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HISTORY
OF
SUBMARINE MEDICINE
IN
WORLD WAR II

By

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and

Mrs. Jessie W. Kohl, P-1, Scientific Staff Assistant

25 May 1947

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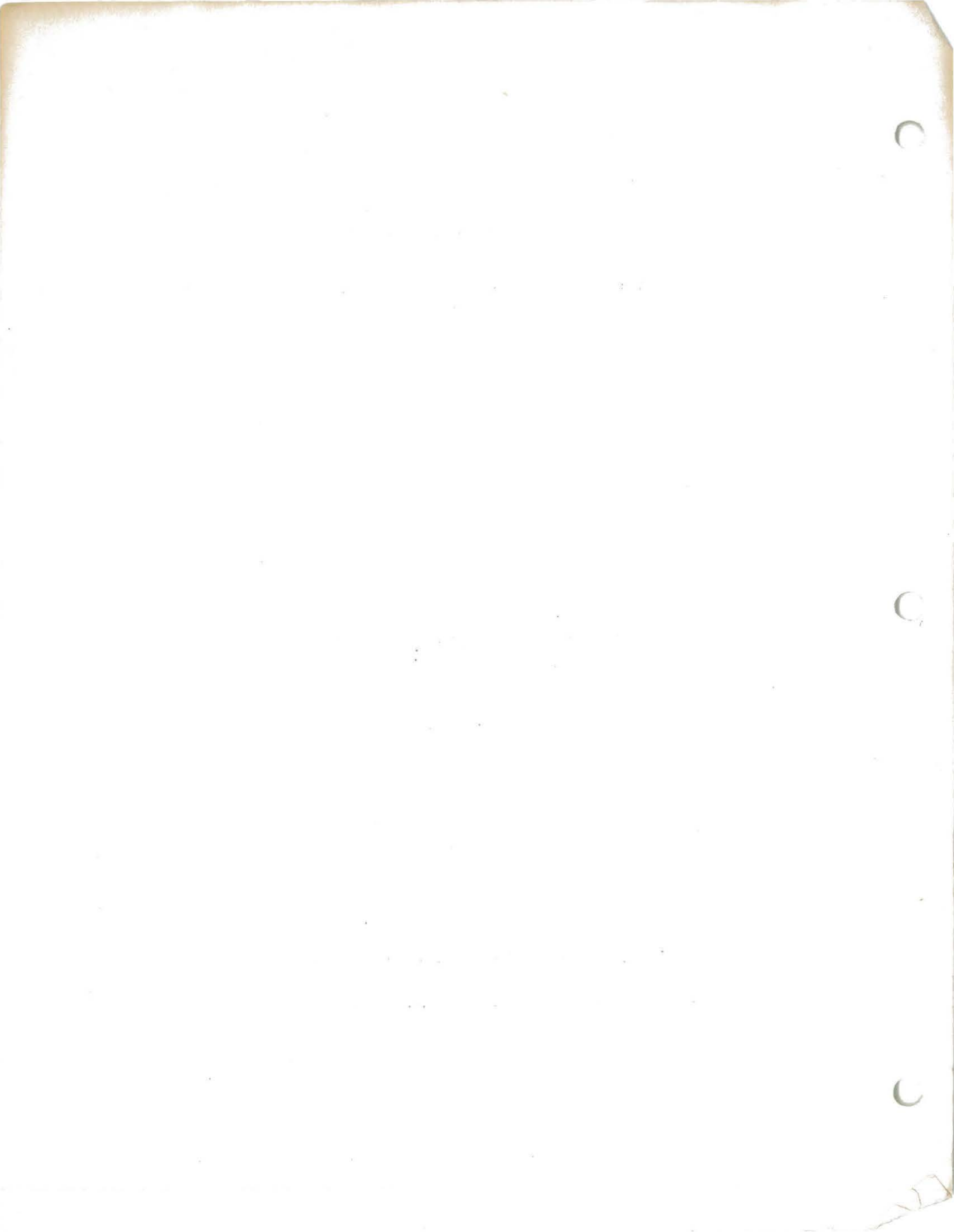
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HISTORY OF SUBMARINE MEDICINE IN WORLD WAR II

I - INTRODUCTION

Submarine medicine is a distinct medical specialty, requiring not only selection of specially qualified and competent Medical and Hospital Corps personnel, but also requiring additional specialized training.

The primary duty of these Medical and Hospital Corps members is the same as for any other type of Navy duty, that is, the care of the sick and injured. They also share with the other units of the Fleet and shore stations the routine duties, - such as inspections, preparation of reports, etc. that pertain to their jobs. However, in addition to these more or less well defined duties, there are many special duties required of both the Medical and Hospital Corps personnel in the Submarine Service.

They must become specialists in submarine construction and operation to the extent at least, that they will be able to understand the problems of maintaining a satisfactory environment for submarine personnel, and understand the problems of submarine safety and salvage. This requires a knowledge of such things as the operation of rescue apparatus, such as the rescue "Bell"; the use of the submarine escape appliance, the "lung", and methods of escape from a disabled submarine; the treatment of casualties that may develop during escape training; the normally required concentrations of oxygen and carbon dioxide, and methods for determining these percentages aboard a submarine; the special angles to the problems of food and nutrition, water supply and sewage disposal peculiar to submarines.

In addition to this, the submarine medical officer must be proficient in the field of personnel selection, and should be able to properly evaluate early signs of fatigue and war neurosis, so as to take men off the boats for proper rest and treatment before any breaks actually develop.

The submarine pharmacist's mate, the only medical representative normally aboard the submarine during war patrol, has additional duties as a member of the crew. He may be assigned such special duties as sonar operator or day or night lookout. He is usually the librarian, and is regularly assigned the cleaning detail for the after-battery compartment. A more detailed discussion of the training and duties of submarine Medical and Hospital Corps personnel follows in Chapter II.

A complete bibliography on all phases of submarine medicine is in process of preparation for the Bureau of Medicine and Surgery by Commander E. C. Hoff (MC) USNR and will be published in book form.

II - MEDICAL PERSONNEL

A. The Submarine Medical Officer.

Prior to the war there were no more than 8 - 10 medical officers actively interested in submarine problems. All such medical officers were primarily trained in deep-sea diving but were supposed to be qualified to handle either diving or submarine activities. The only exception to this type of training was that three young medical officers completed part of the regular officer class at Submarine School at New London in the officer class graduating in May of 1933.

With the advent of the war, a greatly increased number of medical officers was immediately necessary and therefore training facilities were set up for instruction of additional medical officers at the Deep-Sea Diving School, Navy Yard, Washington, D.C. For the first two years of the war, medical officers were trained solely as deep-sea divers, and as before were not given any additional training preparing them for submarine activity. The inadequacy of this partial training was pointed out and the Officer-in-Charge of the Experimental Diving Unit, Navy Yard, Washington, D.C. by letter EDU/P11-1, dated 11 May 1943, requested the

Commanding Officer of the U. S. Submarine Base, New London, Connecticut, to give some further training to the class of officers of the Medical Corps then under instruction at the Deep Sea Diving School. It was requested that the facilities of the Submarine Base, New London, be made available for additional training for this group for a period of two weeks, beginning 28 June 1943, "for lung tank instruction and escape, inspection and instruction trips on submarines, dark adaptation instruction and similar matter. Since many of these doctors will be assigned to submarine rescue vessels, it is considered that they should have more first hand knowledge of submarine practice than it is possible to give them in Washington, D. C."

The Commanding Officer of the New London Submarine Base approved this request and the first class of medical officers (five in number) arrived for further training in the Medical Research Department of the Base, on 28 June 1943. The staff of this department gave whole-hearted approval of the plan for giving future submarine medical officers a good indoctrination course in submarines at the Submarine Base, New London, and outlined a curriculum which included: submarine escape training; numerous submarine trips, both by day and night; inspection trips on an ASR, demonstration of its diving equipment, the rescue "Bell", etc.; lectures and demonstrations and actual participation in the submarine selection system; and the selection system for sound-listening personnel. They also visited various training activities, including the Submarine School and all of its departments; the Pharmacist's Mates School, the Interior Voice Communication School and the Lookout Training School. They also toured the Electric Boat Company, near the Submarine Base, New London, and observed submarines under construction.

So successful was the outcome of this two weeks of training that each subsequent class at the Experimental Diving Unit was sent on to New London in its turn for this additional training, until in October of 1944, when the training period was extended to a full three weeks. This arrangement continued until the end of the war period.

In order to give further emphasis to this distinct medical specialty, an insignia was devised in 1943 to be worn by qualified submarine medical officers; and the requirements for designation as a Qualified Submarine Medical Officer were set up. They were subsequently revised, as per the Circular Letter No. 44-44 quoted below:

MANUAL CIRCULAR LETTER NO. 44-44

44-883--Changes in Articles D-7020, H-9604(2), D-5112, and E-1314,
BuPers Manual

Pers-10D-JK, A2-2/EN4, 27 July 1944

ACTION: ALL SHIPS AND STATIONS

(Enc.: (A* Copy of subject changes)

1. The secretary of the Navy having approved the enclosed changes in Articles D-7020, H-9604, D-5112, and E-1314, Bureau of Naval Personnel Manual, on 13 July 1944, they are published for the information and guidance of all concerned.--BuPers, L.E. Denfield.

Enclosure (A)

CHANGES IN BUREAU OF NAVAL PERSONNEL MANUAL

Revise entire article E-1314 to read as follows:

"E-1314. Qualification for Submarine Medical Officer.

A candidate for classification as a submarine medical officer must qualify as follows:

(1) Served in this capacity for a period of twelve months in a submarine squadron, or in a vessel whose mission is diving, or at a shore station where his primary duties have been with divers or the training of submarine personnel.

(2) Be a graduate of the Deep Sea Diving School, Navy Yard, Washington, D.C., or have served a three year tour of duty at the Experimental Diving Unit, Navy Yard, Washington, D.C.; or be a graduate of the course given for medical officers at the Submarine School, New London, Conn.

(3) He shall be recommended by his squadron commander, or if shore based, by his commanding officer,--after having satisfactorily proven his practical ability in submarines and deep sea diving. He shall further be recommended by his squadron medical officer and senior medical officer, wherever such have cognizance over him. Following this, he will demonstrate his knowledge of submarine and diving medicine by an examination, which shall consist of:

- (a) A written examination, prepared by a Central Board of Medical Officers, located at the Experimental Diving Unit, Navy Yard, Washington, D.C., and consisting of three or more medical officers, at least two of whom shall be qualified in submarine medicine. This examination shall be complete in nature and shall cover the following listed subjects: physiology of respiration, treatment of caisson disease, selection of submarine personnel, submarine escape--utilizing the rescue chamber or the lung, emergency measures to be used in a disabled submarine on the bottom in deep water, (i.e. oxygen requirements; how much oxygen to be released per man per hour; what measures are to be taken against noxious gases, such as chlorine; physiology of bubble formation; gas laws; helium diving; oxygen poisoning; effects of pressure on the body.)
- (b) An article or paper of sufficient scope for comprehensive coverage of some phase of submarine medicine or medical aspects of deep sea diving. (This is not to be required if the individual has published at least one scientific article dealing with submarine or diving problems.)

(4) The following is the detailed qualification procedure to be followed:

- (a) Letter requesting examination originated by candidate stating his qualifications, routed via cognizant medical officer and squadron commander to the Central Board of Medical Officers for Qualification of Submarine Medical Officers, Experimental Diving Unit, Navy Yard, Washington, D.C.
- (b) Forwarding by the Central Board of Medical Officers of questions for supervised examination.
- (c) Return of examination of papers to Central Board with article referred to in Paragraph 3-b, or copy of published paper, as an enclosure.
- (d) Recommendation by Board to the Chief of Naval Personnel, via the Chief of the Bureau of Medicine and Surgery.
- (e) Notification by letter to the candidate, by the Chief of Naval Personnel.

(5) In cases where qualified Medical Officers who are former members of the Central Board are available in fleet units, a Board may be formed locally by precept from local commanders to facilitate and expedite qualification. Three or more medical officers will constitute this Board, to include the qualified Central Board Member. Proceedings, examination, and article as an enclosure, are to be forwarded to the Chief of Naval Personnel, via the Central Board and the Chief of the Bureau of Medicine and Surgery."

Navy Dept. Bulletin

31 July 1944

Because of the resignation of many of the regular Navy Medical officers, following the end of the war, as well as the separation from the service of all of the Reserve medical officers, the number of available submarine medical officers became entirely too small to even fill the most urgent needs of the Submarine Service.

In order to meet this need in October of 1946, a plan was worked out by BuMed and BuPers, whereby officers of the Medical Corps, interested in becoming submarine medical officers, might attend a regular six-months course at the U. S. Naval Submarine School, New London, Connecticut. A curriculum was worked out whereby this group of doctors (12 in number) might attend the regular line officer classes for one half of their time, and the other half of their time would be spent under the direction of the Medical Research Laboratory, acquiring the specific background required for submarine medicine. All details have been arranged and the first class is expected to arrive on 7 July 1947, to become a part of the 85th officer class of the Submarine School.

In addition to this, in order to attract desirable candidates to this special branch, both the Commander Submarine Force Pacific and Commander Submarine Force Atlantic, in October of 1946, suggested to the Chief of the Bureau of Naval Personnel that ten definite submarine medical officer billets be established, as follows: one submarine medical officer on the staff of each Submarine Force, SubLant and SubPac; and one submarine medical officer assigned to each of the four Pacific Squadrons and each of the four Atlantic Squadrons. Nine such billets were subsequently approved (27 January 1947),--the shore-based squadron at Pearl Harbor being the only billet deleted. These nine billets are sea-duty billets, providing desirable submarine duty and sea pay.

The assignment of these billets went a long way toward establishing the rightful place of the submarine medical officer within the Submarine Force, and served to formulize the situation which existed to a limited degree during the war.

In the early part of the war, a medical officer was assigned the combination job of Senior Medical Officer at the Submarine Base Dispensary, Pearl Harbor, and duty on the staff of the Commander Submarine Force, Pacific Fleet. However, the Pacific Force Medical Officer job was not operated to the fullest extent, nor to the best interest of submarines, until the arrival of a submarine trained and submarine-mind Force Medical Officer in March of 1944. Then the program of submarine medicine was activated; distribution of supplies was organized so that every submarine got what it needed

and wanted. Careful check-up was made on all submarine crews, both before going on patrol and immediately upon return from patrol. Several special research projects were initiated, and data on these studies were obtained during submarine trial runs. A Warrant Pharmacist was attached to the staff of ComSubPac to assist with the handling of personnel problems, and the maintenance of more complete liaison with the Hospital Corps details officers of CinCPac and ComSerForPac. With this assistance it was possible to keep accurate records of the distribution of all submarine Hospital Corpsmen in the Pacific area, the number of patrols made by each man, etc. This new regime also instituted an aggressive health program, which included conferences with Commanding Officers and extensive work with the pharmacist's mates. In addition to this, a pool of submarine pharmacist's mates (graduates of the School for Pharmacist's Mates Entering the Submarine Service, at New London, Connecticut) was established. This pool was intended to furnish replacements as necessary. And in order to keep the men interested and in best possible trim for transfer to fighting submarines, a system of continuous refresher training was made available to the men thus standing by.

On 20 April 1942, a medical officer was assigned additional duty on the staff of Commander Submarine Force, U. S. Atlantic Fleet, whose primary duties were the examination and selection of officers and men for the Submarine Service, and the conduct of experimental work in connection with submarine activities.

A medical officer was also assigned to each submarine squadron, but unfortunately in many cases these medical officers were not the trained and qualified submarine medical officers. In fact, in almost every case, the Senior Medical Officer at submarine bases or on tenders inherited the designation of Squadron Medical Officer, and was in most instances, neither selected, trained, nor qualified for this task. The actually qualified submarine medical officers serving with the squadrons were in many cases junior to the designated Squadron Medical Officer and thereby considerably hampered in the work they wanted to do for the Submarine Service. A lesson should be learned from this so that such a situation can never again be allowed to exist.

Other qualified submarine medical officers were utilized at submarine base dispensaries and in research activities at NMRI, at Bethesda, and at NMRL, at New London, and at the Experimental Diving Unit, Navy Yard, Washington, D. C.

There was some agitation during the war period, for attaching a medical officer to the regular complement of all submarines, but both the limitation of space aboard submarines and the shortage of available medical officers precluded the adoption of this arrangement. The greatest number of qualified submarine medical officers existing at any one time during the course of the war was twenty-seven. Three medical officers actually made submarine war patrols,--one such officer was lost with the USS WAHOO.

The senior author of this history would like to point out that should another such situation arise, more submarine medical officers should certainly ride the boats,--if for no other reason than to learn submarine problems and conditions first-hand and to conduct experimental work actually during patrol conditions.

B. The Hospital Corps Officer in the Submarine Service.

In the normal course of events, when a qualified submarine pharmacist's mate is promoted to warrant or commissioned rank, he is lost to the Submarine Service by transfer to other activities. However, during the war certain of these well-trained and well qualified Hospital Corps officers were utilized in the following billets: as assistant on the staff of ComSubPac; at submarine base dispensaries; as the officer heading the School for Pharmacist's Mates Entering the Submarine Service, Submarine Base, New London; and in research programs being conducted at the Naval Medical Research Institute at Bethesda, Maryland, and at the Naval Medical Research Laboratory, at New London, Connecticut. In any future emergency, it is believed that all Hospital Corps officer billets at submarine shore stations or aboard submarine tenders should be filled by Submarine trained personnel.

C. The Submarine Pharmacist's Mate.

No submarine carried a pharmacist's mate in the crew until the V-boats, BASS, BARRICUDA, and BONITA, commissioned in 1924, 1925, and 1926, respectively. Until that time the medical officers of the submarine tenders and bases cared for the health of submarine personnel. With the improvement and development of submarine design, longer and longer periods of absence from the tender or base became feasible, and therefore the need for hospital corpsmen's being assigned to independent duty on submarines became increasingly necessary.

From the very beginning, the attachment of a pharmacist's mate as a regular member of the submarine crew has proved to be a very satisfactory arrangement. A good pharmacist's mate, like a good cook, often proved to be one of the most valuable men aboard the boat, from the point of view of morale, quite apart from the specific duties performed.

The accomplishments of submarine pharmacist's mates during the recent conflict have received high acclaim, in the official patrol reports, in the record of commendations and awards, as well as in press and radio. The initiative and resourcefulness they displayed deserves a chapter all its own.

This splendid record and the more-than-adequate service rendered by Pharmacist's Mates during this war makes it appear that rigid selection and adequate training of the submarine pharmacist's mates is the answer, rather than assigning medical officers.

The submarine pharmacist's mate, like all other submarine rates, is a volunteer, and at the time of the onset of the war, such volunteers were obtained by direct transfer from the Forces Afloat or shore stations, to the Submarine School for basic training in submarine operation. During peacetime this was a satisfactory arrangement.

However, early in the war it became imperative to establish a school for intensive training of pharmacist's mates prior to their entry into the Submarine School because of the inadequate amount of training possessed by pharmacist's mates being transferred to the Submarine Service; and also because, as the war progressed, the demand for trained pharmacist's mates increased far beyond the available supply.

Accordingly, the School for Pharmacist's Mates Entering the Submarine Service was established at the New London Submarine Base in April of 1943. The input to this school continued to be furnished by volunteers from the Forces Afloat and shore activities, but as the manpower situation became more acute, the training of the men being received was found to be so poor that a different arrangement was made early in 1945, whereby this school received a quota of students from the graduates of the U. S. Naval Hospital Corps School, at Norfolk, Virginia, where pharmacist's mates were being trained for independent duty.

Thus the volunteer pharmacist's mates from the Fleet went directly to the Norfolk School where they received 16 weeks of training, then on to the School at New London, where 8 weeks of additional training were given in the special phases of pharmacist's mates duties aboard submarines. Then the pharmacist's mate went on to the Submarine School at New London for basic training in his line duties. From there he was assigned either directly to a submarine, or to further training for Lookout, Sonar, or Radar duties, and then to a submarine.

In November of 1944, a pool of pharmacist's mates was established in the staff allowance of ComSubPac where pharmacist's mates from the Submarine School were not only held actually awaiting assignment as replacements aboard submarines, but also attended refresher courses in the local post-graduate school. Additional numbers of trained pharmacist's mates were also carried on all submarine tenders and held in pools at various submarine bases and stations, in order to furnish emergency replacements as necessary. In most cases this method of assignment worked

adequately, but in some situations the medical officer of either the tender or the dispensary saw fit to hold the specially selected and trained submarine pharmacist's mates and transfer to active duty on submarines the poorer, non-submarine-trained material. This situation would automatically be taken care of in the event of any future emergency, when presumably only a qualified submarine medical officer will ever be designated as the Squadron Medical Officer.

It should be pointed out that graduation from the School for Pharmacist's Mates Entering the Submarine Service does not automatically make a man "Qualified in Submarines". Graduation from the School automatically makes a man a submarine technician and his personnel accounting records are so marked, but in order to acquire the designation "Qualified in Submarines", a pharmacist's mate must have served aboard a submarine until he has completed certain requirements to the satisfaction of the submarine's skipper and have been recommended by him for his designation. Just as all other ratings on the boat, in order to be designated as "Qualified in Submarines", a man must have completed a notebook, which contains drawings and diagrams of all of the systems throughout the boat,--the ventilating system, the system of tank arrangements, the hydraulic system, etc. This notebook must have been graded and passed by a qualified submarine man. The man must have served from six months to a year aboard a submarine (in wartime, sometimes two war patrols were considered sufficient to qualify a man) and must be recommended by the Commanding Officer.

Aboard a submarine, the pharmacist's mate is responsible for the care of the sick and injured and the maintenance of the health of the crew. He is thus responsible for all of the routine medical duties laid down in the Manual of the Medical Department. However, in addition to this, war experience demonstrated the desirability of the pharmacist's mate performing general submarine operational duties and other special duties as were assigned, such as sonar operator, radar operator, day or night lookout, librarian, compartment cleaner, oiler of the periscope, etc.

Thus, the pharmacist's mate is an integral part of the crew. He knows his men and his boat thoroughly and is therefore in a position to render the best possible medical service--preventive and clinical.

III - DEVELOPMENT OF THE USE OF SELECTION PROCEDURES FOR THE SUBMARINE SERVICE

One of the most important contributions to the efficiency of the submarine force was that made in the field of the selection of the officers and men best fitted for this duty.

At the onset of the war the only examination for entry into submarine duty was the physical examination prescribed under Article 1535 of the Manual of the Medical Department. No mention of intelligence quotient, of psychological fitness, or psychiatric selection was contained therein, although these items became of great importance to the submarine selection system during the war. It is true, of course, that under pre-war conditions, some of the factors found in this type of selection were automatically covered by the requirement of satisfactory performance of at least three years of sea duty with the Fleet prior to making application for submarine duty. However, this automatic screening became inoperative immediately with the beginning of the war when the manpower needs of the Submarine Service were so suddenly expanded that large numbers of personnel were received fresh from civilian life.

A. Physical Examination.

The physical requirements maintained during the war were those of the Manual of the Medical Department, Article 1535, with the exception that certain requirements were modified to meet the demands of the situation. As an example and notable in this regard is the dental examination. It had been found that certain dental officers, unfamiliar with service necessities, had been rejecting

as many as 50% of candidates in the preliminary examination, in some instances making the requirements much more stringent than set forth in the Manual. It has been aptly said that "We're gonna fight 'em, not bite 'em". A statement from a SubLant publication* clearly illustrates the policy in regard to the dental requirements. "The strict dental requirements for submarines were specified due to the erroneous impression that the mouthpiece of the submarine escape appliance, the 'lung', must be firmly gripped by the teeth. Actually, the 'lung' mouthpiece is properly held by the lips with scant or no gripping of the teeth. Many a man has left his dentures in his locker while taking lung training. Emotional stability is much more important as a factor in learning the use of the lung. Dental requirements in submarines are satisfied by good oral hygiene (no pyorrhea alveolaris, Vincent's infection, or excessive caries), no marked deformity of mouth or teeth (very marked over or under-bite or dental protrusions make lip-gripping of mouthpiece difficult). Properly fitting bridges or dentures are not considered cause for rejection. It is required that sufficient opposing teeth be present to perform good mastication."

Also, rejection for venereal disease was modified, not only because of the personnel shortage, but also because of the advent of new types of treatment enabling men to return to duty in a shorter period of time.

B. Special Senses.

The development of specialized submarine tasks necessitated the introduction of special examinations. In this connection, particular mention should be made of the necessity for testing night vision in order to properly select night lookouts, or at least eliminate the dangerously night-blind. The first work on this problem started in the submarine service in April of 1941 and was continued and greatly developed throughout the war. The experimental phase of this work for the entire Navy was largely done in the Medical Research Laboratory, Submarine Base, New London, and will be discussed in more detail in the chapter on research.

* "Outline and Discussion of Methods Used in Selecting Enlisted Candidates for Submarine Training", 1943.

Submarine personnel were also tested for their visual ability to become good radar operators. The technique of this testing process was set up and validated by the National Defense Research Committee working in connection with range finders, height finders and radar operators. Requirements were found to be: normal near visual acuity and normal phoria measurements.

Also additional tests as well as modification and improvement of old tests were found necessary, both in the field of testing far visual acuity and color vision.

One of the most important contributions made by the Submarine Force to the Navy as a whole, was the early development and application of selection procedures for picking sonar operators. The pioneer work was done by the staff of the Medical Research Laboratory at New London. Early recognition of the value of this work came from the Navy as well as from the N.D.R. Committee group, and the work done at New London formed the basis of the selection procedures developed for the selection of sonar operators for all of the Fleet units. The files of the Medical Research Laboratory at the U.S. Naval Submarine Base, New London, Conn., contain the letters, reports, etc., which corroborate this statement, and will be mentioned again in the chapter on that laboratory.

C. Psychological Testing.

Paper-and-pencil psychological tests are extensively used in the selection process. The early impetus for the development and application of these tests came from the civilian research groups, such as the NDRCommittee Section - The Brown University Division. Many of these early tests were proven to be of great value in eliminating the psychologically and psychiatrically unfit personnel.

Psychometric testing is a part of the psychological testing program. The Submarine Service became interested in intelligence tests early in 1942, in order to assure the selection of individuals of average or better than average intelligence, capable

of being trained to handle the complicated equipment of a submarine. Again as in several of the other fields, experimental work on this program was done at the Medical Research Laboratory at the Submarine Base, New London and will be discussed in the chapter on Research.

D. Psychiatric Interview.

The first truly psychiatric selection interview for the Submarine Service was conducted in 1943, with the attachment of a trained psychiatrist to the Medical Examining group at New London. Prior to this time, selection interviews were conducted by trained Medical Corps and Hospital Corps personnel who were however nonpsychiatrically trained individuals. Of special interest is the method employed at New London using the combination of paper-and-pencil tests and psychiatric interview to complement each other. Many of the "boot" training camps and other training centers required their psychiatrist to attempt to interview as many as 20-30 men per hour, straight through the day. This obviously was not only impracticable, but literally impossible. In the Submarine Service, by using the psychological paper-and-pencil tests for the original screening, and asking the psychiatrist to interview only those in the 'failing' or 'doubtful' categories, he was able to render much more effective service. This point should be clearly publicized and established as the procedure for the entire Navy in case of another mobilization.

As an indication of the examinations given routinely at Medical Research Laboratory, New London, we list the following:

Officer candidates for Submarine School

Enlisted candidates for Submarine School

- all candidates for Submarine School were given physical, psychological, and psychiatric examinations, and aptitude tests for various special jobs, and those who passed were then given submarine escape training

- 180 Officer candidates for "Qualification in Submarines"
- 180 Pharmacist's Mates for Submarine PhM School
- 480 Enlisted candidates for qualification as deep-sea diver
- Special test in Color Vision
- Special tests in Night Vision
- Selection tests for Sonar Operation
- Selection tests for Radar Operation
- Re-check examination for New Construction crews
- Basic battery tests for those who were found to lack same in their Service Record.

As an indication of the volume of this examination program the following excerpt from Medical Research Laboratory's Semi-Annual Report for the period July through December 1944 is indicative:

July 1, 1944 to December 31, 1944

	<u>Passed</u>	<u>Failed</u>	<u>Total</u>
For Submarine School:			
Enlisted candidates from Fleet and other stations	4,423	1,099	5,522
Enlisted candidates from this base (including re-exams).....	336	147	483
Officer candidates for Submarine School	607	33	640
Physical Exam. of officers for the designation "Qualified in Submarines".....	46	1	47
Pharmacist's Mates examined for entrance into PhM School.....	83	40	123
Physical examination for Divers	169	28	197
Exam. for duty as instructor in Escape Training Tank.....	7	2	9

Re-check examination for New Construction submarines	160	0	160
Special Color Vision Tests			480
Night Vision Tests.....	8,570	711	9,281
Sonar Selection tests.....	1,544	374	1,918
Radar Selection tests	438	89	527
			<u>19,387</u>

E. Pacific Reprocessing.

It should be noted that the Pacific Fleet medical organization found it highly desirable to conduct careful screening and reprocessing of submarine crews in order to eliminate those individuals who due to the pressure of circumstances in the early days of the war (especially the week following Pearl Harbor), had been inducted directly into the submarine force without previous selection and training. This activity of ComSubPac functioned very effectively and served to eliminate many men who should never have been assigned to the Submarine Service.

F. Trips made in the Interest of Submarine Selection.

Of particular importance to the Submarine Service was the method of insuring a continuous flow of the best type of officers and men for training for submarine duty.

Early in the war, it was found that the personnel situation was such as to make it highly desirable to actually go to the source of supply of submarine officers and select those volunteers best suited for submarine duty. Thus early in 1943, the first of a continuous series of interview boards was established, each board consisting of a representative of the staff of Commander Submarines, Atlantic Fleet; a representative of the submarine personnel

division of BuPers, and a medical representative from the staff of the Medical Research Laboratory at New London. These boards travelled to the various officer indoctrination units and working in cooperation with the selection and medical departments, studied the records of the volunteers for submarine duty, and interviewed those candidates deemed to be desirable. After the establishment of this system, those individuals sent to New London were found to be much more likely to pass the more detailed and rigid examinations, tests, and interviews, administered by the submarine medical group at New London, than had been the case when groups of unscreened volunteers had been sent. Thus many man-hours were saved as well as much disappointment and resentment which inevitably results from rejection of candidates after arrival at ^{the} Submarine Base, New London.

The same Board served as a Final Review Board for all officer candidates following their entrance examination at Submarine Base, New London. The proficiency of this Board was checked against the final accomplishment of each class and was found to be exceedingly high, in fact, the judgment of this Board was considered by the Submarine School to be sufficiently accurate to be the final authority as to whether or not a candidate should enter the School.

In so far as the enlisted personnel were concerned,--to actually interview and examine candidates at the various Training Centers, Class-A Schools, and other activities sending men to the Submarine Service, was of course impossible. However, it was found highly desirable for a representative of the Submarine Medical Examining Section at the Submarine Base, New London, to travel to all of these units throughout the U. S. and have indoctrination conferences with the medical officers, the dental officers, the psychological, the psychiatric, the classification and selection officers. Following these conferences the input of men to New London consistently improved so that attrition dropped as much as 75% from individual Training Centers and Schools. These conference trips had to be repeated periodically because of the transfer of indoctrinated officers from the various units, but the expenditure of time and effort on the part of the Submarine Medical Examiner was compensated for many times over by the saving of time, money, and good will

on the part of the candidates, for no man likes to be ok'd at one station, then travel great distances to another, only to be turned down as unfit.

Of historical interest in connection with these trips would be some of the almost incredible situations found in the examining units of various organizations. Complete misunderstanding of submarine requirements, as well as complete lack of any organization in the examining group was frequently noted. At one station, it was found that dental officers were rejecting 87% of all candidates on the basis of minimum degree of dental defects, such as slight overbite, underbite, a few missing teeth, etc. It was only rarely that the psychologist, the psychiatrist, and the selection officer were found to work together or even know the part played by the other in selection procedures. Physical examinations were done by all types of completely untrained personnel. Examining facilities were totally lacking, or completely inadequate in many cases. In fact, the situation generally encountered leads one to wonder how anyone was properly selected for any particular Navy task. Accordingly, a statistical accounting system was set up in 1944, and complete reports were furnished to all stations monthly.

G. Submarine Escape Training Tank.

Not only was the Submarine Escape Training Tank used as a method of training individuals in the use of the submarine escape appliance, but it was used by the selection group at New London as a measure of identifying the emotionally unstable and psychiatrically unfit candidates,--it being assumed and at least partially established that men who failed notably in the adjustment necessary to proper performance of 'lung' training, would not be likely to make the adjustment necessary for submarine activities, particularly during contact with the enemy, such as depth charging.

H. Indoctrination of BuPers Selection and Classification Officers.

One of the most effective means of obtaining good submarine personnel was the indoctrination at the Submarine Base, New London, Connecticut, of a group of officers being sent from the Bureau of Personnel to outlying units to act as classification and selection officers. By a carefully planned and executed program, a large group of such officers were indoctrinated into submarine life and into the needs of the submarine service, particularly in so far as personnel were concerned. This job was so well done that by the end of the war, there was hardly a boot camp, Training Station, or Class-A School that did not have a submarine indoctrinated enthusiast aboard. It can readily be seen that the value to the Submarine Service of such an individual was inestimable.

I. Report of Rejections to the Originating Activity. IV - TRA

In the course of the trips taken by the Submarine Medical Examiner to the Training Centers and activities furnishing submarine quotas, it became apparent that these stations did not know the fate of the candidates for Submarine School, and that a much healthier state of affairs would obtain, if a report were furnished by the New London examining group back to the station of origin,--giving the disposition of each man sent, and the reason for the rejection, if any.

J. Summary.

In summary, we list the following points considered to be of utmost importance to the Submarine Service in the field of personnel selection during the recent war:

(a) Modification of the submarine physical examination to include an intelligence test and psychological and psychiatric testing techniques. As a matter of fact, the latter three are considered to be of a great deal more importance than the straight physical examination.

(b) The adoption of paper-and-pencil psychological and psychiatric tests and their combination use to relieve the psychiatrist of the necessity of seeing all candidates.

(c) Development of Special examinations for specific submarine tasks, such as night-lookout, radar, and sonar.

(d) Selection trips by Boards of Examiners for purposes of pre-selection of officer volunteers for submarine duty. In connection with this the use of a Board of Examiners at the Submarine Base for final evaluation and selection of officer candidates.

(e) Trips by a qualified submarine medical officer to all activities furnishing enlisted candidates for purpose of indoctrination of personnel in examination of men for submarine duty.

(f) The establishment of techniques of reporting back to supplying activity all information concerning the success or failure of their candidates.

(g) Indoctrination training at Submarine Base, New London, Connecticut, for the BuPers selection and classification officers thus ensuring an informed and interested nucleus of individuals in all Naval activities charged with selection of personnel.

IV - TRAINING ACTIVITY

The training program operating within the submarine service during the war reached an unbelievably high level of efficiency. Courses of instruction were developed, and techniques of training were perfected, new and improved equipment for the purposes of training and indoctrination were developed. The center of much of this training was at the Submarine School, New London, Connecticut. However, training activity within the submarine force was located at almost every submarine base, notably Pearl Harbor. The contribution of the medical department of the New London Submarine Base to this general training program was heavy and unusual, in that it included a number of activities normally considered to be under the sole jurisdiction of the Line. A listing of these various training activities and a brief statement concerning the development of each will be the contents of this chapter,--with the School for Pharmacist's Mates Entering the Submarine Service occupying its rightful position as the most important single contribution to training so far as the submarine medical activities were concerned.

A. School for Pharmacist's Mates Entering the Submarine Service.

The need for a School for Pharmacist's Mates Entering the Submarine Service had been felt for some time, but became more urgent in the spring of 1943 when a survey of the background of a group of pharmacist's mate candidates for submarine duty revealed that the average PhM volunteer for submarine duty was sadly lacking in experience and knowledge of the Hospital Corps. Most of these men were returned to general service and consequently a shortage of pharmacist's mates qualified for independent duty aboard submarines developed. Also, at this time, due to the publicity given to several appendectomies performed aboard submarines, there was considerable agitation to have a medical officer placed aboard each boat. This was impossible due to an already acute shortage of Medical Officers, therefore, a school for these submarine pharmacist's mates was decided upon as the best possible answer to both problems. Authority was granted on 7 May 1943 (BuPers ltr. P-242FJF/Nc38) by the Chief of the Bureau of Personnel to establish the school with the first class to convene on 15 June 1943. Four Chief Pharmacist's Mates were immediately ordered from ComSubPac for duty as instructors, and an Ensign in the Hospital Corps, who was exceptionally well trained and qualified in submarines was assigned as the administrative head of the school.

The curriculum decided upon was of six weeks duration, with four weeks of theory and two weeks of practical work in the Dispensary.

The subjects taught were: First Aid and Minor Surgery; Medical and Diagnostic Procedures and Treatment; Hygiene and Sanitation; Nursing; Materia Medica and Toxicology; Clerical Forms and Procedures; Anesthesia; Laboratory; Venereal Diseases; and Pharmacy and Chemistry. Each school day was divided into six one-hour periods, one of these being a lecture by a Medical Officer.

As this school was designed to help prepare a man for independent duty aboard submarines, great stress was given to those subjects that have to do with the saving of life and limb. What not to do, as well as what to do and the ability and necessity of thinking each situation through for one's self was emphasized. These conditions peculiar to submarines were also taught, i.e., gases present and those that may be formed, the effects of increased pressure on health, as well as the effect of those conditions inherent in submarine life,--close confinement, lack of sunshine and fresh foods, etc. Much time was also given to the administration of intravenous medicines and the use of the sulfonamides.

Mindful of the great responsibility that a pharmacist's mate assumes when he goes aboard a submarine, this school was from the very beginning extremely rigid in its qualifications. The entrance requirements were strict, and the subject material was concentrated and streamlined. Since this was so, and since the volunteers coming in from the Fleet had woefully meager background of training and experience, a rather high rate of attrition developed. Therefore, in March of 1945 a change was made in the source of supply of the quota for this school. Since that time all students received for this School have been graduates of the U.S. Naval Hospital Corps School at Norfolk, Virginia, where pharmacist's mates receive sixteen weeks of training for independent duty. With the inauguration of this system, attrition dropped to normal limits and the arrangement is considered satisfactory for retention.

There have been a few changes and additions in the curriculum, and shifts in points of emphasis, changes in personnel and hours, but basically the School has not been changed much. There have been over two hundred graduates from this school and there is not one case on record where a man has been reported for not being able to do his job. On the contrary, comment from the Pacific was very complimentary, showing that these men did an excellent job. Many of the graduates wrote back to the School, expressing satisfaction with the instruction received there and sent in notes on conditions encountered, which first-hand material was an interesting and valuable addition to the classroom presentations. The following pictures with attached annotations illustrate certain phases of the submarine pharmacist's mate's duty. (No pictures available for this copy).

B. Refresher Training for Pharmacist's Mates Awaiting Assignment.

At one point in 1944, more pharmacist's mates were being graduated from the School for Pharmacist's Mates at New London, than could be immediately assigned to boats. Therefore, in November of 1944 authorization was obtained from BuPers and BuMed for the establishment of a pool of pharmacist's mates at Pearl Harbor, from which periodic and emergency replacements could be made among the pharmacist's mates permanently assigned to submarines.

With the acquisition of the pool allowance and the personnel therefor, it was possible to proceed with the establishment of a local post-graduate school for the pharmacist's mates thus held awaiting assignment, in order to keep them busy, interested, and to give them the advantage of every additional day of training possible. Qualified Medical Officers, the Hospital Corps officer assigned to the pool, and experienced submarine pharmacist's mates were utilized as instructors. The establishment of this replacement pool was also valuable in that it permitted the replacement of some pharmacist's mates who had not attended the New London School and permitted them to attend this refresher training school.

The radar and sound schools were made part of the regular curriculum of this refresher training school, along with instruction in first aid, minor surgery, war instruction in general medicine and surgery, plus a rather vigorous course in clerical procedures. This was in line with the policy of submarine commanders who wished to use the pharmacist's mates as soundmen and radar operators, since in so many cases they had demonstrated their ability to readily absorb this technical training, and it was believed that this would not interfere with the performance of the pharmacist's mates regular medical department duties. It might be noted in passing that the pharmacist's mates generally became star pupils in the Radar and Sound courses, even to the point of surpassing the grades attained by officer members of the same classes. It is believed that such measures helped make the pharmacist's mates key members of each submarine crew and helped sustain the idea that submarine pharmacist's mates are as a rule outstanding.

The creation of this pool made possible the establishment of the policy of relieving the pharmacist's mate at the end of his fifth successive patrol, which proved to be an excellent morale factor. Dissemination of the news concerning the inauguration of this policy - was sufficient to produce maximum performance for five patrols. Relief after five patrols could be followed by immediate transfer to a

submarine under construction which meant 3-6 months 'stateside duty' and consequent rest and rehabilitation, or transfer to the pool with duty at a Submarine Base Dispensary until such time as New Construction was available. The attendant periods of decreased operational activity, during fitting out, amply provided for leave and constituted an adequate rest and recuperation interval, and usually involved return to the continental limits of the U.S.A., which was most welcome and a very efficient form of recuperation. In one or two months, these former submarine pharmacist's mates usually expressed a desire to return to active patrol status.

C. Deep Sea Diving School, Washington, D. C.

Although this Navy school was not directly a part of the Submarine Force medical training, yet all of the Submarine Force medical officers took courses of instruction given at this School. As pointed out in the introductory chapter, this training constituted the only submarine preparation for many of our submarine medical officers. It is considered that this training was very valuable, but entirely inadequate for proper coverage of submarine duty. Therefore, as will be seen in the next paragraph, training dealing more directly with submarine problems was added.

