepts in check. If you said safety tracks, remember the TYPHOON's size. TYPHOON has about a 25-meter beam. These are pretty good sized "tracks." Why aren't they on the missile deck (<u>PROCEEDINGS</u>) as they are on DELTAs (pages 69 and 70)? Notice the crimps in the tracks on TYPHOON's afterdeck. Is that representative of a strong rail? But the real clincher: the photograph of an ECHO-II on page 50 shows what appears to be two pair of tracks, the inboard or larger pair being closer in dimension to the "tracks" on more recent classes. Other photographs show that they are sometimes light or white in color, that in some cases they go along the very edge of the deck and outboard or over the edge to pass obstacles. The more classes you look at in Berg's collection, the more variations in track patterns you will notice, not only between classes but also among classes.

Well, enough of the TYPHOON -- not that we have covered all or even most of the possible questions, but let's make sure that the player's interest is sustained. I think the interested submariner will have difficulty in finding a single picture in Berg's collection that he is willing to pass over. For example, the photograph of the OSCAR on the frontispiece (page 4, unnumbered), as well as the VICTOR (page 42), show a very wide vertical slot down the bow of these subs. Be careful now about a guess based upon U.S. design practice. These slots are much wider and longer than they need to be, if they were only torpedo-loading hatches. They are well forward of the main deck and, in some cases (see the SIERRA on page 96 of the PROCEEDINGS (December, 1985)), extend below the water line. The hoarfrost on the OSCAR reveals lines and shapes along this slot that are hard to understand. The entire slot is apparently subdivided, but is altogether rather large and located in a position subject to greater stress than traditional loading hatches. While we worry about shutter door noises, one should wonder why two of the Soviets' quietest submarines have been designed with such large noisemakers at such a critical location. And, in that same context, why are they so long and so wide? (Since the slot is along the curved bow and extends well forward of the pressure hull, a weapon-torpedo loading hatch even shorter than those on the flat-decked fleet-boats would be adequate).

The bulb-shape of the sail's base, the blunt trailing edge of the "upper" sail structure, and the fences or vortex generators on the TYPHOON may be better explained as aerodynamic features rather than traditional submarine hydrodynamic ones. Photographs of other classes, such as the apparent coke-bottle shape of the BRAVO (page 78) and the complex curvatures pictured on the DELTA-III (page 70) and VICTOR-III (page 44), are also reminiscent of lessons learned in the aero community decades ago. The full shape of the sail of the ALFA elicited the author's comments that it "is narrow on the top and widening downward, so that the sides blend with the hull" and "it is not possible to step out from the side of the fin (sail)." Some Soviet sail shapes, such as ALFA and AKULA, appear to be closer to the design of aircraft wings than those of U.S. submarines. Indeed, the photograph of the ALFA (page 40) makes one recognize just how important streamline design is to the Soviets. Maybe this game would be more interesting if an aircraft pilot or designer were to assist!

One more rule of this game should be consistency. Make sure your answers are consistent within a photograph and between photographs. For example, hesitate to explain a particular circumstance because the weather is cold in one photo and in another a warm sun is in evidence. This points out another value of Berg's work. Since most of the submarine classes are presented with multiple photographs, similarities and differences can be pointed out. The BRAVO is a late 60s non-nuclear, so the splotches all over its surface (page 78) might be evaluated as peeling paint. But, on the rubber-coated ALFA there is a similar discoloration. Is it paint -- or a Polymer slime? Other submarines also have discolorations which appear to be more like selective wetting. That is, some panels appear water-covered, while others adjacent and closer to the water, appear dry. Some of the darker stains on the TYPHOON give the appearance of leaks -- leaks coming out of the coating and leaks coming from between the coating panels.

Helpful hint. One should develop Soviet patterns. While Western submarine designs have nearly 12% reserve buoyancy, the freeboard of the TYPHOON suggests more than 25%. Soviet literature states that reserve buoyancy and its distribution (not concentrated at a few points) are direct measures of the ship's survivability. The photograph of the VICTOR-III on page 44, with the horizontal control surfaces (bow and stern planes) breaking the sea surface, demonstrates the extraordinary reserve buoyancy of this class. With the bow still high, the stern is nearly half out. It is clear that during normal surfacing, the VICTOR still has a sizable reserve buoyancy. In fact, this photograph gives credence to the Soviet open-source articles which suggest that they still build hard tanks in order to tolerate the loss of a compartment. There is still another test for your skills in this photograph. Although the VICTOR is described as having contra-rotating propellers, it is apparent from the photo that both the forward and after screw are pitched in the same direction. Thus, they would be better described as tandem propellers.

<u>The Soviet Submarine Fleet: A Photographic Survey</u> should provide interesting reading and perusing for both the layman and submariner, especially the submariner. For the submariner, good eyes, interest, and a commitment not to fall victim to U.S. ways of designing submarines is all that is needed to really enjoy the book. All lines on the deck are not necessarily safety tracks, all hatches do not necessarily house communication buoys, and all long deck hatches may not be for torpedo loading. There are many important features of Soviet submarines that remain unidentified and need an experienced mind and an experienced eye to evaluate. Berg and Moore present that opportunity in their new book. For all of us, they have provided an extraordinary addition for our reference library.

K.J.M.

<u>SUBMARINE</u>

By Jonathan Crane. Published by The British Broadcasting Corporation, 1984.