D. Submarine Training of Medical Officers at the Medical Research Laboratory, New London.

Much of this material has been presented previously in Chapter II, under the heading of the Submarine Medical Officer. However, at this time it is well to reemphasize the necessity of a medical officer's having actual submarine training if he is going to work with the Submarine Force. It is felt that the presently planned program of six months training at the Submarine Base, New London, one half of the time to be spent in the regular Officers Course at the Submarine School, and the other half of the time to be spent in purely medical submarine training in the Medical Research Laboratory, is the perfect solution to this problem. As indicated in Chapter II, the course of additional training at the Medical Research Laboratory, which was begun in 1943, at first covered two weeks, then was extended to three weeks of indoctrinational training. In each case, the medical officer trainees expressed a desire for a longer period of this type of training,--"more of the same". A typical schedule of the material covered in this course, as it was given during the war appears below.

OUTLINE OF CURRICULUM FOR SUBMARINE MEDICAL OFFICERS

A. Selection of Submarine Personnel.

- 1. Physical Examination
- 2. Psychiatric examination
- 3. Recording data on cards, coding of disqualifications
- 4. Aerotitis, Reports by Fowler, Haines and Harris. Demonstration of use of radium by Dr. Haines

5. Night Vision
Lectures and demonstrations

- 6. Color Vision
Lectures and demonstrations
- 7. Visual Acuity
Lecture and demonstration
- 8. Audiometry
Lecture and demonstration

B. Duties of Squadron Medical Officer

- 1. Property and Accounting
 - 2. Military duties
 - 3. Medical supplies on Submarines
 - 4. Tender Medical Department
- C. Submarine Escape and Rescue.
- 1. Present methods (seminar)
 - 2. Analysis of previous escapes (seminar)
 - 3. Air Embolism (seminar)
 - 4. Underway on ASR-PETRAL
 - (a) HeO2 diving
 - (b) simulated Event-1000

D. Training Tank

E. Medical and Miscellaneous Aspects of S/M Operation - (seminar)

1. Ventilation, revitalization, CO₂, etc.
2. Diseases encountered during patrols
3. Foul Weather gear
4. Water and Food
5. Fumigation

E. Escape Training Tank.

The submarine Escape Training Tank was designed to permit the thorough training of all submarine personnel in the use of the 'lung' or submarine escape appliance, under conditions which would simulate as closely as possible those conditions that exist during an actual escape from a disabled submarine. This tank contains a vertical column of water 100 feet high and 18 feet in diameter. It has a capacity of about 280,000 gallons of water. Integrated with the tank are escape locks or compartments which duplicate those installed in submarines. These locks are located at depths from the top of the tank of 18 feet, 50 feet and 100 feet, thus permitting escapes under conditions identical to those existing in similar depths at sea.

All submarines are supplied with submarine escape apparatus and the crew must be properly trained in the use of the lung, either at the Tank located at New London or at Pearl Harbor.

In order to escape from a sunken submarine, it is necessary that the pressure within the compartment or ship from which egress is to be made be equalized with the outside water pressure. To equalize the pressure in an escape compartment with the outside water pressure, the compartment is flooded by admitting water through various valves; as the water rises, it compresses the air in the upper part of the compartment. When the water rises to the top of the escape door or telescopic trunk, it causes a pressure within the compartment equal to the sea pressure or outside water pressure. At this stage it is very easy for the hatch or door to be opened by hand.

The occupants of the escape compartment stand in compressed air formed by the flooding referred to above. After the pressure is equalized, the hatch is opened and a buoy with an ascending line is

released through the open hatch and an escape is made to the surface with the use of the lung.

All officers and men are required to make escapes at the Escape Training Tank, and in addition to providing training in an important safety measure, this program also provides an excellent indicator of the temperamental qualities of the men concerned.

Qualification at the Escape Tank consists of the following essentials: (a) pressure test of 50 pounds per square inch in recompression chamber; (b) a lecture on construction, operation, safety features, and precautions in use of the lung; (c) shallow water training for confidence in breathing under water; (d) 12-foot training to attain proper relaxation and confidence; (e) 18-foot, and 50-foot training to permit the student to become highly trained in the use of the lung so that should he be called upon to use this device to save his life, he would have no fears as to its life-saving qualities.

Through the years from September 1930 to the present date, an accurate record has been kept of all lung escapes as indicated below:

Fiscal Year	Q U A L I F I C A T I O N S			TOTALS
	18-foot	50-foot	100-foot	
1 July				
1930-31	556	405	338	1,299
1931-32	770	189	179	1,138
1932-33	490	244	216	950
1933-34	562	252	141	955
1934-35	264	104	104	472*
1935-36	454	84	84	622
1936-37	637	41	41	719
1937-38	1,813	121	121	1,555
1938-39	1,321	62	62	1,445
1939-40	1,375	189	149	1,713
1940-41	3,695	123	13	3,831
1941-42	4,621	2,231	1,405	8,257
1942-43	8,014	6,463	1,882	16,359
1943-44	13,569	12,590	811	26,970
1944-45	8,895	6,710	786	16,391
TOTALS	46,536	29,806	6,332	82,676

* It is interesting to note that more men were trained during the three days-January 3, 4, and 5, 1944 (527) than for the entire fiscal year 1934-35 (472). In the month of January 1944, more men were trained than in any single year from 1930 through 1941, 18-ft. 1,352; 50-ft. 1,308; 100-ft. 122; total 2,782.

The reason for including the account of the Tank training in this report is two-fold: (1) as already pointed out in Chapter III, it was used as one method of personnel selection, and (2) and more importantly, the Tank was actually under the administrative control of the Medical Officer in Charge of the Medical Research Department from 23 February 1944 to 17 January 1946, and it is likely that control of this activity will again be given to that officer, for the reasons outlined in a letter of which we quote the pertinent paragraphs pointing out the reasons why the tank should be under the control of the MO-in-C of the Medical Research Laboratory:

"(a) The first phase of the training, that is 50-lb pressure test, is officially part of the submarine physical examination, routinely conducted by medical officers attached to our laboratory.

"(b) The tank training is carefully graded and conspicuous failure in training is considered by the Submarine Medical Examiner as a cause for rejection on psychological grounds.

"(c) If an accident occurs during training, it is considered to be a medical emergency and the medical officer takes over control and supervision of the treatment.

"(d) By order, a medical officer must constantly be in attendance during the pressure test as well as the actual 'lung' escape training.

"(e) The Medical Research Laboratory has several official research projects under the management and technical control of the Bureau of Medicine and Surgery which must be accomplished in the training tank under medical supervision, and for which BuMed funds are provided.

"(f) Because of the volume of this research as well as use of the Training Tank for various personnel selection validity studies, the Tank is used more than 50% of the time directly by the Medical Research Laboratory."

During the operation of this Tank under Medical Officer supervision 26,997 escapes were made entirely without casualties.

F. School for Second Class Divers.

No detailed description of this activity is included and the only reason for mentioning it in a history of submarine medicine is that this School was organized under the administration of the Medical Officer in Charge of the Medical Research Laboratory, Submarine Base, New London, Conn.

A brief history follows:

A School for Qualification of Second Class Divers was established at the Submarine Base, New London, Connecticut by letter NB7/P11-1(MR), Serial No. 920 of 8 March 1944 to the Chief of the Bureau of Naval Personnel, as provided for in BuPers Manual Art. D-5327(C)(4), for the dual purpose of (1) training men for the qualification of Second Class Diver, and (2) in order to provide an adequate number of trained personnel to handle all the routine salvage inspections and be ready for any emergency diving.

G. Lookout Training School.

Following receipt of reports from British sources (where a state of war had existed for two years) concerning the importance of training lookouts, Commander Submarines, Atlantic Fleet, became interested in the possibilities of such training for the submarine service and directed that a night lookout training table be set-up similar to that used by the British. Accordingly a trainer was set up in Building #16 at the New London Submarine Base in 1941, where it was used continuously for the training of personnel attached to ships operating out of this Base until February 1943, when this instruction was moved to the newly constructed building #126. From the beginning commanding officers were enthusiastic about this training and the program was very popular with the men themselves, and with the many visitors who were favorably impressed with this stage and the accompanying lecture material.

Briefly, this original trainer provided a reasonably realistic horizon with a sea foreground simulating the situation confronting a lookout at sea. It provided varying lighting effects so as to produce the effect of a horizon, and ship models were placed at various sectors for the training of lookouts in the calling of relative bearing and the general duties of a lookout watch. An essential part of this lookout training was the lecture material which served to indoctrinate and motivate the men concerning the value of the lookout's job. This lecture was put out in printed form by ComSubsLant as a pamphlet entitled HANDBOOK OF NIGHT LOOKOUT TRAINING.

On 15 June 1942, an officer from the Office of the Commander of the Eastern Sea Frontier, visited the New London Submarine Base to see what was being done in night vision, became very much interested in the night lookout training stage, requested blueprints of the existing stage and further details concerning the proposed modifications which were planned. On 10 July of the same year, an officer of the Interior Control Board, visited Submarine Base New London and also became

very much interested in the night lookout training stage. Because of the interest at these two sources, a greatly improved version of the Lookout Stage was built at Tompkinsville, S.I., N.Y., embodying several additional improvements. This stage was completed early in October 1942. Following this, arrangements were made to present to the Bureau of Naval Personnel, officially, the idea of constructing similar stages of a "portable" type for distribution throughout the Navy for the training of all personnel. The suggestion was accepted by BuPers and the trainers ordered. A realistic horizon was provided upon which the trainee was required to sight and identify small ship models which were placed upon it. The apparatus provided also for reproduction of distant gunfire, of moonlight, and of recognition lights. Its advantages as a training device lay in its realism, and the interest which it aroused in the men. Its value in indoctrination and preliminary training of beginners was unquestioned. In operation, lookouts were posted in pairs and located and reported in proper phraseology the position of model ships. On 25 November 1942, the Chief of Naval Operations, requested the Submarine Base, New London, to train instructors for the various lookout training centers which it was contemplated would be established, using the night lookout trainers developed by the base, and at that time being prefabricated by BuPers for release throughout the Navy. This training program was assigned to Medical Research Laboratory due to its interest and activity in Night Vision testing and research.

The Medical Research Laboratory was officially designated by BuPers as the experimental station for the entire lookout training program,--by BuPers ltr. P-2423-RB of 18 December 1942.

The first of the prefabricated type of lookout trainers was installed in Building #126, Submarine Base, New London, and instructor training started there on 22 February 1942. The first group of 30 instructors finished training there early in 1942. This group of instructors were assigned to train men in the technique of setting up a lookout stage and teaching classes, therefore they were given all the information necessary to start from the packing boxes and continue on to the completion of an adequate course of instruction for lookouts.

In March 1943, Commander Submarine Force, Pacific Fleet, recommended the establishment of the Renshaw Recognition training system at submarine activities. Following investigation and conferences, this training was adopted, modified to fit submarine service needs, and included as a part of the night lookout training program already in operation at the Submarine Base, New London.

As the work in visual, night visual, general lookout, and recognition training began to increase, it was obvious that a regular school should be organized. Accordingly, in May of 1943 letters were submitted by the Commanding Officer, requesting the establishment of such a school. By ComSubsLant ltr. to Commanding Officer, Submarine Base, P11-1, Serial 2172, dated 15 June 1943, the establishment of a Lookout School was directed. A new building was requested to provide adequate space for this School. Authorization was granted; the building (#156) was constructed, and first occupied in February 1944. There the Lookout School continued throughout the remainder of the war period.

In the same correspondence referred to above, it was suggested to the Bureau of Naval Personnel that lookout training schools be established for the general service similar to the one being established at Submarine Base, New London, which resulted in the eventual establishment by the Bureau of Personnel of general lookout training schools in conjunction with recognition training at all of the various training centers.

In order to facilitate the establishment of these combination lookout-recognition schools, it was found necessary to give the recognition officers in the field additional training in lookout work. Therefore, they were ordered to the Medical Research Department, Submarine Base, New London, for temporary duty, additional instruction, in order to enable them to train lookouts when assigned either to basic training schools or the "L" divisions aboard ships. This activity trained around 200 line officers, all of whom had previously graduated from the U. S. Naval Training School (Recognition) at Ohio State University. Since the advantages of this additional instruction were acknowledged by all hands, a course in lookout procedures was added to the curriculum of the Naval Training School (Recognition) at Ohio State University early in July of 1943, so that all graduates of this School would be trained in both lookout and recognition procedures and would not have to be sent to New London for additional instruction.

A detailed account of the curriculum, statistics on number of men trained, and other developments in the Lookout Training School are contained in the History of the Medical Research Laboratory.*

During a typical period of six months, the following instructional program was carried out in organized classes:

* "History of the Medical Research Laboratory - 7 Dec 1941 to 7 Dec 1945" by J.W. Kohl, and annual supplements to same published as of 1 July of each subsequent year.

- a) 5,141 enlisted men received a three-hour course in Night Lookout training in Building 126; - 1,068 of these used the NLOT Stage twice.
- b) 939 enlisted men from New Construction attended the three-day course.
- c) 1,931 enlisted men from Basic School and Advanced Schools attended the six-day course.
- d) 40 recognition officers attended a six-day course.
- e) 508 Submarine School student-officers attended a two-day course.
- f) From 10 April 1944 to 22 June 1944, a varying number of student-officers were received for Recognition Training. These officers were the overflow from the Attack Teacher. Each officer received from three to fifteen hours of instruction--the average being about nine hours.
- g) Eight hours of aircraft recognition are given to each class of the Quartermaster-Signalman School.

Because of the intensive interest in and pioneer research in techniques of night vision and night lookout training in this laboratory, a variety of new equipment was developed, tested experimentally, and added to the School's training devices; important modifications were also made on existing equipment.

All during the period of the conduct of this School, it was constantly being visited by interested individuals from all branches of the armed services and from various allied countries, therefore the School was constantly acting as a center for dissemination of knowledge concerning the latest methods of night vision testing and night lookout training.

In summary, it is considered to be of particular interest in a medical history of submarines to realize that the submarine service was the first in the U. S. Navy to inaugurate night lookout training and that this training was developed under the auspices of the Medical Research unit at Submarine Base, New London, Connecticut.

It is also of particular significance to realize that this unit was utilized to train not only submarine personnel, but that it was also the experimental center for all of the Navy's official activity in the field of lookout training, and that it was, perhaps even more importantly, utilized as the center for training all instructors sent out through the Navy to conduct the general program of lookout training.

In addition to this, the Navy's Recognition Program at Ohio State University was taken under study at the Medical Research Laboratory and through its advice was so modified that night lookout training was combined with and added to all recognition training being done by the Navy. Actually, many of the Recognition School officers received additional training at the Lookout Training School, Submarine Base, New London, and upon their return, acted as instructors of the combined lookout and recognition courses.

Here again, a medical unit of the submarine force made a major contribution to the efficiency of the submarine service and, in addition, to the general efficiency of the entire Navy.

H. Interior Voice Communication School.

The Medical Research Department of the Submarine Base, New London, Conn., through its liaison with the Applied Psychology Panel of the Office of Scientific Research and Development, had been interested for some time in the general problem of telephone talker selection and training. On 1 May 1944, a Bureau of Personnel directive authorized the establishment of telephone talker schools in all Class A, B and C Schools.

The Medical Research Department immediately began the necessary preliminary negotiations for the organization of a telephone talker classification and training program for the Submarine Service. Following a long series of conferences and official letters concerning personnel, equipment, and curricula, the "Telephone Talker School" was finally officially established by the Bureau of Personnel Director of Training in confidential letter Pers-41218-vm of 17 July 1944 and assigned for operation to the Medical Research Department.

A study of the needs of the Submarine Service was at once undertaken with the assistance of the National Defense Research Committee - Project N-118.

This preliminary study of the situation indicated that a course in Telephone Talking alone would not be sufficient to eliminate on our

boats the inefficient voice communications which made this training necessary. It was determined, and this determination was approved by Commander Submarines, Atlantic Fleet, that training was necessary in all of the following basic subjects, if the desired ends were to be accomplished:

- a. How to increase intelligibility in use of all communication instruments, over noise.
- b. The formulation of brief, efficient, and standard orders, commands, and reports of execution of orders.
- c. Efficient operation and handling of equipment in order to reduce casualties.
- d. The use of Standard Phraseology and Procedures for all types of interior communications.
- e. Suggested organization for sound-powered and broadcasting circuits under various battle and operational conditions.
- f. Examples of Standard Terminology for various stations on submarines requiring any form of voice communication with another station.
- g. For Officers; Methods of Shipboard Instruction to be used for advanced training.

With the aforementioned facts in mind, the name of this School was properly changed from the "Telephone Talker's School" to the "Interior Voice Communications School", in order to assist in its taking over a broader field of instruction.

Work on teaching the seven subjects listed above continued with the instruction modified and changed frequently as new data became available. It is considered that a most valuable contribution was made in this field to efficient submarine operation.

In collaboration with N.D.R.C. personnel and with assistance from Submarine officers representing the Training Officer, Staff, ComSubs-Lant, the following publications were drawn up and approved for publication:

- a. Submarine Telephone Talkers' Manual.
- b. Suggested Ship's Organization: Chapter on Interior Voice Communications for fleet type submarines.

- c. Pamphlet: Standard Submarine Phraseology.
- d. Classroom Pamphlet: Standard Submarine Phraseology and Procedures.
- e. A complete Instructors Handbook for instruction in Submarine Interior Voice Communications.

Much work was done toward the development of effective means of classification of all men. However in the final analysis all men were trained and following an evaluation of their ability records were stamped and checked as to whether a man was "Well Qualified", "Qualified", or "Not Qualified".

The following instruction schedules are illustrative of the activity of the school.

a. Basic School:

210 men each two weeks; each man 5½ hours of instruction.
Classes in units of 30 men each.

b. Advanced Schools:

200 men each two weeks; each man 2 hours of instruction.
Classes of 30 men or less.

c. Student Officers:

150 officers every four months and give 12 hours of instruction to each officer - in classes of 15 officers each.

d. New Construction Submarines:

(1) Basic Course:

Approximately 250 men per month. - 8 hours instruction per man. Class: 30 men.

(2) Advanced Course:

Officer instructor accompanies boat during shakedown as often as requested by Commanding Officer.

During a six months period of time, the School gave approximately 25,100 man-hours of instruction to 4,400 officers and men.

In addition to training students, it was necessary to train instructors for the increased submarine training program. The parent school

gave a one month's course to six officer instructors for the schools being set up at advanced submarine bases. Instruction was also given for approximately twenty enlisted instructors assigned to these various bases as the first instructor units.

Equipment was also assembled for transfer to other submarine activities. An entry in a history of the school clearly shows this activity:

"Including the set of equipment sent to Pearl Harbor recently, a total of seven IVC training rooms have now been established and equipped for submarine advanced training bases. Utilizing the officer and enlisted instructors trained and the curriculum prepared in New London, the advanced schools are also now in operation."

One of the most important parts of the training program was the teaching of the use of standard procedures, a type of practical drill developed which greatly facilitated the instruction in voice communication procedures, phraseology and terminology for the submarine crew. These drills, by the use of scripts made up of leading orders and messages, forced the student to utilize correct procedures, phraseology, and terminology while simulating the actual operations and speaking the actual words involved in the conditions of the drills. During the course the student participated in practical drills simulating the maneuvering watch, general drills, torpedo approach, battle surface, and other standard patrol operations.

All officer and enlisted students from the schools and from boats undergoing training became thoroughly familiar with the actual voice communication installation of the submarine. Intensive lecture periods, utilizing visual training aids facilitated this job as well as teaching the organization of communications during the various types of operations.

Some minor differences were necessary between the courses of instruction for enlisted students and officers, and for submarine crews. The average course, however, was lengthened to twelve hours and followed the schedule listed below:

Period One - (55 minutes)

Lecture: Importance of Interior Voice Communications.

 Introduction to Submarine IVC Equipment and
 Organization.

**Basic Principles of Intelligibility over Sound
Powered Phones.**

**Drill: Proper Handling and Stowage of Sound Powered
Phones.**

Simple messages and Acknowledgements.

Period Two - (80 minutes)

Lecture and Demonstration:

Basic Voice Communication Procedures.

Period Three - (40 minutes)

**Drills: Basic Voice Communication Drills --
Simple Application of Rules of procedure.**

Period Four - (60 minutes)

**Lecture: Description and Location of IVC Equipment,
Operational Organization and Use.**

Period Five - (90 minutes)

Practical Drill: The Maneuvering Watch.

General Drills.

Period Six - (90 minutes)

Practical Drill: The Torpedo Approach.

Period Seven - (90 minutes)

Practical Drill: Patrol Drill.

Period Eight - (90 minutes)

Practical Drill: Battle Stations Surface.

Test.

**Three additional periods were added to this schedule for training
of student officers: an instructional tour of a new construction boat to**

study the IVC installation (preceding period four), and two hours instruction and drill in methods of shipboard instruction.

In carrying out instructional schedules during a six months period the IVC School gave the following man-hours of instruction:

<u>To</u>	<u>Amount</u>
Submarine School - Enlisted	23,925
Submarine School - Officers	2,760
Submarine Crews	39,000
Total	65,685

In the early stages of the development of this school it became apparent that it was necessary to standardize the use of voice communications in the various submarine schools, new construction boats, and training boats. Continued efforts were made to accomplish this. All instructors in the enlisted submarine school were processed by this school; practically all training submarines were sent here for IVC training; and through the device of extensive pre-training conferences with boat's officers, all new construction submarines set up almost identical communications organizations and utilized the standardized set of procedure as recommended.

In order to further standardize the training given in all submarine areas, an IVC instructions training kit was prepared and distributed consisting of:

1. A complete Instructor's Handbook for Submarine Interior Voice Communications.
2. Interior Voice Communications Training Records:
 - a. The Maneuvering Watch Drill
 - b. The Torpedo Approach Drill
 - c. The Thames Patrol Drill
 - d. The Battle Surface Drill
3. Interior Voice Communications Training Charts.
 - a. Typical Submarine Sound Powered Installation

- b. Typical Submarine Broadcast and Talkback Installation.
- c. Interior Voice Communications Organization for Normal Cruising, Diving and Surfacing, and Maneuvering Watch.
- d. Interior Voice Communications Organization for Battle Stations Torpedo and Battle Stations Surface.

A determined effort was made to maintain a close liaison with all outlying schools which was partially successful.

From July 1, 1945, this activity continued to function in the training of all classes of submarine officers and men, but with the cessation of hostilities, and consequent reorganization, it was felt that the logical place for such training was in the Basic Course of the Submarine School. It was therefore transferred 31 December 1945 from the Medical Research Department to the Submarine School, as directed by the Commanding Officer of the Submarine Base.

It was the almost unanimous opinion of all of Commanding Officers that the training given in this School was of real importance in the improvement of interior voice communication aboard submarines. This improvement was dramatically demonstrated on many occasions and for training purposes wire recordings were made showing "before" and "after" examples very effectively.

The role of the medical department in this activity is one that deserves an additional note. We believe that the reason that the program was so well developed and handled was that in general medical and psychological personnel have a keener understanding of the potentialities of the individual for assimilation of material and also have a better understanding of the requirements of a training program. This and other training programs handled by psychologist personnel, we believe clearly indicate that Naval training courses in many instances could be immeasurably improved, were they taken out of the hands of traditionally-trained line officers and put in the hands of those trained specially for instruction and design of programs of instruction.

Because of the real success of this program, it is to be hoped that it will not be dropped from the curriculum when Lookout Training School is transferred to the auspices of the Submarine School.

V - SPECIAL CARE OF SUBMARINE PERSONNEL

As was pointed out in Chapter II on Selection, great care was exercised in picking proper personnel to man the submarines during World War II. In addition to careful screening and selection, every effort

was made to insure adequate and proper training of all of the submarine personnel. Also, every effort was made to properly indoctrinate all personnel into the submarine service,--a unit notable for its esprit de corps, so that they would realize that they were in the very best possible specialty of any of the military services. All of this was exceedingly important and very new, but none of it would have been successful, were it not for the special care exercised in maintaining this highly selected and trained personnel at a very high point of readiness both physically and in matters of morale.

As part of this maintenance of physical fitness, the Pacific Submarine Force conducted pre-patrol examinations of all personnel to make certain that no one was permitted to go on a wartime patrol, who was in any way physically or emotionally below par. In addition to special examination of the crew, the pharmacist's mate was called in for pre-patrol conferences in order to supply him with additional late information relative to new approaches to the treatment of various diseases and also to talk over any special personnel problems presented by any members of the crew.

In addition to these very excellent approaches, the Pacific Force Medical Officer also established the custom of holding brief conferences with the Commanding Officer and Executive Officer and Pharmacist's Mate of each vessel prior to its departure on patrol. An excerpt of a report from the Pacific Fleet Medical Officer, entitled "Submarine Medicine, Health, and Morale", will serve to amplify this statement.

"Each submarine prior to departure on patrol received a briefing by conference with the Force Commander, on matters of change in tactics policies and doctrines referable to the conduct of operations. Medical department activities were likewise affected by changes in phases of warfare, so it was considered advisable to arrange a conference briefing, attended by the Commanding Officer and/or Executive Officer, and Pharmacist's Mate of each vessel, in which the Force Medical Officer covered subjects orally that were difficult to accomplish by directives. The oral discussion was supplemented by written or mimeographed instructive material. These conferences were particularly used in the final war phases when targets became increasingly scarce and when many vessels had life guard duties for air craft strikes as primary missions. On other occasions rescue duty was assigned as an additional mission. After having departed on a routine patrol, other vessels performed rescue missions simply by accidental encounter or in picking up prisoners of war from their own destroyed targets. In all these instances it is evident that survivors likely to be encountered would require medical attention for any or all of the hazards of warfare at-sea. Much briefing was directed toward the care of survivors but also included other items.

"Vitamins were included in the discussion in an attempt to survey the different methods of usage and to make suggestions that bottles of vitamin tablets placed near drinking fountains in such a position as to be unavoidable by the drinker was an additional reminder and incentive to insure usage. Personal attention on the part of the pharmacist's mate was advised to insure daily ingestion by all lookouts."

Actually, aboard submarines we find that again great emphasis is placed upon special care given to officers and men of the submarine crew. A brief listing of measure taken to insure both health and a high state of morale will serve to illustrate this point. Submarines were air-conditioned and actually more habitable than any other type of ship of combat type. Berthing space was adequate and of excellent quality, much better than even some of our largest battleships. Food was not only of highest quality and great quantity, but offered a variety not encountered on any other type of ship, and in addition to this, was well prepared, for cooks were carefully selected for submarine duty. The icebox was open and snacks available at any time. Ice-cream was served the crews daily. Every effort was made to insure catering to the appetites of submarine personnel. Not only was there ample drinking water available; water was also available for bathing and laundry and all other uses in much greater quantity than was found on larger ships. Smoking was allowed, except in most unusual circumstances. Vitamin tablets were provided for all members of the crew. Ultra-violet lamps were included in each medical allowance for use by the crew; in short, every effort was made to make certain that everything was done that could possibly contribute to the maintenance of both health and morale.

One of the most important innovations put into effect by the Pacific Force Medical Officer was the careful post-patrol examinations which were conducted in order to ascertain which individuals might need medical or dental treatment, or who might be candidates for transfer to a Rest Camp. In this connection, it is believed of sufficient interest to again quote verbatim from "Submarine Medicine, Health and Morale", reporting the procedure used in conducting the post-patrol activity.

"The usual succession of events was about as follows for the Pearl Harbor refits: All Force and Squadron Staffs as well as the Base Heads of Departments were notified of the arrival from the signal tower, - approximate arrival data having been distributed by the Force Commander on the preceding day. The above array of officers gathered as a greeting party at the arrival berth along with the band rendering appropriate exhilaration, mingled with the hails and greetings from the large attendant gathering of officers and men who did not form part of the official greeting committee. Two other conspicuous items of the

greeting party were two trucks, one laden with accumulated mail and the other stacked with fresh fruits and ice-cream. Obviously all these are morale factors, even though the ravenous manner in which fruit disappeared might indicate the presence of some food deficiency. At present, it is the opinion that this is merely a "sight hunger" augmented by youthful over-enthusiasm. The fruit and mail were put aboard only second to the gangway and the most senior Staff officers, the latter greeted the commanding officer and the remainder of the ship's company with congratulatory remarks upon the success of their late mission. Of first concern to the medical department of course, were the immediate emergencies, for which an ambulance was kept in readiness near the berthing area. Immediate arrangements were made for physical and dental examination of the entire ship's company, officers and men. Experience had taught that these examinations must be arranged for at the earliest possible time after arrival because once the crew has been dispersed to the recuperation area, it was next to impossible to congregate them subsequently. Prudence dictated that prompt examination was necessary to elicit minor changes likely to disappear quickly. The usual scheme was to have the Pharmacist's Mate appear with the crew at the Sickbay about 0830 on the succeeding morning. All health records were transported to the Sickbay in a specially made container furnished by the base, for minimizing record loss.

"First and foremost, the entire crew was transported to the Photo-fluoroscopic Unit for chest x-rays. It suffices for the present that any evidence of acid-fast infection resulted in removal entirely from the submarine service.

"The next item on the program was a complete physical examination including checkage of weight, conducted in a special examining room. Qualified submarine medical officers only conducted the examinations, the crew being stripped and conducted through the examining room on almost a production line basis. These examinations were accomplished on both officers and men. The dental department was the next recipient of the crews where each man received a complete dental examination, and the needed dental repair was made a matter of record.

"Results of both the physical and dental examinations were entered upon 6 by 7 inch cards. These cards thereafter became the property of the boat and formed a continuous history of the major and minor illnesses of each individual as long as he was a member of the ship's company. Upon transfer to any other submarine force activity the card was likewise transferred to the receiving unit and the reason,

if any, for transfer indicated thereon. If transferred out of the submarine service, the card was returned to Sub Base, Pearl Harbor, and placed in the dead files. It is realized that the standard Health Record is a continuous history, but it failed to serve the intended purpose in that only conditions sufficiently grave to warrant admittance to the Sick List find entry therein. Also, at each reenlistment much of the pertinent history details were removed and transmitted to the Bureau of Medicine and Surgery.

"Upon completion of the examination, those individuals who needed no attention had their cards returned to the Pharmacist's Mate of the boat concerned. Cards of those needing treatment were retained by the examining officer for further study, treatment and disposition entries.

"Inasmuch as the entire crew was to be transferred to the Rest and Recuperation Annex located in the Royal Hawaiian Hotel, a distance of some 12 miles from the base, immediately upon completion of the examination, it was evident that most of the treatment and dental repair work would be accomplished at the Annex. It was therefore necessary to establish a medical and dental dispensary in the Annex. Naturally those individuals who had very minor ailments were allowed to proceed to the Annex, where they were treated by a medical officer regularly stationed in the Annex Dispensary and furnished by the Sub Base, Pearl Harbor, complement. The Annex medical officer was advised of this condition and treatment needed on the history card. Graver ailments were either retained at the base and treated in the base ward or as the occasion demanded, transferred to the hospital. Concerning those latter individuals, those not likely to be fit for the next patrol, the Commanding Officer of the boat was so advised in order that early replacements were possible.

"The dental department transferred the information concerning the dental repair needed on a special card to the two dental officers regularly stationed at the Annex and furnished by the base complement. Dental repairs were accomplished during the rest and recuperation period.

"When all medical and dental treatment needed was complete, such was indicated on the cards and the latter returned to the base for preparation of a summary report. The completed cards were then returned to the boat's Pharmacist's Mate along with the summary report. The original summary report was sent to the Squadron Commander conducting the refit, one copy was retained in the boat file, one copy was sent to the Force Record Office, and one copy was retained for presentation along with the completed cards to the next refitting agency.

"These provisions resulted in the exact medical status being a matter of knowledge to the Squadron Commander, the Commanding Officer of the boat, as well as the Pharmacist's Mate, and the Force Medical Department. Also, the next refitting agency had an individual history of each crew member prior to his appearance for the next refit examination. The Pharmacist's Mate of the boat was required to bring the individual history cards up to date by addition from a rough log any conditions occurring while on patrol. Cards, summary report copy and rough logs were together presented to the medical officer of the next refitting agency for examination, information and guidance. Conditions occurring on patrol are made known to the Force Medical Department by preparation by the boat Pharmacist's mate of a Form "A" and transmitted when mailing facilities were available."

Of all of the measures used to insure the utmost in caring for the welfare of the Submarine Force, we believe that the submarine rest and recuperation program leads the list in importance. It is amply and rather interestingly discussed by the previous mentioned report from which we quote: "Men, like machines, require refitting for peak efficiency, when required to experience continual daily physical and emotional strain as imposed by submarine wartime patrols. Patrols usually occupied a period of 30 to 60 days, exceptions occurring of both longer and shorter duration. Factors determining the length of the patrol period were expenditure of fuel and ordnance materials in the majority of instances. Battle or engineering casualties constituted a smaller group of patrol terminating factors. The need for rest and recuperation for the crews during the ship's refit was recognized early in the war and a program was formulated and put into operation.

"The refit periods, usually, were of two weeks duration followed by a training and reloading period of 7 to 10 days. Under this regime each vessel was able to make four to five patrols per year. Owing to the enormous size of the operational areas and the large number of submarines in the Force, it was necessary to establish a number of refitting points being located in the following places: Midway, Majuro, Guam-Saipan Area, Milne Bay, Manus, Fremantle Area, Brisbane Area, Subic Bay, Pearl Harbor and Mare Island. These refitting area, because of their location, divided the refit periods into two general classes. One type might be entitled the "glamorous" type, of which Mare Island, Pearl Harbor, Fremantle and Brisbane were the composite members. The second type might be known as the "athletic" recuperation period, with Midway, Majuro, Guam-Saipan Area, Manus and Milne Bay as the composite members. Obviously, each of these types was so named because of the kind of recreation afforded. In type one, opportunity was

afforded for recreation offered by more or less well populated areas, where mixed community social life formed a large part of the recreational program. Type two, in the remote forward areas, by location limited the recreational period program, mainly to individual and competitive sports. Despite the classification into the two general types mentioned, all of the refit points cannot be described as having only the type characteristic under which they were classified.

"Naturally, the Mare Island refits, with the opportunity for leave and visits to home and relatives, were the most popular from the personnel standpoint. This type of refit had only been granted when vessels were in need of Navy Yard overhauls, occurring once per five or six patrols. In general, these Navy Yard overhauls, afforded the best rest period of any of the refit locations. The crews appeared refreshed and eager for resumption of combat patrol duty. In a few instances the return to the Continental limits revived the memory of the comforts of Mainland duty to the point of producing reluctance to resume patrol status. Notably among the latter exception were the young individuals who had ventured into matrimony during the overhaul period. At each stop on the outward journey to the patrol areas, the recently wed were frequent visitors to the medical departments with imagined or exaggerated illness being projected as the basis of their lost motivation.

"The Brisbane and Fremantle areas were extremely popular to submarine personnel as refit and rest points. The novel experience of a new and strange land, plus the cooperation and generosity almost to a fault, of a friendly people amplified the opportunity of social intercourse and recreational activity, to the extent of removing entirely from the fields of memory the recent life aboard during patrols.

"A unique refit plan was initiated and maintained at Pearl Harbor. The nationally famous Royal Hawaiian Hotel was leased and converted into a rest camp. This elegant hostelry with its awe-inspiring and ample grounds was esthetically and terrestrially ideal to rest and relaxation. The opportunity for water sports at the adjoining Waikiki Beach was unlimited. All possible types of sports equipment were procured or constructed. Beer gardens and soft drinks facilities were provided. Motion pictures, stage plays, libraries, boxing matches, photographic equipment, orchestra recitals, and sight-seeing tours, were all parts of a recreational plan, which had as its motive to be complete to the point of lacking in appeal to no one regardless of their tastes. In addition, the adjacent city of Honolulu furnished opportunity for contact with activities of urban community life to include female companionship and alcoholic beverages. The use of alcohol at this rest camp was confined to beer.

"The Midway, Majuro, Guam-Saipan, Manus and Milne Bay rest and recuperation camps stressed athletic games, interest in the flora and fauna of the locale, bathing and water sports, recreation halls with suitable inside games, amusement machines and beer. Motion pictures and occasional stage shows were available.

"In all the rest and recreational camps there seemed to be two basic ideas, first, the idea of compulsory participation was entirely dispensed with, the facilities were provided, but the initiative was dependent upon the individual and his desires of the moment. Every effort for additional appeal was made by procurement of adequate and diversified equipment. In the field of sports, athletic specialists were employed, who, when interest was exhibited coached and explained, in an endeavor to create greater interest. Notable was this opportunity for participation with or against the specialists, some nationally famous in athletic events. The motive of voluntary participation was also maintained in those who were not athletically inclined, as a rule, or for the moment. The individual himself dictated his method of rest and recuperation.

"The second basic idea of the rest and recuperation plan was to create a period with as complete disassociation from the submarines themselves as possible. This plan was inaugurated by removal of the crews from the boats and transfer to the rest camps as soon as possible after arrival from patrol. Relief crews were provided to board the ship upon arrival and conduct the material refit of the vessel. Rest camps were as a rule located considerable distance from the berthing areas to increase the reality of the separation. Crews did not return to their vessels until the refit was complete and time for the training period was at hand.

"If it is necessary to answer the question as to which type of rest and recuperation period is most efficient, the answer is not apparent. Inasmuch as all the refit establishments were not purely of one type or another, but rather having characteristics of both types of recreation, it is possible that a mixed type of program is most ideal. It was a matter of observation that in both the so-called "glamorous" and "athletic" recreation period, after the initial eight or ten days, there was a noticeable lag in participation in either social life or sports, whichever predominantly offered by the camp. Some individuals shift from sports to social life or vice versa, others prefer quiet relaxation or sleep. This observation may be interpreted as an indication that the rest status was obtained in a shorter time than thought necessary or that the mixed recreation was most efficient.

"Despite the lack of a clear indication as to the nature of the most desirable rest and recuperation plan, the operational results, the low incidence of physical and mental disease, the minimal attrition, were ample evidence to warrant the program as enacted."

VI - SUBMARINE MEDICAL FACILITIES AND EQUIPMENT

Facilities for medical care of submarine personnel during the period of World War II, consisted of: dispensaries, located at the various submarine bases; the submarine tenders and their medical staffs and large medical spaces and storehouse of medical supplies; and the submarine medical department itself, consisting of one Pharmacist's Mate and his supplies and equipment.

No detailed discussion is believed necessary or desirable concerning the dispensaries available for the care of submarine personnel, as they were in no way significantly different from other dispensaries organized for the care of other Naval personnel, however, the writers of this history would like to point out that they believe that in any future emergency every effort should be made to have as many as possible of the medical personnel, from the Senior Medical Officer on down, qualified in submarines. This would in a large measure provide for the necessary understanding of submarine problems and insure a more sympathetic handling of submarine personnel.

With the submarine tender, as with the dispensary, it is not believed that a detailed discussion of all the facilities and equipment and supplies is in order in this type of history, such information being available elsewhere. It may be stated that in general these medical facilities, equipment and supplies were adequate for submarine needs.

One distinctive feature of the equipment of the submarine tender was the inclusion of a pressure chamber for the handling of decompression for any diving, rescue, or salvage operations that might be necessary. This of course required that some member of the medical department have additional knowledge of handling of problems connected with high pressure air.

Again, as in the case of the dispensaries, it was abundantly shown, as pointed out in previous chapters, that the Senior Medical Officer of the tender should, if possible, be a Qualified Submarine Medical Officer. If this is not possible, then the Qualified Submarine Medical Officer aboard, even though he be junior in rank, must be designated as the Squadron Medical Officer, in order to have a proper functioning of the submarines attached to the tender.

In the case of the submarine, it is well to be reminded that the medical department consists of one specially selected and specially trained Pharmacist's Mate, and that only in rare instances is there a medical officer ever carried aboard a submarine. It is believed desirable to include in this discussion of the submarine medical department, the allowance list of supplies and equipment issued to each vessel upon its commissioning. It should be pointed out that this list is changed from time to time officially, and that the actual list of materiel aboard changes even more frequently as individual Pharmacist's Mates add to or subtract from this allowance according to their own individual preferences and desires. The typical wartime commissioning allowance follows:

SUBMARINE
COMMISSIONING ALLOWANCE

Class 1 - Drugs, Chemicals and Biological Products

<u>Stock No.</u>	<u>Item</u>	<u>Unit</u>	<u>Issued</u>
1-106-245	Acetophenetidin, Acetylsalicylic Acid and Caffeine Tab. 1000s	Bottle	1
1-010-000	Acetylsalicylic Acid Tablets, 0,324 Gm. (5 gr.), 1000s	Bottle	2
1-048-010	Alcohol, $\frac{1}{2}$ gal., (Ethyl)		
1-054-750	Alkaline Aromatic Solution Tablets, 100s	Bottle	1
1-061-075	Ammonia Spirit, Aromatic, 2cc., 4s	Pkg	4
1-061-100	Ammonia Spirit, Aromatic, $\frac{1}{2}$ pt.	Bottle	4
1-068-605	Amphetamine Sulfate, Racemie, Tablets, 0.01 Gm (1/6 gr.) 100s	Bottle	1
1-098-502	Benzedrine Inhaler, 250 mg.	Each	10
1-099-082	Benzoin Tincture, Compound, 1 pt.	Bottle	1
1-104-000	Bismuth Subcarbonate, 1 lb.	Bottle	1
1-106-640	Boric Acid, 1 lb.	Bottle	1
1-106-647	Boric Acid Ointment, 4 oz.	Tube	24
1-106-712	Brandy, 2 oz.	Bottle	20
1-108-470	Butacaine Sulfate, 5 Gm. (Butyn Sulfate)	Bottle	1
1-108-485	Butacaine Sulfate Ophthalmic Ointment, 12 tubes (Butyn Sulfate)	Box	1

1-109-500	Caffeine and Sodium Benzoate Injection, 0.5 Gm ($7\frac{1}{2}$ gr.), 2cc., 12s	Box	1
1-111-000	Calamine, Prepared, 1 lb.	Bottle	1
1-121-220	Camphor and Soap Liniment Powder, 57 Gm.	Jar	2
1-124-511	Capsule, Gelatin, Pharmaceutical, No. 1, 100s	Box	1
1-129-010	Cascara Sagrada Tablets, 0.25 Gm. (4 gr.) 100s	Bottle	6
1-137-310	Chloroazodin Saline Mixture Tablets, 0.55 Gm. ($8\frac{1}{2}$ Grs.), 100s	Bottle	1
1-148-985	Codeine Sulfate Tablets, 0.032 Gm. ($\frac{1}{2}$ gr.) 100s	Bottle	1
1-160-100	m-Cresylacetate, 1 oz. (Cresatin)	Bottle	1
1-165-000	Dextrose and Sodium Chloride Injection, 1000cc., 6s	Box	1
1-175-300	Epinephrine Hydrochloride Injection, 1:1000, 1cc., 12s	Box	1
1-175-330	Epinephrine Hydrochloride Injection, 1:1000, 1 oz.	Bottle	1
1-204-005	Foot Powder, 4 oz.	Can	40
1-218-000	Glycerin, 1 lb.	Bottle	2
1-223-000	Glycyrrhiza and Opium Compound Tablets 1000s	Bottle	1
1-227-000	Hexavitamin Tablets, 100s (Multivitamins)	Bottle	100
1-229-000	Hydrogen Peroxide Solution, 1 pt.	Bottle	2
1-235-000	Iodine, 1/4 lb.	Bottle	1
1-235-120	Iodine Tincture, 10 cc, 3 vials	Pkg	6
1-240-995	Ipecac and Opium Tablets, 0.324 Gm. (5 gr.) 100s Dover's Powder)	Bottle	1
1-245-200	Jelly, Lubricating, 4 oz.	Tube	1
1-263-020	Magnesium Sulfate, $2\frac{1}{2}$ lb.	Can	1
1-273-915	Mercuric Oxide, Yellow, Ophthalmic Ointment 1%, 1/8 oz, 12s	Box	1

1-278-700	Mercurous Chloride, Mild, Compound Ointment 50 tubes	Box	2
1-285-705	Merthiolate Tincture, 1 pt. (1:1000)	Bottle	1
1-295-510	Morphine Tartrate Syrettes, (0.032 Gm. ($\frac{1}{2}$ gr.), 5s (1.5cc)	Pkg	7
1-300-810	Neosynephrine Hydrochloride Solution, 1%, 1 pt.	Bottle	2
1-301-805	Nikethamide Injection, 25%, $1\frac{1}{2}$ cc, 5s	Box	1
1-323-030	Opium Tincture, Camphorated, 1 pt. (Paragoric)	Bottle	1
1-336-000	Petrolatum, Liquid, 1 q.	Can	2
1-338-025	Petrolatum, White, 1 lb.	Can	2
1-339-600	Phenobarbital Tablets, 0.032 Gm. ($\frac{1}{2}$ gr.), 100s	Bottle	4
1-386-585	Quinacrine Hydrochloride Tablets, 0.1 Gm. ($1\frac{1}{2}$ gr.) 100s (Atabrine)	Bottle	5
1-391-000	Quinine Sulfate Tablets, 0.324 Gm. (5 gr) 1000s	Bottle	1
1-404-675	Silver, Mild Protein, Tablets, 0.299 Gm (4.6 grs), 100s	Bottle	1
1-404-740	Silver, Strong Protein, Tablets, 0.150 Gm. (2.3 gr.), 100s	Bottle	1
1-415-000	Sodium Bicarbonate, 1 lb.	Can	1
1-417-020	Sodium Bicarbonate Tablets, 0.648 Gm. (10 gr.) 1000s	Bottle	1
1-429-500	Sodium Chloride Isontonic Solution, 1000cc, 6s	Box	1
1-429-520	Sodium Chloride Tablets, 2.25 Gm. (34.7 gr.) 100s	Bottle	1
1-445-000	Sodium Salicylate Tablets, 0.324 Gm. (5 gr.) 1000s	Bottle	4
1-462-100	Sulfadiazine, 1 oz.	Bottle	4
1-462-140	Sulfadiazine Ointment, 5%, 1 lb.	Jar	1
1-462-200	Sulfadiazine Tablets, 0.5 Gm. ($7\frac{1}{2}$ gr) 1000s	Bottle	1

1-462-300	Sulfadiazine Sodium Injection, 5 Gm. 20 cc. 6s	Box	1
1-463-490	Sulfanilamide, 1/4 lb.	Bottle	2
1-463-975	Sulfathiazole, 1 oz.	Bottle	4
1-464-100	Sulfathiazole Tablets, 0.5 Gm. (7½ gr), 1000s	Bottle	1
1-467-050	Sulfur Ointment, 1 lb.	Jar	1
1-471-755	Tetracaine Ointment, 1 oz. (Pontocaine)	Tube	1
1-472-600	Thiamine Hydrochloride Injection, 0.05 Gm (1/12 gr.) 500s	Bottle	8
1-501-000	Zinc Oxide, 1 lb.	Bottle	1
1-502-000	Zinc Oxide Ointment, 1 lb.	Jar	1
1-607-104	Plasma, Normal Human, Dried, 500 cc.	Pkg	4

Class 2-Surgical Dressings

2-002-185	Bandage, Cotton, Elastic, 2 ins by 5½ yards. 12s	Pkg	1
2-002-200	Bandage, Cotton, 3 inches by 5½ yards. 12s, Elastic	Pkg	1
2-006-204	Bandage, Gauze, Roller, Camouflages, 2 inches by 6 yards 12s	Pkg	11
2-006-206	Bandage, Gauze, Roller, Camouflaged, 3 inches by 10 yards 12s	Pkg	4
2-013-500	Cotton, Absorbent, 4 oz.	Pkg	60
2-014-000	Cotton, Absorbent, 1 lb.	Roll	4
2-017-425	Dressing, First Aid, Camouflaged, Large	Each	14
2-017-430	Dressing, First Aid, Camouflaged, Medium	Each	50
2-017-435	Dressing, First Aid, Camouflaged, Small	Each	24
2-017-585	Dressing, Gauze, and Adhesive Plaster, Camouflaged, 1" x 3", 100s	Pkg	4
2-017-680	Dressing, Head, Adjustable, Compressed, Camouflaged	Each	6
2-022-000	Gauze, Plain, 36 inches by 25 yards	Pkg	4

1-278-700	Mercurous Chloride, Mild, Compound Ointment 50 tubes	Box	2
1-285-705	Merthiolate Tincture, 1 pt. (1:1000)	Bottle	1
1-295-510	Morphine Tartrate Syrettes, (0.032 Gm. ($\frac{1}{2}$ gr.), 5s (1.5cc)	Pkg	7
1-300-810	Neosynephrine Hydrochloride Solution, 1%, 1 pt.	Bottle	2
1-301-805	Nikethamide Injection, 25%, $1\frac{1}{2}$ cc, 5s	Box	1
1-323-030	Opium Tincture, Camphorated, 1 pt. (Paragoric)	Bottle	1
1-336-000	Petrolatum, Liquid, 1 q.	Can	2
1-338-025	Petrolatum, White, 1 lb.	Can	2
1-339-600	Phenobarbital Tablets, 0.032 Gm. ($\frac{1}{2}$ gr.), 100s	Bottle	4
1-386-585	Quinacrine Hydrochloride Tablets, 0.1 Gm. ($1\frac{1}{2}$ gr.) 100s (Atabrine)	Bottle	5
1-391-000	Quinine Sulfate Tablets, 0.324 Gm. (5 gr) 1000s	Bottle	1
1-404-675	Silver, Mild Protein, Tablets, 0.299 Gm (4.6 grs), 100s	Bottle	1
1-404-740	Silver, Strong Protein, Tablets, 0.150 Gm. (2.3 gr.), 100s	Bottle	1
1-415-000	Sodium Bicarbonate, 1 lb.	Can	1
1-417-020	Sodium Bicarbonate Tablets, 0.648 Gm. (10 gr.) 1000s	Bottle	1
1-429-500	Sodium Chloride Isontonic Solution, 1000cc, 6s	Box	1
1-429-520	Sodium Chloride Tablets, 2.25 Gm. (34.7 gr.) 100s	Bottle	1
1-445-000	Sodium Salicylate Tablets, 0.324 Gm. (5 gr.) 1000s	Bottle	4
1-462-100	Sulfadiazine, 1 oz.	Bottle	4
1-462-140	Sulfadiazine Ointment, 5%, 1 lb.	Jar	1
1-462-200	Sulfadiazine Tablets, 0.5 Gm. ($7\frac{1}{2}$ gr) 1000s	Bottle	1

1-462-300	Sulfadiazine Sodium Injection, 5 Gm. 20 cc, 6s	Box	1
1-463-490	Sulfanilamide, 1/4 lb.	Bottle	2
1-463-975	Sulfathiazole, 1 oz.	Bottle	4
1-464-100	Sulfathiazole Tablets, 0.5 Gm. (7½ gr), 1000s	Bottle	1
1-467-050	Sulfur Ointment, 1 lb.	Jar	1
1-471-755	Tetracaine Ointment, 1 oz. (Pontocaine)	Tube	1
1-472-600	Thiamine Hydrochloride Injection, 0.05 Gm (1/12 gr.) 500s	Bottle	8
1-501-000	Zinc Oxide, 1 lb.	Bottle	1
1-502-000	Zinc Oxide Ointment, 1 lb.	Jar	1
1-607-104	Plasma, Normal Human, Dried, 500 cc.	Pkg	4

Class 2-Surgical Dressings

2-002-185	Bandage, Cotton, Elastic, 2 ins by 5½ yards, 12s	Pkg	1
2-002-200	Bandage, Cotton, 3 inches by 5½ yards. 12s, Elastic	Pkg	1
2-006-204	Bandage, Gauze, Roller, Camouflages, 2 inches by 6 yards 12s	Pkg	11
2-006-206	Bandage, Gauze, Roller, Camouflaged, 3 inches by 10 yards 12s	Pkg	4
2-013-500	Cotton, Absorbent, 4 oz.	Pkg	60
2-014-000	Cotton, Absorbent, 1 lb.	Roll	4
2-017-425	Dressing, First Aid, Camouflaged, Large	Each	14
2-017-430	Dressing, First Aid, Camouflaged, Medium	Each	50
2-017-435	Dressing, First Aid, Camouflaged, Small	Each	24
2-017-585	Dressing, Gauze, and Adhesive Plaster, Camouflaged, 1" x 3", 100s	Pkg	4
2-017-680	Dressing, Head, Adjustable, Compressed, Camouflaged	Each	6
2-022-000	Gauze, Plain, 36 inches by 25 yards	Pkg	4

2-034-510	Plaster Adhesive, Surgical, 2 in. by 5 yd.	Spool	11
2-035-500	Plaster, Adhesive Surgical, 12 in. by 5 yd.	Roll	1
2-041-200	Suspensory, 12s	Pkg	1

Class 3-Surgical and Diagnostic Supplies

3-038-200	Applicator, Wood, 1/8 by 12 inches, 500s	Pkg	1
3-070-100	Atomizer, Hand, Glass	Each	2
3-070-140	Bulb, Rubber, Hand Atomizer	Each	1
3-096-500	Bath, Eye	Each	3
3-104-100	Blower, Powder	Each	2
3-176-500	Catheter, Urethral, Rubber, Nelaton, 10Fr.	Each	1
3-176-520	Catheter, Urethral, Rubber, Nelaton, 14Fr.	Each	1
3-176-540	Catheter, Urethral, Rubber, Nelaton, 18Fr.	Each	1
3-212-800	Cot, Finger, Large, 12s	Each	1
3-245-500	Depressor Tongue, Wood, 100s	Box	3
3-333-600	Forceps, Dressing, Straight, 5½ inches	Each	1
3-379-800	Forceps, Tissue, Spring, 5 inch	Each	1
3-390-700	Gag, Mouth Screw Type	Each	2
3-397-880	Gloves, Surgeons, Size 8	Pair	2
3-419-200	Holder, Needle, Hegar-Mayo, 7 inch	Each	1
3-447-100	Blade, Operating Knife, No. 10, 6s	Pkg	1
3-447-120	Blade, Operating Knife, No. 11, 6s	Pkg	1
3-447-800	Handle, Operating Knife, No. 3	Each	1
3-465-900	Loupe, Binocular Berger	Each	1
3-495-400	Needle, Hypodermic, 23 gage, 3/4 inch, 12s	Box	1
3-497-980	Wire, Hypodermic Needle, 4 inch, 12s	Bundle	1
3-524-420	Needle, Suture, Surgeons Regular, 3/8 Circle, Pkg.	Pkg	1
3-524-540	Needle, Suture, Surgeons Regular, 3/8 Circle, Cutting Edge, Size 16, 6s	Pkg	1

3-540-200	Otoscope, Electric	Each	1
3-594-800	Razor, Safety Str. Type	Each	1
3-599-940	Resuscitor, Portable	Each	1
3-594-800	Blade, Straight Safety Razor, 5s	Pkg	1
3-683-800	Scissors, Bandage, Lister, 5½ inch	Each	1
3-649-100	Scissors, Operating, Curved, Double Blunt 5½ inch	Each	1
3-670-420	Shield, Eye, Single	Each	12
3-713-100	Sphygmomanometer, Aneroid	Each	1
3-721-200	Splint, Basswood, 12s	Pkg	1
3-732-800	Splint, Wire Mesh, 5½ in. by 1 yd.	Rolls	2
3-739-800	Spud, Eye, Dix	Each	1
3-742-300	Stethoscope, Ford	Each	1
3-758-380	Suture, Dermal, Size 0, 12s	Pkg	1
3-767-900	Suture, Silk, Braided, Single Armed, Size 0, 12s	Pkg	1
3-767-940	Suture, Silk, Braided, Single Armed, Size 2, 12s	Pkg	1
3-774-600	Suture, Silk, Twisted, Size 000, 12s	Pkg	1
3-782-920	Suture, Surgical Gut, Nonboilable, Type A Plain, Size 0, 12s	Pkg	1
3-782-940	Suture, Surgical Gut, Nonboilable, Type A Plain, Size 1, 12s	Pkg	1
3-782-960	Suture, Surgical Gut, Nonboilable, Type A Plain, Size 2, 12s	Pkg	1
3-795-850	Syringe, Ear, Pomeroy, 2 oz.	Each	1
3-796-600	Syringe, Irrigating, Urethral, 1/8 oz.	Each	12
3-803-800	Syringe, Luer, 2 cc	Each	3
3-804-100	Syringe, Luer, 10 cc	Each	2
3-829-400	Tourniquet, Elastic 2 1/8 inch	Each	14
3-853-100	Tube, Colon, 30Fr.	Each	1
3-865-800	Tube, Stomach, 30Fr.	Each	1

3-876-715	Tubing, Rubber, Red 1/4 inch	Foot	12
3-878-525	Tubing, Rubber, Latex, 1/8 inch outside diameter, 1/32" wall	Foot	15

Class 4-Laboratory and Pharmacy Equipment and Supplies

4-089-962	Box, Ointment, Tin, 1 oz., 12s	Pkg	1
4-090-300	Box, Powder, Dispensing, 3 in nest, 12s	Pkg	1
4-097-000	Bulb, Rubber, 3 ml., 12s	Each	1
4-102-820	Burner, Alcohol (Barthel)	Each	1
4-187-525	Corkscrew	Each	1
4-228-120	Dropper, Medicine, 12s	Pkg	1
4-276-100	Funnel, Glass, Ribbed, 16 oz.	Each	2
4-275-120	Graduate, Glass, 125 ml.	Each	1
4-311-120	Label, Direction, 100s	Pad	1
4-361-000	Paper, Filter, Qualitative, 250 mm., 100s	Pkg	1
4-365-030	Paper, PH indicator 100s	Bottle	1
4-395-000	Slide, GL, Micro. 72s 25 by 75 mm.	Box	1
4-397-350	Spatula, 3 inch Blade	Each	1
4-401-200	Stand, Apparatus Support, Base 6 1/2 by 9 in.	Each	1
4-401-315	Ring, Sup. 3 1/2 inches W/SC. Clamp	Each	1
4-401-325	Ring, Sup. 3 1/2 inches W/SC. Clamp	Each	1
4-401-340	Ring, Sup. 5 inch W/SC Clamp	Each	1

Class 5-Dental Equipment and Supplies

5-018-000	Blower, Chip	Each	1
5-019-000	Bulb	Each	1
5-142-200	Cement, Temp. Antiseptic	Pkg	1
5-182-000	Cotton Roll, 1/2 inch, 100s	Box	1
5-189-000	Cup, Drinking, Paper	Ctn	10
5-235-050	Dispenser, Paper Cup	Each	1
5-266-050	Excabator, Darby-Perry, 21	Each	1

5-280-000	Explorer, No. 6	Each	2
5-311-000	Floss, 100 yds, waxed	Spl	2
5-365-405	Instr. Plastic, Woodson 2	Each	1
5-375-010	Lamp, Alcohol, Metal	Each	1
5-375-020	Wick, Alcohol Lamp, Small	Each	1
5-419-005	Mirror, No. 5, Magnifying	Each	1
5-419-350	Handle, Mirror, Cone Socket	Each	2
5-426-150	Pliers, No. 6, Dressing	Each	2
5-513-250	Bag, Paper, Waste Recple	Pkg	5
5-541-150	Scaler, B, SSW	Each	1
5-547-150	Scaler, Zerfing	Each	1
5-562-000	Slab, Mixing, Glass	Each	1
5-568-000	Spatula, Cement, No. 324	Each	1

Class 7 - Hosp. Equip. and Sup. Furniture and Fixtures

7-084-525	Sterilizer Inst. 13 by 5 by 3 inches 110 V AC-DC	Each	1
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Physical Therapy Equip. and Sup.

7-129-815	Lamp, Ultraviolet SP, Des. 110 V 60 C. AC	Each	1
7-352-465	Pitcher, 1 qt. CRS	Each	1
7-706-425	Bag, Hot Water or Ice, Combination	Each	2

Ward Nursing and Miscellaneous Equipment and Supplies

7-709-220	Basin, Pus, CRS	Each	1
7-710-945	Basin, Wash, 4½ qts. CRS	Each	1
7-717-025	Bedpan, CRS	Each	1
7-725-925	Brush, Hand	Each	1
7-800-656	Flashlight, Hand	Each	1
7-819-000	Hone, Oil, Arkansas Stone	Each	1
7-822-075	Irrigator, 2 qt. CRS	Each	1
7-807-000	Glass, Medicine, 1 oz.	Each	3

7-327-075	Jar, Dressing, CRS	Each	1
7-837-705	Litter, Semi-rigid, Canvas	Each	1
7-877-000	Pins, Safety, Large, 12s	Card	1
7-932-000	Thermometer, Clinical, Oral	Each	4
7-938-945	Tray, Instrument, 2 by 8 by 10 inches	Each	1
7-944-090	Urinal, Male, CRS	Each	1

Class 9 - Field Equip. and Sup. Kits etc.

9-207-125	First Aid Kit, Gun Crew	Each	10
9-214-775	First Aid Kit, Life Boat	Each	1
9-219-175	F-A Fit, Mo. and H.C., Large	Each	1
9-235-875	Forceps Set. Hemo. Forceps	Each	1
9-565-825	Surg. instr. Kit, Dressing	Each	1
9-610-325	Water Test. and Screening Kit	Each	1

Class 10 - Professional Books

10-160-630	Handbook, Hosp. Corps, 1939 Ed.	Each	1
10-167-600	Man Med Dept. USN	Each	1
10-308-000	Treat. Cas. Chem. War, NM220	Each	1
10-443-030	Prin. Nursing, Harmer, 4th Ed.	Each	1
10-567-120	Man Naval Hyg. NavMed 126	Each	1
10-747-570	Outline Treat. Frac., ACS 3 Ed.	Each	1
10-748-275	Spl. App. Bandages, US Army	Each	1

Class 14 - Blank Forms

14-101-100	Annual Syphilis Report, 20s	Pad	1
14-103-300	Report of Allotment Expenditures and Obligations, 25s	Pad	1
14-105-500	Individual Statistical Report of Patient	Card	36
14-106-600	Individual Statistical Report of Patient	Card	36
14-107-700	Hospital Ticket 50s	Pad	1
14-108-800	Health Record, Cover	Each	6

14-109-900	Health Record, Physical Examination, Set of 2	Set	6
14-110-000	Health Record, Immunization Record	Sheet	
14-113-300	Health Record, Abstract of Service	Sheet	6
14-116-600	Health Record, Medical History	Sheet	50
14-123-300	Certificate of Death 50s	Pad	3
14-130-000	Med. Stores Ledger Sheet 100s	Pad	3
14-136-600	Receipt, Transfer and Status Card, H.C. 75s	Pad	1
14-137-700	Roster Report of the Hospital Corps, 100s	Pad	1
14-285-500	First Aid Battle Casual, Man.	Each	1
14-289-900	Electric Shock First Aid Treatment	Each	1
14-291-100	Venereal Disease Contact Reports, 25 sheets	Pad	1
14-293-300	Emergency Medical Tag 25 sets	Pad	1
14-296-600	Emergency Medical Tag, Poster	Each	1
14-297-700	Indiv. First Aid Packet (Poster)	Each	1
14-309-900	Monthly Morbidity Report, 50s	Pad	1
14-310-000	Immunization Record, U.S.Navy, 500s	Pad	1
14-311-100	Report of Burial, 50s	Pad	1
14-344-400	Prosthetic Laboratory Card	Each	1
14-500-100	Catalog of Navy Material, BuMed Section	Each	1

There is real need for a complete and exhaustive study of the entire medical allowance aboard submarines. This need is many fold, but among the phases which need study can be listed the following:

- (a) Revision of the commissioning allowance in the light of the above recommended study.
- (b) Revision of the method of obtaining replenishment supplies.
- (c) Designation of the activity from which the supplies are to be obtained. In this connection we might note that there has been many changes during the past several years. We believe that

all replenishment supplied for submarines should be obtained either from the Submarine Tender or Submarine Bases, in case of shore-based squadrons. The submarine Pharmacist's Mate should not under most conditions have to obtain supplies from a Medical Supply Depot, because in general the quantity that would be the smallest amount supplied is too large a quantity for submarines where storage space is an acute problem.

- (d) The entire problem of medical supplies must be evaluated in the light of acute problem of storage space, particularly as we look forward to newer types of submarines, such as the guppy-snorkel, whose modifications further limit the already critical storage problem.
- (e) Of paramount importance is the preparation of a real Handbook for use of the pharmacist's mate, giving not only general medical diagnosis and minor surgical care, but specifically covering the use of each item of equipment and supplies which he carries. The Handbook available during the war period did not in any sense meet the requirements and it was found necessary to mimeograph and distribute all types of instructive material. This should definitely be corrected prior to any future mobilization.
- (f) One item that we believe it is imperative to clarify is the dental first-aid kit. None of an official nature was furnished from the Supply Depot during the war period. Several unofficial versions were constructed in an attempt to meet this need. In the Pacific area, such kits were obtained by directing a letter to the Force Medical Officer; in the Atlantic, such kits were supplied at the Submarine Base, New London and also at the Portsmouth Navy Yard. No general agreement could be found as to what should be carried in the kits and therefore no general training program could be instituted covering the use of either the equipment or the medicaments.

VII - ANALYSIS OF SUBMARINE PATROL REPORTS

During each submarine war patrol, a complete running account was kept of all pertinent information. This report, made by the Commanding Officer, included whatever medical information was considered pertinent. In this instance 'medical' is used in its broadest sense to include personnel problems, food, habitability, as affected by temperature,

humidity, air-conditioning, etc., as well as in the more strictly medical sense, including such things as accidents, injuries, illnesses and psychiatric difficulties.

There were approximately 1520 submarine patrols made during World War II, the reports of most of which were available for study of the medical problems encountered.

A complete study of these patrol reports was completed in the Research Division of Bureau of Medicine and Surgery, where all pertinent information likely to be of any value or interest to medical officers was abstracted and compiled by Comdr. Ivan F. Duff, USNR in a very complete report, entitled "Medical Study of the Experiences of Submariners as Recorded in 1471 Submarine Patrol Report of World War II". This study (classified CONFIDENTIAL) analyzed all phases of medical interest in exhaustive detail and is available to authorized personnel from the Research Division of Bureau of Medicine and Surgery. Present plans call for its publication in a permanent form.

At the Medical Research Laboratory, Submarine Base, New London, Connecticut, a similar study was made, in which 1489 patrol reports were carefully studied. The procedure at New London was first to prepare typed excerpts from patrol reports of all information of possible medical interest. This was a time-consuming operation, but was a necessary preliminary to the second phase of the work, which was the further reclassification of the material under appropriate headings, for example, all of the original material was separated under such headings as: medical conditions occurring; accidents and injuries; psychiatric casualties; surgical conditions; abdominal surgery; habitability, from the standpoint of air-conditioning, temperature, humidity, etc.; food, water, specific mention of PhM, including commendation, etc.; and general personnel problems of significance to those interested in personnel selection.

The two individuals primarily interested--one from Res. Div. in Washington and one from MRL, New London, collaborated on a series of papers, based on the above material. Although these papers have been, or are being published elsewhere, it is believed that it is worthwhile reporting them in this history, because they distilled out a considerable amount of the valuable information contained in the above rather voluminous study of the patrol reports. These papers will be presented in the following order:

- (1) Surgical Care on a Wartime Operating Submarine.
- (2) Medical Aspects of Submarine Warfare - The Human Factor as Reflected in War Patrol Reports.

- (3) Psychiatric Casualties in Submarine Warfare.
- (4) Lung Training Pays Off - (a semi-popular article)
- (5) Analysis of Submarine Food Problems in World War II.
- (6) Upper Respiratory Infections and Contagious Diseases aboard Submarines.

SURGICAL CARE ON WARTIME OPERATING SUBMARINES

By

C. W. Shilling, Captain, Medical Corps, U. S. Navy and

Ivan F. Duff, Commander, Medical Corps, U. S. Naval Reserve

Introduction

In order to properly appreciate the submarine surgical problem it is necessary to understand that although a submarine does not ordinarily carry a doctor, its complement does include a Pharmacist's Mate, whose training is akin to, though more extensive than, that of a skilled civilian first-aid man; but who, on a submarine, is necessarily the medical officer, the dentist, the nurse, and the chaplain all rolled into one.

A rigorous selection program chooses a trained Pharmacist's Mate from the general service who is at least 20 years old, is a high school graduate, is above average intelligence, and, as nearly as can be determined, is an emotionally stable, psychiatrically and physically sound adult. His additional training is designed to so equip him that he can diagnose and treat the more common illnesses, perform routine minor surgery and in the absence of a medical officer, care for major surgical emergencies which may arise. There were under his care in the Submarine crew approximately 8 officers and 75 men.

To a civilian doctor this must sound impossible of achievement, and echo of charlatanism. We are confident, however, that the following performance report will speak for itself and require no apology. The qualified submarine Pharmacist's Mates were a credit to the Medical Corps; and they were often, by all odds, the most valuable, and at the same time, the best liked men on the "boats".

As complete a story as possible of surgical care on a wartime operating submarine will be considered in this paper. The primary

source of material, admittedly incomplete and sometimes inadequate for statistical study, is the official patrol report made by the Commanding Officer of each submarine at the conclusion of a war patrol. Of the more than 1500 war patrol reports, 1489 were studied in preparing material for this article. Additional material has been gathered from official medical records, from personal experience of the authors, and from discussions held with many returned officers and Pharmacist's Mates of the submarine force.

Injuries and Occasion for Traumatic Surgery Aboard Submarines

Injuries were very common aboard combat submarines as substantiated by the fact that on 685 patrols, some 1208 injuries were considered sufficiently important to justify mention in the official patrol report. In order of frequency there were: lacerations, contusions, sprains, abrasions, burns, shrapnel and gun shot wounds, fractures and heat exhaustion.

Injuries were commonly sustained by personnel of the bridge watch, particularly in the lightning-like maneuvers necessary to clear the bridge in the relatively few seconds that elapse between the time the diving signal is given and the submarine is actually submerged. Smashed fingers, broken ribs, dislocations, bruised shoulders, and lacerations of various degrees were the result of this mass exodus of eight or so men from the bridge through a twenty-four inch hatch, and down the slippery and precipitous ladder into the conning tower.

The bridge of a submarine affords scant protection against heavy weather, and not infrequently, it may be inundated to waist depth. Personnel frequently sustained painful and serious injuries when thrown about the bridge and against the periscope shears by the rough seas.

To a lesser degree, all hands below deck were subject to the fury of the weather. Men were sometimes thrown from their bunks. Burns, caused by the spilling of hot coffee and scup, were commonly reported. The routine checking of torpedoes during rough weather was accompanied by the hazard of painful bruises, smashed fingers and in one case, by a fatal intracranial injury. The accumulative effect of continual harassment in severe storms was such that often commanding officers submerged the ship to weather out the storm and rest all hands.

Some of the most stirring chapters of submarine warfare concern gun engagements, literally duels to the death between enemy surface craft and submarines. Exciting though these encounters always were, they sometimes exacted their price in terms of painful shrapnel and

bullet wounds. Ten submariners lost their lives in these engagements. In addition, exposed to the force of the sea, men were sometimes thrown about the deck, against the gun mount, and on occasion were washed over the side. On three occasions, personnel on the bridge of submarines were seriously wounded (two fatally) when the ship was strafed by enemy planes.

Pharmacist's Mates were also called upon to treat injuries which could be attributed to other sources than these hazards on wartime operating submarines. Japanese taken aboard, as prisoners, were frequently found to be seriously injured. It can be pointed out with pride that the care furnished them by the representatives of the medical profession aboard submarines was always adequate and oftentimes brilliant.

The thoroughness of the training and caliber of the performance of submarine Pharmacist's Mates is nowhere more apparent than is the care afforded survivors recovered in air-sea-rescue operations. Throughout the war, 110 U. S. Submarines in 200 separate pick-ups recovered a total of 542 American and Allied airmen downed in Pacific waters in operations extending from Tokyo Bay to the Solomon Islands. Of these survivors, 259 (48%) when rescued required medical care, essentially for exhaustion and primary shock consequent to over-exertion and over-exposure. Ten percent were suffering from severe wounds with severe secondary shock. Nine aviators, when recovered, were dead. Only two aviators died aboard submarines under the care of Pharmacist's Mates.

Excerpts from Patrol Reports Dealing with Injuries

In order to illustrate some of the conditions described above, the following authentic excerpts from patrol reports have been selected:

"One man received a severe laceration of the forearm which required seven stitches. Two men were injured by misfire of the 20MM gun. In one of these cases it was deemed necessary to amputate two toes of the right foot. Due to a shortage of surgical instruments, (Editor's Note: this was early in the war) a pair of sterilized side cutters were used to cut portions of the shattered bone. Because the "phalanges.....were completely shattered, they were not sutured but left open to allow free drainage. A generous amount of sulfanilamide powder was used. The other man was wounded in the shoulder but no lead or foreign body could be located. This man was back to duty in three days with no complications."

"The medical department in the person of the Chief Pharmacist's Mate did a particularly capable job in handling the Jap prisoner of war recovered after his plane was shot down. Though suffering from shock, second degree burns of the face and hands and several other serious wounds from gunshot and the crash, he was brought around very well and will probably arrive in port almost fully recovered."

"Two wounded men were in excellent hands under the care of the Chief Pharmacist's Mate. Their recovery from wicked flesh wounds caused by a Jap .50 caliber machine gun bullet is a tribute to his skill and ability. Two men with multiple shrapnel wounds were admitted to the sick list for a total of 50 man-days."

"An injured German prisoner was treated for a dislocated left knee, broken right collar bone, badly lacerated mouth and nose and three missing teeth. Recovery to date is satisfactory except that he succeeded in mis-aligning his clavicle after it was lined up properly."

"The price of sinking one sampan, damaging one and learning the use they are put to (Editor's note: Submarine traps) was three men wounded. One man received two .25 caliber hits in the left side just beneath the floating ribs, the bullet ranging upward, fracturing the rib and puncturing the left lung, the other bullet lodged in the diaphragm above the stomach. A second man received five hits in the right shoulder over the scapula: the third was struck in the right hip by a piece of flying metal as the target exploded. In view of the nature of the wounds, left the area 24 hours early, setting course for Midway at best speed. The Chief Pharmacist's Mate.....is particularly commended for his quick and efficient action in caring for these three wounded shipmates. By his proficient skill and painstaking efforts he prevented complications of severe wounds and enabled return of his patient to the facilities of a hospital, well on the road to recovery. He has been recommended for promotion and the Bronze Star Medal."

"Two men were knocked unconscious by heavy seas while standing lookout watch and suffered minor contusions of the shoulder, chest, and kidney areas. Another man suffered lacerations of the scalp when he hit his head on the conning tower ladder while clearing the bridge in rough weather."

"One man suffered a compound fracture of his right ring finger and a simple fracture of his index finger when a store-room hatch cover fell on his fingers. The boat was dived to a hundred feet to furnish a stable platform for sewing up the fingers and setting the bones. While the finger tips are still stiff one month after the accident, they have healed nicely and PhMlc _____ is to be commended for his efficiency and skill."

"The _____, on her second patrol, established an all time record for the recovery of friendly aviators when in five rescues she picked up a total of 30 men. The first man was recovered on 25 May 1945 with severe lacerations and second degree burns. Five days later five more were recovered, all in good condition, 18 minutes after their plane had crashed. On 29 May, sixteen were rescued, two of whom were seriously injured, one with severe head and body injuries, the second with a possible fracture of the back and skull. One man of this group died about six and a half hours after recovery and was buried at sea on 30 May. On the afternoon of the same day 7 survivors from an Army bomber, clinging to a life raft buffeted in tremendous sea with waves at least 30 feet high, were brought aboard. One of these men had a bullet wound of the foot, a second a fractured clavicle." (Editor's note: the problems which confronted the CPhM during this 6 day period must have been at times overwhelming.)

On 1 June, a medical officer from a destroyer boarded the submarine; on the same day the survivors were transferred at Iwo Jima:

Another Pharmacist's Mate had an entire surgical clinic on his hands with three women and three civilian men seriously wounded out of a group of 14 individuals rescued at sea. There were shrapnel wounds in all parts of their bodies requiring surgical treatment. In his own words, the Pharmacist's Mate so described one case:

"This woman had a piece of shrapnel at the bottom of her breast; there was a wound about three inches long and about two inches deep. First I stopped the bleeding. Then I cleaned it thoroughly with alcohol and put sulfanilamide powder in the wound. Then I put in 14 stitches and applied sterile dressings. She also had minor wounds which I cleaned with merthiolate." (Editor's note: when this boat finally put its passengers ashore fourteen days later, not a single case had become infected. What trained surgeon could have done any better?)

Appendicitis Aboard Combat Submarines in World War II

Probably no other single disease is cause for more anxiety to Submariners than is appendicitis. Since medical officers could not be carried on submarines, it became doubly important to formulate a policy governing the treatment of all cases of appendicitis, and to promulgate it as widely as possible. To accomplish this, all officers at the Submarine School, U. S. Naval Submarine Base, New London, Conn., both in the basic and prospective commanding officers' classes, and of course, all Pharmacist's Mates in the Submarine service and those in the "School for Pharmacist's Mates Entering the Submarine Service" were carefully indoctrinated along the following lines:

The diagnosis of appendicitis, without laboratory facilities and in relatively untrained hands is difficult and the errors in diagnosis might exceed the correct diagnosis. Gastric and gastro-intestinal disturbances and constipation are common in submarines and add difficulty to diagnosis. For these reasons conservative rather than surgical treatment should be instituted.

Moreover, even if the diagnosis is certain, with modern conservative treatment more cases will recover than will go on to rupture--the percentage again is against surgery.

They were also taught that even though their patient might turn out to belong to the small percent that would go on to rupture, the odds were still in the patient's favor--that he would wall off the infection and develop an abscess which could be drained at a later date.

Realizing all of this, and most importantly, taking into account the relative inexperience of most of the Pharmacist's Mates and the almost impossible conditions under which an operation would have to be undertaken, the final obvious order was--"Never resort to surgery." This order was put into effect toward the end of the first year of the war.

The conservative medical treatment recommended was: NO food by mouth; the smallest sips of water by mouth (any evidence of dehydration treated by interavenous fluids); NEVER give a cathartic to a case of suspected appendicitis; a low gentle enema repeated, if necessary, until results are satisfactory (many of their cases of "acute appendicitis" were cured this way); absolute bed rest; sedation until resting quietly; icebag over right lower quadrant; sulfa drugs in adequate dosage and with proper safeguards; and, as it became available, penicillin.

The Incidence and Mortality Rates of Appendicitis in Civilian Personnel in a group of comparable size and age to the one with which we are dealing is unknown. However, according to the Public Health Service in some 8,758 families of all ages who were under observation in 18 states during 12 consecutive months, appendicitis developed at a rate of 6.6 per thousand in males and 12.3 in females. For males, the incidence per age group is presented in Table 1. These figures are of interest because they indicate that between the ages of 15-35 appendicitis is very common--"the most common major surgical disease".

Table 1

INCIDENCE OF ACUTE APPENDICITIS IN MALES*

Age	Per Thousand
Under 5 years	1.8
From 5 to 9 years	5.0
From 10 to 14 years	8.3
From 15 to 19 years	9.8
From 20 to 24 years	10.1
From 25 to 34 years	12.1
From 35 to 44 years	7.0
From 45 to 54 years	2.7
From 55 and over	2.4

 * From the Public Health Reports, Reprint No. 1981, Vol. 53, No. 36, Sept 9, 1938.

Incidence and Mortality Rates of Appendicitis in Personnel Aboard Combat Submarines

The average complement aboard submarines on war patrols was approximately 75 enlisted men and 8 officers. The average age of the officers was 26.7 years and of the men about 22 years. At the conclusion of the war, in a group of 318 submariners picked at random, the average man had made 6.17 war patrols. The average strength of the submarine force in 1943 was about 8,755 men, in 1944 it was about 13,345 men. At no time during the conflict did the entire Submarine force exceed a strength of 25,433 men.

According to the statistical division of the U. S. Navy Bureau of Medicine and Surgery, the diagnosis of acute appendicitis was made 78 times in 1943 (or 8.9 cases per thousand) and 124 times in 1944 (or 9.2

times per thousand), among personnel attached to submarines, but not necessarily on war patrols. It will be noted that this percentage is slightly under that to be expected according to Table 1, which argues in favor of the correct diagnosis having been made by the Pharmacist's Mates.

From information available in the submarine patrol report, it appears that Pharmacist's Mates made the diagnosis of Appendicitis (acute, chronic, or Diagnosis Undetermined, admitted for observation) on 116 war patrols in 127 instances during the entire war. On eight patrols more than one man was admitted with the diagnosis. In sixteen instances one case of appendicitis was reported from the same submarine on two successive patrols, presumably by the same Pharmacist's Mate.

The authors know of instances in which, during a two week period spent at a rest camp between war patrols, the diagnosis of acute appendicitis in more than one individual from the same boat was verified surgically. And although there is no doubt that submarine crews were sometimes "appendicitis conscious" a few Pharmacist's Mates were plagued on successive patrols, by different individuals who undoubtedly had appendicitis.

In the majority of instances from information available in patrol reports, the diagnosis as made by the Pharmacist's Mates cannot be verified. There can be no doubt, however, that in thirty-four instances their patients were sufficiently ill to warrant eventual transfer for medical treatment, frequently at sea from one submarine to another for further transfer. In eleven instances acute appendicitis was the cause for submarines to either leave their areas of operation, their formation, or terminate their patrol. Twelve cases of appendicitis occurring on patrol, upon arrival at port, are known to have been followed by surgical treatment. Ten of these were either definitely stated to have had or likely to have had a ruptured appendix. This series of cases accounted for a total of almost 578 sick or man days lost--while on patrol--an average of about 4.6 sick days per case. In a few instances following return to port, prolonged hospitalization was necessary.

To the best of our knowledge and experience, throughout the War in the Submarine Force, in not one single instance had death been reported due to, or related to acute appendicitis arising on a submarine war patrol. Commanding Officers and higher authorities were so impressed by the performance of Pharmacist's Mates in handling these truly acute emergencies that in twenty-two instances they were especially commended in official patrol reports.

Patrol Report Excerpts With Reference to Acute Appendicitis
show this problem and how it was handled on our submarines on war
patrols.

"The most disconcerting thing that happened during the entire patrol (early in 1942) was a case of acute appendicitis that fortunately turned out to be something else. The patient had all the symptoms of acute appendicitis. The decision was made to operate. Preparations were being made when the patient was seized with a violent spell of vomiting and cramps. The pain subsided and the temperature increased to 104° F. with symptoms indicating the appendix had ruptured. Further observation indicated a gastro-intestinal disorder and at the end of four hours the temperature had decreased to 101° F. where it remained for eight days. At the end of two weeks the patient was able to be up and around."

"The third day out of 'Pearl' a signalman came down with an acute attack of appendicitis. The 'doctor' was ordered (Editor's note: by the Commanding Officer) not to operate, and was instructed to keep the patient quiet, start treatment and get him well (This order might be difficult to carry out). It seems to me that there had been too much publicity lately about such cases and we thought we'd do our best to lick it and try and prevent an epidemic of appendicitis. The patient was confined to his bunk and ice packs were given continuously for four days. The morning after the initial attack, sulfathiazole was administered every four hours for the next four days. The patient had no more sharp attacks but the area remained tender for the next two days, after which the tenderness subsided and he was allowed up and about. No recurrent symptoms during the remainder of the patrol. The Pharmacist's Mate is to be commended for his devotion to duty and his efficient handling of this case."