In 1983 the BBC made a television "mini series" about The Royal Navy's submarine service that consisted of six thirty minute programmes. The series was split into three sections; one about life onboard an SSN, one following the fortunes of four candidates in the Commanding Officers Qualifying Course and the last about life onboard an SSBN. This book is written by the director of the film crew and is split in the same way but with the addition of a fourth chapter containing a potted history of submarines from 332 BC until the advent of the Polaris Submarine in the mid '60's.

The book starts dramatically with a boat rendezvous off Campbeltown Loch in a grey choppy Scottish day as the film crew board HMS WARSPITE which was sailing to take part in Exercise Ocean Safari '83. What follows is an accurate and sympathetic description of life onboard a modern SSN, written not in any sneering way but with a genuine respect of the submariners by the film crew. "The whole concept of taking a miniaturised nuclear power-station to sea, throwing it around at violent angles from the surface to several hundred feet down is somewhat audacious."

That is not to say that an unrealistically rosey picture of life onboard is painted -- the portrait contains "warts and all." WARSPITE fared with mixed success during the Exercise and no cloak is drawn across an early detection by an Atlantique aircraft after which the Captain in masterful understatement commented that "We have not had a good day." For the American reader this chapter has much that he will find strange and amusing; for instance the officers and ratings have sherry together after church, served off a silver salver.

The second chapter follows the varied fortunes of four officers in the Commanding Officers Qualifying Course -- "The Perisher" so named, not as the book implies because many fail, but from the diminutive of "The Periscope Course," its original name. Undoubtedly this is the highlight of the book, as it was of the television series. It is a compelling account of this gruelling course whilst remaining accurate and containing sufficient technical detail for the reader to understand what is happening. When the two episodes of The Perisher were shown on British Television, the whole country stopped to watch as if mesmerised by the gyrations around the periscope. "Teacher" became "public enemy number one" for failing a student, numerous articles appeared in the national press and civilian friends telephoned asking, "Did you really do that?" with renewed admiration in their voices. The book cannot catch the fast moving pace of the film but despite that it is a well written and interesting account which all U.S. submarine Commanding Officers will enjoy reading if only to find out how their British opposite numbers are trained.

The Perisher, which lasts five months, consists of two main phases; the first has the students conducting visual attacks over a three week period against a steadily increasing number of ships -- one frigate at the start rising to four frigates and a target at the end. The attacks are contrived and artificial with little direct tactical significance; the aim of this phase in the words of Teacher is "to put the student to the limits. We create these kinds of situations so that he is aware of his personal limitations." Anyone who has witnessed the Perisher at sea knows how true that is.

The second part of the course is to train the students in a realistic tactical scenario and is split into two further phases, ocean and inshore. In the book only the latter is covered. It is again an accurate portrayal of the evolutions that are conducted, in this case a minelay, a photo-reconnaissance and finally the landing of special forces. Of the ten students who start the Perisher only six pass which is "par for the Course."

The third chapter, "Submersible to Submarine," appears to have been added to the book to pad it out. It is not badly written but seems to have little relevance to the other three chapters; while, the early history of submarines is very much better covered elsewhere, (for example: Submarine Boats by Commander Richard Compton-Hall.)

Chapter four, "Bomber," returns to the filming, this time onboard HMS REPULSE, one of the Royal Navy's four Polaris submarines. Much is made of the problems of the families while their husbands are away on patrol and the unenviable task that wives face in compressing all the affairs of home into forty short words that make up a "family gram." There is a short description of a practice firing sequence and a rather poorly written section about the efficacy and morality of the nuclear deterrent.

I hope this book will be published in the USA and that the PBS television stations show the BBC series "Submarine" as it has succeeded in capturing the atmosphere of today's submarine service. The American viewer may not like all that we Brits do onboard our submarines but those who have worked with us at sea know that although we have different ways we can and do keep up with the best.

Commander James F. Perowne, OBE Royal Navy

[Ed. Note: CDR Perowne sent a VHS videocassette of "SUBMARINE" to the Naval Submarine League for those who wish to borrow it.]

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ELITE FORCE (14 1/2 minutes)

Mr. Charlton Heston describes the opportunities that are available to qualified college students and graduates in the Navy's Nuclear Propulsion Officer Candidate program. (This is a recruiter oriented film.)

PRIDE RUNS DEEP (28 1/2 minutes)

Story of the Navy's Submarine Force. Excellent photography. Provides the audience with a close-up look of the crew in action aboard an FBM submarine. This film conveys the deep sense of pride that is shared by all submariners.

THE CHALLENGE IS MET (26 minutes)

Describes the conversion of twelve Poseidon submarines to carry the Trident 1 missile. Discusses the necessity for the Trident submarine and follows missile development and ship construction through R & D. Follows USS OHIO through initial upkeep at Bangor, Washington, and ends with Trident on patrol. This film contains great shots of missile launches.

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Articles for this publication will be accepted on any subject closely related to submarine matters. Their length should be a maximum of about 2500 words. The content of articles is of first importance in their selection for the Review. Editing of articles for clarity may be necessary, since important ideas should be readily understood by the readers of the Review. Initially there can be no payment for articles submitted to the Review. But as membership in the Submarine League expands, the Review will be produced on a financial basis that should allow for special awards for outstanding articles when printed.

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The success of this magazine is up to those persons who have such a dedicated interest in submarines that they want to keep alive the submarine past, help with present submarine problems and be influential in guiding the future of submarines in the U.S. Navy.

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