"The quick diagnosis and correct treatment of a case of acute appendicitis, by _____ is deserving of particular attention and commendation. When the patient was turned over to the Medical Officer at Darwin, he was well along the road to recovery. This reflects credit not only on the individual but the Medical Service and to the medical course at New London, Connecticut."

".....had an attack of acute appendicitis, commenced ice packs and sulfadiazine treatment (May 1944). Temperature

varied from 101.5 to 99.6 for next two days and pain became progressively worse. A Medical Officer from a destroyer came aboard to check patient's condition. Because of better facilities and probability of operation prior to arrival in Majuro, patient was transferred to the destroyer."

"Shortly after reaching the patrol area, one man was suspected of acute appendicitis. The treatment used was preventative with the aim of minimizing the possibility of the appendix rupturing, or in the event that it did rupture, this man was made a strict bed patient. Daily treatment consisted of ice bags to abdomen, frequent administration of morphine tartrate to relieve the pain and control intestinal peristalsis, sulfathiazole and sodium bicarbonate 4 daily doses of each, and a 5% dextrose saline injection and no food by mouth. Sulfathiazole was discontinued after three days as it brought on vomiting. On the fifth day the ice bag was replaced with a hot water bottle. This continued for six days. The Chief Pharmacist's Mate is commended for his quick diagnosis and application of preventative measures. His professional ability is considered to be outstanding."

Appendectomies Performed Aboard Submarines on War Patrols

Although sufficient publicity has been given those appendectomies performed by Pharmacist's Mates at sea aboard submarines, for the sake of completeness and because of their interest the authors verify these cases as follows:

The first was done aboard the USS SEADRAGON, on 11 September 1942, concerning which little technical information is available. Subsequent to the operation, which lasted about three hours, the patient was on the sick list for fourteen days.

The second man, who had been ill for about forty-eight hours, was operated upon aboard the USS GRAYBACK, on 14 December 1942. At the operation, which lasted about 1½ hours, the appendix was discovered to be ruptured; sulfanilamide powder was instilled locally, drainage was instituted (an elastic rubber band) and the abdomen was closed. Ether was used as an anesthetic, the first assistant was a Motor Machinist's Mate First Class. "Spoons were flattened and used for retractors, long nose pliers from the engine room were utilized. A submarine escape 'lung' mouthpiece was used for administering the ether."

The third and last case was performed aboard the USS SILVER-SIDES on 22 December 1942. The patient had been ill for about twelve hours prior to the operation, which was performed on the wardroom table, with the submarine submerged at 100 feet. The effectiveness of the spinal anesthesia having worn off

"Ether was administered, following the directions on the can. This anesthetized the operating staff as well as the patient. One hour after completion (the operation lasted about four hours) we tangled with a destroyer. The patient convalesced the following morning--to the tune of torpedo firing, two depth charge attacks, two 'crash dives' and an aerial bombing which knocked him out of his bunk. The conduct of the patient, was exemplary throughout the operation and the period following."

Comments made by the Commanding Officer of one submarine concerning the operation performed aboard his ship are highly pertinent and, in the light of the above circumstances, understandable:

"It is recommended that all men who have a previous history of, or indications of chronic appendicitis not be sent out on patrol until their appendix has been removed. This also applies to any other ailment which may require an emergency operation at some future date."

Higher authority observed in connection with the operation on the SEADRAGON:

"The incident is believed to be the first of its kind in submarine history. While this case had a happy ending it is pointed out that this particular Pharmacist's Mate had had considerable experience in assisting at surgical operations it is hoped that his success will not encourage others to take risks."

One point of great interest to doctors charged with planning for any future emergencies is to be emphasized. With the remarkable history of NO mortality in the 127 cases of appendicitis recorded in the Patrol Reports and with the low morbidity, there appears to be no cause for the undue alarm which was experienced at least early in the war. Medical Officers can, with confidence, continue to teach conservative measures for the treatment of acute appendicitis with the assurance that the best possible treatment is being given to the men of the Submarine Service under the circumstances.

In not a few instances submarine personnel returning from war patrols on which they had had attack of acute appendicitis were completely recovered when seen by Medical Officers. The decision as to whether such men should be permitted to remain aboard submarines once having had an attack of appendicitis and without surgical treatment must be governed by local circumstances. In general, if conditions permit, an interval appendectomy is believed a wise decision.

Summary

On submarines, injuries were frequently sustained by above deck personnel in foul weather and in clearing the bridge. Major wounds were sometimes sustained in surface engagements with the enemy. Pharmacist's Mates were frequently called upon to treat serious wounds sustained by prisoners of war and rescued aviation personnel. Of a total of approximately 542 American and Allied aviation personnel rescued by submarines throughout the war, only two of the many seriously wounded, died while under the care of submarine Pharmacist's Mates.

Submarine Pharmacist's Mates were carefully indoctrinated in the conservative medical treatment of acute appendicitis. They made this diagnosis in 127 instances aboard operating submarines. Ten cases likely had a ruptured appendix when seen by medical officers. As far as is known, in not one single instance was a death reported due to, or related to acute appendicitis arising on a submarine war patrol. This is a fact which should be of considerable interest to all submariners and physicians charged with planning for possible future emergencies.

Submarine Pharmacist's Mates may well be proud of their performance record throughout World War II. These men, carefully chosen, patiently and thoroughly trained, aptly and often times brilliantly shouldered the immense responsibilities that were theirs. That they performed so excellently is a significant indication of what can be done in training lay personnel to handle medical problems.

MEDICAL CARE ON WARTIME OPERATING SUBMARINES

by

C. W. Shilling, Capt. (MC) USN and Ivan F. Duff, Comdr. (MC) USNR

Introduction

In order to properly appreciate the submarine medical problem it is necessary to understand that although a submarine does not ordinarily

carry a doctor, its complement does include a Pharmacist's Mate, whose training is akin to, though more extensive than that of a skilled civilian first-aid man; but who, on a submarine, is necessarily the medical officer, the dentist, the nurse, and the chaplain all rolled into one.

A rigorous selection program chooses a trained Pharmacist's Mate from the general service who is at least 20 years old, is a high school graduate, is above average intelligence, and, as nearly as can be determined, is an emotionally stable, psychiatrically and physically sound adult. His additional training is designed to so equip him that he can diagnose and treat the more common illnesses, perform routine minor surgery and in the absence of a medical officer, care for major surgical emergencies which may arise. There were under his care in the submarine crew approximately 8 officers and 75 men.

To a civilian doctor, this must sound impossible of achievement, and echo of charlatanism. We are confident, however, that the following performance report will speak for itself and require no apology. The qualified submarine Pharmacist's Mates were a credit to the Medical Corps; and they were often, by all odds, the most valuable, and at the same time, the best liked men on the "boats".

As complete a story as possible of medical care on a wartime operating submarine will be considered in this paper. The primary source of material, admittedly incomplete and somewhat inadequate for statistical study, is the official patrol report made by each submarine commander at the conclusion of a war patrol. One section of these reports deals specifically with features of health and habitability as they were encountered.* Additional material has been gathered from official medical records, from personal experience of the authors, and from discussions held with many returned officers and Pharmacist's Mates of the submarine force.

Preventive Medicine

Preventive medicine on a submarine includes the usual shipboard problems of supply and purity of food, and water, the proper stowage, refrigeration, and preparation of food the inspection of food handlers, the disposal of garbage and other waste material, the sanitary condition and adequacy of the toilet and wash room facilities, the general health of the men, and instruction in first aid.

* 1489 patrol reports have been available for study.

In addition to these routine measures, the submarine Pharmacist's Mate must be familiar with the medical aspects of the air conditioning problem, such as the oxygen supply, carbon dioxide removal, temperature and humidity control, and the potential hazards of noxious gases. He must also be familiar with the submarine escape problem and capable of instructing others in the use of the submarine escape appliance, the "lung".

General Incidence of Medical and Surgical Conditions Reported from
Combat Submarines.

Pharmacist's Mates attached to submarines on war patrols reported the four or five most commonly encountered medical conditions as acute communicable diseases, injuries, disturbances of the digestive tract, diseases of the skin, and diseases of the urogenital system. The incidence (per thousand) of diseases and injuries reported from submarines and destroyers in 1944, according to the statistical division of the U.S.Navy Bureau of Medicine and Surgery, is presented in Table I.

Table I

INCIDENCE OF DISEASES AND INJURIES BY CLASS OF
DISABILITY, DESTROYERS AND SUBMARINES*

1944

<u>CLASS</u>	<u>SUBMA- RINES</u>	<u>DESTROYERS</u>
Injuries	39.9	39.6
Communicable Diseases Transmissible by Oral and Nasal Discharges.	33.9	40.8
Venereal Diseases	24.1	23.4
Other Diseases of the Infectious Type	16.9	22.1

*Exclusive of Combat Injuries.

Cold statistics cannot tell the true story however, for the illness of even one man in so closely integrated a crew prevents flexibility of the organization and often produces considerable inconvenience. This was particularly true when it was necessary to engage in prolonged

periods of contact with the enemy with a crew whose efficiency and endurance had already been reduced by prevalent colds, etc.

Upon occasion in this last war the incidence (sick or man-days lost) and cumulative effect of acute respiratory diseases aboard submarines on war patrols assumed military significance. Installation of germicidal lamps in the ventilation system of submarines was considered. Actually, a battery of such lamps was installed on one submarine, but unfortunately, loss of the ship prevented an adequate and complete evaluation of its efficiency.

Medical Conditions Acute Communicable Diseases Aboard Submarines

As is evident from Table I, acute communicable diseases were common aboard operating submarines, having been reported in over 400 patrols, on 211 of which they accounted for 1068 sick or man-days lost. Despite the obvious incompleteness of the reporting, some details in regard to these illnesses are pertinent and of interest.

Colds (including "Acute Catarrhal Fever") and "Sore Throats"

As in any branch of the service, these two diseases were very common, and relatively speaking, few submarine patrols were made without a varying incidence of them. In some 140 patrol reports they were thought sufficiently important to justify special notice. Because of their interest and for the sake of completeness a few of these comments have been taken from the patrol reports and will be quoted and discussed in the following paragraphs.

It is quite natural to assume that men returning from leave brought the germs and viruses of these infections aboard the submarine which, as the following excerpts indicate, could be traced to unavoidable contact with shore based personnel, lowered individual resistance, inclement weather during the training periods, etc.

"The were numerous colds aboard when we left Australia".

"The epidemic of mild 'Cat Fever' (Editors Note: Short for the official navy diagnosis of Catarrhal Fever, Acute which is really a severe acute "cold" with fever) that started prior to leaving Pearl Harbor continued throughout the patrol involving 20 men, seven of whom were turned in from three to eight days."

"On departure, two thirds of the crew had colds which persisted for several days with noticeable reduction in efficiency."

"Shortly after leaving Pearl Harbor, several cases of severe septic throats occurred--believed contracted from an epidemic raging at the Submarine Base upon departure."

As the following excerpts indicate, submarines on patrol commonly reported "epidemics" of colds, sore throats, etc. within the first one to three weeks of the cruise, not infrequently before the submarine reached her operating area.

"A small epidemic of colds (16 colds, 4 tonsillitis, 2 ear-aches, 2 'Cat Fever') occurred in the first two weeks."

"A mild epidemic of colds and sore throats occurred in the first week involving 80% of the officers and crew."

"The usual run of sore throats and minor colds in the first two weeks."

"As the patrol progressed, the cold germs gradually retreated."

Generally these infections were short lived, reaching peak in the first and second weeks and disappearing thereafter. Upon occasion, however, as noted below, they persisted throughout the patrol.

"Approximately 70% of the crew suffered from colds and 'Cat Fever'. The combination of colds, lack of sleep, and lifeguarding (Air-Sea Rescue patrol for downed aviators--Editor's note) resulted in a certain nervousness and irritability which fluctuated in intensity with the magnitude of the three items mentioned."

"A mild epidemic of colds occurred in the latter part of the patrol, believed due to lowering of resistance because of the length of the run."

"There were four cases of mumps, one case of measles, and two cases of 'Cat Fever'--the latter being on the sick list on arrival at Midway at the end of the patrol."

Patrols made in northern areas of operation, particularly in winter, were especially apt to be handicapped by these acute infections. As indicated by the following excerpts the operating conditions encountered in these areas were extremely unfavorable.

"With 27 days spent submerged, the boat was cold and damp; health was only fair, 50% of the crew had colds."

"The temperature in the conning tower varied between 28 to 32° F; bridge personnel were constantly drenched with salt water spray, hail, and snow; ice accumulated two inches thick on the boat at night."

"Operating in a cold climate with an average temperature of 34° F, eliminates the generally encountered fungus infection but reciprocates with an increase in the number of minor colds."

Also, colds were commonly experienced, as observed in 26 reports, with the passage of the ship from warmer climates to cooler operating areas, particularly if the three weeks refit period had been conducted at a tropical or semi-tropical base.

"An epidemic of colds broke out--as the result of the sudden change in climate from Guam to the cold dampness of the weather in the Japanese Sea made in little more than a week."

"Ninety percent of the crew had colds due more or less to the sudden change of climate from Pearl Harbor to Dutch Harbor."

Interestingly enough, however, the reports of 43 patrols made in tropical waters were concerned with the incidence of acute respiratory infections.

"It was uncomfortably hot on all day dives. Health was fair with many colds. Two were admitted to the sick list with 'Cat Fever'."

"A high incidence of coughs and colds and two cases of 'Cat Fever' coincided with our passage across the equator."

In a few instances the onset of colds was related to submerged operations, as noted in the following excerpts.

"After the first all day dive of thirteen hours duration, twenty men developed colds."

"A severe epidemic of common colds was experienced at the start of daylight submerged patrolling."

Ample evidence exists, however, that once the colds had run their course, everyone became more or less immune to the common offending organism. Should, however, a new strain of organism be introduced, difficulty was again experienced:

"Four cases of 'Cat Fever' were observed to develop after a short stop over (Editor's note: a matter of hours) at Saipan."

One submarine, having sunk an enemy submarine, rescued one survivor:

"The German had a cold when captured. He brought a new variety of cold germs aboard resulting in another epidemic of colds and sore throats."

Another submarine participated in the mass rescue of British and Australian prisoners of war. Some of these men developed an acute bronchitis within a few hours after they were taken aboard the submarine. Nine, when X-ray facilities were available, showed evidence of acute broncho-pneumonia.

Other Acute Communicable Diseases Aboard Submarines.

Other types of acute communicable diseases (classified according to Navy diagnostic nomenclature) reported were: Influenza (23 cases), Mumps (21 cases), Measles (20 cases), Pneumonia (12 cases), Chicken Pox (2 cases), Meningitis (2 cases), and Scarlet Fever (1 case). The fact that submarines on patrol were relatively free of mass illnesses such as these can be credited to luck, and to the sagacity of the Pharmacist's Mates in treating and isolating, so far as possible, their patients from the rest of the crew. Fifteen cases of Malaria and five cases of Dengue Fever occurred - which developed following refits in tropical ports. A number of submarines experienced varying incidence of what was apparently Acute Infectious Jaundice--22 cases having occurred on fourteen patrols. It would appear that some of these cases were contracted during refits on Guam.

The Tuberculosis Problem Aboard Submarines

The general problem and the incidence of tuberculosis aboard submarines was of concern to interested doctors throughout the war. Some of their comments taken from official Submarine Force documents may be of interest.

"The expansion of personnel brought into contact many individuals with quiescent or minimal tuberculous lesions not readily discernable on routine physical examination."

"Prolonged residence in specialized craft such as submarines, where sunlight is nil and outside ventilation is reduced to only parts of each day were ideal for activation of quiescent tuberculosis and the close association in sleeping and working spaces, was even more ideal to droplet spread of disease, enhanced by the presence of increased heat and humidity."

"Recognition of the problems involved led to the inauguration of periodic chest x-ray examinations of submarine personnel."

These surveys were accomplished at Pearl Harbor, Mare Island, California and New London, Conn. Table 2 is a summary of such examinations at Pearl Harbor, T.H. Submarine Base.

Table 2* **
TUBERCULOSIS

The following summary shows the results of x-rays of all submarine force personnel between 1 November 1944 and 1 October 1945. The complement as of 1 July 1945 was 21,522 enlisted men, and 3,911 officers (including Submarines, Tenders, Bases, etc.). 23,232 men were examined by photofluorograms. The incidence of tuberculosis (per 1000) in the Submarine Force was 0.43%, classified as follows:

	<u>Primary Type</u>		<u>Transferred</u>
1. Stable	11,411		0
2. Unstable	2		0
	<u>Re-Infection Type</u>		
1. Minimal	(a) Active	61	61
	(b) Inactive	41	18
2. Moderately	(a) Active	20	20
	(b) Inactive	1	1
3. Far Advanced	(a) Active	1	1
	(b) Inactive	0	0
	Total		<u>101</u>

*Through the courtesy of the Force medical Officer, of the Submarine Force, U.S.Pacific Fleet, Captain O.D.Yarbrough, (MC), USN

**Commander R.S.Henry, (MC), USNR, the medical officer who installed and directed the local fleet unit, cannot be praised too highly for the excellent way in which he has conducted the photofluorographic program.

Excerpts from the Pacific Submarine Force Medical Officers report add interesting sidelights to the facts presented in the table:

"In only one vessel, where an open case was found, were there any additional cases that were considered to be infected from the open case."

"Results of the program.....are very gratifying to the Force Medical Officer, especially after the misgivings that accompanied reliance on tuberculin tests for crews in which tuberculosis was found prior to the establishment of the photo-fluorographic unit."

"It is regrettable that two of the tuberculosis cases occurred in medical personnel, one in a medical officer and one in a submarine Pharmacist's Mate."

"The incidence of tuberculosis in the entire fleet (based upon 185,000 photofluorograms) was 0.32%."

The incidence of tuberculosis in submarine crews and in surface craft crews is presented in Table 3, and it was found in a survey taken at the Mare Island Naval Shipyard, California.

Table 3* **

TUBERCULOSIS

Month	Number X-Rayed	Submarines	
		Hospitalized for TB	Indications for Clinical Study
Aug.	246	1	2
Oct.	275	1	0
Dec.	451	0	0
Total	<u>972</u>	<u>2</u>	<u>2</u>

(Editor's Note: Incidence 0.41)

Month	Number X-Rayed	Surface Craft	
		Hospitalized for TB	Indications for Clinical Study
Aug.	2,978	12	4
Oct.	865	1	0
Dec.	1,071	3	1
Total	<u>4,914</u>	<u>16</u>	<u>5</u>

(Editor's Note: Incidence 0.42)

*Through the courtesy of Commander J.E. Compson (MC) USNR, Senior Medical Officer, Mare Island Naval Shipyard, Mare Island, California.

**The three months shown in this report were taken at random from 1945 records.

The statistical division of the Bureau of Medicine and Surgery has reported the incidence of all forms of tuberculosis officially reported as occurring in submarine personnel as seven cases in 1943 (08 per 100), and eight cases in 1944 (06 per 100). These figures, in combination with those shown in Tables 2 and 3 indicate that the incidence of tuberculosis among submarine personnel was very low. The incidence of the disease among incoming university students--presumably never subject to previous screening--is said to be about 0.7 per 100.

Diseases of the Digestive System Aboard Combat Submarines.

As noted in Table 1, diseases of the digestive system accounted for 24.1 admissions per thousand to the sick list. According to the war patrol reports the four most commonly encountered conditions of this class were acute gastro-enteritis, chronic constipation, acute appendicitis, and "Diagnosis Undetermined (Abdominal Pain)". Most cases of gastro-enteritis, and practically all cases of constipation were not admitted to the sick list. The bulk of sick days attributed to this class (578 of a total of 995) were due to acute or chronic appendicitis, which will be discussed under the section of this paper dealing with Surgical Conditions.

Gastro-Enteritis and Food Poisoning.

Careful analysis reveals notations concerning food poisoning in only 34 patrol reports. In only nine of these was food definitely incriminated. Offending agents were listed as canned orange juice, canned sardines, custard pie, beef, surveyed "Avoset" (stabilized cream), spoiled chicken (2), tinned hash and tinned salmon. The remaining reports mentioned the occurrence only in general terms.

That mass food poisoning aboard an operating submarine may, by incapacitating the crew, cripple the striking force of the ship is illustrated by the experience of one submarine, where, at least in part such a mass illness was responsible for the submarine's inability to carry through a successful attack against a Japanese carrier. Food poisoning occurred on 7-9 July believed due to frozen chicken (which was spoiled) served for dinner on 7 July. Two-thirds of the crew and all of the officers were involved with diarrhea and vomiting. Two men were still vomiting after five days and were not fully recovered ten days after they had been stricken. The submarine sighted a carrier on 10 July and the following comment concerning the attack was made:

"Loss of depth control on the one attack made was most unfortunate in that it prevented firing at carrier. The order to

make ready the tubes was given rather late; this was combined with personnel errors in hurriedly preparing all tubes. At this time nearly all of the crew was handicapped by sickness from the food poisoning."

Constipation.

Constipation being considered almost an occupational disease among submarine personnel is generally taken for granted. The following excerpts from patrol reports will illustrate its frequency.

"Constipation was the most common complaint, being most prevalent in the first two weeks of the cruise; after this period the requests for laxatives dropped off to the level observed in normal operating (peace time) conditions."

"The most common complaint was constipation, involving 90% of the crew." This Pharmacist's Mate stated that on a 56 day patrol with a crew of approximately 75 men he had dispensed three quarts of mineral oil, one pint of castor oil, two pounds of Seitz powder, three bottles of cascara and twenty soap and water enemas. (First patrol of the ship early in the war. Admittedly over-emphasized and over-treated. Editor's Note).

Constipation, in submarine personnel, is associated with the problem of diet (the small amount of available roughage, insufficiency of fresh fruit, excess of carbohydrates); improper eating habits; irregularity of meals; lack of sleep; lack of exercise; motion of the ship; and heads (toilets) which are sometimes difficult to operate. When intelligently managed by the Pharmacist's Mate, constipation was not, however, an insurmountable problem.

Venereal Disease.

The Manual of the Medical Department of the U. S. Navy states that a man with an active venereal disease shall be disqualified for entrance into the submarine service and that a proven history of syphilis shall be sufficient to disqualify. Men already serving aboard submarines who contract venereal diseases are to be transferred to the tender or hospital facility ashore as soon as possible. The occurrence of diseases of the urogenital system among submarine personnel on war patrols has been summarized from the official patrol reports and is presented in Table 4.

Table 4

DISEASES OF THE UROGENITAL SYSTEM

DISEASES	NO. PATROLS REPORTING	NO. CASES REPORTED	NO. SICK DAYS REPORTED
Gonorrhoea Urethra, Acute	37	109	45
Urethritis Acute, non- venereal	23	67	26
Gonorrhoea Urethra (DU)*	25	56	31
Prostatitis, Unclassified	8	24	6
Penile Lesions (DU)*	18	20	28
Syphilis	11	16	52
Renal Disease (DU)*	10	15	22
Calculus, Urinary System	12	13	35
Epididymitis, Acute and Orchitis, Acute	10	11	25
Cystitis, Acute	5	5	29
Balanoposthitis	<u>1</u>	<u>1</u>	<u>0</u>
Total	170	337	299

*DU stands for Diagnosis Undetermined, indicating that it was impossible to be absolutely certain or to prove the diagnosis. It should be pointed out that the reporting, especially for Gonorrhoea, Urethra, is undoubtedly incomplete as medical facilities of submarines do not include microscopes.

The following excerpts from patrol reports concerning venereal disease aboard submarines are quoted for their interest:

"Four men with gonorrhoea were taken to sea (Editor's note: early 1942) and given a short course of sulfathiazole tablets orally as prescribed and furnished by a Dutch doctor at Soerabaja. The treatment was apparently 100% effective in 3 of the cases and partially effective in the other case."

"One case of gonorrhoea appeared shortly before arriving at Saipan enroute to the patrol area. Sulfa drugs were administered aboard and he was treated with penicillin upon arrival at Saipan. The patient continued the patrol with no apparent ill effects."

"There is one suspected case of chancroid which developed about three weeks after departure on patrol. Subject man has been isolated to the extent necessary to prevent contamination of other personnel."

"One case of venereal disease developed after departure Fremantle that required transfer at Darwin enroute north due to the fact that his health record contained the statement that he should not be given sulfa drugs for treatment of any illness."

"One case of Diagnosis Undetermined Syphilis was noted and precautionary measures were used until a positive diagnosis could be established."

"The presence of pediculi and scabies among the crew caused further discomfort."

Upon one occasion a submarine, at the conclusion of a long patrol, underwent a two weeks refit period at an advanced base. When the ship arrived post-patrol physical examinations were confined to a discussion with the Pharmacist's Mate. A few weeks before the termination of the next patrol one man who had made all patrols advised the Pharmacist's Mate of a venereal disease which he had concealed for a period of at least six weeks and during the last refit. Examination disclosed the presence of multiple penile and perineal lesions. When the submarine finally came alongside another tender-ship these lesions were easily proven to be syphilitic. In addition, the patient had an acute cerebro-spinal syphilis. The entire crew were given blood seriological tests for syphilis, all of which were negative. This incident is reported in such detail to emphasize two points: (1) Apparently, aboard submarines, the hazards of contacting a venereal disease by casual contact are at a minimum, despite the necessity of sharing bunks and the markedly limited lavatory facilities; and (2) Post-patrol physical examinations while admittedly a chore, and often productive of but little in the way of pathology, were none-the-less worth doing well for the occasional time they did pay dividends. Such cursory "Examinations" as described above may well, upon occasion, prove embarrassing to the examining physician.

Skin Diseases as Related to Air Conditioning Aboard Submarines.

Most fleet-type submarines were equipped with two, four-ton air conditioning units installed in the ventilation supply lines. As the war progressed these were supplemented by additional cooling and blower

units. Without air conditioning and adequate ventilation (lack of installations, lack of refrigerant, insufficient or mal-functioning cooling units, etc.) the habitability of a submarine on an active war patrol may become so poor that through material defects and/or lack of personnel endurance and efficiency, the safety and ability of the submarine to carry out her mission may be seriously compromised. The following excerpts from reports of war patrols made without, or with inadequate air conditioning, have been selected to emphasize this point and to show the relation of excessive heat and humidity to skin disease and heat exhaustion. Actually, only a very few patrols were made under such harrowing conditions.

"Shortly after midnight the.....dove at nearly full speed on four engines.....the interior of the ship being as hot as a fireroom that has been secured. Noisy air conditioning equipment was secured as we went in across the bow of the escort. Temperature in the maneuvering room was 130° F. and the engine rooms were about the same.At about 2 A.M. men in these two compartments were near prostration from the heat; one man was already receiving treatment. The men on the wheels and planes were being rotated every 5 to 10 minutes by which time they were totally exhausted. Men had never before been seen to sweat so profusely. There was cheerful chatter by the men on station about how much Tojo had to pay for his high grade of depth charging but response was slow and acuity dull. Errors were prevalent. It was evident that the ship was no longer in condition to fight or to defend itself.....At 2,35 A.M. the Executive and the Engineering officers advised me to surface before dawn to rehabilitate the ship and crew if at all possible."

"Due to faulty air conditioning units the boat was oppressively hot and humid.After two weeks of all day submergence all the bunks were wet and sticky. Clothing in lockers.....were green with mildew. Temperatures well over 100° F. with high humidity levels made it practically impossible to get any rest while submerged. There were two cases of heat exhaustion. The entire crew had prickly heat. Some cases covered the entire body. Thirty percent.....developed some type of fungus infection." Following repair of the air conditioning system on the succeeding patrol the commanding officer commented: "At last we have found out that submerged time need not be a taste of hell--this is the first patrol this boat has been anywhere near livable. General improvement in the condition

of personnel and reduction of heat rash and skin diseases was quite noticeable in comparison with previous patrols."

On another boat on which it is presumed the air conditioning must have failed completely we find that "90% of the officers and crew had 'prickly heat', 68% 'Guam blisters' (Editor's Note: probably dermatophytosis), 20% had boils and 12% had fungus infections of the ears."

Psychiatric Casualties Aboard Combat Submarines.

A complete and detailed report concerning psychiatric casualties aboard submarines on war patrols has been accepted for publication in The American Journal of Psychiatry. In the present report, for the sake of completeness the authors would like to briefly review some points which they made in that article.

The frequency of psychiatric cases was unbelievably low, with only 56 occurring in submarine War Patrol Reports available for study. Only two cases of epilepsy were recorded, and five cases that could be classified as true psychosis. This is truly a remarkable record.

The cases which did occur were handled efficiently:

"On one patrol a case of mental derangement occurred, with repeated attempts at suicide. The Pharmacist's Mate handled the case with skill, restraining the patient with sheets, giving sedatives, and bringing him to port without mishap, in spite of the patient's acute depressed state."

It is believed that this remarkable record may be attributed to: (1) Careful selection of candidates for the submarine service; (2) Thorough training of submarine personnel and elimination of the unfit; (3) Morale, or Esprit de Corps of the submarine service; (4) Pre- and Post-patrol physical examinations to determine fitness for continuance on patrols; (5) Generous use of rest camps, and rotation to the "States" for leave and to pick up "New Construction" submarines; and (6) Confidence in the submarine, their officers, and their shipmates.

Surgical Conditions.

Injuries and Occasion for Traumatic Surgery Aboard Submarines

Injuries were very common aboard combat submarines as substantiated by the fact that on 685 patrols, some 1208 injuries were considered sufficiently important to justify mention in the official patrol

report. In order of frequency these were: lacerations, contusions, sprains, abrasions, burns, shrapnel and gun shot wounds, fractures and heat exhaustion.

Injuries were commonly sustained by personnel of the bridge watch, particularly in the lightening-like maneuvers necessary to clear the bridge in the relatively few seconds that elapse between the time the diving signal is given and the submarine is actually submerged. Smashed fingers, broken ribs, dislocations, bruised shoulders, and lacerations of various degrees were the result of this mass exodus of eight or so men from the bridge through a twenty-four inch hatch, and down the slippery and precipitous ladder into the conning tower.

The bridge of a submarine affords scant protection against heavy weather, and not infrequently, it may be inundated to waist depth. Men were sometimes lost when washed overboard, and personnel frequently sustained painful and serious injuries when thrown about the bridge and against the periscope shears by the rough seas.

To a lesser degree, all hands below deck were subject to the fury of the weather. Men were sometimes thrown from their bunks. Burns, caused by the spilling of hot coffee and soup, were commonly reported. The routine checking of torpedoes during rough weather was accompanied by the hazard of painful bruises, smashed fingers and in one case, by a fatal intracranial injury. The accumulative effect of continual harassment in severe storms was such that often commanding officers submerged the ship to weather out the storm and rest all hands.

Some of the most stirring chapters of submarine warfare concern gun engagements, literally duels to the death between enemy surface craft and submarines. Exciting though these encounters always were, they sometimes exacted their price in terms of painful shrapnel and bullet wounds. Ten submariners lost their lives in these engagements. In addition, exposed to the force of the sea, men were sometimes thrown about the deck, against the gun mount, and on occasion were washed over the side. On three occasions, personnel on the bridge of submarines were seriously wounded (two fatally) when the ship was strafed by enemy planes.

Pharmacist's Mates were also called upon to treat injuries which could be attributed to other sources than these hazards of wartime operating submarines. Japanese taken aboard, as prisoners, were frequently found to be seriously injured. It can be pointed out with pride that the care furnished them by the representatives of the medical profession aboard submarines was always adequate and oftentimes brilliant.

The thoroughness of the training and caliber of the performance of submarine Pharmacist's Mates is no where more apparent than in the care afforded survivors recovered in air-sea rescue operations. Throughout the war, 110 U. S. Submarines in 200 separate pick-ups recovered a total of 542 American and Allied airmen downed in Pacific waters in operations extending from Tokyo Bay to the Solomon Islands. Of these survivors, 259 (48%) when rescued required medical care, essentially for exhaustion and primary shock consequent to over-exertion and over-exposure. Ten percent were suffering from severe wounds with severe secondary shock. Nine aviators, when recovered, were dead. Only two aviators died aboard submarines under the care of Pharmacist's Mates.

Excerpts from Patrol Reports Dealing with Injuries.

In order to conclude the section and in order to illustrate some of the conditions described above, the following authentic excerpts from patrol reports have been selected:

"One man received a severe laceration of the forearm which required seven stitches. Two men were injured by misfire of the 20MM gun. In one of these cases it was deemed necessary to amputate two toes of the right foot. Due to a shortage of surgical instruments, (Editor's Note: this was early in the war) a pair of sterilized side cutters were used to cut portions of the shattered bone. Because of the phalanges.....were completely shattered, they were not sutured but left open to allow free drainage. A generous amount of sulfanilamide powder was used. The other man was wounded in the shoulder but no lead or foreign body could be located. This man was back to duty in three days with no complications."

"The medical department in the person of the Chief Pharmacist's Mate did a particularly capable job in handling the Jap prisoner of war recovered after his plane was shot down. Though suffering from shock, second degree burns of the face and hands and several other serious wounds from gunshot and the crash, he was brought around very well and will probably arrive in port almost fully recovered."

"Two wounded men were in excellent hands under the care of the Chief Pharmacist's Mate. Their recovery from wicked flesh wounds caused by a Jap .50 caliber machine

gun bullet is a tribute to his skill and ability. Two men with multiple shrapnel wounds were admitted to the sick list for a total of 60 man-days."

"An injured German prisoner was treated for a dislocated left knee, broken right collar bone, badly lacerated mouth and nose and three missing teeth. Recovery to date is satisfactory except that he succeeded in mis-aligning his clavicle after it was lined up properly."

"The price of sinking one sampan, damaging one and learning the use they are put to (Editor's note: Submarine traps) was three men wounded. One man received two .25 caliber hits in the left side just beneath the floating ribs, the bullet ranging upward, fracturing the rib and puncturing the left lung, the other bullet lodged in the diaphragm above the stomach. A second man received five hits in the right shoulder over the scapula: the third was struck in the right hip by a piece of flying metal as the target exploded. In view of the nature of the wounds, left the area 24 hours early, setting course for Midway at best speed. The Chief Pharmacist's Mate..... is particularly commended for his quick and efficient action in caring for these three wounded shipmates. By his proficient skill and painstaking efforts he prevented complications of severe wounds and enabled return of his patients to the facilities of a hospital, well on the road to recovery. He has been recommended for promotion and the Bronze Star Medal."

"Two men were knocked unconscious by heavy seas while standing lookout watch and suffered minor contusions of the shoulder, chest, and kidney areas. Another man suffered lacerations of the scalp when he hit his head on the conning tower ladder while clearing the bridge in rough weather."

"One man suffered a compound fracture of his right ring finger and a simple fracture of his index finger when a store-room hatch cover fell on his finger. The boat was dived to a hundred feet to furnish a stable platform for sewing up the fingers and setting the bones. While the finger tips are still stiff one month after the accident, they have healed nicely and PhMlc _____ is to be commended for his efficiency and skill."

"The _____, on her second patrol, established an all time record for the recovery of friendly aviators when

in five rescues she picked up a total of 30 men. The first man was recovered on 25 May 1945 with severe lacerations and second degree burns. Five days later five more were recovered, all in good condition, 18 minutes after their plane had crashed. On 29 May, sixteen were rescued, two of whom were seriously injured, one with severe head and body injuries, the second with a possible fracture of the back and skull. One man of this group died about six and a half hours after recovery and was buried at sea on 30 May. On the afternoon of the same day 7 survivors from an Army bomber, clinging to a life raft buffeted in tremendous sea with waves at least 30 feet high, were brought aboard. One of these men had a bullet wound of the foot, a second a fractured clavicle."

The problems which confronted the CPhM during this 6 day period must have been at times overwhelming. On 1 June a medical officer from a destroyer boarded the submarine; on the same day the survivors were transferred at Iwo Jima.

Another Pharmacist's Mate had an entire surgical clinic on his hands with three women and three civilian men seriously wounded out of a group of 14 individuals rescued at sea. There were shrapnel wounds in all parts of their bodies requiring surgical treatment. In his own words, the Pharmacist's Mate so described one case:

"This woman had a piece of shrapnel at the bottom of her breast; there was a wound about three inches long and about two inches deep. First I stopped the bleeding. Then I cleansed it thoroughly with alcohol and put sulfanilamide powder in the wound. Then I put in 14 stitches and applied sterile dressings. She also had minor wounds which I cleansed with merthiolate."

When this boat finally put its passengers ashore fourteen days later, not a single case had become infected. What trained surgeon could have done any better?

Appendicitis Aboard Combat Submarines in World War II.

Probably no other single disease is cause for more anxiety to Submariners than is appendicitis. Since medical officers could not be carried on submarines, it became doubly important to formulate a policy governing the treatment of all cases of appendicitis, and to promulgate it as widely as possible. To accomplish this all officers at the Submarine

School, U. S. Naval Submarine Base, New London, Conn., both in the basic and prospective commanding officers' classes, and of course all Pharmacist's Mates in the Submarine Service and those in the "School for Pharmacist's Mates Entering the Submarine Service" were carefully indoctrinated along the following lines:

The diagnosis of appendicitis, without laboratory facilities and in relatively untrained hands is difficult and the errors in diagnosis might exceed the correct diagnosis. Gastric and gastro-intestinal disturbances and constipation are common in submarines and add difficulty to diagnosis. For these reasons conservative rather than surgical treatment should be instituted.

Moreover, even if the diagnosis is certain, with modern conservative treatment more cases will recover than will go on to rupture--the percentage again is against surgery.

They were also taught that even though their patient might turn out to belong to the small percent that would go on to rupture, the odds were still in the patient's favor--that he would wall off the infection and develop an abscess which could be drained at a later date.

Realizing all of this, and most importantly, taking into account the relative inexperience of most of the Pharmacist's Mates and the almost impossible conditions under which an operation would have to be undertaken, the final obvious order was-- "Never resort to surgery". This order was put into effect toward the end of the first year of the war.

The conservative medical treatment recommended was: NO food by mouth; the smallest sips of water by mouth (any evidence of dehydration treated by intravenous fluids); NEVER give a cathartic to a case of suspected appendicitis; a low gentle enema repeated, if necessary, until results are satisfactory (many of their cases of "acute appendicitis" were cured this way); absolute bed rest; sedation until resting quietly; icebag over right lower quadrant; sulfa drugs in adequate dosage and with proper safeguards; and, as it became available, penicillin.

The Incidence and Mortality Rates of Appendicitis in Civilian Personnel in a group of comparable size and age to the one with which we are dealing is unknown. However, according to the Public Health Service in some 8,758

families of all ages who were under observation in 18 states during 12 consecutive months, appendicitis developed at a rate of 6.6 per thousand in males and 12.3 in females. For males, the incidence per age group is presented in Table 5.

TABLE 5

INCIDENCE OF ACUTE APPENDICITIS IN MALES*

Age	Per Thousand
Under 5 years	1.8
From 5 to 9 years	5.0
From 10 to 14 years	8.3
From 15 to 19 years	9.8
From 20 to 24 years	10.1
From 25 to 34 years	12.1
From 35 to 44 years	7.0
From 45 to 54 years	2.7
From 55 and over	2.4

* From the Public Health Reports, Reprint No. 1981, Vol. 53, No. 36, Sept. 9, 1938.

These figures are of interest because they indicate that between the ages of 15-35 appendicitis is very common -- "the most common major surgical disease".

Incidence and Mortality Rates of Appendicitis in Personnel Aboard Combat Submarines. The average complement aboard submarines on war patrols was approximately 75 enlisted men and 8 officers. The average age of the officers was 26.7 years and of the men about 22 years. At the conclusion of the war, in a group of 318 submariners picked at random, the average man had made 6.17 war patrols. The average strength of the Submarine Force in 1943 was about 8,755 men, in 1944 it was about 13,345 men. At no time during the conflict did the entire Submarine Force exceed a strength of 25,433 men.

According to the statistical division of the U. S. Navy Bureau of

Medicine and Surgery, the diagnosis of acute appendicitis was made 78 times in 1943 (or 8.9 cases per thousand) and 124 times in 1944 (or 9.2 times per thousand), among personnel attached to submarines, but not necessarily on war patrols. Frequently men were transferred directly to the submarine tender where the diagnosis was made or they were picked up while in rest camp or on leave and thus the case was not counted in the actual submarine war patrol report. It is assumed that these diagnosis followed surgical treatment of the disease.

For information available in the submarine patrol report, it appears that Pharmacist's Mates made the diagnosis of Appendicitis (acute, chronic, or Diagnosis Undetermined, admitted for observation) on 116 war patrols in 127 instances during the entire war. On eight patrols more than one man was admitted with the diagnosis. In sixteen instances one case of appendicitis was reported from the same submarine on two successive patrols, presumably by the same Pharmacist's Mate.

The authors knew of instances in which, during a two week period spent at a rest camp between war patrols, the diagnosis of acute appendicitis in more than one individual from the same boat was verified surgically. And although there is no doubt that submarine crews were sometimes "appendicitis conscious" a few Pharmacist's Mates were plagued on successive patrols, by different individuals who undoubtedly had appendicitis.

In the majority of instances from information available in patrol reports, the diagnosis as made by the Pharmacist's Mates cannot be verified. There can be no doubt, however, that in thirty-four instances their patients were sufficiently ill to warrant eventual transfer for medical treatment, frequently at sea from one submarine to another for further transfer. In eleven instances acute appendicitis was the cause for submarines to either leave their areas of operation, their formation, or terminate their patrol. Twelve cases of appendicitis occurring on patrol, upon arrival at port, are known to have been followed by surgical treatment. Ten of these were either definitely stated to have had or likely to have had ruptured appendicitis. This series of cases accounted for a total of almost 578 sick or man days lost--while on patrol--an average of about 4.6 sick days per case. In a few instances following return to port, prolonged hospitalization was necessary.

To the best of the authors' knowledge and experience, throughout the War in the Submarine Force, in not one single instance has death been reported due to, or related to acute appendicitis arising on a submarine war patrol. "For the Navy the statistics vary little from year to year; the figures for the last five years available show the number of deaths from appendicitis of all types to be well under one percent of operations for the disease". (U. S. Naval Medical Bulletin, Vol. 35.1937, The Navy and Appendicitis, L. W. Johnson, Captain (MC) USN, H. R. Boone, Commander (MC) USN, pp. 44). Commanding officers and higher authorities were so impressed by the performance of Pharmacist's Mates in handling these truly acute emergencies that in twenty-two instances they were especially commended in official patrol reports.

Patrol report excerpts with reference to acute appendicitis show this problem and how it was handled on our submarines on war patrols.

"The most disconcerting thing that happened during the entire patrol (early in 1942) was a case of acute appendicitis that fortunately turned out to be something else. The patient had all the symptoms of acute appendicitis. The decision was made to operate. Preparations were being made when the patient was seized with a violent spell of vomiting and cramps. The pain subsided and the temperature increased to 104° F, with symptoms indicating the appendix had ruptured. Further observation indicated a gastro-intestinal disorder and at the end of four hours the temperature had decreased to 101°F, where it remained for eight days. At the end of two weeks the patient was able to be up and around".

"The third day out of 'Pearl' a signalman came down with an acute attack of appendicitis. The 'doctor' was ordered (Editor's note: by the Commanding Officer) not to operate, and was instructed to keep the patient quiet, start treatment and get him well (this order might be difficult to carry out- Editor's note) - It seems to me that there had been too much publicity lately about such cases and I thought we'd do our best to lick it and try and prevent an 'epidemic' of appendicitis. The patient was confined to his bunk and ice packs were given continuously for four days. The morning after the initial attack, sulfathiazole was administered every four hours for the next four days. The patient had no more sharp attacks but the area remained tender for the next two days, after which the tenderness subsided and he was allowed up and about. No recurrent

symptoms during the remainder of the patrol. The Pharmacist's Mate is to be commended for his devotion to duty and his efficient handling of this case." "The quick diagnosis and correct treatment of a case of acute appendicitis by _____ is deserving of particular attention and commendation. When the patient was turned over to the Medical Officer at Darwin, he was well along the road to recovery. This reflects credit not only on the individual but the Medical Service and to the medical course at New London, Conn."

".....had an attack of acute appendicitis, commenced ice packs and sulfadiazine treatment (May 1944). Temperature varied from 101.5 to 99.6 for next two days and pain became progressively worse. A Medical Officer from a destroyer came aboard to check patient's condition. Because of better facilities and probability of operation prior to arrival in Majuro, patient was transferred to the destroyer."

"Shortly after reaching the patrol area, one man was suspected of acute appendicitis. The treatment used was preventative with the aim of minimizing the possibility of the appendix rupturing, or in the event that it did rupture, this man was made a strict bed patient. Daily treatment consisted of ice bags to abdomen, frequent administration of morphine tartrate to relieve the pain and control intestinal peristalsis, sulfathiazole, and sodium bicarbonate 4 daily doses of each, and a 5% dextrose saline injection and no food by mouth. Sulfathiazole was discontinued after three days as it brought on vomiting. On the fifth day the ice bag was replaced with a hot water bottle. This continued for six days. The Chief Pharmacist's Mate is commended for his quick diagnosis and application of preventive measures. His professional ability is considered to be outstanding."

Appendectomies Performed Aboard Submarines on War Patrols.

Although sufficient publicity has been given those appendectomies performed by Pharmacist's Mates at sea aboard submarines, for the sake of completeness and because of their interest the authors verify these cases as follows:

The first was done aboard the USS SEA DRAGON on 11 September 1942, concerning which little technical information is available. Subsequent to the operation, which lasted about three hours, the patient was on the sick

list for fourteen days.

The second man, who had been ill for about forty-eight hours, was operated upon aboard the USS GRAYBACK, on 14 December 1942. At the operation, which lasted about 1-1/2 hours, the appendix was discovered to be ruptured; sulfanilamide powder was instilled locally, drainage was instituted (an elastic rubber band) and the abdomen was closed. Ether was used as an anesthetic, the first assistant was a Motor Machinist's Mate First Class. "Spoons were flattened and used for retractors, long nose pliers from the engine room were utilized. A submarine escape 'lung' mouthpiece was used for administering the ether",

The third and last case was performed aboard the USS SILVERSIDES on 22 December 1942. The patient had been ill for about twelve hours prior to the operation, which was performed on the wardroom table, with the submarine submerged at 100 feet. The effectiveness of the spinal anesthesia having worn off.

"Ether was administered, following the directions on the can. This anesthetized the operating staff as well as the patient. One hour after completion (the operation lasted about four hours) we tangled with a destroyer. The patient convalesced the following morning--- to the tune of torpedo firing, two depth charge attacks, two 'crash dives' and an aerial bombing which knocked him out of his bunk. The conduct of the patient... was exemplary throughout the operation and the period following."

Comments made by the Commanding Officer of one submarine concerning the operation performed aboard his ship are highly pertinent and in the light of the above circumstances, understandable:

"It is recommended that all men who have a previous history of, or indications of chronic appendicitis not be sent out on patrol until their appendix has been removed. This also applies to any other ailment which may require an emergency operation at some future date."

Higher authority observed in connection with the operation on the SEA DRAGON:

"The incident... is believed to be the first of its kind in submarine history. While this case had a happy ending, it is pointed out that this

particular Pharmacist's Mate had had considerable experience in assisting at surgical operations. . . it is hoped that his success will not encourage others to take . . . risks."

One point of great interest to doctors charged with planning for any future emergencies is to be emphasized. With the remarkable history of NO mortality in the 127 cases of appendicitis recorded in the Patrol Reports and with the low morbidity, these need not be cause for the undue alarm which was experienced at least early in the war. Medical Officers can, with confidence, continue to teach conservative measures for the treatment of acute appendicitis with the assurance that the best possible treatment is being given to the men of the Submarine Service under the circumstances.

In not a few instances submarine personnel returning from war patrols on which they had had an attack of acute appendicitis were completely recovered when seen by medical officers. The decision as to whether such man should be permitted to remain aboard submarines once having had an attack of appendicitis and without surgical treatment must be governed by local circumstances. In general, if conditions permit, an interval appendectomy is believed a wise decision.

SUMMARY

On submarine war patrols the most common medical conditions which the Pharmacist's Mates were called upon to treat were acute communicable diseases, injuries, disturbances of the digestive tract and diseases of the skin and urogenital system. The incidence of these conditions aboard a submarine when compared with surface craft (destroyers) appears to be about the same.

Relatively few submarine patrols were made without a varying incidence of acute upper respiratory infections commonly experienced in the first two weeks of operations. These could be traced to contact with shore based personnel, inclement weather conditions during training period immediately preceding the patrol, and rapidly encountered changes in climate. Such immunity thereafter afforded the crew did not necessarily protect them from strains of organisms introduced from the "outside" world.

The incidence of tuberculosis among submarine personnel is low (0.43%) and does not vary significantly from the general fleet (0.32%).

That the overall method of selecting, training, and handling submarine personnel was satisfactory, is evidenced by a very low rate of psychiatric breakdowns.

Venereal diseases, when sulfanomid drugs and penicillin becomes available, present no special problems aboard submarines. Despite the necessity of sharing bunks and markedly limited lavatory facilities, the hazards of contracting syphilis by casual contact are at a minimum aboard this type of craft.

Injuries, which are common aboard submarines, were frequently sustained by above deck personnel in foul weather and in clearing the bridge. Major wounds were sometimes sustained in surface engagements with the enemy. Pharmacist's Mates were frequently called upon to treat serious wounds sustained by prisoners of war and rescued aviation personnel. Of a total of approximately 542 American and Allied aviation personnel rescued by submarines throughout the war, only two died while under the care of submarine Pharmacist's Mates.

Submarine Pharmacist's Mates were carefully indoctrinated in the conservative medical treatment of acute appendicitis. They made this diagnosis in 127 instances aboard operating submarines. Ten cases likely had ruptured appendixes when seen by medical officers. As far as is known, in not one single instance was a death reported due to, or related to acute appendicitis arising on a submarine war patrol. This is a fact which should be of considerable interest to all submariners and physicians charged with planning for possible future emergencies.

Submarine Pharmacist's Mates may well be proud of their performance record throughout World War II. These men, carefully chosen, patiently and thoroughly trained, aptly and oftentimes brilliantly shouldered the immense responsibilities that were theirs. That they performed so excellently is a significant indication of what can be done in training lay personnel to handle medical problems.

MEDICAL ASPECTS OF SUBMARINE WARFARE
THE HUMAN FACTOR AS REFLECTED IN WAR PATROL REPORTS*

by

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Although World War II produced a tremendous volume of literature on the many phases of military medicine, little information is available in the unclassified literature concerning the medical problems of submarine warfare. It is the purpose of this paper to discuss some of these problems in the light of personal experience and material available in submarine combat patrol reports.

During the war American submarines made over 1500 patrols. The commanding officers' reports of 1471 patrols were available for study to evaluate the human factor in combat problems. The conditions under which the reports were composed and the significance of medical details compared with data relating more specifically to the mission of the submarines' accounts for some inadequacies of this source of information. Commanding officers were not trained medical observers and the emphasis which they place on the human factor in combat depended largely on personal aptitudes and interests.

These 1471 reports, upon which this paper is based, cover patrols made between December 7, 1941 and August 14, 1945. The great preponderance of them were made in the Pacific theater, from Australian to Japanese and Arctic waters. The majority of the patrols were carried out by the modern "fleet-type" submarines; a relatively small number of patrols were made by the smaller and obsolete "S-boats".

To understand the conditions under which submarine officers and men lived and fought, a description of conditions aboard the typical combat submarine is necessary. This was an existence characterized by very crowded living and sleeping conditions, limited water supply, and frequent high temperatures and humidity resulting from engine room heat and shutting down of ventilation during certain periods of enemy contact. Many missions were marked by days of fruitless patrolling and almost unbearable monotony and boredom, sometimes broken by contact with the enemy when

excitement and tension were at a very high pitch. Some patrols, though of short duration, were very active, with men remaining at battle stations for hours on end.

It is common knowledge that submarines are built very compactly and that living arrangements are dictated by and secondary to military requirements. Sleeping accommodations were so limited that with an average-sized crew of 75 it was always necessary for some of the men to share bunks by sleeping in shifts. Stowage space for personal gear was extremely limited. The only recreation possible was reading, card playing, and listening to records. Once the submarine was underway, no one was allowed topside except the authorized watch. An active patrol often necessitated dawn-to-dusk submergence, with the result that sometimes men did not see the sun for days at a time. While submerged, air within the ship was cooled and freshened by the air conditioning units and recirculated. Depletion of oxygen and excess carbon dioxide accumulation sometimes occurred during periods of prolonged submergence. Though the supply of fresh water taken on at the start of the patrol was augmented by distillation, the total amount was so small that showers frequently had to be limited to once a week. Condensate water from the air conditioning system was available for general cleaning, use in the washing machine, and sometimes for bathing.

Submarines had the deserved reputation of serving the best food in the Navy. The supply of fresh meat, vegetables, and frozen foods was normally exhausted before the patrol was concluded, resulting in a monotonous diet the last few weeks.

The men and officers serving aboard submarines were carefully selected on the basis of high physical and psychological requirements. Though a policy of frequent rotation to duty ashore was maintained, some men and officers accumulated an amazing number of war patrols to their record.

No doctors were assigned to duty on submarines in World War II, their place being taken by very carefully selected and trained Pharmacist's Mates, of whose performance records the Navy is justly proud. Medical facilities and supplies, although not elaborate, were generally adequate, and included sulfonamids, and later, penicillin.

Military Significance of Health of Personnel

Exclusive of men lost on 52 overdue submarines; only 62 deaths occurred on operations, the causes of which were as follows:

DEATHS OCCURRING ABOARD SUBMARINES ON WAR PATROLS

<u>Cause of Death</u>	<u>Number of Men</u>	<u>Patrols Reporting</u>
Asphyxiation	26	1
Drowned - lost over the side	17	13
Killed - battle injuries	12	10
Killed - accidental	3	3
Suicide	1	1
Malignancy	1	1
Pneumonia	1	1
Unknown	1	1
TOTAL	62	31

The success of a submarine's mission was sometimes compromised by defects in personnel health or by defects in the habitability of the ship. Serious or widespread illness was reason for either termination or interruption of approximately 4 percent of all patrols. The cause of termination of 29 patrols on the basis of illness has been analyzed as follows:

CONDITIONS OF HEALTH LIMITING DURATION OF SUBMARINE OPERATIONS

<u>Condition</u>	<u>No. of Patrols</u>
Excessive personnel fatigue	9
Illness of Commanding Officers	6
Acute Appendicitis	2
Battle Casualties	5
Multiple Asphyxiations	1
Serious Injury	1
Pneumonia	1
Mumps	1
Mental Disease	1
Copper Sulfate Poisoning	1
Diagnosis Unknown (Fever)	1
TOTAL	29

Personal fatigue of this magnitude occurred only in the first two years of the War, terminating patrols of eight fleet-type submarines. In five other instances personnel endurance was exhausted and would have terminated the cruise had not operation orders done so. There was nothing unusual about the illnesses of commanding officers. The remainder of these patrols were terminated consequent to unavoidable hazards and circumstances.

On approximately 2 percent of all operations, unfavorable submarine habitability became a major factor. On 23 patrols reduced efficiency of operations was caused by or related to impaired habitability. Eight patrols were terminated due to certain deficiencies of environment, the nature of which was as follows:

<u>No. of Submarines</u>	<u>Year</u>	<u>Factor Limiting Endurance</u>
1	1942	Lack of Air conditioning
4	1942-1944	Limitation of Potable Water Capacity
1	1942	Serious Battery Fire
1	1942	Serious Control Room Fire
1	1944	Excessive Copper-salt Content of Drinking Water

Ships manned by tired and ill men are not effective fighting units. Illness, when it deprived the submarine of the services of key men, had considerable military significance. The impersonal and abstract qualities of figures make it difficult to convey the immediate importance of this data. However, the actual or threatened impairment of military potentialities -- which sometimes occurred is quite apparent in the following selected excerpts from war patrol reports:

On the 4th patrol of the N... (1943): "Air conditioning installations proved inadequate. The highest temperature and humidity level recorded was 124°F and 98 percent during an invasion period lasting for about thirteen hours.

... Excessive heat and humidity reduced the efficiency of all hands to a marked degree after about two weeks of operation."

The P.... on her 5th patrol recounted an experience sometimes encountered on northern operations. "The first dive made..... lasted longer than expected with no carbon dioxide absorbent spread. At the end of 14 hours all hands had difficulty in breathing, carbon dioxide concentration at that time being 2.5 percent. 800 pounds of oxygen were bled into the boat, with slight relief. Upon surfacing two hours later the concentration in the conning tower was 3.5 percent."

The S.... on her 7th patrol on one occasion was forced to submerge, having sighted an enemy plane. While still going down a bomb or depth charge landed on her port side. "A terrific explosion jarred the boat. All hands not holding on to something were knocked from their feet.....Fire in the Maneuvering Room. All power lost.....Thick toxic smoke filled the Maneuvering and After-torpedo rooms. All hands aft were sick. We went up and down three times and had started down the fourth time before power was regained. In the Maneuvering Room the situation was bad. All hands were violently ill. The angles which the boat had taken had not helped."

On the second patrol of the P.... "During operations the commanding officer collapsed losing partial use of his legs, due apparently to a spinal or nervous system injury. This unfortunate illness necessitated return of the submarine to Saipan."

Mass illness cannot help but adversely affect performance aboard a submarine, as aboard the H... (no.5)"Loss of depth control on one attack was most unfortunate, in that it prevented firing at a carrier. The order to make ready the tubes had been given rather late. This was combined with personnel errors in hurriedly preparing all tubes.....at that time nearly all the crew were handicapped by sickness from food poisoning."

The commanding officer of the S..... observed with regard to illness of personnel: "Decrease in the number of men in a crew on a long patrol does not permit flexibility of the organization without loss of efficiency when through illness or accident a man is placed on the binnacle list."

Medical Problems Encountered

Infections of the Respiratory Tract

A high incidence of "colds" was commonly experienced within the first three weeks of the cruise, frequently before the submarine reached the operational area. These upper respiratory tract infections were sometimes associated with noticeable reduction of personnel efficiency. Patrols in northern operational areas, particularly in the winter, the cold and dampness of the interior of the ships, overcrowding, and inadequate protective clothing. Colds commonly accompanied the rapid passage from warm to cooler operational areas. The most practical form of prophylaxis was afforded by optimal atmospheric and living conditions while on patrol and carefully supervised recuperation at rest centers. The effectiveness of germicidal lamps aboard submarines warrants investigation.

Injuries

The bridge of a submarine offers little protection and men were frequently seriously hurt in heavy weather. Because of the danger of being swept over the side in heavy seas, members of the bridge watch and gun crews, and men working topside, should be required to wear life-jackets, whistles, and man-lights. The majority of injuries were unavoidable and were most commonly incurred while precipitously clearing the bridge and descending below through the narrow hatchway. Accidental shifting of skids of torpedo racks in rough seas resulted in two serious head injuries, one of which was fatal. Poorly illuminated hatches accounted for many injuries. In gun attacks approximately 61 men were injured, 12 fatally. Ammunition explosions seriously injured 8 men.

Diseases of the Gastro-Intestinal Tract

Appendicitis caused more anxiety than any other disease; the diagnosis was commonly made by Pharmacist's Mates. Although this illness interrupted or terminated operations in 11 instances, not a single death is known to have followed appendicitis originating on a war patrol.

Psychiatric Casualties

A collection was made of the cases which could have possibly been

neuropsychiatric or emotional in origin. Only those reactions interfering with performance of duty were apparently recorded, for but 56 cases were found. Statistically, this gives an amazingly low incidence of emotional disturbances. In spite of their great responsibilities, there is patrol report evidence of only 4 cases in which the crews lost confidence in their commanding officer or he lost faith in himself. It appears that the "breaking point" was indefinitely deferred and psychiatric casualties were largely eliminated under conditions which submarines encountered in World War II. The reasons for this are important and have been summarized elsewhere* under the following headings:

REASONS FOR LOW PSYCHIATRIC CASUALTY
RATE IN SUBMARINE PERSONNEL

1. Initial meticulous selection
2. Thorough and specialized training
3. High morale associated with success of combat submarines
4. Esprit de corps among submarine crewmen
5. Adequate rest and rehabilitation facilities and frequent rotation policies
6. Frequent pre- and post-patrol medical examinations

Air-Sea Rescue Operations

Submarines recovered 549 survivors in Air/Sea Rescue Operations. The part played by the Pharmacist's Mates in this undertaking was very important. Forty-eight percent (48%) of the aviators required medical care when recovered from the sea; although 18 percent were seriously injured, only two died aboard submarines. Submarines assigned to Air-Sea Rescue Operations should be especially prepared and equipped to permit increased bunking space and clothing allotments for survivors. Members of the rescue crew must be carefully picked and trained. Pharmacist's Mates should be specifically indoctrinated as to the type and treatment of expected casualties.

*Duff, I. F. and Shilling, C. W. - Psychiatric Casualties in Submarine Warfare, Am. J. Psychiatry March 1947, 607-613.

Factors Affecting Submarine Habitability

Those conditions most frequently mentioned as influencing habitability were: the adequacies and inadequacies of ventilation and air conditioning; the discomforts incident to long dives (as carbon dioxide accumulation, depletion of oxygen, increase of pressure and humidity); the influence of weather; overcrowding; deficiencies of the water supply and sanitary tanks; fires; certain noxious agents as chlorine gas, carbon tetrachloride, and material damage consequent to depth charging, accidental flooding, etc.

Space permits discussion of only the more important components of habitability aboard submarines. In patrol reports, reference was made to habitability as follows:

HABITABILITY REPORTS OF FLEET-TYPE SUBMARINES

	1941		1942		1943		1944		1945		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Excellent	0	0	8	8	24	16	41	14	33	16.5	106	14
Good	5	50	34	34	82	55	170	59	117	58.5	408	54
Fair	3	30	33	33	36	24	55	19	44	22.0	171	24
Poor	2	20	25	7	5	5	23	8	6	3.0	63	8
	<u>10</u>		<u>100</u>		<u>149</u>		<u>289</u>		<u>200</u>		<u>748</u>	

These figures indicate the improvement in habitability which took place as the War progressed. Thus, after 1942, the percentage of "excellent" reports was doubled; the percentage of "fair" reports was significantly lowered; the incidence of "poor" reports was cut to one-third in the last three years of the War. Reports of "good habitability" rose to remain at a level between 55-60 percent. It may be said, then, that about 70 percent of all patrols reporting on habitability were made under either good or excellent living conditions.

Relationship between reports of "poor habitability" and success of operations exists although it is not constant. Thirty-nine of the 63 patrols experiencing "poor" habitability were successful; the majority of those that were not were made in the early years of the War.

Ventilation and Air Conditioning in Relation to Atmospheric Conditions

Contrary to popular belief, atmospheric conditions within a submarine submerging for a relatively short time are normal. Inasmuch as the hatches are closed before diving, the pressure within the boat is theoretically unchanged; actually, there is a slight rise in pressure, due to compression of the hull, leaking air tanks, etc. When surfaced, a constant current of air is sucked through the main induction valve (located in the superstructure of the ship) to the diesel engines; the engines also exhaust the air from within the ship, setting up a current of fresh air through the open hatchways. When submerged, there being no means by which air may be obtained from the outside for combustion, the diesel engines are shut down. The air contained within the ship is forcibly recirculated after passing through two main and one auxiliary air conditioning unit.

Without adequate air cooling and ventilation, habitability on an active war patrol may become so poor that material defects and decreased personnel endurance may compromise the effectiveness of the ship. The relationship of excess heat and humidity in the conning tower to the efficiency of control parties during long approaches to an enemy target is very important.

To elude anti-submarine activity most submarines at one time or another "ran silent". In only one patrol report was habitability, under such circumstances, reported as "good". Poor atmospheric conditions, the product of excessive heat, humidity, pressure, oxygen depletion and carbon dioxide accumulation, were the rule. The manner in which the extremes of these conditions were tolerated by this group of carefully selected, trained and disciplined men was very important in determining whether the submarine would survive.

With so many sources of heat, the temperature and humidity jumped in "silent running" to high levels, particularly in the maneuvering room where it sometimes reached 125° F. All hands stripped down to shorts; socks and shoes were removed, despite which men perspired excessively until, in an hour or so, the decks might be slippery with sweat. Towels used to keep perspiration out of the eyes became wringing wet; shoes and socks could be wrung out like rags. Everyone drank a great deal more water and took salt and aspirin tablets. As time went by, the air became oppressive and stifling, and it was difficult to breathe; headaches were prevalent and severe. It was often impossible to sleep; heat rash sometimes caused serious

discomfort. The enervation from the heat became so marked that physical exertion, such as required to change and maintain depth control, would exhaust a planeman. Controllermen had to be spelled frequently. Efficiency and reaction times were reduced marked degrees, errors were prevalent, even among key men. There was a marked increase in accidents when the damage of depth charging necessitated long hours of repair work. Constant attention was necessary to see that instructions were carried out properly and promptly. Tempers were short, nerves on edge. The apathy which developed sometimes was startling. As the youngsters folded up the older and more phlegmatic men would take over. Some without permission, others after requesting relief, would quietly shove off and lie down on the coolest spots of decking. Sometimes situations ended with two men taking turns, the off-watch man resting on the deck beside his station. Generally there was no evidence of hysteria, the men carrying out their duties to the limit of physical and mental endurance. Oftentimes upon surfacing there was distressing nausea and vomiting. Under such conditions the boats were no longer in position to fight or defend themselves. Though the more marked of these effects passed off quickly with rest and fresh air, the men were oftentimes fatigued and extremely tense for days thereafter.

Ventilation and air conditioning were the subjects for critical comment in over 400 instances, better than half of which offered suggestions for improvement. Inadequate and unequal distribution of air between the forward and after compartments of the ship and inadequate cooling capacity of the air conditioning units were the most common complaints. Other frequent criticisms concerned material defects of the air conditioning apparatus, the hazards of outboard ventilation in heavy weather and ventilation when submerged. The majority of reports concerning auxiliary ventilation and cooling installations were favorable, although it was sometimes noted that they failed to compensate for the basic inadequacies described above.

Cold and Habitability

Poor living conditions often prevailed on cold water operations. "The torpedo rooms were very wet. Metal fittings throughout the ship sweated constantly. Heaters had to be used sparingly to conserve the batteries. With sea water at temperatures of 27° F., single hull portions of the ship were impossible to heat. There was ice constantly

in the torpedo room bilges and pipes containing water, such as shower drains, were frozen solid".

Excess Carbon Dioxide, Oxygen Depletion, Their Measurement, and Facilities for Air Purification

Limiting values of oxygen and carbon dioxide, after submerging, were theoretically not attained until the expiration of a period of hours calculated from a formula which although adjustable, was derived on the basis of peacetime complements and operating conditions. Adequate instruments to measure the amount of carbon dioxide and oxygen were not available. Need for air purification was commonly based on subjective evidence, as headache, dyspnea, and failure of the air to sustain a flame. When the need became obvious, varying amounts of carbon dioxide absorbent, which is caustic and irritative, were spread; the atmosphere was further improved by releasing oxygen or compressed air into the ship.

On several patrols excessive levels of carbon dioxide seriously and adversely affected personnel efficiency. For various reasons it is difficult to correlate reported increased levels of this agent with associated symptoms. With this in mind, after reviewing the 89 reports containing adequate data, the following comments are made:

The formula used for calculating the time-limiting values of carbon dioxide and oxygen was not always applicable to war time operations; the time at which symptoms of intolerance became evident did not necessarily always follow the calculated time. In 22 out of 26 reports the actual time of acceptability of the air ran from one to six hours less than the calculated figure. Half of the reports came from patrols made in northern areas of operations where, because of weather conditions and the long hours of daylight, prolonged submerged operations were common. Moreover, the ships were cold and damp, requiring more exertion upon the part of each man to keep warm. These factors, in addition to the ship routine and the increased complement, made it frequently necessary to revitalize the atmosphere. Air purification was also a matter of particular concern aboard submarines used as troop transports. On the 5th patrol of the N___ when 109 Army Scouts (in addition to the crew of 96) were transported in the Aleutian area, perilous levels of carbon dioxide were experienced. This was

particularly true when the Scouts were making ready to disembark. The day preparations were made to land the level rose to 4%. This defect of habitability, in conjunction with the overcrowding, the cold, and the heavy condensate, no doubt explains the statement: "Delay from day to day had a marked effect on most of the Army Scouts...".

Much fundamental and careful research has been carried out concerning the physical and mental effects of anoxia and carbon dioxide poisoning. Studies have been made to improve the available methods of air purification and detection of undesirable changes in the atmosphere. There has been need for positive application of this knowledge to improve submarine habitability. Today, with the advent of snorkelling, the need is even greater. The development of an instrument panel in the control room, which would record at all times the oxygen, carbon dioxide, carbon monoxide, hydrogen and hydrocarbon content of the submarine's atmosphere, together with the temperature and relative humidity, would be a real step forward. It would obviate the necessity of relying upon variable subjective symptomatology, inaccurate formulae and obsolete equipment for such fundamental data.

Toxic Gases

Toxic gases are commonly thought to be a hazard on submarines. It is true that carbon tetrachloride, when used as a cleaning agent, produced distressing and disabling physical effects, and for this reason its use was abolished. Although chlorine gas formation, especially after flooding of torpedo battery compartments, was not uncommon, only two serious encounters with it occurred. Formation of arsine and stibine gases in detectable and detrimental quantities was not experienced. Methods for eliminating hydrogen were apparently satisfactory. Thus, the problem of "toxic gases" is seen to have been more potential than actual in World War II aboard submarines. Of much greater significance were the relatively simple factors of extreme heat and humidity.

Fires

The relationship between fires and habitability was very important. The dense, thick black clouds of smoke quickly spread throughout the compartment. The acrid, phenolic fumes were not only irritative and blinding, but also extremely nauseating. With the intense heat, compart-

ments quickly became untenable. The toxic, blinding and demoralizing effect of a smoke-filled compartment emphasizes the necessity for thorough and frequent instruction in the operation of protective equipment, without which men may be quickly overcome. Adequate and effective fire fighting equipment is a necessity.

Potable Water Supply

In the early days of the war, limitation of fresh water was sometimes cause for great concern and was a factor limiting the duration of a few patrols. Fortunately, evaporating units of today are reliable in service and are capable of producing an entirely adequate supply of fresh water.

Condensate water from the air conditioning apparatus was sometimes used to augment the supply of fresh water. Dr. George Schiff made a war patrol aboard a submarine to study this problem and concluded that by filtration sufficient condensate could be chemically and bacteriologically purified to make 300 gallons available for daily general use. Condensate was utilized for bathing, in washing machines and for general cleaning. Various methods of collection and storage were in use. In view of the critical nature of weight and space aboard submarines there were no authorized provisions for storage beyond a 20 gallon tank installation for collection of condensate water to be used in washing machines.

Impairment of fresh water potability sometimes occurred. On a number of patrols contamination with copper sulfate took place at levels sufficient to impair efficiency of personnel and to terminate one patrol. It appears reasonably certain (from investigations carried out at the Naval Medical Research Institute), that copper and nickel were derived from the action of vapor and hot water on the metal tubes in the stills. Present arrangements call for replacement of these by tubes coated with tin. When this is done, water contamination by copper sulfate may be important only historically.

Submarine Ration

The inherent limitations and discomforts of life aboard submarines make special efforts to provide a good ration imperative. Food was excellent and well deserved the reputation which it came to have among

other less elaborately fed branches of the Service. Certain problems, however, existed. More active participation by squadron medical officers is needed to assure submarines of a satisfactory ration. The whole problem should be investigated with a view toward constructing an exact although flexible master ration plan. More thorough schooling of commissary officers, stewards, cooks, bakers and supply officers is indicated. The one single item of food most commonly the cause for complaint was the quality and percentage issue of boned beef. Submarines should be given a high priority, especially at advanced bases, to obtain frozen fruits and vegetables, whose importance was amply demonstrated. Certain luxury foods are important to provide variety and enliven what otherwise may be a monotonous diet. The significance and importance of ice cream in providing variety in the diet and as a morale builder is quite apparent from the patrol reports.

Sanitary Tank-head System

Waste products from the lavatories, galley, etc., were collected in sanitary tanks. Military security prevented emptying of the tanks except upon surfacing under cover of darkness. The tanks were then "blown" dry by compressed air. They could be flushed with sea water only with difficulty. Upon a long patrol, despite frequent emptying and the use of various disinfectants, the tanks became unpleasantly odorous and were the cause for many justified complaints. Correction of this - essentially mechanical defect should not be too difficult. One may conjecture, in this respect, to what extent the present problem might become magnified aboard submarines equipped for snorkelling and submerged for long periods of time.

Overcrowding

Bunking facilities aboard many submarines were designed for peacetime complements which were increased as the war progressed. With the addition of electronic apparatus and new types of torpedoes which required frequent routining, space became more and more critical. Adequate provision for bunking and personal needs could not be made. Overcrowding on the average patrol probably produced no lasting effect on personnel efficiency. On submarines used in Air-Sea Rescue Operations and as troop transports, serious overcrowding was experienced. In preparing for the future, the use of submarines for such purposes merits review in the light of lessons so recently learned.

Protective Clothing

To maintain a reasonably long and alert watch in the most severe weather, bridge personnel must remain comfortably warm and dry. Adequate protection of the face, hands and feet is fundamental. On cold water operations it was quite apparent that the available items of protective clothing were woefully inadequate. Production of improved garments with special needs of the Service in mind, should be investigated. Designs of clothing must be practical, tailoring neat, with a minimum of bulk, to facilitate rapid and easy clearance of the bridge and easy stowage. Quality of the material must incorporate a minimum of weight and bulk and a maximum of durability, practicability and safety. The fabric should have rapid drying qualities, Permeability to water vapor is desirable. Great merit exists in the recommendations for production of a satisfactory one-piece exposure suit.

Other Factors Influencing Personnel Endurance

Length of Operations

In 1941 and 1942 little was known concerning the length of war patrols men might be expected to tolerate. Accumulated experience tended to modify some of the earlier impressions.

At the time of leaving the area of concentrated activities an attempt was made by commanding officers to estimate the remaining days of personnel endurance. This figure was arrived at subjectively. Though it was reported as "0" days on 25 patrols, this did not necessarily mean that the crew was in a state of collapse, but rather that the men were no longer on their toes and that their fighting efficiency had dropped. Early evidence of fatigue was commonly observed about the 40th to 50th day on station.

A patrol carried out in good weather with plenty of targets, with good fire control, and without depth charges could last for longer than one on which any one of these features was missing. The monotony of a submerged patrol without contacts was very fatiguing unless some change of pace or diversion was introduced. Short aggressive patrols were said to take as much or more out of the men than did the longer patrols. If lulls in activity occurred, material reduction in efficiency could be fore-

stalled. If not, fatigue began to be apparent. Although aggressiveness and desire to close with the enemy might not have slackened, the fighting edge of the ship was definitely impaired, in that the reserve strength of the crew to meet possible emergencies was lacking. Failure to "shift to the second string" under such circumstances was sometimes cause for regret. On these occasions fatigue sometimes became dangerous, endurance approaching near physical and nervous exhaustion. The last week of the patrol was generally the hardest. Recuperation during the quiet return voyage was often noticeable and sometimes acted to create a false impression of the crew's endurance upon arrival at port. When fatigue was excessive, recuperation might not take place, especially if considerable action had been experienced in the last week on station.

Extensive surface operations, while inherently decreasing the amount of rest, increased the general well-being of the crew. On prolonged submerged operations a routine was necessary which would keep efficiency at the highest level. Continual rough seas with "colds", seasickness, need for securing egress of air from the outside and inability to sleep produced a very depressing effect. Under such circumstances, withdrawing from station for a short rest was authorized.

The question of how long men might make efficient consecutive patrols was subject of much interest. There is no all-inclusive answer. Some men made an astounding number of war patrols without apparent ill effect. The receipt of "new blood", through the enforced rotation policy, resulted in general improvement in spirit and workmanship which was conducive to an aggressive spirit and closely integrated crew.

Morale

A high state of interest and aggressive determination was essential to the success of operating submarines and was closely related to personnel endurance and morale. The greatest single factor contributing to a high state of morale was successful engagement with the enemy. Once a new ship had successfully completed a patrol, the battle was half won. All hands then felt their footing to be secure, for they had ceased to be a "detail" and were instead a fighting unit. There was nothing quite so shocking as a "zero run", especially to the crew of a

boat with a long record of success. On patrols characterized by lack of worthwhile contacts, disappointment, and lost opportunities, poor performance of the deck watch might be observed. As the war progressed and targets became less common, the "lethargy of long diving days, of rough, sleepless nights and limited exercise had to be mitigated by a clear portrayal of the part submariners were playing in the overall strategical and tactical plans." The highest qualities of leadership on the part of the officers and alert patience on the part of all hands were essential.

There were many "creature comforts" which were very important in maintaining morale. These included good food, mail, movies, books, magazines, phonograph and re-broadcast records, adequate quantities of fresh water, mascots, church services, favorable publicity, and the possibility of "new construction" with the attendant four to six months period of "state-side" duty. The great importance of adequate and comfortable facilities to permit rest and recuperation at the end of patrols contributed greatly, with the above, to the sustained pattern of success which characterized warfare in World War II.

Medical Care and Facilities Available to Submarines

The advantages of having specially trained medical observers aboard operating submarines for research purposes is obvious. The desirability of having a physician attached to one of a group of submarines on Air/Sea Rescue Operations is clear. Medical Officers especially experienced in submarine medicine are needed at advanced bases where they should be attached to submarine squadrons. They should familiarize themselves with the boats and develop a close liaison with commanding officers and pharmacist's mates. Certain medical conditions (unusual fatigue, chronic recurrent appendicitis, chronic seasickness, inability to equalize increased pressure, active venereal disease, tuberculosis, etc.) should be detected and corrected for they may not only be disqualifying but may interfere with personnel efficiency. Men showing evidence of emotional tension must be carefully evaluated before being permitted to return to submarines. Transfer at sea of injured and ill personnel was frequently necessary, and facilities to accomplish this rapidly and safely under the most adverse conditions must be available.

SUMMARY

The reports of 1471 submarine war patrols made during World War II have been studied to evaluate the human factor in submarine combat problems.

No health problems entirely peculiar to the Submarine Service exist. As in all other branches of the military forces, the most common causes for man-days lost aboard combat submarines were acute infections of the upper respiratory tract, injuries, and diseases of the gastro-intestinal system. That not a single death occurred from appendicitis originating on a war patrol is attributable to intelligent medical care by well-trained pharmacist's mates.

In the nearly four years of the war, only 62 deaths from all causes (including battle injuries) occurred aboard submarines on patrol, exclusive of those lost on overdue ships. While the health of submarine personnel was generally very good, it is significant that serious individual illness or mass sickness terminated or interrupted 29 out of 1471 patrols.

Despite the special hazards under which submarine crews lived and fought, which are popularly thought to contribute to psychiatric breakdown, the actual psychiatric casualty rate, as shown in these reports, are amazingly low. This record is essentially a reflection of careful selection of personnel.

The medical problems peculiar to submarines arise from unfavorable changes in habitability which may occur, chiefly in combat. The most important of these are excess heat and humidity, the accumulation of carbon dioxide, and the depletion of oxygen from the air under certain conditions. That only 31 patrols in World War II were interrupted or terminated because of these or other deficiencies of habitability speaks well for the progress which was made in the control of these problems. Until these deficiencies have been completely overcome, they will continue to be a limiting factor in submarine operations.

PSYCHIATRIC CASUALTIES IN SUBMARINE WARFARE

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Reports dealing with psychiatric casualties related to conflict are prevalent in the medical literature of World War II. Casualties were sufficiently common that the term "Combat Fatigue" or "Operational Fatigue" came to be generally used by lay as well as medical personnel (although these terms are not included in the official Navy diagnostic nomenclature). Both at the front aboard combat ships and in the various hospital facilities, new methods of treatment were tried out, the most successful of which was enforced rest by the use of deep sedation, following which men were returned to combat, or if not completely recovered were rotated to rest camps. Those not recovering were surveyed out of the Service.

In all of this welter of activity and resultant reports, no one has completely evaluated the psychiatric casualties occurring on submarine war patrols; and therefore, in this paper it is planned to undertake a complete review of this subject.

The official patrol reports submitted by commanding officers have been used as the source of information for all of the statements made and the illustrations in this article. In World War II approximately 1,520 war patrols were completed by U. S. Submarines. Of this number 1,042 were officially designated as having been "successful" and 478 as unsuccessful in the completion of their mission. From these patrols 1,489 reports have been available for study (21 reports being classified as SECRET or TOP SECRET were inaccessible; and it is definitely known that there were five patrols for which no reports are in existence). Admittedly, and for various reasons, the patrol reports were sometimes incomplete. However, as far as the data in which we are interested is concerned, there exists no other comparable or more complete source of information.

There can be no doubt that the trauma sometimes experienced by personnel in the Submarine Service was as great, if not greater, than that experienced by any other group in the war. With every depth charge attack the officers and men could not help but wonder when the next one would make a direct hit. They all knew that submarines were being lost

to enemy counter-attack. While being hunted, unable to fight back, the forced inactivity was in itself an additional emotional trauma, to say nothing of the terrific heat and high humidity which developed within the submarine during the time when it was necessary to turn off all air conditioning and ventilation systems in order to run as silently as possible. Other encountered hazards such as aerial bombs, the continual harrassment of enemy radar-equipped night planes, floating mines, shallow water patrolling, air-sea rescue operations, etc., could not help but impose severe emotional strain. If we add to these hazards the strain of reconnaissance operations, mine laying, and fruitless days of patrolling without enemy contacts, the very high caliber of leadership-demanded of the commanding officers and the stamina required by individual men becomes apparent. In spite of these demands upon the commanding officers, there is patrol report evidence of only three cases in which the men apparently lost confidence in the commanding officers, or the commanding officer lost confidence in himself, or his boat.

The following excerpts from patrol reports vividly demonstrate the type of emotional trauma which we have been mentioning:

"A terrific explosion jarred the boat. All hands not holding on to something were knocked from their feet. At 330 feet, 'Fire in the maneuvering room, all power lost'. Thick toxic smoke filled the maneuvering room and after-torpedo rooms. All hands aft were sick. We went up and down three times and had started down the fourth time before power was regained. In the maneuvering room the situation was bad. All hands were violently ill."

In silent running necessary after such conditions, excessive heat and humidity became very serious factors, as described in another patrol report:

"For the first two hours we were in a mighty tough spot. Extreme discomfort was suffered from the accumulated heat and humidity. All hands stripped down to shorts and the men took off their shoes and socks... the predicament of the ship was a fact fully recognized by the older and more experienced men. As the youngsters folded up, the others took over. The most startling effect was the apathy engendered by the combination of heat, pressure, physical effort and mental stress. Some without permission, others after requesting relief, would seek the

the closest clear space on the deck, lie down, and fall asleep. Most stations ended up with two men taking turns, relieving one another when necessary, the off-watch resting on the deck beside his station."

Another report vividly portrays the tense situation:

"Men quickly shed their shoes without orders on the first and last attack. While things were quiet overhead it was noticed that flashlights, wrenches and valves were moved with the greatest of caution and stealth, and the movement of all hands was done with forethought and deliberation. Conversation was unconsciously carried on in whispers when there was a lull in an attack and it looked as though we were getting clear."

In order to evaluate the psychiatric casualties, all available patrol reports were carefully read and all applicable remarks found therein were carefully tabulated in searching for psychiatric casualties occurring aboard combat submarines. The following are brief resumés which indicate in general the types of psychiatric casualties encountered on submarine war patrols. Each quotation represents an episode on an individual submarine patrol unless otherwise noted.

The general manifestations evidenced by the men under stress (psychic trauma, physical strain of repairing materiel casualties in excessive heat, humidity and pressure) are described as excessive physical weariness, lethargy, and sometimes heat exhaustion. General sequellae sometimes observed after such experiences were described as follows:

"it was noted that within a period of 24 hours following depth charge attack, several cases of mild gastric disturbance consisting of slight nauseating and cramp-like feeling developed; rapid recovery without treatment followed."

Aboard another submarine it was reported that: "It is interesting to note that approximately one-half of the crew complained of headaches, slight diarrhea and acidosis for three or four days following the depth charge attack."

Notation of a generalized impairment of appetite for a period of eighteen hours or so following severe depth charging attacks was made by another commanding officer.

Some individuals manifested gastric symptoms to the exclusion of others, as for instance: "One petty officer, making his first patrol, suffered attacks of acute nausea (vomiting blood) during the depth charge attack. These attacks continued for the next five days. He was extremely nervous for the remainder of the patrol and will be transferred upon arrival in port as temperamentally disqualified for submarine duty." And, "One man during depth charge attack became very nervous and nauseated.

And again: "Patient has been extremely nervous during this run. Has been complaining of almost constant headaches, dizziness, spots before his eyes, gripping pains in the stomach, all of which certainly are a product of the mind."

Upon occasion men experienced symptoms of strain before reaching the area of combat: "One enlisted man suffered from nervous strain prior to arrival on station. Settled down and performed well throughout remainder of patrol."

And again: "One Chief Petty Officer suffered from nervous strain prior to arrival on station. Recovered sufficiently well to perform all duties capably while on station. Will be transferred to the relief crew for proper rest period upon arrival in port."

More commonly, however, acute manifestations of strain were seen during or immediately after enemy counter-attacks, as: "One Chief Petty Officer definitely cracked under the strain of too much bombing and depth charging and deep diving. He was unable to eat or sleep for a period of four days. Codeine produced no effect and as a last resort morphine was used. He had a very bad influence on the rest of the crew throughout the patrol and could not be trusted to man his regularly assigned station without supervision."

And again: "Only one man on his first patrol showed obvious signs of being temperamentally unsuited for submarine duty when he became extremely nervous and overwrought during a heavy depth charge attack. The fact that this man had undergone a severe injury to his finger early in the patrol may have been a contributing factor."

Sometimes as observed, the acute symptoms subsided, allowing the individual to carry out his duties with no, or varying degrees of impairment. In other instances symptoms recurred (sometimes with successive enemy counter-attacks) or persisted throughout the patrol, making it necessary to remove the man from the Watch List.

"After the severe bombing attack.....two men suffered psychoneuroses and were extremely nervous the remainder of the run. Both men are being disqualified from submarines."

As illustration of the multiple precipitating factors which render a diagnosis difficult, this report further states:

"Three other men suffered heat exhaustion on the same night during the four hour dive without the ventilation system running."

Other excerpts illustrating the sometimes incapacitating effects of these experiences are as follows:

"A forty-five year old Chief Radioman with previous "S" boat experience (war patrol) suffered from nervous exhaustion following the bombing. He continued on duty, insisting he was all right as soon as we received a message telling us when to terminate the patrol. Three weeks after the bombing he collapsed on watch and later recovered sufficient strength to return to the watch list. The crew's nervous tension relaxed after 26 December 1944. We had attacked an air and surface escorted convoy and escaped without being detected by either planes or surface escorts. Confidence had returned, and two officers were unnerved to the point of being unreliable in their performance of duty, and were setting a very bad example for the crew. This was the eighth patrol for one officer and the first for the other. Only two enlisted men became obviously unreliable in their performance of duty."

"Two key men.....so nearly approached complete nervous and physical collapse that it was necessary to place them on the Sick List relieved of all duties. One of these was in charge of an operation that nearly wrecked No. 4 torpedo tube.....one of two serious casualties resulting from what, in normal times, could only be called sheer stupidity."

These acute symptoms were sometimes seen in men making their first patrol, on occasion before the submarine reached its area, others were manifested by men who had made successive war patrols as follows:

"One soundman second class, who was the battle station bow planesman, was unable to undergo the mental strain of depth charging or explosions of any nature. This was his second offensive patrol, the first having been made on this boat. This man appeared jittery at times on his first patrol, but went to pieces completely on the second. He was treated by the pharmacist's mate.....at all times when danger was not immediately apparent, his performance of duty was satisfactory. He was transferred to the relief crew of an advance base." Another example: "The man responsible for this error (serious materiel casualty) has made four patrols on this ship and is an experienced and reliable petty officer; he is, however, showing strong tendencies toward nervousness and will be left in this time for a rest." And, "an electrician's mate who had been given a rest period of eight months in the relief crew was taken aboard, but unfortunately this did not cure him of excessive nervousness when under enemy counter-attacks."

On occasion hysterical symptoms were reported in men under great strain. One of our older submarines, earlier in the war, on her first patrol sank a Japanese cruiser. Concerning the immediate and severe depth-charging which the ship immediately experienced, the commanding officer stated:

"This was a new experience for us all, and I consider the behavior of the officers and crew, with one exception, to have been excellent. This one man got hysterical and had to be held down by others." And again, "The health was good with the exception of an attack suffered by a torpedoman second class who has made eight previous patrols. This man went into a coma for the better part of two days during which time he could neither talk nor understand what was being said to him. He would sit upright in his bunk for hours with all muscles tensed and during these periods had difficulty breathing. When he finally came out of it, the only explanation he could give was that he had had a bad dream." And, "During the first depth charging, one man, who had had previous war patrol experience in Asiatic station "S" boats, broke down and later said that he had lost his nerve. On subsequent depth chargings this man proved unstable and broke down and cried on several occasions."

Two instances of partial facial paralysis were observed in these patrol reports, both of which were associated by the Commanding Officers with psychic strain. Concerning one of these episodes, it was stated:

"A surprise night bombing on the fifth night in the area was a distinct shock to the crew. Much enemy night air activity necessitates frequent night dives. The attendant nervous tensions coupled with prevalent rough seas interfered materially with the sound sleep of the crew. A 21-year old machinist's mate with no previous war patrol experience developed a partial paralysis of the left side of his face following the above bombing. He appeared otherwise normal."

There were five cases reported which were undoubtedly in the nature of frank psychoses. One of these occurred on an Aleutian patrol early in the war and was apparently the cause of considerable apprehension aboard the submarine, it being written:

"One man suspected of being mentally unbalanced was put under close observation and removed from the watch." "Our patient is definitely unbalanced and a menace to the safety of the ship. Confined to the Ward Room, guard posted." It was necessary to re-call this submarine from patrol nine days after she reached her area of operation to remove this patient."

Transfer of a second psychotic patient was made at sea from one submarine in enemy controlled waters to another in order that he might be returned for medical care. His management enroute to Base proved difficult, and restraint was necessary, -- "His obstreperous behavior demoralized every compartment in which he was confined."

A third case involving a pharmacist's mate was later hospitalized with a diagnosis of dementia praecox. The fourth case, a man who had made many previous war patrols, committed suicide aboard the boat enroute to the area of operations and was buried at sea.

The following information is available concerning the fifth psychotic episode reported aboard submarines on war patrols:

"During the close depth charge attack, one man, a chief commissary steward, a veteran of patrols on other submarines, showed extreme nervousness and mental depression. Later he was caught in the act of apparently committing suicide by the pharmacist's mate who took an open knife from his hand as he attempted to slash it across his throat. Three other men witnessed this scene. Early in the patrol he was given small amounts of sodium amytal and elixir of phenobarbital to quiet his nerves, and kept bothering the pharmacist's mate for more after the depth charging. He reported aboard the day before we left for patrol. Found in his jacket was a recent request for disqualification for submarine duty. His presence aboard is a definite hazard to our morale and he will be temperamentally disqualified and transferred upon arrival for mental observation."

No mention of homosexual behavior occurs in these patrol reports; however, the authors know of nine cases, of which only three either occurred aboard combat submarines or in men who had had submarine duty.

All of the cases which could possibly be diagnosed as neuropsychiatric or emotional casualties are presented in the following table according to standard Navy nomenclature.

Diseases of the Mind and Nervous System Classes XV and XVII

<u>Diagnosis*</u>	<u>No. of Patrols Reporting</u>	<u>No. of Cases Reported**</u>
Psychoneurosis, anxiety***	23	25
Psychoneurosis, hysteria	8	9
Psychoneurosis, unclassified	6	6
Psychosis, unclass.	5	5
Neuritis, unclass.	6	6
Paralysis, unclass.	2	2
Paralysis, facial nerve	2	2
Epilepsy	2	2
Migraine	2	2
Diagnosis Undetermined-		
-syncope	2	2
-vertigo	1	1
	<u>59</u>	<u>62</u>

* U.S. Navy Medical Department Nomenclature - 1945
** Classified as nearly as possible from sometimes inadequate case histories from patrol reports.
*** It has been pointed out that this diagnosis (psychoneurosis, anxiety) is too low, and that a trained and emotionally neutral observer during almost any depth charge attack would almost certainly detect true symptoms in many of the crew. However, perhaps some slight disturbance was considered to be a reasonable and normal reaction to the situation. At any rate it is apparent that only those reactions interfering with performance of duty were recorded. "The depth charge attacks had little effect on personnel. They came to be expected and accepted as routine and to all appearances were ignored. The experience of the heavy grapnel banging against the ship's hull at 340 feet caused some raised eyebrows, the commanding officer's being as high as any."

It is painfully apparent to the authors that the medical officers on the submarine tenders at the various Submarine Bases and rest camps missed a golden opportunity in not carefully studying and reporting these cases, when on return from the submarine patrol adequate historical material was readily available.

To evaluate the true significance of this total of 56 possible psychiatric casualties (neuritis not counted), it is necessary to have information concerning the number of men exposed to the emotional trauma so vividly described in the patrol reports and so indelibly recorded in the memory of all submariners.

There were, as noted earlier, 1520 war patrols (all areas) and there was an approximate average of 75 men aboard on each patrol, making a grand total of 114,000 man-patrols. In the same way there were 12,160 officer-patrols, and human nature being what it is, they were as likely to break as the men; and perhaps more so, because they more fully realized the dangers and responsibilities that were theirs.

This total of 126,160 man-patrols and 56 possible psychiatric casualties give the amazing percentage of .00044 casualty cases of a psychiatric nature occurring per man-patrol.

Another method of approach would be to take the average number of patrols per submariner, making at least 1 or more patrols. From the thousands of questionnaires returned after the war in connection with a survey which was conducted on submarine personnel, we picked a random sample of 318 returns. In this group 14 was the largest number of patrols made by one man, and the average number was 6.17 patrols per man. Thus, if we divide the man-patrols (126,160) by the average patrol per (6.17) we have 20,447 men making an average of 6.17 patrols. Again, 56 cases is an amazingly low figure.

"It is interesting to note that during the six war patrols made to date and in spite of the severe depth charging on each patrol involving a total of over 500 depth charges, only one man has cracked up. This was on the first patrol and the man was a veteran of several war patrols on another vessel."

Another approach would be to consider that the maximum number of men attached to submarines, relief crews, rest camps, and on staffs, at any one time was 19,000. Even if we made the erroneous assumption that these men were the only ones attached for the duration of the war, we would have an admission rate of only 2.94 per thousand.

Even though these figures may be somewhat incomplete, and therefore lead us to an underestimate; nevertheless, it must be obvious that the Submarine Service had a very enviable record so far as emotional or psychiatric breaks are concerned.

The reasons for this record are important, particularly in the light of planning for any future national emergency. The authors believe they may be completely summarized under the following general headings:

- (1) Selection of the candidates for the Submarine Service.
- (2) Training of Submarine personnel.
- (3) Morale, or Esprit de Corps of the Submarine Service.
- (4) Pre- and Post-Patrol physical examinations to determine fitness for continuance on patrols.
- (5) Generous use of Rest Camps and rotation to the States for leave and pick up "New Construction" submarines.
- (6) Confidence in the submarines, their officers, and their shipmates.

(1) Selection:

Foremost in a discussion of selection for the Submarine Service is the fact that every man is a VOLUNTEER. He may have been drafted into the Navy, but he goes into the submarine branch of his own free will. This not only is a selective process in itself, but also a motivating force for the man to continue in this activity.

Much has been written about the process of selection for the Submarine Service. Here we will be content with simply mentioning that all the men had to meet rigid standards both as to educational, psychometric, and psychiatric, as well as physical fitness standards. An attempt was made in this screening process to eliminate all those with obvious defects and in addition an attempt was made to eliminate those who had latent defects, as indicated by the psychological and psychiatric evaluations. That there were reported as occurring only one case of Dementia Praecox and two of Epilepsy on submarines during the War indicates that this screening was of an extremely high order. None of the other reasons--training, morale or rest could account for this.

(2) Training:

Training was conducted in an exceptionally proficient manner by the Submarine School, which is an established activity of long standing and known excellence. "Refresher" training and "New Construction" training courses were also conducted in order to keep both officers and men up to standard. A man who is sufficiently trained and drilled in his job has a maximum of confidence in himself and is most likely to withstand the trauma and rigors of warfare. He knows what to do and how and when to do it, and reacts automatically in times of emergency.

(3) Morale:

There is no question that from start to finish the submarine engenders in the men a special spirit which undoubtedly served to carry them over many a tough spot and caused them to realize fully that they were a part of an organization which has a high reputation to live up to. They were a group that lived together as one family and they realized that if one man failed, all would fail in their mission. For this reason there was less likelihood that they would allow themselves to give way to the pressure of the moment.

(4) Pre-and Post-Patrol Physical Examinations for Continuance on Patrol

Pre- and post-patrol physical examinations undoubtedly served to pick up men who were in need of a period of rest and rehabilitation prior to the time when they would actually have experienced an emotional break.

(5) Rest Camps and Rotation:

The generous use of rest camps, we believe, proved to be the greatest single factor in the excellent record achieved by the submarines. It was the general policy that no man made more than two consecutive patrols without a period in a rest camp. Again, an equally important factor was the rotation to the U.S. to pick up a new boat and of course the incidental leave was an effective form of rehabilitation.

(6) Confidence in Submarines, Officers, and Shipmates:

The construction of the submarine, the demonstrated ability to withstand enemy counter-attacks, and the demonstrated effectiveness of their weapons could not but engender confidence in all the men. In addition to this, they were well aware that both their officers and shipmates were not only very carefully selected but highly trained, thus assuring the maximum in efficiency and mutual protection.

(7) The lessons that one can learn for application to the planning of any future conflict have been amply covered in this series of reasons showing why the Submarine Service fared so well in contrast to other services insofar as psychiatric breaks are concerned. It is apparent that by selection, by training, by building morale, by frequent examinations, by generous use of rest camps, and by instilling confidence, the breaking point was indefinitely deferred and psychiatric casualties were largely eliminated under conditions which submarines encountered in World War II.

SUBMARINE ESCAPE ("LUNG") TRAINING PAYS OFF

BY

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One of the most colorful and interesting parts of the training of submarine personnel is found in connection with the use of the Submarine Escape Device, commonly called the "lung". This device was developed in 1929 by Lieutenant Charles B. Momsen, USN, (now Admiral), Chief Gunner Tibbals, and Mr. Hobson of the Bureau of Ships. After the experimental work on this device had been completed in the Deep Sea Diving School in Washington, the first training was conducted in the swimming pool of the Y.M.C.A. in New London, Conn.

The Escape Training Tank at the U.S. Naval Submarine Base, New London, Connecticut, was constructed at a cost of \$120,000 and completed on the 20th day of August 1930. The principal characteristics are an overall height of 138 feet, 6 inches, which provides a vertical column of water 100 feet high and 18 feet in diameter. It has a capacity of about 280,000 gallons of water. Integrated with the Tank are escape locks, or compartments which duplicate those installed in submarines. These locks are located at depths from the top of the Tank of 18 feet, 50 feet, and 100 feet. Thus permitting escapes to be made under conditions simulating those existing in similar depths at sea, and with identical pressure factors.

This Submarine Escape Training Tank was designed to permit the thorough training of all submarine personnel in the use of the "lung", or submarine escape appliance, under conditions that exist during an actual escape from a disabled submarine. All submarines are equipped with submarine escape apparatus, but the crew must be

properly trained in the use of the "lung", either at the Tank located at New London, or at Pearl Harbor, T. H.

With the advent of World War II, "lung" training took on new impetus, in order to keep pace with the large numbers of men being trained for the Submarine Service. The proportions of this increase in the number of men trained will be seen by reference to the accompanying table (TABLE I). In spite of this great expansion in training, many men who entered the Submarine Service at advanced bases did not receive "lung" training.

Although it was considered unlikely that the "lung" would be used for escape in wartime disasters, training in its use was continued throughout the war period for several reasons. It was considered to be an excellent morale factor for the men; and it was known to afford a sense of security and comfort for the families of the men. But more importantly, it was used by the Medical Research Department of the Submarine Base, New London, Connecticut, in their selection program, as a means of selection from the standpoint of emotional stability. Men who became excessively nervous, or actually went to pieces during the training were disqualified for submarine duty on the ground of emotional instability. If so simple a task as "lung" training was too much for them to take, what could one expect when the depth charges were rolling? And it was felt that no possible factor of safety should be omitted. There was always the off-chance that some men might be saved through their knowledge of the use of the "lung".

The British used "lung" in escaping from the THETIS in 1939. Also, during the war there was evidence of German escapes made with their "lung". In one recorded instance, twenty-one survivors are known to have escaped from a disabled German submarine at a depth of approximately 120 feet; "A few used lungs, but the majority came up without them".

As noted earlier, most of those responsible for the training of American submarine personnel in the use of the escape device felt that there probably would not be any opportunity to use the "lung" for actual escape under wartime conditions. In this assumption they were mistaken, however, for the "lung" was used by the men of one disabled submarine for a very dramatic escape, and the training given at New London enabled two of the men to make a successful "free escape" (without a "lung"). A

description of this incident follows.*

One of our U.S. submarines, while conducting a most successful attack against the enemy in the shallow waters off the coast of Formosa, in 1944, was struck by one of her own torpedoes, when that torpedo, -- the last one to be fired, made an erratic run. Maneuvers to dodge the torpedo failed, and "the ship was struck abreast of the after torpedo room with a violent explosion. The tops were blown off the only regular ballast tanks aft and the after three compartments flooded instantly. The ship sank by the stern, much as you would drop a pendulum suspended in a horizontal position, there being insufficient time to carry out the last order to close the hatch."

Of the nine men on the bridge at the time of the explosion, three men (The Commanding Officer, a Radar Technician, and a Chief Boatswain's Mate) were thrown clear of the ship and managed to stay afloat until picked up by the Japanese along with other survivors about eight hours later.

No details are known concerning seven of the nine men who were in the Conning Tower at the time of the explosion, and were lost. Information concerning two others follows in the account of an exciting "free escape" by one of them, as related by that officer after his return to New London. (We might add that he felt very strongly that the importance of "lung" training could not be overemphasized.)

Excerpts from Lieutenant S _____'s account follows:

"The boat seemed to bounce up and down. I didn't lose my footing. I heard the order to close the hatch and the Skipper wanted to know if we had any propulsion. I started forward to look at the pit-log which I remember seeing, - then the lights went out. The conning tower filled almost immediately with water. I was hanging on, leaning against the No. 2 periscope shaft, which was down. With the sudden downward angle of the boat, men and loose gear were bumping and falling by me with the rush of the water. I apparently rose up along the periscope shaft. My nose and mouth were out of water, - in an air bubble in the overhead of the conning tower, where the No. 2 periscope goes through and where

*The sources of this material are the official Patrol Report, and personal interviews and correspondence with four survivors.

there is an indenture between the cork and the hull. I remained there, in the quietness, with my nose and mouth cramped up against the cork to breathe. I thought that I had better figure out what else I should do - wanted to know where I was. For some reason, I thought the boat was upside down - I had a fear of going up the periscope well and being caught in the pump room. I ducked out and began to feel around, treading water all the time, then I seemed to rise and come up into a real big bubble with my whole head and face out of the water. I felt around and found the engine order telegraph and knew that I was in the forward end of the conning tower. The air must have been trapped between the hatch and the forward bulkhead. I thought that I'd better get out - felt around and located the ladder and the trunk circling the top of the ladder at the hatch. I figured that I might be able to hit into another air bubble, so I went through the hatch which opens up underneath the cowling on the bridge and found another pocket of air trapped there. In popping out of the water I must have made a noise for there was a voice asking: "Who is it?" I answered with my name, and asked: "Who are you?" It was the soundman who had been opposite the TDC in the conning tower. He said: "Do you know where we are?", and I said: "I think we are under the bridge". Then he asked: "What are you going to do?", and I told him that I thought we'd better get out of there and try to get to the surface. He said: "Can I go with you?" I answered: "Sure". He asked: "How?" I told him to hold on and ducked down under the cowling with him holding my legs - but as soon as I pushed down he let loose. I didn't see him again.

I began to swim up, using both hands as hard as I could - the whole idea was to get up - I wanted air and lots of it. I had no sensation of being under pressure, but I thought of my lung training lecture about letting the air out and knew that as I came up I would have to force the air out - so I heaved it out - all at once - and then just as I thought I'd have to swallow some salt water, I burst out on the surface and began swimming. I could see the bow of the boat sticking out of the water ahead to about the windlass which is just forward of the hatch, (the hatch to the forward torpedo room thus being under water.)

Lieutenant S _____ is of the opinion that the angle of the boat at this time was such that his free escape from the bridge to the surface was a distance of approximately fifty feet.

Events as they befell those men still alive and occupying the unflooded portions of the ship appear to have been as follows: "In the explosion-- which was very violent, whipping the boat, breaking high pressure airlines, lifting deck plates, etc., numerous personnel as far forward as the control room sustained broken limbs and other injuries. The immediate results to the ship were to flood the three after compartments. Even the forward engine room was half flooded before the after door could be secured. When the survivors from here and the after battery reached the mess room, they found water already above the eye-port in the door of the control room. Testing the bulkhead flapper, and finding that the water had not yet reached this high, they opened the door, letting the water rush past them as they proceeded through to the control room and the forward torpedo room. Personnel in the control room had succeeded in closing the conning tower hatch which had been sprung in the explosion and was leaking badly. During this time, all secret and confidential publications were destroyed--first by burning in the control room and then in the forward battery compartment as the control room was flooded."

One survivor, in describing what occurred in the forward torpedo room, stated: "We fired the last two fish on the surface and approximately 45 seconds later the submarine shook with a hit aft. We knew we'd been hit severely, but didn't know where, or with what damage. We lost forward motion in a few seconds. The bow remained buoyant as the stern dropped to the bottom leaving the submarine at a very steep angle. All loose gear fell to the forward battery bulkhead and the men held on to anything they could reach. Almost immediately after the stern struck bottom, I heard air rushing through the main ballast tank blowers and knew the men in the control room were trying to blow us to the surface, but we didn't budge. We closed the water-tight door between the forward room and the forward battery so we could secure our compartment. There were about ten men in the room at this time. One Chief Torpedoman in charge of the forward room made his way up into the escape trunk, opening the lower hatch."

"Since it was quite possible the conning tower might be flooded and we were sure the after-torpedo room was, that left only the forward torpedo room for escape purposes. Therefore, we couldn't escape without waiting for everyone left alive to get to the forward room. Fifteen minutes later a group of about fifteen men had made their way into the forward room. When we opened the door there was such a difference in air pressure between the compartments that it literally blew the men into

the forward room, and when it had equalized there was quite an increase in pressure. These men had come from the control room. It had been apparent to them that the ship must be levelled off before the mechanical lungs could be used. Hydraulic power no longer existing, they had finally succeeded in turning the vents by hand. The ship slowly sank and rested on the bottom at 30 fathoms."

"We found out from these men that the boat was flooded up to the forward engine room. There were about 45 men in the torpedo room now, and the angle of the boat had lessened quite a bit. We were secured in the forward room and knew the boat would never run again, but were confident we could escape.

"Lungs were passed to everyone and strapped on. Instructions on how to use them were reviewed. Over half of the men didn't seem to remember how to use one. Life jackets were distributed and those who didn't get them were instructed to use their lungs as such when they reached the surface. At this time Jap patrol boats evidently picked us up again and dropped about ten depth charges which shook us severely, but did no real damage. Everything came to a dead stand-still until they had left and there was no danger of them picking up our sounds.

"One officer decided that there might be a chance to blow the boat to the surface, thereby making it much easier and quicker for everyone to escape. He was going to lead a party of six men back to the control room to see what they could do. When they started to open the watertight door to the forward battery, a terrific blast of black smoke came into the forward room from a fire in the forward battery. Although the door had only been cracked for a second, the smoke completely filled the compartment and the lights became only dim gloom. Almost immediately some of the men began to gag. They were instructed to take a few breaths through their "lung" when the irritation became too severe.

"The men lay on the bunks discussing ways and means of survival. They knew or had a good idea of the depth of the water and that they were only about ten miles from the Formosa coast.

It was decided that an officer and three men should attempt the first escape. "They went up into the escape trunk and we handed them a rubber lifeboat that they were going to try to get to the surface. They

TABLE I

QUALIFICATIONS

SUBMARINE ESCAPE TANK

Fiscal Year	18-foot	50-foot	100-foot	TOTALS
1 July				
1930-31	556	405	338	1, 299
1931-32	770	189	179	1, 138
1932-33	490	244	216	950
1933-34	562	252	141	955
1934-35	264	104	104	472*
1935-36	434	84	84	622
1936-37	637	41	41	719
1937-38	1, 813	121	121	1, 555
1938-39	1, 321	62	62	1, 445
1939-40	1, 375	189	149	1, 713
1940-41	3, 695	123	13	3, 831
1941-42	4, 621	2, 231	1, 405	8, 257
1942-43	8, 014	6, 463	1, 882	16, 359
1943-44	13, 569	12, 590	811	26, 970
1944-45	8, 895	6, 710	786	16, 391
TOTALS	46, 536	29, 806	6, 332	82, 676

*It is interesting to note that more men were trained during the three days, January 3, 4, and 5, 1944 (527) than for the entire fiscal year of 1934-35 (472). In the month of January 1944, more men were trained than in any single year from 1930 through 1941, 18-ft. 1, 352; 50-ft. 1, 308; 100-ft. 122; total 2, 782.

were to rig the trunk, escape, and the last man out was to signal by tapping when he had left, then I would pull down on a lever in the overhead which would close the door and then drain the trunk for another party, (with rupture of the air lines they were lacking the required pressure to blow the trunk down.) After waiting about 40 minutes with no signal whatever, I closed the lever anyway and drained the trunk. We knew there were men in it before it was drained, but decided to find out from them what had gone wrong. The officer had escaped, but the other men were still in the trunk. A difference of opinion among them as to how the trunk operated had caused the delay, and after it was finally rigged they had difficulty getting the life buoy attached to the line on the reel. The officer hadn't waited for them to rig the buoy, but dove out the hatch. It was right after that that I had closed the door from below, locking it, and making it impossible for the others to escape.

"One of the three men came down into the forward room stating he didn't care to attempt it again. They decided not to attempt to take the life boat to the surface because it was too bulky and heavy. Another officer and three men went into the trunk. Then it was decided to try five men, so a second officer entered the compartment. The same arrangements were made for rigging and draining. After another 40 minutes, we began to worry about them having been unable to signal, and I listened close to the hatch. I could distinctly hear moaning, but nothing else. After draining the trunk, it was found that the three men had escaped; one officer was in a stupor as we took him down and the other officer had been pinned to the trunk bulkhead by the line attached to the buoy. He was cut loose, lowered to the deck, and wrapped in blankets... The first officer said he would not attempt another escape, but that there was no reason why every other man in the compartment shouldn't escape. Japanese ships patrolling the area began dropping charges within a one-mile radius, so we stopped operations till they secured."

Our narrator led the next escape. The group this time consisted of himself and three other men. He says: "We had cut the buoy line to get the officer down and not knowing that it had also been secured outside the trunk, we took a life-ring with us to use as a buoy. This ring had been taken off a Jap ship on a past patrol. I had no difficulty flooding the trunk to equalize the pressure, but when I tried to open the door it was stuck, but finally swung open. When I attempted to charge my lung from the manifold, I found there wasn't any oxygen."

"This worried the other men, even though I explained they could blow up the lungs with their own breath and that it would serve the purpose. I felt very exhausted--like I couldn't get any air into my lungs, and began to get dizzy, so I knew I had better get out while I could. It took me about 15 minutes to rig the trunk, including preparing the life-ring as a buoy. I would have let the ring go to the surface and then gone up the line, but I was so near passing out I went up with it. The other men in the trunk could have escaped if they had only stepped out the hatch. They didn't want to try the escape without oxygen, although I explained how they could. Two of the men went back down to the compartment. A torpedoman remained in the trunk after it was drained and had the men below turn on the remaining oxygen valve. Thus, I was the only one of my group to leave the ship on this try. However, the torpedoman led the next escape.

"I took the life-ring that had been attached to the line and stepped out the hatch, and started rapidly to the surface holding on to the ring. I had no difficulty breathing through the lung other than for the pressure. After about twenty feet, the line began jerking badly. The torpedoman still in the trunk attempted to slow me down, but in doing so I lost my lung; so I blew air out all the way to the surface trying to equalize the expanding air, the way the lung would have done. Upon reaching the surface I was very exhausted and sick and vomited for about a half hour.

"After floating around a few minutes, I heard a machinist's mate who had escaped previously, calling me. He was hanging on to the life-buoy about 50 yards away. He cut the line and we tied the buoy and ring together. He had been unable to reach the only other man he had seen in the water, before the tide carried him from sight. We could easily see the coast of Lormosci, also the masts of two ships we had sunk, and the bow of our last target was only about a mile from us. The tide was never constant, or we could have attempted swimming to the nearest ship. We were unable to do anything else but hang on to the buoy and wait for someone else to come to the surface.

"In about 45 minutes, an officer (the one who had been caught in the line) and two other men reached the surface, at about three minute intervals. They were all very exhausted.

"We could see two destroyers slowly sweeping the water between us and the coast, and realized they were either trying to find us or pick

up survivors of their own ships sunk the night before. One of them finally spotted us after 2 hours and came by within a hundred yards dropping a buoy, then sweeping around in a circle. At this time another man came to the surface and I swam over and pulled him to us, as he was evidently unable to keep his head out of the water. He seemed in a stupor and kept gasping, as if he couldn't breathe, and couldn't understand anything, and soon died."

It appears likely, from available information, that thirteen men left the submarine via the escape trunk. Five of these, as described above, reached the surface and were able to cling to the buoy until picked up. These men are known to have been physically exhausted from their ordeal in the submarine (smoke, pressure, heat, and accumulated carbon dioxide). Two of them are known to have been nauseated and to have vomited for half an hour or so while clinging to the buoy.

Three others reached the surface but were unable to hang on or breathe, floated off and were drowned. One of these apparently had an air embolism. The other five were not seen after leaving the trunk. It is not inconceivable that perhaps they lost their mouthpieces, held their breath and died of air embolism or drowning.

It appears likely that approximately forty-five men were alive in the forward torpedo room of the submarine at the time plans were made for escaping. Two of these men are known to have been seriously injured and were conceivably unable to escape.

Concerning the twenty-eight or so men remaining, who perished in the torpedo room, the Commanding Officer has stated: "At the time the last party escaped, the fire in the forward battery had reached such intensity that the paint on the bulkhead of the forward torpedo room was scorching and running down. Considerable pressure had built up in the forward battery, making it difficult to secure the after torpedo door sufficiently tight to prevent the acrid smoke from seeping by the gasket. It is felt that this gasket blew out, either due to pressure or an ensuing battery explosion, and that the remaining persons were asphyxiated. Our narrator stated: "Even if conditions hadn't gotten any worse than when I was last there, I would say the men left below were all dead or unconscious from pressure, lack of oxygen, or the smoke, within an hour after the last two men escaped."

The practical lessons concerning submarine escape that may be learned from the experiences related above appear to be as follows:

1. The submarine escape "lung" and the standard escape gear appears to have well accounted for itself under practical trial in war time. All of the lungs had been checked, aired out, counted and restowed prior to departure of the submarine from Pearl Harbor. There were enough for every man in the crew and 10% more.

2. Provision must be made for vocal communication between the escape trunks and adjacent compartments, --as by sound-powered telephones. Under strain and in confusion, signals by hammer are not effective. Moreover, as in this case, they may well have led to increased enemy anti-submarine activity. One of the major difficulties encountered was the lack of proper means of communication between those in the escape trunk and those below in the torpedo room. They didn't know what was going on or what trouble they were having.

3. A re-design of the oxygen supply for the escape trunk is apparently needed, for on this submarine and on other representative submarines examined subsequently, the oxygen flask for charging the "lung" was in the adjacent compartment with the charging manifold in the escape trunk. The valve governing the flow of oxygen was thus in the compartment and could not of course be operated from the trunk once locked inside.

4. In similar manner, the emergency lights were controlled from below, instead of being turned on from within the trunk.

5. It should be pointed out clearly to all submarine personnel that in the absence of oxygen compressed air can be safely used, and in the absence of compressed air, the "lung" can be safely filled with the individuals' own breath.

6. It should be pointed out more forcefully that in the absence of a "lung", or in the event of its loss, "free escape" from considerable depths is not only feasible but was done with success by two men on this submarine, and has been done by several Germans from equal or even greater depths, during this war. The authors believe that at least all officers should be required to demonstrate their ability to make a "free escape" from the 100-foot lock in the Escape Training Tank,

7. It is urged that the 100-foot escape be made mandatory, for as noted in this episode, confidence engendered by this escape will be of great value.

8. All personnel should be given additional instruction in the operation of all of the current submarine escape trunks and compartments. It is felt that perhaps this type of intensive training in the procedure of submarine escape, the use of the "lung", the operation of the escape trunk, upon the part of submarine officers, would have resulted in this case in a more positive and adequate leadership under the conditions of stress as were encountered. Differences of opinion among the first men attempting escape wasted valuable minutes. The men weren't sure of escape procedure and were afraid they would make a mistake that would be fatal to those below. Escape procedure is very simple on paper, but somewhat different where every man's life depends on it.

9. There is apparently still room for some improvement in the mouthpiece of the "lung" so that it will not be so easily lost, and in the harness, in order that it may be held more firmly to the body.

10. Ample evidence exists of the extreme toxic qualities of smoke from fires aboard submarines. This is particularly true of fires in the main batteries. It is recommended that all personnel be more thoroughly indoctrinated in the dangers and mitigation of the effects of this smoke.

11. In this connection, more thorough dissemination of the facts concerning the effect of increased atmospheric pressure, oxygen lack, carbon dioxide increase, and the effects of other toxic gases than smoke, is definitely indicated.

12. Wide dissemination of the events as they occurred aboard this submarine is recommended as being of value to the entire Submarine Service.

This brief review of the lessons to be learned from this tragic episode is not intended to detract in the least from the remarkable display of courage, judgment, and resourcefulness in the face of almost insurmountable odds.

Not only is there ample evidence of how well "lung" training paid off in general, but there are numerous specific references in the statements of the submariners showing how individual memories of details of the "lung" training lecture and training escapes saved their lives. The authors will, I am sure, be forgiven for taking pride in such statements as the following:

"We were secured in the forward room and knew that the boat would never run again, but we were confident we could escape. Lungs were passed to everyone and strapped on. Instructions on how to use them were given."

"Life jackets were distributed and those who didn't get them were instructed to use their lungs as such when they reached the surface."

"A terrific blast of black smoke came through the door and completely filled the forward room. Almost immediately some of the men began to gag. They were instructed to take a few breaths through their "lung" when the irritation became too severe." "We were able to breathe through them without their being inflated."

"When I attempted to charge my lung from the manifold, I found there wasn't any oxygen. This worried the other men, even though I explained they could blow the lungs up with their own air and that it would serve the same purpose."

"I felt at ease using the lung and knew it would work after I tested it under the water before leaving the trunk. I had made the 100-foot escape before."

"After about twenty feet, the line began jerking----I lost my lung. So I blew air out all the way to the surface, trying to equalize the expanding air, the way the lung would have done."

"Suddenly I realized that I must be way down under the water, under pressure, though I never felt it. Remembering that when I was in the Diving Tank at the Sub School, they cautioned us about holding our breath when we were escaping from under water because our lungs would burst as the external pressure decreased and that we must come up slowly....I reasoned....that I would relax my lips completely and that as I came up the air would force itself out."

The officers and men of the Submarine Service should take justifiable pride in this escape which was one of the outstanding highlights of the entire submarine campaign, which, as all know, is replete with examples of unparalleled heroism.

ANALYSIS OF SUBMARINE FOOD PROBLEMS IN WORLD WAR II

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Ordinarily physicians are not greatly concerned with the details of food supplies. In the Navy the Supply Department has cognizance of commissary matters. The Naval Medical Officer, however, "...in carrying out his responsibility related to food", is specifically charged with the duty of "inspecting, as to quality, all fresh provisions issued an authorized mess". A study of patrol reports leads to the conclusion that this duty too often was not assumed by medical officers associated with the Submarine Force, and that, specifically, submarine squadron medical officers should actively concern themselves not only with the quality of food issued to submarines, but with the planning of menus to provide a dietetically acceptable ration.

It will be known that an adequate and palatable diet is necessary for the smooth functioning of any military organization. Recognition of the many inherent limitations and discomforts of life aboard submarines makes it imperative to exert a special effort to provide a good ration. This is necessary for health, personnel, endurance, and morale. In general, the food served aboard submarines in World War II was excellent and well deserved the reputation which it came to have among other less elaborately fed branches of the Armed Services.

The Submarine Ration

The ration provided a submarine needs to fulfill certain requirements. It must have been selected to occupy a minimum of space and evidence excellent keeping qualities under sometimes adverse conditions of stowage. From it a daily well-balanced menu incorporating a maximum of food value and variety and a minimum of waste should be easily prepared.

Submarines have always had a more generous ration allowance than other ships or stations with a similar complement. At the outbreak of the war the allowance was 85¢ per man per day. As the war progressed and costs increased, the ration allowance was increased until at the end of the war submarines were allowed \$1.00 per man per day when based in the Continental United States, and \$1.05 in foreign ports.

In addition to more money, submarine commissary officers and stewards have complete freedom in the type and quantity of foods they may draw within the limitations of availability. They may draw fresh or fresh frozen fruits and vegetables as desired. They never have to use "unit loads". The only

exception to this freedom is in the case of beef. In most places submarines were officially required, throughout the war, to draw the standard proportions of steaks and roasts (2), stewing beef (1), and ground beef (1).

Planning of menus and of the quantity and distribution of stores to be carried was the prerogative of the submarine commissary officer and commissary steward either working alone or in conjunction with the tender or base commissary officer. No overall master menu was developed during the war. However, several of the bases and tenders worked out sample menus for two or three months which could be used as a guide if the submarine wished.

Patrol Information

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In order to evaluate accurately the food problems as they existed aboard submarines during World War II, the authors have thoroughly studied all of the available submarine patrol report comments concerning food and water. Of the 1520 patrols made, reports of 1489 were available for study. The known excellence of the food aboard submarines was undoubtedly the reason that many commanding officers made no mention of it. However, 286 paused in their busy routine to make favorable comments concerning either the food, its preparation, or the cooks and bakers. The adverse or constructive criticisms made by a few of the commanding officers will be more thoroughly studied in the following sections of this paper.

Stowage Space

The amount of space aboard a submarine which may be allotted for food stowage has military significance. For like the fuel, oil, and ammunition capacity, it is definitely one of the factors limiting the length of a submarine patrol. In World War II this was particularly true for the smaller and older "S" class submarines. The amount of food which they could carry to provide a well-balanced menu did not, in general, extend over a 30-35 day period. Although these boats made patrols lasting longer than 30 days, the majority

* (One section of the official report made at the conclusion of each submarine war patrol dealt specifically with the health of the crew and encountered conditions of habitability (food, water, ventilation, etc.)

of them so doing turned in comments such as follows:

"Very little reserve is left in this class of ship after 35 days on patrol. Provisions for all practical purposes are exhausted. The base of the icebox loomed very large during the last week. No one went hungry, but there was a decided reduction in the quantity and variety of food."

Fleet type submarines commonly departed on patrol with food supplied calculated to provide for 70 to 90 days. In the early days of the conflict, especially in the active war zone, it was sometimes difficult to obtain food and supplies. Shortage of provisions occurred on a few occasions giving rise to comments such as these:

"Inexperience in planning and procurement for such a long patrol made the diet unsatisfactory. Difficulty in obtaining food at Soerabajo prevented getting a full larder. Food had to be rationed."

Or again

"Food supply was low, the decision to remain on station was based on a 5 day supply of food. The patrol could not have continued for a longer period without a serious reduction in efficiency and health--due to an unbalanced ration."

Occasionally, as the war progressed, deficiencies in the quantity and variety of food were reflected in a monotonous diet. This was due to different factors--unusually long patrols or unexpected extension of operations, inexperience in loading, poor quality of available food before departure, refrigeration failure, and sometimes accidental flooding of supplies while on patrol. At the end of an 80 day patrol, one of the longest made by any submarine during the war, it was reported:

"It was very fortunate that we had taken on a 90 day supply of food (83 men aboard)-- by the 77th day choice and variety had disappeared and all food came out of cans. Planning menus was difficult. Five days of provisions were left at the end of the patrol."

Another such long patrol was unexpectedly extended; at the time the ship left her area "food stocks had been reduced to the level that cabbage and asparagus were served for breakfast." On a third patrol, of 60 days' duration, largely due to the inexperience of the commissary officer and the poor quality of food available, "Supplies were entirely expended except for the two cans of catsup." A fourth submarine after completing an arduous 61-day patrol

stated that on about the 30th day, due to the necessity of securing refrigeration during a severe and prolonged depth charging attack, "All fresh meat, vegetables, and fruit had to be surveyed. The diet from then on consisted of canned food. In view of the possibility of refrigeration failure, it is necessary to carry a good reserve of canned food."

Stowage space aboard fleet-type submarines varies with the make of the boat. Some of the newer ships are provided with double storerooms, others have a single compartment for dry storage with additional locker space in the torpedo rooms. All boats have an icebox and a chill room. Anyone who has ever been aboard a submarine at the time supplies are being loaded has marveled at the ingenuity evidenced by the crew in making stowage space available. Literally, every inch of space was used. Ice boxes were crammed, potatoes were stored in hatches, under the deck grating of the cool room; showers were piled high with crates of vegetables and fruit, cases of food were stacked in the pump and engine rooms, in passageways, and pushed under benches. When this space was reduced, individual cans were tucked between the hull and the torpedoes, under bunks, behind manifolds and in individual personal lockers. It is estimated that an enterprising commissary officer can carry sufficient food, with a complement of 90, to last for 100-150 days, depending on the type of the boat. These figures would assume particular importance in any plan for transporting large numbers of personnel, as troops, by submarine.

Commissary Personnel

Considerable difficulty was sometimes experienced, and especially at advanced bases, in the satisfactory procurement of food.

In part, as indicated in a number of these reports, poor or unsatisfactory food, while on patrol, was due in some instances to lack of experience of members of the submarine's commissary department.

Typical comments were:

"Food was lacking in variety--a deficiency which probably may be traced to the inexperience of commissary department personnel."

"Inexperience in planning and procurement for such a long patrol made the diet unsatisfactory."

"Quality of the food was good but ran out of several items due to carelessness in loading."

"Provisioning for the next patrol will be undertaken with the assistance of more experienced base or tender personnel."

As the veteran commanding officer of one submarine wrote:

"Fresh frozen foods and "Avoset" ran out too early on the patrol because of the decision to load the refrigerator with an excessive amount of meat at the expense of other foods. As a result, we arrived in Saipan with a certain amount of meat but low in certain canned foods. There should no longer be any necessity to load to the hilt with the old staples, missing out on taking aboard the more desirable items of food that are available. At any rate, the Commissary Officer and steward should be furnished a sample list of provisions listing the items--with alternatives and quantity--that are recommended to be carried by submarines on war patrols. There has never been anything published to guide the commissary officer to the best of my knowledge, although unlimited information must be available. The only system has been the ordering of food carried on previous patrols, which often goes amiss when certain items are not available. It is felt that this haphazard ordering of provisions could be eliminated by preparation of a standard provision list for submarines that would be mandatory on their part to follow. This list could be prepared with alternatives to give it sufficient flexibility to satisfy any boat."

Meat

The one article of the submarine ration most frequently the subject for comment was meat, its quality and quantity. Early in the war, for reasons of space economy, boneless beef was made available to submarines. It comes as steak and roasting, stewing and boiling, and chopped beef. Current regulations of the Bureau of Supplies and Accounts for all ships require that 30% of the meat be drawn in inferior quality. In practice, at times, submarines starting on patrol were issued beef in the following proportions: roasts and steaks 50%, hamburger 25%, stewing and boiling meat 25%. This regulation resulted in considerable criticism, particularly with reference to Australian beef, which is inferior in quality to beef from other sources. Various observations may be of interest:

"Steaks and roasting beef, though a bit tough, are satisfactory; stewing and boiling beef is 60% waste, and, like hamburger, is tough, stringy, and unpalatable."

"All of the boned beef taken on this patrol was tough and could have been put to better use in a shoe factory."

"When meat loaf is too tough to eat, that is a new low."

"This is a satisfactory proportion, but since stewing and boiling meats are not considered worth the icebox space, it is generally left at the base and other frozen items, such as shrimp, frozen foods, and sausage are taken in quantity to fill the space."

"It is understood that commonly submarines draw their inferior meat (and pay for it) and immediately survey it."

"One commanding officer recommended that ground beef be removed from the mandatory items for submarines."

"There is only one icebox in which must be stored various kinds of food and which must be entered daily on two or three month patrols. Ground meat absorbs odors quickly and becomes unpalatable after a few weeks at sea. Arrangements should be made so that submarines going on war patrols can increase the percentage of roasts and steaks but reduce the percentage of ground meat. It becomes the practice of tenders to store meat turned in by submarines returning from patrol and re-issue these same meats when submarines draw stores for succeeding patrols."

It is felt, in all fairness that this latter practice was certainly not common. It must be emphasized again that more unfavorable comments were made concerning the quality and proportion of issued beef (and not always Australian) than any other single item on the submarine ration. In view of this, the authors are of the opinion that Bureau of Supplies and Accounts regulations should be reviewed with the possibility of making a satisfactory adjustment in the currently allowed percentage of meat issue provided operating submarines. At any rate,

"At no time should meat of inferior quality be issued submarines for use on war patrols. Various cuts of good meat are recommended."

"Limited storage space makes it necessary that every piece of meat be usable in some manner."

Ice Cream appears to have been the most popular so-called luxury item served on the boats. A few quotations will serve to reinforce this statement:

"Once again, (10th patrol of this ship) and despite the cold and bitter weather, ice cream was the most popular dish."

".....and frequent ice cream was enthusiastically received."

"The ice cream machine being very popular with the crew."

"The ice cream freezer paid for itself many times over, it being estimated that one ton of ice cream was consumed during the patrol, cold weather notwithstanding."

"The ice cream maker turned out a fine product...this device should be placed on all boats."

"The ice cream maker continues to be worthy of its weight in gold."

"On long, hot dives, ice cream is really appreciated and easy to take."

"Generally found that near the end of the patrol, ice cream was the food that did not suffer with repetition."

Staple Items of Food

Like meat, potatoes are basic in the diet of the average American. It is exceedingly interesting, in view of this fact, that few unfavorable remarks appear in these reports concerning this vegetable. Most submarines were able to carry a large enough supply of fresh potatoes to last for a variable period well into the patrol. Early in the war a "spud" locker was made out of the trunk of the crew's mess hatch for extra stowage space aboard many boats, augmenting, by about 50%, the supply which could be carried. Widespread alterations to the hatches eventually eliminated this stowage space. (To supply potatoes every day for 90 men on a 60-day submarine patrol, approximately 2800 pounds are required.) By ingenious stowage (beneath the deck grating in the coat room in one of the crew's showers, under mess tables, benches, etc.) it is said that a total of 3,000 pounds can be loaded aboard. Canned, water-packed potatoes were frequently available. Some submarines regarded them superior to regular fresh potatoes; certainly they were more convenient to use. Dehydrated potatoes and onions were recommended on long cruises to save space. One pound of dehydrated potatoes and onions were recommended on long cruises to save space. One pound of dehydrated potatoes makes ten pounds of mashed potatoes. Two submarines observed:

"Rice is an excellent substitute for potatoes and was served frequently."

"In the last two weeks when potatoes ran out, rice, spaghetti, macaroni, and increased consumption of bread and cake filled our need for starch."

About 2600 pounds of flour are required for a 70-day patrol. This, which comes in ten pound cans, was commonly stored in the engine rooms. Some boats had special storage racks in the torpedo rooms for flour and coffee. Bagged flour is unfit for patrol use, due to the lack of proper stowage facilities; and the ever present danger of oil contamination.

Remarkably enough, considering the universality of coffee drinking in the Navy, coffee was only the subject of two unfavorable comments in all of these reports.

"Food was excellent and well prepared, with the exception of coffee. Any resemblance between the stuff we have and real coffee is purely coincidental. It was either burned in roasting and is very stale, or both."

"The food was generally very good, well prepared, and plentiful. The only exception being the coffee, which was pretty bad, causing many to give thanks for Nescafe."

Canned and evaporated milk was used aboard these ships. One boat reported:

"Klim" makes very good cocoa and chocolate milk, and is satisfactory on cereal, but is not recommended for use as whole milk for drinking."

Another commanding officer suggested that powdered milk be provided in small containers to prevent spoilage. Souring of condensed milk, especially an Australian brand, was not uncommon. "Avoset", stabilized cream, was very popular aboard submarines and was used in coffee and on cereal and fruit. Many cooks used it to fortify canned and powdered milk, serving it as a beverage. It must be kept at an even temperature and sours quickly when opened and left at room temperatures.

Fresh eggs were a boon and much appreciated:

"Eggs for breakfast was one of the most popular items served."

"It was a distinct pleasure to have fresh eggs at the start and end of the patrol instead of the usual Spam and dried egg omelet."

If available in quantity, enough eggs could be carried to last throughout the patrol. Freshness of eggs was hard to guarantee, especially at advanced bases. Powdered eggs were used with some success in cooking, but generally they were not greeted with enthusiasm in taking the place of the "strictly fresh egg."

Difficulty was not uncommonly experienced in keeping butter sweet and palatable.

"Eight cases of eggs and 100 pounds of rancid butter were surveyed-- brought from the States."

"Butter went bad after the first week."

"After two weeks at sea found that all the eggs were rotten and the butter rancid."

One submarine experiencing rancid butter, "despite excellent refrigeration", recommended a separate butter locker be installed in the cool room.

Another commanding officer reported: "Butter as usual became unpalatable. A special sealed wrapper should be provided to prevent the absorption of all the odors in the refrigerator space."

This, it seems to the authors, is an important suggestion.

Some boats used and recommended canned butter; another boat recommended that all contracts for a special brand of canned butter be cancelled. "No boats should be stocked with it." "Tinned butter should be chilled to avoid running."

In some reports excess spoilage of certain staple articles of food was reported--particularly due to the presence of weavils, as in the rice, wheat flour, cereal, macaroni, noodles and cocoa. Some commanding officers reported that certain brands of canned foods (particularly Australian) were unsatisfactory--as canned carrots, bologna, salmon, and orange juice. In five reports it was stated that the yeast taken aboard was entirely unsatisfactory.

Supply of Vegetables and Fruit Carried by Submarines

During the war the quantity of fresh vegetables and fruit that could be carried aboard submarines was limited, not only by the amount of available space but by the available supply at refitting bases.

Mention has been made of the importance of potatoes in the submarine diet. Other fresh vegetables and fruit, as onions, tomatoes, lettuce, carrots, cabbage, apples, oranges, etc., were especially appreciated for the variety and interest they lent to meals which otherwise became very monotonous.

One commanding officer observed: "Fresh provisions of an excellent and superior quality should be made available for the crews of submarines on patrol-- the importance of this is hard to over-estimate. We had tomatoes for two weeks, onions and cabbage for four weeks, lettuce for three weeks, and potatoes for five weeks."

"Loading the icebox with fresh lettuce and tomatoes paid dividends for the first two weeks of the patrol."

"About the 50th day fruit and fresh vegetables became the usual topic of conversation."

"Fresh provisions taken on at Tulagi were a great help. The lack of frozen foods was offset by an abundance of fresh fruit."

"A quantity of locally produced (Soerabaja, Java) concentrated lime and lemon juice was carried and proved a delicious and refreshing drink. Since this product was fresh, it is considered to have supplied, in part, the vitamin deficiencies of our ration due to our inability to stock sufficient fresh food for the entire patrol."

The advent of quick-frozen fruits and vegetables was a boon to the submarine cook and crew. They are convenient, simple to prepare, cook with a minimum of waste, and can be easily stowed. Unfortunately, however, they require refrigeration, the amount of which space aboard a submarine is definitely limited. Comments regarding this type of commodity were, on the whole, very enthusiastic:

"Quick-frozen foods are excellent."

"The value of such items as frozen strawberries, corn, beans, peaches, and vegetables cannot be too strongly stressed."

"Even a small quantity enlivens an otherwise drab bill of fare."

"Are worth their weight in gold toward the end of the patrol."

"It is unfortunate that the space available restricts the amount of fresh frozen foods that can be taken aboard."

"By the institution of rationing, quick frozen strawberries, peaches and peas were served throughout the patrol."

Unfortunately, and especially at advanced bases, it was not always possible to supply operating submarines with fresh vegetables and frozen foods in adequate quantities.

"The absence of frozen foods was heavily felt and was a great disappointment in view of all the correspondence during the past year regarding the desirability, benefit, etc., of supplying submarines on long patrols with them."

"A small selection and quantity of frozen foods were available; supply officers should keep the stock of these items high at all times."

"Highly recommend that the high priority assigned this type of food be rigidly enforced--that shore stations and tenders do without to such an extent that operating submarines may benefit."

Special Submarine Foods

Several different articles of food, often called "special submarine foods", were especially appreciated because, like fresh and frozen vegetables and fruit, they served wonderfully to relieve the monotony of the regular diet. Moreover, they provided "a maximum of food value in a minimum of space with great keeping qualities and little waste."

Inasmuch as many submarines served only a lunch as the noon meal during submerged operating, canned luncheon meats were highly desirable--as canned ham, meat spreads, Spam, Vienna sausages, canned boned chicken and turkey, roast beef, potted deviled meats, lamb and beef stew, meat loaf, sardines, shrimp, crab and lobsters.

"Our irreplaceable community stock of canned tuna, shrimp, and crab disappeared during the last refit and was missed by all hands, particularly for the noon meal on all-day dives."

Canned bacon was found very convenient. Tinned soup, mushrooms, peanut butter, pickles, jelly, preserves, mustard, etc., went far in stimulating appetites which, sometimes on long patrols, became dispirited.

Fruit juices of all kinds were much appreciated, and, as indicated above, were very important in supplying the vitamin requirements of the ration. An ample supply of fruit juices is believed responsible for the marked decline in the number of bleeding gums among the crew.

Canned orange juice in a few instances was reported as being bitter and unpalatable. Many submarines carried blends of orange, tomato, and grapefruit juices; lemon, lime and orange concentrates were available, as were powdered lemons. Other preparations included apple, currant, prune, and sauerkraut juice, etc. One commanding officer pointed out the tendency of submarine personnel to consume liquids--one patrol it might be coffee, another might find the same crew consuming large quantities of tea. On some boats "Coca Cola" was very popular. "Coca Cola" made with water and put in the cold room to 'ice up' was a delicious drink at any and all hours of the day.

Two other suggestions concerning the stocking of submarines with these various food items have been made:

"It is not considered advisable to stock fresh frozen vegetables or fruits, as tinned vegetables and fruits are always available, more economical, easier to store, taste as well, save cold storage space for essential items, and have all the nutritional advantages of frozen items.

"Most yards and bases have standard items in small pack, such as No. 2 or 2-1/2 tins, suitable for use on small submarines. By using this small pack greater variety of vegetables and fruits can be stored and some waste avoided. Spices, sauces, catsup, etc. are available in small cans or bottles. A wider variety can be carried to season food so that it is more appetizing."

Dehydrated and Concentrated Foods

Dehydrated foods--potatoes, onions, cabbage, carrots, eggs and soup stock--were available to operating submarines, being recommended to save space on long cruises. As pointed out, one pound of dehydrated potatoes makes ten pounds of mashed potatoes. Dehydrated potatoes are palatable when mashed or french-fried. They do not approach the fresh variety. Powdered eggs were used in cooking and baking with success. When prepared, as scrambled or in omelets, they were not greeted with enthusiasm.

Only four patrol reports out of the 1458 reviewed showed any enthusiasm for dehydrated foods.

Vitamin Capsules

During the war multiple vitamin capsules were supplied to the submarines. A capsule per day supplied one half the minimum daily requirements. About

85 patrol reports mentioned having used these capsules, particularly for the lookouts. In general, it was felt that the varied submarine ration contained all of the required vitamins. However, in order to be certain there were no deficiencies, the use of the multiple vitamin capsules was recommended. That the vitamin intake was ample was evidenced by the fact that only in two patrols in the earliest months of the war, and then only under the most unusual circumstances, was there any evidence of avitaminosis.

Refrigeration Odors and Taste in Foods

As pointed out above, submarines are equipped with a chill room and an icebox. These, unfortunately, must be entered many times in a patrol. Food, especially meat and butter, crowded into this refrigerating space, absorbs various odors and becomes "strong".

"Towards the end of the patrol food begins to acquire an 'icebox' taste."

"Fresh meat, although kept at 20°F again acquired a most unpalatable taste early in the patrol, in spite of every effort to locate and remedy the cause. This condition has existed on every patrol. Ventilation was increased, a charcoal filter was installed, and the icebox was inspected by a medical officer--".

Another submarine reported: "The objectionable icebox odor was eliminated by careful observance of cleanliness, stowage and ventilation of the refrigeration spaces. In two refits the spaces have been scrubbed with soap and water, wiped down with alcohol and aired out with portable blowers for two days. Meat and provisions have been stowed in such a manner as to allow the circulation of air. An electric fan was installed to provide circulation of air and temperature was maintained at a low level by limiting the frequency of opening the door to an absolute minimum."

A few boats obtained deodorizing equipment. One commanding officer reported most enthusiastically concerning the use of "Ozonelite" procured from an Australian firm:

"The usual odor of an objectionable nature observed when the cool room door was opened disappeared. There was no discoloration of the meat."

In these patrol reports sometimes considerable meat, and in some instances fresh frozen vegetables were surveyed while at sea. In part, this was undoubtedly due to the poor quality of food issued the submarine prior to her departure on patrol. It should be pointed out in this connection that potatoes which have been frozen, meat which has been thawed and re-frozen, or which has

been removed from a submarine upon the completion of a patrol should never be reissued to submarines. It is true that iceboxes were commonly loaded beyond their capacity.

"The present arrangement of the icebox is not satisfactory. Either a re-arrangement of the coils, shelves and ventilation or a compromise of each is required to utilize the present refrigeration space. The excessive amount of meat spoilage (1000 pounds) shows the necessity of an improvement inasmuch as the icebox was never out of commission."

"Feel that the increase in personnel over the designed complement necessitates carrying more food so that proper circulation is not obtained near the bottom of the icebox."

Again, "Inasmuch as all running equipment, including refrigeration machinery, was commonly secured during 'silent running' in evasive tactics, impressive amounts of meat, etc., spoiled due to temporary rise in the temperatures of the refrigeration spaces."

Cooks and Bakers

Unless care is taken in its preparation, the finest of food may prove unsatisfactory.

"We had one inexperienced cook. Constant effort and the use of the Navy Cook Book was required on the part of the commissary officer to keep the food palatable."

The commanding officer of another submarine pointed out "a cook with enthusiasm for his job and inspiration can do much to improve the food situation."

Another stated: "Three unimaginative cooks and the Navy Cook Book are a bad combination for even the hardest working commissary officer."

"Only the best cooks obtainable should be assigned to the exacting cooking duties aboard a submarine and between patrols it is believed that a brief course of instruction in diet and preparation of healthy menus should be given to all submarine cooks by a qualified medical officer."

"The practice that some ships followed while in the Bay Area of permitting the ship's cooks to take part time work in the galley of the St. Francis Hotel was followed by this command and has paid ample dividends. This is the first good commissary department that we have had in five patrols."

By and large, however, it is believed that most cooks and bakers aboard submarines performed their duties with satisfaction, if not aplomb, for they were commended by their commanding officers in 47 of these reports in glowing terms:

"The cooks and bakers made meals a pleasure."

"The unsung heroes of these patrols are the cooks--their's is a difficult task and one that is always well done."

"The abundance of fresh bread, cakes, rolls and cookies provided by a conscientious cook went a long way in making this a fine ship."

An effort should be made to provide all submarines with a good baker."

".....who are responsible for the particularly high morale around chow time."

Meal Time

When there is a break in the normal conditioned routine some men react unfavorably. A submarine on patrol certainly enforces many violent changes. Some patrol comments relative to this were:

"Night was turned into day for meals."

"Two meals were served, one in the morning and one in the evening, with soup and sandwiches at noon and midnight."

"During the period of all-day dives, breakfast was either cold or cooked prior to submerging, lunches were cold, and a hot meal was cooked and served after surfacing at night."

"Meals were served at the regular times with hot soup and crackers available at midnight. This midnight snack became more and more popular as the patrol progressed."

The majority of the boats maintained normal meal hours.

That the problem of meal time was not considered important is evidenced by the fact that only 12 comments were made in patrol reports. Yet we know that every officer and man who served aboard submarines was affected. It is

interesting to conjecture how much bearing this break in the long established meal time routine had on such problems as gastric distress, peptic ulcers, constipation, and even general fatigue.

Food Poisoning

One of the ever present worries of every conscientious cook or baker is the occurrence of group food poisoning. Such episodes may be not only incapacitating but definitely dangerous. Careful analysis of the patrol reports reveal notations concerning food poisoning only 34 times. Many of these reports mention the occurrence only in general terms, as: "Sixty-five percent of the crew were mildly affected on one occasion by food poisoning."

Some of the reports listed the offending agents: canned orange juice, canned sardines, custard pie, beef, surveyed "Avoset", spoiled frozen chicken, tinned hash and tinned salmon. That mess food poisoning aboard an operating submarine may not only be incapacitating but cripple the striking force of the ship as illustrated by the following excerpt:

"Food poisoning occurred on 7-9 July--believed due to frozen chicken (which was spoiled) served for dinner on 7 July. Two-thirds of the crew and all of the officers were involved with diarrhea and vomiting. Two men were still vomiting after five days and were not fully recovered ten days after they had been stricken."

The submarine sighted a carrier on 10 July, concerning which it was observed:

"Loss of depth control on the one attack made was most unfortunate, in that it prevented firing at a carrier. The order to make ready the tubes was given rather late; this was combined with personnel errors in hurriedly preparing all tubes. At this time nearly all of the crew was handicapped by sickness from the food poisoning."

The incapacitating nature and serious military significance of this illness may be recognized when it is further explained that mass illness, in part, may have been responsible for the submarine's inability to carry through a successful attack against a Japanese carrier.

For the benefit of medical officers studying the etiological agents causing a general poisoning on a submarine, it is well to bear in mind two possibilities in addition to food-- the drinking water and a volatile chemical such as carbon

tetrachloride. At the risk of seeming to belabor the point, the following pertinent quotation is presented:

"The period November 6th to November 10th contained the greatest amount of sickness, about twenty people being sick enough to vomit at this time, and it was necessary to turn two men in. These latter two men were never able to resume their normal duties. This particular period occurred soon after a particularly bad tasting batch of water was put in use and is believed to be the cause of the illness. The taste of this water was distinctly like iodine and samples were taken for analyzation. The two more seriously sick men were subject to cramps and pain in the stomach and they were unable to retain any foods or liquids for a period of five days, in spite of the use of amphojel, soda, paregoric, and rhubarb and soda mixture. Intravenous feeding was finally resorted to in the case of one of these men and after two days we were improved sufficiently to go on a liquid diet and two days later on a soft diet."

Next patrol of the same ship says: "No evidence of stomach upsets experienced on the two previous patrols was noted. This condition had been attributed to contaminated drinking water. During the last refit period the senior medical officer advanced the opinion that it was caused from inhaling carbon tetrachloride fumes. This liquid had been carried below decks for cleaning electrical appliances. All carbon tetrachloride was removed from the ship and nothing was done to the fresh water system. It now appears that the trouble had been remedied."

We wish again to emphasize that operating submarines, as judged by the record of the patrol reports, were singularly free from "food poisoning", with a record of only 34 instances out of 1489 patrol reports studied; and in only 9 of these 34 was food actually incriminated.

Miscellaneous

A few interesting and largely unrelated comments concerning food habits of submariners, etc., were observed in these patrol reports. One submarine, early in the war, reported that an average of 1.5 pounds of meat had been used per man per day. Total food consumed averaged 5.6 pounds per man per day; this was a 47-day patrol, thirty-one days of which were spent submerged in the vicinity of Truk. One commanding officer was of the opinion that serving a light lunch at noon "curbed the tendency to overeat from boredom, with a beneficial effect on the crew." Aboard another submarine, also early in the war, "food consumption was observed to fall off noticeably, the decline being most noticeable during the fourth week". Others reported a decline in appetite after prolonged periods of silent running and depth charging. Two commanding

officers, following cold weather patrols, reported an increase in food consumption. A third reported that cold weather operations were accompanied by a marked increase in the consumption of coffee (tripled). Others observed difficulty in baking under conditions of increased humidity within the ship. More than one cook on a war patrol has experienced and complained bitterly of collapse of his cakes during depth charge attacks. Two commanding officers encouraged the chewing of gum by their crew, one of whom was convinced of its beneficial effects, in that it reduced the amount of smoking during depth charging and was believed to account for a "noticeable reduction in the usual number of gastro-intestinal complaints usually observed during the course of a long patrol."

SUMMARY

1. The ration provided submarines in World War II succeeded in meeting their somewhat specialized requirements, namely: ease of stowage, excellent keeping qualities and ease of preparation in providing a well balanced daily menu incorporating a maximum of food value, variety, and a minimum of waste.
2. More active participation of submarine squadron medical officers in the problem of supplying men on submarine patrols with a satisfactory ration is indicated.
3. It is urgently recommended that this entire problem be re-studied in the less hurried atmosphere of peacetime with a view toward constructing a master ration plan for the Submarine Service, sufficiently exact to be helpful as a guide and at the same time flexible enough to allow for satisfying individual preferences.
4. The need for more thorough schooling and training of the entire team (commissary officer, commissary steward, cooks, bakers and supply officers) is apparent and will go far toward eliminating some of the problems of the submarine ration.
5. The one single item of food most common cause for unfavorable comment by commanding officers of combat submarines was the quality and percentage issue of boned beef. A review of this situation, with a view to possible corrective measures, may be in order.
6. With reference to individual food items provided submarines, the following points appear worthy of emphasis:
 - (a) The significance and importance of ice cream in providing variety in the diet as well as nourishment is apparent. In addition, it rates high as a recognized morale builder aboard submarines.

(b) Submarines should be given a high priority in the obtaining of available supplies of frozen fruits and vegetables, the importance of which, in the submarine ration, has been amply demonstrated.

(c) Certain luxury foods ("Avoset", canned luncheon meats, sea foods, 'Nescafe', jams, etc.), particularly when available in small pack size, are important in providing variety and enlivening what may otherwise be a monotonous diet.

7. The foregoing comments are intended not as a criticism of the commissary department of the submarines or the supplying organization, but as suggestions designed to make more perfect an already smoothly functioning organization. In fact, from all information available, it is apparent that the submarines in World War II amply earned their reputation of being "the best feeding ships in the Navy."

UPPER RESPIRATORY INFECTIONS AND CONTAGIOUS DISEASES
ABOARD SUBMARINES IN WARTIME 1942-1945

There has always been a great deal of speculation concerning the incidents of upper respiratory, infectious and contagious diseases and their transfer from one to another in submarines. A study of this nature would certainly be of value in any attempt to determine the need for such equipment as ultra violet lights for the control of bacteria in the air or for any other air purification equipment.

With this in mind, the students in the school for Pharmacist's Mates entering the Submarine Service were given as an assignment the review of all the submarine patrol reports, with a view toward pulling out every mention of incidents of upper respiratory, infectious and contagious diseases and their transmission from one to another.

The material which follows are these extracts quoted verbatim from the patrol reports, and we believe it is amply indicated that there is a problem yet to be answered so far as the Submarine Service is concerned, in the matter of removal of bacteria from the air.

U.S.S. ALBACORE, 4th Patrol, 4-6-43 to 5-26-43, Bismarck Sea Area. Numerous colds at start of patrol were aggravated by wet weather.

U.S.S. ALBACORE, 6th Patrol, 8-23-43 to 9-26-43, Bismarck Sea Area. Numerous colds were prevalent at the start of the patrol, but they cleared up on reaching warmer climate.

U.S.S. ALBACORE, 7th Patrol, 10-12-43 to 1-25-44, Truk, New Hanover Area. One man had catarrhal fever throughout the run and was in a rundown condition. He is being transferred for a rest.

U.S.S. ALBACORE, 8th Patrol. One case of DU (Sinusitis) retained on the sick list for seven days and returned to duty, two cases of catarrhal fever.

U.S.S. AMBERJACK, 2nd Patrol. Twenty-six cases of colds, seven hundred and eighty treatments.

U.S.S. APAGON, 2nd Patrol, 1-15-44 to 3-9-44, Mariannas Area. Three cases of common colds and some sore throats and five cases of Vincent's Angina.

- U.S.S. ARCHERFISH, 2nd Patrol, 3-16-44 to 4-27-44, Palau Area. There was a small epidemic of common colds during the first two weeks after departure of patrol. Number of cases sixteen, days lost, none.
- U.S.S. ARGONAUT (SML) (First), 1st Patrol. After forty-one days without sunlight toward the end of the patrol, the number of colds and sore throats has increased, 40% of the crew.
- U.S.S. BALAO, 3rd Patrol, 12-8-43 to 1-15-44, Bismarck Sea Area. A few colds noted, especially among the bridge personnel.
- U.S.S. BALAO, 9th Patrol, 5-3-45 to 6-7-45, East China and Yellow Seas. Colds were prevalent especially among the bridge personnel.
- U.S.S. BARB, 3rd Patrol, 2-1-43 to 3-9-43, Off Spain. Twelve cases of colds.
- U.S.S. BARB, 4th Patrol, 4-1-43 to 5-14-43, Norway & Ireland. Thirteen cases of colds.
- U.S.S. BECUNA, 4th Patrol, 4-15-45 to 5-24-45, South China Sea. Our last leave period was spent in unhealthy surroundings, since that time until almost the end of the patrol an unusually high number of cases of sore throat, severe head and chest colds and associated illnesses, including two abscessed throats were experienced. Eleven man days were lost among the crew because of illness, and one officer was on the sick list for one day.
- U.S.S. BESUGO, 4th Patrol, 3-24-45 to 5-20-45. The usual colds were experienced upon leaving port. The GERMAN POW had a cold when captured. He brought a new variety of cold germ aboard, resulting in another epidemic of sore throats and colds.
- U.S.S. BLUEGILL, 5th Patrol, 3-12-45 to 4-18-45, Java Area. Colds were unusually numerous in the early part of the patrol, but cleared up as the patrol progressed.
- U.S.S. BONEFISH, 7th Patrol, East China Area. The health of the crew was, in general, fair with only five mild cases requiring treatment. These men developed complications resulting from colds.
- U.S.S. BOWFIN, 6th Patrol. In general the health was excellent after overcoming the initial epidemic of colds and sore throats that prevailed from Pearl to Midway.
- U.S.S. BOWFIN, 9th Patrol. Quite a number of colds developed in the damp Japan area.

- U.S.S. CABRILLA, 1st Patrol. After our first day dive about twenty men developed colds, but the epidemic was of short duration.
- U.S.S. CAVALLA, 5th Patrol, 4-20-45 to 5-27-45, South China Sea. Health of the crew has been fair. There were two admissions to the sick list due to catarrhal fever, and many cases of head colds.
- U.S.S. CERO, 8th Patrol, 6-27-45 to 7-30-45, East of Honshu. The health of the crew during the patrol was very good. There were a few slight colds attributed to change in climate.
- U.S.S. COBIA, 5th Patrol, 5-9-45 to 6-18-45, Gulf of Siam. A minor epidemic of colds and catarrhal fever commenced during the training period and persisted through the first two weeks of the patrol.
- U.S.S. CREVALLE, 7th Patrol, 5-27-45 to 7-5-45, Sea of Japan. An epidemic of colds broke out, but was not too severe. This was expected, as the change in climate from Guam to the cold dampness of the weather in the Japan Sea was made in slightly over a week's time.
- U.S.S. CROAKER, 1st Patrol, 7-19-44 to 8-31-44, East China Sea. A mild epidemic of colds and sore throats occurred during the first week, about eighty percent of the officers and crew were affected.
- U.S.S. CROAKER, 3rd Patrol, 12-13-44 to 2-12-45, Luzon Straits. Because of consistently damp weather in this area numerous colds developed.
- U.S.S. FLYING FISH, 5th Patrol. Three cases of mumps with complications in two cases.
- U.S.S. GABILAN, 5th Patrol. It was noted that after two or three hours of silent running fifty percent of the crew caught colds.
- U.S.S. CATO, 5th Patrol. Carrying over one hundred men (non-naval) the crew developed over forty-five colds.
- U.S.S. GRAMPUS, 3rd Patrol. Epidemic of catarrhal fever one day after departure involving over seventy percent of the crew.
- U.S.S. GRENADIER, 1st Patrol, 2-4-42 to 3-23-42. A number of the officers and crew developed colds, some of which were severe.

- U.S.S. GROWLER, 1st Patrol, 6-20-42 to 7-17-42. There were eighteen cases of slight colds; no one was incapacitated for duty. The ship was kept comfortably warm, except when running silently. Heaters were secured then and naturally the ship became cold and clammy.
- U.S.S. GUARDFISH, 12th Patrol, 5-8-45 to 6-26-45. Minor colds were prevalent due to the cold, damp weather encountered, but all responded to treatment. In general the health of the crew was excellent.
- U.S.S. GURNARD, 6th Patrol, 7-8-44 to 9-5-44, Mindanao Sea. There were six man days lost due to catarrhal fever, acute.
- U.S.S. HADDOCK, 3rd Patrol, 12-28-42 to 2-13-43. During the first three weeks about forty percent of the officers and crew had colds which were probably due to the change in climate.
- U.S.S. MINGO, 1st Patrol, 6-25-43 to 8-21-43, Palsu Area. Numerous colds at the start of the patrol, but were all gone in two weeks.
- U.S.S. NAUTILUS, 1st Patrol. During the first two weeks about twenty-five percent caught colds, none of which were serious.
- U.S.S. NAUTILUS, 5th Patrol. Ninety percent of the crew had chest colds at one time or another. The more or less sudden change from tropical to Arctic area is the obvious cause.
- U.S.S. PAMPONITO, 6th Patrol. There were several colds the first week after leaving Subic Bay. One man was on the binnacle list for two weeks with a fever from a cold.
- U.S.S. PETO, 2nd Patrol, 6-10-43 to 8-4-43. There were numerous members of the crew with colds when the patrol started and three mild cases of influenza. This cleared up during the second week.
- U.S.S. RAY, 4th Patrol, 4-23-44 to 6-14-44. Numerous colds the first two weeks.
- U.S.S. RAY, 7th Patrol, 4-30-45 to 6-16-45. Approximately thirty-five men contracted common colds and five cases of mild tonsillitis occurred.
- U.S.S. REDFIN, 3rd Patrol, 5-26-44 to 7-14-44. Many of the crew suffered from colds contracted during leave and training period.
- U.S.S. SARDA, 8th Patrol, 8-1-43 to 9-15-43. Besides a bad seige of colds that made the rounds, only minor complaints were encountered.

- U.S.S. SAWFISH, 12-17-44 to 2-4-55. A great number of common colds were encountered due to sudden change in weather conditions.
- U.S.S. SEADRAGON, 9th Patrol, 12-14-43 to 1-30-44. At the start of the patrol there was an epidemic of common colds, lasting about two weeks.
- U.S.S. SEAL, 2-19-42 to 4-9-42. An epidemic of colds made the rounds the first two weeks.
- U.S.S. SEGUNDO, 3rd Patrol, 2-1-45 to 3-26-45. Colds were prevalent during the first week in the area, but attribute this to the fact that the ship had operated in the tropics for the previous seven months.
- U.S.S. SHAD, 2nd Patrol. There were fourteen cases of colds and sore throats, the greatest amount of these occurred during the first half of the patrol.
- U.S.S. SHAD, 8th Patrol. Half of the crew had colds. Epidemic naturally ascribed to sudden passage from a warm climate to a cold one.
- U.S.S. SNAPPER, 1st Patrol, 12-19-41 to 2-10-42. While up in the cold area near Hong Kong, several men had colds which cleared up when we reached warmer weather.
- U.S.S. SNAPPER, 2nd Patrol, 3-6-42 to 4-25-42. At the start of the patrol four officers and many men had heavy colds which gradually cleared up as we got into warmer climate.
- U.S.S. SNAPPER, 8th Patrol. Epidemic of common head colds approximately seventy-five percent of the officers and men were affected with these and while disagreeable none were sufficiently serious to require men to be taken off duty. It is felt that this epidemic was caused by the difference in weather conditions between Pearl Harbor and this area.
- U.S.S. SPEARFISH, 2nd Patrol. The health of my crew is beginning to wane as evidenced by an enormous increase in colds. More than half of the officers and men were affected.
- U.S.S. SPEARFISH, 7th Patrol. About twenty percent of the crew and three officers suffered from prolonged coughing spells which had the effects of whooping cough, but without nausea and vomiting.
- U.S.S. SPEARFISH, 9th Patrol. Other than a rather severe epidemic of common colds at the start of daylight submerged periods, the health in general was excellent.

U.S.S. SUNFISH, 6th Patrol, 1-15-44 to 3-7-44. A continuous epidemic of mild catarrhal fever that started prior to leaving Pearl. Continued throughout the patrol.

U.S.S. SUNFISH, 7th Patrol, 6-22-44 to 8-1-44. We had expected several colds due to the cold and damp weather, especially as several members of the crew still had colds and coughs hanging on that they had contracted in the states. Surprisingly all colds cleared up and no new ones were started.

U.S.S. S-31. Health of the crew was good, except for common colds and epidemic of sore throats thought to be caused by improper disinfecting of mess gear.

U.S.S. S-32, Attu. A marked lowered resistance of the personnel resulting in an increase of colds and apparent coughs. The fact that only one week was spent in port for refitting between the last patrol and the present one, plus an increasing time spent submerged may account for this condition.

U.S.S. S-33, 3rd Patrol. Health and habitability was only fair. Fifty percent of the crew suffered from colds of varying durations.

U.S.S. S-41, 5th Patrol, 9-2-42 to 10-14-42, New Caledonia Area. Numerous colds were experienced. Commanding Officer confined during last four days with severe cold and sore throat.

U.S.S. TARPON, 10th Patrol, 12-4-43 to 1-14-44. The general health of the crew was good. At the start of the cruise about one-third of the crew had severe colds and several cases developed into catarrhal fever which gradually cleared up without any admission to the sick list.

U.S.S. TRITON, 1st Patrol. During first weeks on station, there were a large number of colds, probably due to change of conditions. Only one serious case developed and that could not be diagnosed. The patient ran a high temperature for two days and was transferred to the Marine Camp at Wake Island for treatment. A good portion of the crew had submarine coughs upon return to Pearl Harbor.

U.S.S. TRITON, 3rd Patrol. Numerous colds, however, were experienced about Midway during the daily submerged running periods, considerably more colds than on the last patrol.

U.S.S. TRITON, 4th Patrol. During early stages of the patrol numerous colds were experienced, mainly due to change in climate. During latter part of the patrol bad colds and coughs increased and personnel resistance was lower. Probably due to eighteen hours submerged daily.

U.S.S. TUNNEY, 3rd Patrol. Numerous colds developed early in the patrol. Three cold cases developed into catarrhal fever, acute. This tendency was quickly checked by adding small quantities of creosol to dishwater. The epidemic of colds also subsided after two days of this precaution.

VIII - RESEARCH ACTIVITIES WITHIN THE SUBMARINE FORCE

Research accomplished anywhere in the Navy was eagerly utilized by the Submarine Force, wherever found to be applicable. Historical accounts of the full research program and its development and utilization will be published elsewhere, and no attempt is made there to even outline the field.

Within the Naval laboratories, the work at Naval Medical Research Institute in Bethesda is notable, in that at times certain phases of the program there were designed to answer directly certain submarine problems. Such research was of course utilized by the Submarine Force to the fullest extent. Examples of such projects are listed below:

- Project X-189 (Bio-3) - Protective Clothing for Subjects immersed in Cold Water.
- Project X-191 (Sub 31) - Application of Body Fat Measurements to the Study of "Bends" Susceptibility.
- Project X-337 (Sub 62) - Oxygen Poisoning - Reaction of men Breathing Pure Oxygen Under Water at Depths usually of 60 feet or less.
- Project X-427 (Sub 87) - Preparation of a Classified Bibliography of Submarine Medicine.
- Project X-436 (Sub 88) - Oxygen Poisoning in Man. Effect of Drugs and Alterations in pH of the Blood and Tissue.
- Project X-443 (Sub 89) - Physiological Factors Underlying the Prevention and Treatment of Compression Sickness.
- Project X-540 (Sub 113) - Design and Modification of Oxygen Breathing Equipment for Use in the Treatment of Caisson Disease.
- Project X-570 (Sub 121) - Evaluation of Effects of Experience During Decompression on the Incidence of Bends.

Project X-539 (Sub 125) - Table for Surface Decompression Utilizing Oxygen, Calculation and Testing of.

Project X-605 (Sub 130) - Physiological Effects of Pressure Changes in Relation to Submarine "Snorkel" Operations.

Project X-755 (Sub 156) - Effects of Silicone Vapor Emanating from Insulation on Electrical Equipment of Submarines.

There were from time to time within the Submarine Force minor researches of an applied or development nature undertaken by medical officers in various parts of the world. These are usually of such a minor nature or such short duration that again no attempt has been made to list them here.

It can be truthfully stated that the only continuous concerted and organized effort of any magnitude insofar as submarine research performed by submarine personnel is concerned was that done by the Medical Research Laboratory, Submarine Base, New London, Conn. A history of this Laboratory for the period from Pearl Harbor to the end of the war, and its development from a two man team of a medical officer and chief pharmacist's mate to an organization occupying three buildings and having 27 officers, 4 civilians, 11 waves, and 100 enlisted men at the height of the war, has been prepared and is available from the Medical Research Laboratory.

However, we believe that it is in order at this time to at least briefly set forth certain phases of the research activity of this organization. In doing this it should be constantly borne in mind that the research staff at New London had many additional routine duties in connection with the examination and general processing, screening and selection of officers and men for the Submarine Service and also in connection with the activities of the various schools giving instruction under the cognizance of the Medical Research Laboratory, so that research was only a part of the effort of the group working at the laboratory during the war.

With this in mind, the following has been bodily lifted from the report entitled HISTORY OF THE MEDICAL RESEARCH DEPARTMENT OF THE SUBMARINE BASE, dated 7 December 1945:

"Establishment as a Base Department, 23 February 1944:

The Medical Research Department was officially set up as a separate department of the U. S. Submarine Base, New London, Connecticut by Base

Order No. 2-44, under date of 23 February 1944, signed by the Commanding Officer of the Base. However, this department had been functioning as a separate unit, for all practical purposes, for at least two years prior to that date, although it was still, officially, an appendage of the Medical Department, --some of the personnel (i.e. Lookout and Recognition Officers) were carried on the complement of the Submarine School, and the rest (Medical Corps and H(S) officers and pharmacist's mates) being part of the Medical Department.

"Previous Recognition by BuMed and BuPers:

Recognition of the work of this department by the Navy Department, that is, both BuPers and BuMed, had come in 1942, with the appointment of the Submarine Medical Examiner, on 11 September and 9 December respectively, as assistant liaison officer between BuMed and N.D.R.C. Committee for the Selection and Training of Sound Operators, and liaison officer between BuPers and the Committee on the Selection and Training of Service Personnel, (later transformed into the Applied Psychology Panel of N.D.R.C.). On 25 April 1943, additional duty orders as Medical Officer in Charge of the Medical Research Laboratory were issued by the Bureau of Personnel to the Submarine Medical Examiner. During all of this formative period 1942-44 and continuing through the present writing, numerous BuMed, BuPers, and BuShips experimental projects have been assigned to this department for investigation, study, and comment.

"Early Work:

During the two years prior to Pearl Harbor the medical officer attached to the Submarine Escape Training Tank and serving in the Medical Department as Submarine Medical Examiner, had initiated several interesting pieces of research on submarine sound problems. He was assisted in this work by a Chief Pharmacist's Mate who was a submarine man of long experience. In collaboration, they wrote a series of articles on "Auditory Acuity Among Submarine Personnel", which was later published in the Naval Medical Bulletin. The first of the series appeared in January 1942. The others followed in April, July, and October of that year. They also had begun some experimental work leading to the development of tests and techniques for the selection of men for sound listening duties on submarines. Many of these tests were later adopted officially for use throughout the Navy.

"Status at the Outset of the War:

At the onset of the war (December 7, 1941) what was to become the Medical Research Department was in its embryonic state. The two-man team mentioned

above was the staff and the working space was an office, a soundproof testing room, and one large classroom and/or examining room in the south wing of the dispensary, Building 86. Both men spent a part of each day at the Escape Training Tank. Then, as now, the primary function of the department was the examination and selection of submarine personnel. This constant stream of candidates for Submarine School and submarine duty, plus their training in the use of the submarine escape appliance, and the complete and accurate records kept on this testing, made available a wealth of data for analysis and study. As we have pointed out, the two were at this time preparing the first reports on their studies in auditory acuity and audiometric testing at this time. (As an almost forgotten angle of the situation in those days, we might point out that the Dispensary building was sand-bagged up to the level of the second story windows, hence, all the work done in this basement wing of the Dispensary was necessarily carried on under artificial lighting and under conditions of very poor ventilation).

"Assistance from National Defense Research Committee:

From the very modest beginning outlined above, several related studies developed, such as, night vision, color vision, and lookout training, and as the volume of work increased, assistance became necessary. Such assistance was secured from several sources, notably N.D.R.C. As early as January 1941, the Division of Preventive Medicine of the Bureau of Medicine and Surgery, became interested in the research on sound problems and put the Laboratory in touch with members of the National Research Council who became and continued throughout the war active supporters of the efforts at New London. Further contacts with these and other forward-looking scientists brought active assistance from the N.D.R.C. group, as well as from the Research Division of BuMed, and financial assistance from the Bureau of Ships. Through the assistance of N.R.C., N.D.R.C., Coordinator of Research and Development, Columbia Division of War Research, Underwater Sound Laboratory, Fort Trumbull, and Brown University Division of War Research and numerous other contacts, the staff was rapidly augmented by a number of civilian scientists.

"Acquisition of Additional Space:

It was soon apparent that more space was necessary and that it would make for greater efficiency and progress if all our activities could be housed in one building, --not one on the Upper Base and one on the Lower Base. Accordingly, a new building was requested and plans drawn. The request was approved and the building (#126) was built, immediately behind the Dispensary, and first occupied on 2 February 1943. This is a two-story frame building, rectangular

in shape. In order to procure a higher priority for the construction of this building, and in response to the Dispensary's need for more beds, the first deck of this building was converted into Dispensary wards (Wards G and H); however, the entire second deck was occupied by the Medical Research Department. This area contains 20 rooms. In one there is an area designed to facilitate the physical examination of submarine candidates (a series of small examining rooms around a central waiting space) and at the other end there is a large dark-room for giving Night Lookout Training and an adjacent dark-room for Night Vision testing. The remaining rooms are classrooms, offices, and laboratory spaces.

"Building #156:

With the further development of the department and the addition of other activities (training as well as research), still another building was found necessary. This was requested, planned and constructed during the latter half of 1943. Building #156, a three-story brick construction, adjoining Rock Lake, was first occupied on 17 February 1944, and houses the Lookout Training School, the School for Pharmacist's Mates Entering the Submarine Service, the Interior Voice Communication School and the Sound Laboratory.

"Building #70:

By the Base Order creating this department, the Escape Training Tank was included, and therefore Building #70 was added to the Medical Research Department. This attachment was a very logical one, since the medical officers of this department (all qualified in submarine and diving medicine) had always been attached to the Tank and supervised the escape training, the satisfactory completion of which is a part of the submarine physical examination. The performance of candidates in the "lung" training program constitutes a further valuable check on the emotional stability of men requesting submarine duty.

"Training Aids Shop, Basement of Bldg. #106:

A need for a shop for the Research Unit for the construction of training aids, and various experimental "gadgets" as well as the repair of models and research devices soon became apparent. First plans called for construction of such a shop in the basement (the unexcavated part) of Building #156, but this plan was not approved. For a while, space for this purpose was made available in the Mess Hall in Building #150, and when it became necessary to move from there, space was made available in the basement of Building #106 on the Lower Base (this basement being reserved as an air-raid shelter in case of emergency and being otherwise unsuitable for occupancy because of the flooding

in of water). Construction of this shop was started on 31 January 1943. This department had previously constructed night vision testing facilities (temporary testing booths and alleys) in an adjacent area in the basement of #106, to accommodate the mass testing of night vision for the entire complement of this Base, as will be mentioned in the section concerning the development of that section of the department. The Training Aids Shop was located in #106 until October 1945 when it was moved to the first deck of #156 because it became necessary to use this space for storage of spare parts for submarines.

"Summary:

Buildings

In summary, then, as of 15 November 1945, the Medical Research Department occupies Building No. 156, the second deck and one-half of the first deck of #126 (South wing), and all of Building No. 70.

Staff

The staff has constantly grown until at the present time it includes:

26 officers (three having been recently released to civilian life-- replacement being received on only one).

22 Chief Petty Officers
35 Enlisted men
11 Enlisted WAVES
4 Civilians - Group IVb

I - EXAMINATION

Officer candidates for Submarine School

Enlisted candidates for Submarine School

--all candidates for Submarine School are given physical, psychological, and psychiatric examinations and aptitude tests for various special jobs, and those who pass are then given submarine escape training.

Officer candidates for "Qualification in Submarines"

Pharmacist's mates for Submarine PhM School

Enlisted candidates for qualification as deep-sea diver

Special test in Color Vision

Special tests in Night Vision

Selection tests for Sonar Operation
Selection tests for Radar Operation
Re-check examination for New Construction crews
Basic battery tests for those who lack same in their Service Records

II - RESEARCH

Auditory -

Sound, including project on aero-otitis media

Visual -

Color Vision

Night Vision and Lookout Training

General ophthalmological research

Training Aids Shop

Personnel Selection

Submarine and Diving Problems

III - INSTRUCTION

Submarine Escape Training School

Lookout Training School

School for Pharmacist's Mates Entering the Submarine Service

School for Second Class Divers

Interior Voice Communication School

"Sound Section"

This activity was the first to be undertaken beyond the routine work of the department, --physical examination for submarine duty and "lung" training. Work on tests for the selection of sound operators was well under way prior to the war. Recognizing this valuable pioneer work, the N. D. R. C. Sound Section agreed to forward the work and assigned in January of 1942 a secretarial and statistical assistant. A short time later a psychologist was attached as an additional statistical and technical assistant. He later transferred to Underwater Sound Laboratory and was replaced by a psychologist serving in uniform (Ensign H(S) USNR.

"The first working space was the one large classroom and two small sound-proof testing rooms in the south wing of the Dispensary basement. Work continued there until 2 February 1943 when the Sound Laboratory moved into the newly constructed Building #126, where there were two small sound-treated testing rooms and a classroom and an office. The sound selection work continued in Building #126 until February 1944, when it was moved to

Bldg. #156, its present location, where on the first deck really soundproof testing space was available for the first time. This space contains a soundproof classroom capable of seating 20 subjects and an audiometry room, capable of seating 12 subjects, and a large office.

"The routine activity of this section was the selection of personnel for training as sound operators for the Sound School of the Submarine School at this Base. Close liaison with the Sound Department of the Submarine School was maintained constantly. However, from time to time, similar selection was accomplished for the Coast Guard, the Inshore Patrol, and the Underwater Sound Laboratory, the U.S.S. SYLPH Sound School, and the Maritime Service, and the Harbor Defense at Fisher's Island, and for the Naval Training Division at the Coast Guard Station at Avery Point, and the West Coast Sonar School. This volume of testing made possible the trial and standardization of many experimental tests and devices. This section cooperated with N.D.R.C. representatives, with the Harvard Psycho-Acoustic Laboratory, and with the University of California, Division of War Research, in running trial tests and various comparative studies.

"Experimental work included studies of protective devices for the ears; the development of a group audiometer test; the development and standardization of a Propeller Noise Injector, and the constant development of tests and equipment to aid in the selection of better men for sound listening assignments on our submarines. Other projects were: a comparison of various measures of auditory acuity and an extensive study of Aero-Otitis Media in Submarine Personnel, --its prediction, prevention, and treatment. A rather extensive report on the Group Audiometer, as well as numerous shorter research reports on other projects were made to the Bureau of Medicine and Surgery and distributed to other interested activities. The Officer in Charge of the laboratory delivered reports both on and work in sound selection and on the auditory acuity studies and aero-otitis media project before the American Academy of Ophthalmology and Otolaryngology, the Association of Military Surgeons, and other groups.

"On 14 and 15 June 1945 a Sound Conference was held at this Base, sponsored by the Research Division, BuMed, with the Sound Section of the Medical Research Department acting as host. Fifty-two representatives were present (in addition to 26 officers from this Base attending) from the following organizations and activities: The British Admiralty Delegation; the British Navy; the Canadian Navy and Air Force; the U.S. Army, Navy and Air Forces; the Veterans Bureau; the Service Rehabilitation Centers at the U.S. Naval Hospital, Philadelphia, and the Deshon General Hospital, Butler, Pa.; the Office of Research and Inventions, the Research Division of the Bureau of

Medicine and Surgery; the Bureau of Ships; the Bureau of Standards; and the Standards and Curriculum Section of the Bureau of Naval Personnel; the Naval Medical Research Institute at Bethesda, Md., the Medical Field Research Laboratory at New River, N.C., and the Naval Research Laboratory at Anacostia, Md., and civilian representatives from O.S.R.D. and N.D.R.C. groups at Harvard University, Princeton University, and University of Pennsylvania, Yale University, the West Coast Sonar School, Johns Hopkins University, and the State University of Iowa. A very profitable two-day period was spent in discussing mutual problems in connection with methods of testing hearing; standard clinical tests, audiometer tests, phonograph record tests, monitored live-voice tests; and several newly developed tests, such as the Sound Recognition Group Trainer, the Propeller Noise Injector, and the Target Discrimination Test and Pitch and Loudness Tests.

"During the final afternoon session of this conference, a proposal was made that a permanent organization be formed to continue work similar to that of the Sound Conference. This committee would continue on into peace time and be the clearing house for all auditory problems and the coordinating group for research projects. This proposal was unanimously approved and arrangements were made for working out the practical details. It was suggested that this committee should include representatives from all of the organizations at the Sound Conference and provide for inclusion of any others who may be interested or valuable to its progress. (This committee was finally organized as of 1947 with Army, Navy and N.R.C. representation).

"Research in Personnel Selection

Research in Personnel Selection was undertaken on a large scale at the Submarine Base with the advent of the N.D.R.C. personnel research program in April 1942. For fifteen months a series of tests of enlisted personnel were investigated by this organization for their relationship to factors in submarine success. Finally, in June 1943, the Office of Scientific Research and Development (OSRD Report #1770) recommended a battery of tests for selecting enlisted submarine candidates. One of the tests (the Enlisted Personal Inventory) which this program was instrumental in developing has since been adopted for general Navy usage. Research on the original battery of tests continued.

"In July 1943, the first research on officer personnel selection was undertaken. With the assistance of the Test and Research Section of the Bureau of Personnel and of NDRC a selection program was developed, and established in the latter part of the year. By January 1944, officer selection was standardized in what is basically its present form; but research on tests continued until demobilization of the officer personnel in 1946.

"As the attention of the Bureau of Personnel became directed to this work, by letter Pers-416 2c-FBH of 6 March 1944, the Chief of Naval Personnel established submarine personnel as a field for study and improvement of selection procedures.

"Two consequences grew out of the interest of BuPers. First, in May 1944, various representatives from BuPers collaborated with this activity in establishing a system of selection for submarine duty which integrates medical, psychiatric, and personnel selection at Training Centers (Pers-6374-hmg, NC of 22 May 1944). This system was effected by Selection Officers, and was judged generally satisfactory. Very shortly the program expanded so that Selection Officers became charged with all assignments from Class A Schools and Training Centers for which requirements were established by BuPers (Pers-6374-EN-NC of 4 July 1944). A second consequence was that field research was undertaken jointly by the Submarine Base and the Bainbridge Naval Training Center, under the joint cognizance of the Bureau of Medicine and Surgery and of the Bureau of Naval Personnel (Pers-1011 NBH of 30 October 1944) to the end that a practical system of personnel selection involving mental, psychological, psychiatric and physical fields be developed.

"Following the establishment of uniform BuPers standards for all submarine personnel, selection research centered to a considerable extent upon developments and refinements of BuPers procedures. For example, accounting practices were developed in order to identify weaknesses and strong points in personnel programs of the various stations supplying men for submarine service. All enlisted personnel leaving the station were examined with a complete program of tests and scores recorded, in order that aptitudes might be identified to the fullest extent. Beginning in 1945, all Submarine School graduates and all enlisted men received for assignment to New Construction, were given a complete set of aptitude examinations and the test scores recorded on Qualifications cards inserted in the Service Record.

"Development of Visual Research Program, U.S. Submarine Base

Visual research at the U. S. Submarine Base, New London, Connecticut may be divided into four sections:

- (a) Night vision testing and research - which will be discussed under four sections:
 - (1) general running history of night vision section,
 - (2) write-up of the part the night vision section played in the development of the Army-Navy-OSRD Vision Committee.

(3) an account of the history of the development of the Navy Radium Plaque Adaptometer and of the training of personnel for the Bureau of Medicine and Surgery for the administration of night vision testing with the R. P. A. throughout the Navy,

(4) listing of reports prepared in this section and current projects.

(b) Night lookout training research;

(c) Color vision testing and research;

(d) General ophthalmological research.

(a) Night Vision Testing and Research:

(1) General running history of night vision section. Following receipt of British reports concerning night blindness encountered upon long submarine patrols, local interest in the subject was aroused. In compliance with verbal orders, in April 1941, the squadron medical officer began a search of available literature on the subject of night vision. Official orders from the Commanding Officer of the Submarine Base followed on 12 May 1941, to "commence investigation and research for the purpose of detecting and control of night blindness, -- this to include the development of a device to test, and a suitable diet to minimize night blindness".

After numerous conferences with specialists in relevant fields and the exploration of all possible sources of information, testing was begun under the supervision of a Board of Medical Examiners for Night Vision, which was established on 3 June 1941, by confidential letter S24-1 (0237) from ComSubLant to Submarines, Atlantic, -- subject: "Night Lookouts; Testing and Training of". This letter directed that personnel attached to the addressed forces for their night vision set up a Board of Night Vision to accomplish this, and also directed that special reports on this testing be submitted.

"After careful investigation of the Wald Adaptometer, the Admiralty Adaptometer, and the Hecht-Shlaer Adaptometer, it was decided to adopt the Hecht-Shlaer for use at this activity as the testing device for night vision.

"In addition to supervising the routine testing of night vision, the Board of Medical Examiners for Night Vision also supervised the night lookout training being given. Because of the close relationship between the two activities, -- night vision testing and night lookout training, and because the continuing members of the Board of Night Vision were attached to the Medical Research group, it was logical that the Lookout School which developed from this

activity should be a part of the Medical Research Department.

"As the testing program proceeded it became apparent that the testing of night vision is a very complex problem, involving many controversial issues and angles. Each of these phases had to be investigated and tried out. It was obvious that not much had been known on this matter, and that much confusion and misinformation had existed. Obviously, it was necessary to decide upon a standard adaptometer for military use and to standardize the testing procedure.

"As the volume of testing increased and additional experimental studies became necessary to provide the answers to some of these problems, the procurement of additional assistance in the way of trained personnel became urgent. In answer to this need, the National Defense Research Committee, through its Brown University Division, furnished the services of a trained perceptual psychologist, who arrived in April of 1942, and continued with the night vision research in his civilian capacity until 31 June 1944, at which time he came to active duty as Ensign H-V(S) USNR, was assigned to the Medical Research Department, and continued this research work as his Navy assignment.

"The night vision testing and research continued in Building #3 in three rooms made available on the first deck, from May of 1942 until February of 1943, when the completion of the construction of Building #126 provided new and more convenient quarters. The civilian assistant made possible a more extensive research program and more complete statistical analysis of the results obtained. An investigation was undertaken of a series of adaptometers for suitability for adoption by the Navy.

"A comprehensive report was issued under date of 25 April 1942 from the Board of Night Vision to the Chief of the Research Division of BuMed, via Com-SubLant. This contained a detailed statement of the problem involved, as well as a report of the progress to that date, and gave an outline of the plan for future investigation. Under date of 18 May 1942, S24-1 WSV/AE, a Report of Test of Six Pairs of Night Adaptation goggles was issued. Routine testing of night vision continued, modified from time to time in accordance with new experimental findings.

"The urgent need for an adaptometer better adapted to the needs of the service situation led to the development and trial of several different adaptometers. One of these was developed through the combined efforts of several members of N.D.R.C., N.R.C., and Army and Navy representatives. It was known as N.D.R.C. Mod. II, and one of the first of these adaptometers to be completed was delivered to this activity on 3 July 1942 for testing prior to putting this device into production. Following test runs here, certain modifications were

made in the instrument. A report on the Reliability Test of this adaptometer was issued on 28 July 1942. As a result of this work, a pilot model of NDRC Mod. II was constructed and used in testing the NEW JERSEY crew. In October 1942 the first comprehensive experiment was run and the pilot model of the present Navy Radium Plaque Adaptometer was recommended for approval. (See Division (3) of this section for complete account of the development of the Navy Radium Plaque Adaptometer).

"Simultaneously with these developments along the line of night vision testing, the night vision training phase of the activity was receiving wide attention and causing repercussions discussed elsewhere in this history.

"On the basis of the Medical Research Department's basic work in night vision and night lookout training, this activity was officially designated by BuPers as the experimental station for the entire lookout training program - (BuPers ltr P-2423d-RB of 18 December 1942).

"The Bureau of Medicine and Surgery assigned research projects to this activity from time to time on the Project "X" Forms of its Research Division, and other projects were instituted by ourselves and approved by the Bureau by means of these Project Forms, (as per example those listed under Division (4) of this section).

"The NRC Subcommittee on Visual Problems, including representatives from many activities, met at this Base on 15 December 1942. This meeting indicated the need for a permanent committee on vision with broad interests and membership, (see Division (2) of this section for an account of the organization of such a committee). At this meeting plans were made for the preparation of a manual on Night Vision. This plan, as it developed, finally resulted in the preparation of several official manuals, both for the Submarine Service and for the general Navy.

"Throughout 1942 and 1943 a series of adaptometers were tested for suitability for the Navy. This series included the Wald, the Admiralty, the Miles Four-Plaque, the Beals Adaptometer, and the Wright Adaptometer.

"In May of 1943, an extensive project was undertaken in connection with the testing and classification of the crew of the battleship U. S. S. NEW JERSEY, using the NDRC Model III Adaptometer. Work was completed during the first week of June and a Preliminary Report dealing with Equipment used was submitted to the Bureau of Medicine and Surgery on 7 June 1943. On 25 June 1943, a general report concerning the night vision testing of the crew of the U. S. S. NEW JERSEY was submitted, and on 3 July 1943 a final report presented the incidental data of

interest in connection with this project.

"By CominCh confidential letter FF1/PII-1, Serial 03473, of 6 October 1943, the cooperation of the Medical Research Laboratory of this Base was requested, with N. D. R. C. in a program of selection and training of night lookouts, as desired by the Bureau of Naval Personnel. The program as arranged called for a study of the predictive value of various tests for night lookout duty, involving an analysis of various adaptometers and the ability of men to see ship targets at sea at night.

"Accordingly, in October and November 1943 a comprehensive experiment was undertaken, involving 150 men specially ordered by BuPers to the Submarine Base to serve as subjects. Extensive field runs were made with the 150 men serving as lookouts. The field tests were conducted aboard the U. S. S. SARDONYX. OSRD confidential Report No. 3357, entitled "A Study of the Prediction of Night Lookout Performance", under date of 15 March 1944, contains the detailed report of this experimental study.

"In November 1943, the first official Navy Radium Plaque Adaptometer was delivered and this was one of the adaptometers studied in the experiment mentioned above.

"In order to establish norms and refine the testing procedure, it was decided that mass night vision testing of large numbers of personnel would be helpful. Therefore, during February of 1944 all personnel of the Submarine School and of the Submarine Base were tested on the Radium Plaque Adaptometer. A total of 5,750 were tested at this time.

"The very complete records of the night vision section of the Medical Research Department reveal that more than 23,000 individuals have been tested for their night vision acuity during the period of this report.

"Further studies were made on the Radium Plaque Adaptometer, e.g., the effect of altering the difficulty, and the reliability of results over a period of time. Other experimental work in the field of night vision and binoculars has been conducted, as follows:

the effect of certain drugs on night vision was determined;

a test of fixed-focus binoculars was run at the request of BuShips, in the Spring of 1943;

a series of studies of submarine illumination were made.

In the summer of 1944 a representative of this department travelled on a new construction submarine to the Submarine Base, Pearl Harbor, T.H., to observe the use and adequacy of red-illumination. Again through the Spring of 1945 a study of conning tower illumination was made in the Mark IV Attack Trainer. Research results of both studies consistently showed the satisfactoriness of red illumination.

Numerous other studies will be indicated by the list of reports and projects appearing in Division (4) of this section.

"The procedure developed at New London was adopted by BuMed and accepted as the basis of comparison for results from other activities. Since February 1944, all submarine personnel have been given the RPA test as a routine part of their physical examination for submarine duty. In December 1944, the entire personnel of the Submarine Base were again tested, -- this constituted a retest for many, a first test for some.

(2) Development of the Army Navy-OSRD Vision Committee

As soon as the visual experimental work was well underway in the Medical Research Department, Submarine Base, New London, an almost constant procession of visitors began to arrive from Army activities, other Naval activities, and from N. D. R. C., N. R. C. and other civilian organizations, as well as from Allied liaison activities, especially Canadian and British. It seemed that it would certainly be valuable to have a group of such representatives get together for an exchange of information and viewpoints.

"Accordingly, this activity was host to a meeting of the N. R. C. Subcommittee on Visual Problems. This meeting was held at this Base on 15 Dec 1942, and was attended by twenty-three representatives: six from N. R. C., five from N. D. R. C., six from Navy, one from U. S. Army, two from Canadian Army, one from Canadian Navy, one from U. S. Public Health Service, and one from Columbia University. Numerous visual problems were discussed, but as the group had no authority, no decision was reached. It was considered that this group did not serve the purpose believed desirable.

"This early meeting led to the definite conviction in the minds of many that a regular committee should be formed having power to make decisions and allocate research. Numerous small committees interested in visual problems met from time to time, an example of which is the Joint Night Vision Committee of BuPers and BuMed, which met on 23 September 1943 in Washington to decide certain problems of testing and of policy. The Subcommittee on visual problems of the N. R. C. Committee on Medical Research, Committee on Aviation Medicine,

is another example. In addition to these meetings, numerous conversations were held with various official representatives of the Army and the Navy, and finally a meeting was held with the Coordinator of Research and Development, resulting in the letter from the Coordinator to the Chief of Bureaus, announcing a meeting on 5 January 1944 to plan for a committee representing the Army and the Navy and N. D. R. C., which would deal with all sorts of visual problems, maintain a library of pertinent information, and coordinate the necessary research. At this meeting the organization was tentatively formed. Continued work on the committee on the part of this department in coordination with various representatives of the Navy Department finally led to the organization of the Army-Navy-OSRD Vision Committee. The first official meeting was held on 7 April 1944 in Room 0144 of the Navy Department.

"This Committee held monthly meetings and continued to function throughout the war in a most satisfactory manner and has now been organized to continue into the peace.

"The Officer-in-Charge of the Medical Research Department and the members of the visual section of the Medical Research Department were actively interested in the joint Army-Navy-OSRD Vision Committee from the time of its inception, and served on many of its committees and subcommittees. The third meeting of this group was held at the U. S. N. Submarine Base on June 1944 with a large representation of service and civilian organizations present. This activity also acted as host to the Fourteenth Meeting, which was held on 11 and 12 September 1945.

"Detailed information as^{to} the matters handled by this committee is available in the Reports of the Proceedings of these meetings which have been bound in pamphlet form.

- (3) Account of the Development of the Navy Radium Plaque Adaptometer and of the Training of Personnel for the Bureau of Medicine and Surgery for the Administration of Night Vision Tests throughout the Navy, using the R. P. A.

In the latter part of 1941 two members of the Medical Research Department visited the Yale Medical School, and demonstrated the use of a radium plaque with superimposed figure which it was thought might be valuable in night vision testing. Again, on 14 July 1942, at a conference at the Submarine Base, the Yale representative told of a radium plaque which he had developed and which he was trying out as a night vision testing device.

"The next step in the development of this adaptometer cannot be documented from the files of the Medical Research Department, but it is understood that the Johnson Foundation was given the Yale Adaptometer and made some modifications on it. It was then taken to the Research Laboratory at the Naval Air Base in Pensacola, where a movable disc was added in front of the radium plaque and called the device the self-luminous telesilhouette adaptometer. This was first officially brought to our attention by the Research Division, in a letter dated 19 September 1942, in which it was suggested that a representative report to New London with the instrument for testing at this station.

"A conference was held in Washington on 25 September 1942 with numerous representatives of the Research Division of BuMed, at which time the Pensacola modification of the telesilhouette adaptometer was discussed. On 12 October 1942 the telesilhouette adaptometer was brought to Medical Research Department, New London, Conn. During the long conference and testing period which ensued, the adaptometer was converted back to a self-luminous plaque with a plain block T of standard Snellen type superimposed upon it. This change was made after conferences in order that it could be made comparable to the NDRC. Mechanical revision was made at this station, and after field testing done under BuMed Research Division Project X-68 (Av-VI-16). The model and our report on it were sent to Washington for final work by Special Devices Division. A long period of time elapsed in which nothing was heard from this model.

"In the period which ensued, a methodological research program was undertaken at this activity, in an effort to determine the most efficient testing procedure for night vision, based upon a device like the R. P. A.

"Following receipt of confidential letter from Commanding Officer, U. S. Fleet, dated 1 July 1943 (FF1/L5-2/P2-5, Serial 02162) addressed to the Vice Chief of Naval Operations, concerning procurement of an adaptometer for night vision testing, the Officer in Charge, Medical Research Department was called to Washington for a conference with ComInCh and BuMed representatives. At this meeting it was decided that the modified telesilhouette adaptometer should be used and it was stated that BuMed had already placed an order for 500 of these devices. The name was changed to Radium Plaque Adaptometer. The first units of R. P. A. s were delivered to the Medical Research Department in October 1943, and were immediately subjected to rigorous field tests. This department continued to work with this device as will be seen from perusal of the list of reports found in Division (4) of this section. A few of the reports are listed here for convenience:

Report of Five Hundred Subjects Tested and Retested for Fifty Trials each on the Navy Radium Plaque Adaptometer 8 March 1944, 6 pp.

Verplanck and R. H. Peckham.

A Report on the Night Vision Testing of 5750 Men. 12 August 1944, 12 pp.

The Reliability of the RPA Over Long InterTest Intervals. (In preparation)

Report: Comparative Study of Adaptometers. 1 December 1942, 31 pp.

A Rapid Procedure for Testing of Night Vision. 5 March 1943, 15 pp.

Field Tests of the Radium Plaque Adaptometer. 26 November 1943, 30 pp.

Instruction for Operations and Maintenance of Radium Plaque Adaptometer. 1 February 1944, 2 pp with D.T. Reed.

"Because of the continued interest in this work and following a series of discussions, the Bureau of Naval Personnel and the Bureau of Medicine and Surgery issued a joint letter, Pers-423h-mjj of 5 January 1944, directing the assignment of Hospital Corps officers to the Medical Research Department, U.S. Submarine Base, New London, for a period of intensive training so as to prepare them to handle the night vision testing program in the various naval districts and activities.

"In February of 1944, the first class of warrant pharmacists arrived for instruction in the technique of the Radium Plaque Adaptometer test. The Medical Research Department, New London, developed and administered the course of instruction. While here these pharmacists were trained to be technicians capable of setting up and maintaining in operation a standard procedure for night vision testing. Their training schedule was designed to train them to be expert operators of the Navy Radium Plaque Adaptometer themselves, and to be able to train pharmacist's mates to operate it; to set up a mass testing program; to understand the operation of several other adaptometers and the principles on which they work; to be able to answer with authority questions on night vision and night vision testing which might be directed to them; to cooperate fully with the Lookout-Recognition Training program; and to be able to check on the accuracy of the testing results obtained. This was accomplished by a comprehensive series of lectures; by group preparation of a handy refer-

ence book for all hands; by participation in all phases of the extensive testing program then underway at this Base; and by having each pharmacist test a minimum of 300 men. At the termination of this large-scale testing program, using the services of the R.P.A. technician, the final testing procedure was adopted by Bu-Med, on the basis of Report No. 5 above. This incorporated the features of testing methods developed here.

"After six weeks of instruction here, these men were ordered to various stations to set up the night vision testing program throughout the Navy. Three additional classes arriving later brought the total number of men so trained up to approximately fifty.

"This department continued to keep in touch with these individuals and by close liaison kept them informed on all the latest developments in night vision testing techniques.

"(4) List of Reports prepared and Current Projects in Night Vision.

The following list of the reports prepared in Medical Research Department indicates the type of work done by the Visual Section. The type and volume of the work still underway is indicated by the list of current projects, which also follows.

Reports prepared:

The following reports cover large scale testing programs which required considerable organization and handling of personnel:

Program: Selection of Lookout Division of U.S.S. NEW JERSEY.

1. A report on the NDRC Model III Adaptometer. 7 June 1943, 9 pp.
2. Night Vision Testing of members of the Crew of the U.S.S. NEW JERSEY.
3. Report on Night Vision Testing of the Crew of the Battleship NEW JERSEY, Incidental Data of Interest. 3 July 1943, 15 pp.

Program: A Field Test of Binoculars Conducted upon a Request Originating in the Bureau of Ships.

4. A Report on Sample Binocular Serial #6268 Mark I Model 2. 23 July 1943, 21 pp.

Program: Training of approximately 50 Pharmacists as RPA technicians, and testing of all personnel of the Submarine Base.

5. Report of Five Hundred Subjects Tested and Retested for Fifty Trials each on the Navy Radium Plaque Adaptometer. 8 March 1944, 6 pp.
6. A Report on the Night Vision Testing of 5750 men. 12 August 1944, 12 pp.
7. The Reliability of the R.P.A. Over Long Intertest Intervals. (in preparation)

Program: Study of the "Validity" of a Series of Adaptometers by Field Experiment with 150 Men Trained as Lookouts.

Collaborated with NDRC in execution of the program - "A Study of the Prediction of Night Lookout Performance", 15 March 1944, 37 pp.

The following reports, training material, and so forth concern lookout and recognition training:

8. Handbook on Night Lookout Training. Submarines, Atlantic Fleet, 1 May 1943, 51 pp.
9. Handbook on Night Lookout Training, Revision I.
10. Report on Night Lookout Training Procedures. 7 August 1943, 22 pp.
11. Report of Conferences on Lookout and Recognition Training held at Section Base, San Pedro, California, 1-4 September 1943. 12 pp.
12. Night Vision Testing and Training Program. 28 December 1943, 12 pp.
13. Report on Field Observations of Submarine Lookouts. 30 September 1944. 8 pp.
14. Memorandum on Lookouts. 2 October 1944. 8 pp.
15. Performance of Submarine Lookouts. 12 October 1944. pp 33-35
Minutes 6th Meeting ANOSRD Vision Committee.
16. Submarine Lookout. Commander Submarines, Atlantic Fleet.
17. First draft of Lookout, A Manual for Lookout Officers. Now being published by BuPers.
18. A Report on Standardization of Night Lookout Stages. 24 May 1945, 7 pp.
19. Modification of Procedures of Sky Scanning for Lookouts Aboard Ship. July 1945 Minutes 13th Meeting ANOSRD Vision Committee.
20. Experimental Evaluation of the Ship Recognition Trainer. (in preparation).

Reports and other material on research in night vision testing.

21. Report on Reliability Test of NDRC Adaptometer Model II, Conducted at Submarine Base, New London. 28 July 1942, 2 pp.
22. Report: Comparative Study of Adaptometers. 1 December 1942, 31 pp.
23. Further Report on the Testing of Efficiency of Night Vision: Comparative Reliability and Validity Measures on the Adaptometer and the Self-Luminous Telesilhouette Adaptometer. January 1943, 38 pp.

24. A Rapid Procedure for Testing of Night Vision. 5 March 1943, 15 pp.
25. A Report on the Test-Retest Reliability of the Admiralty Mark I Adaptometer. 1943, 4 pp.
26. A Report on the Test-Retest Reliability of the Miles Four-Plaque Adaptometer. 1943, 4 pp.
27. A Report on the Test-Retest Reliability of the Wright Adaptometer. 1943, 3 pp.
28. The New London Hand Dark Adaptometer. 3 pp.
29. Field Tests of the Radium Plaque Adaptometer. 26 November 1943, 30 pp.
30. Instruction for Operations and Maintenance of Radium Plaque Adaptometer. 1 February 1944, 2 pp.
31. Instructions for Administering the Night Vision Test with the R. P. A. 1 Mar 1944, 5 pp.
32. Adaptometers for Night Vision Selection and Classification. 18 June 1944, pp 38-43 of minutes 3rd meeting ANOSRD Vision Committee.
33. The Effect of Increasing the Difficulty of the R. P. A. Test of Night Vision. 25 September 1945, 18 pp.

Reports on Submarine Illumination.

34. Submarine Lighting Requirements for Night Operations. August 1944, 4 pp.
35. Preliminary Report on Conning Tower Illumination. April 1945, 18 pp.
36. Final Report on Conning Tower Illumination. (in preparation)

Miscellaneous Topics.

37. Binoculars with Treated Surfaces. 21 August 1942, 4 pp.
38. Determination of Sky Brightness (A) A Table of Sky Brightness Measurements. 9 August 1944, 2 pp.
39. Use of Binoculars at Night. 31 August 1943, 11 pp.
40. Visual Acuity and Contrast Discrimination through Neutral and Color Filters. 12 June 1945. Confidential supplement to minutes of 12th meeting of ANOSRD Vision Committee.
41. Some Notes on Visual Devices and Procedures on New German Submarines. September 1945, Minutes of 13th Meeting of ANOSRD Vision Committee.
42. The Effects of Paradrine on Night Vision Test Performance. 25 May 1944, 13 pp.
43. Report of Test of Six Pairs of Night Adaptation Goggles. 18 May 1942, 2 pp.

Current Projects:

X-268 (Av-156-a) Field Test of Radium Plaque Adaptometer.

X-270 (Av-158-c) Preparation of Lookout Training Manuals.

X-271 (Av-159-c) Construction and Experimental Testing of Recognition Training
Devices

X-350 (Av-197-c) Predictive Value of the Navy Radium Plaque Adaptometer and
Other Physiological Measures of Night Vision for Score on a
Performance Approximating the Standing of a Night Lookout
Watch.

X-519 (Av-373-p) A Study of the Illumination of the Submarine Conning Tower.

X-612 (Av-314-p) Field Test of Optical Equipment.

X-662 (Av-347-p) Field Test of Optical Instrument and Auxiliary Experiments.

X-638 (Av-330-p) Field Test of the Use of Filters and Goggles in Penetrating
Haze.

X-663 (Av-341-p) Field Test of Dark Adaptation of Divers.

"The three projects X-612, X-662, and X-638 constitute one comprehensive project being conducted for the Bureau of Ordnance covering the field testing of optical equipment. This experiment is a large scale undertaking designed to answer many of the critical problems with respect to the relative importance of magnification, exit pupil and field size. Begun in July 1945, it has involved the full-time operation of a Destroyer Escort, for three and one-half months, and a supervisory observation and statistical staff of four officers and sixty to seventy enlisted men. Preliminary results indicate that the project will be successful and that, on the basis of the results obtained, decisions with respect to optical design may be made on a practical as well as a theoretical basis. Certain phases of the experiment, originally designed for shipboard study, have been transferred to land and will be performed in January, February, and March.

(b) Lookout Training Research:

It should be noted that research in this field included the development and field testing of equipment; introduction and trial of techniques of teaching; coordinating of the recognition training and lookout training programs with the night vision research developments. Discussion of training is reported elsewhere in this history.

(c) Color Vision Testing and Research:

This section of the department really had its origin at a conference held on 11 May 1942 at the Bureau of Medicine and Surgery, concerning the need for re-evaluation of color vision testing and color vision standards. Following this conference, research was initiated on the Royal Canadian Color Vision Lantern, the American Optical Company's Pseudo-Isochromatic Plates, and laboratory

tests of color vision which were used for validation. Representatives of Yale Medical School and of New York University, and officers of the Inter-Society Color Council acted as consultants.

"In order to forward this color vision research, a research associate in the Psychology Department at New York University was commissioned as Lieutenant H-V(S) USNR, and called to active duty in the Medical Research Department. He reported for duty on 10 May 1943 and began a job analysis of color vision in the Submarine Service. A battery of color vision tests and standard procedures were adopted for testing candidates for Submarine Service. The following year the reasons for the failure of the standard Navy test, the A-O plates, were investigated and reported to the Bureau of Medicine and Surgery and a total of over thirty tests for color vision were investigated for reliability. It was decided that the most valid of these tests was a lantern type test. Early in 1944, a lantern was designed by this laboratory for Navy use which was intended to incorporate all the necessary characteristics of a serviceable Navy lantern.

"During the first half of 1944, the Color Vision Laboratory cooperated extensively with the printers of the revised A-O test plates and an experimental purchase, incorporating a number of suggestions by the New London laboratory, was authorized by the Surgeon General in June.

"In the years 1943 and 1944 the Color Vision Laboratory aided the Camouflage Section of the Bureau of Ships in many projects tested at the Submarine Base. In August 1944, a conference was held at the Coordinator's Office which resulted in a request that the Color Vision Section of the Medical Research Department design and build a working model of a permanent Camouflage and Visibility Theater. A staff drawn from the Bureau of Ships, the David Taylor Model Basin, and the Naval Research Laboratory worked over the plans for this Visibility Theater submitted by Medical Research Laboratory. The Medical Research Department was requested to construct this working model, by BuShips confidential letter X-S19-7 GB:vob of 23 October 1944. Construction was begun in the Training Aids Shop in December 1944 and completed in time for demonstration as one of the features of the Army-Navy-OSRD Vision Committee meeting which was held at this Base on 11 and 12 September 1945. This model was dismantled, transported to the David Taylor Model Basin and reassembled there in November 1945.

"As an example of the type of activity of the Color Vision Section, we quote in its entirety the section of the Semi-Annual Report of Activities of the Medical Research Department concerning that laboratory: (July 1944 through December 1944).

"The activities of the Color Vision Laboratory consist of (a) routine examination, (b) research, and (c) development.

"As has been mentioned under Section I, the Submarine Examination Section of this report, screening tests for vision and color vision were given to 640 officers and 6,005 enlisted men. In addition, batteries of special selection tests for color vision were given to 480 officers and men.

"Research was continued under Bureau of Medicine and Surgery project assignments as follows:

X-457 (Av-241-k) - Two prototype models of a Navy Lantern built by Macbeth Daylighting Corp., and are undergoing trials for reliability, validity, and mechanical efficiency.

X-480 (Av-255-p) - The second edition of the American Optical Company's Pseudo-Isochromatic Test Plates was printed from color specifications furnished by this laboratory, and a copy of the new edition is being tested on 400 men in accordance with the directions in the project form.

X-493 (Av-263-p) - Testing was begun with the first two visual screening devices received, -- the Telebinocular and Ortho-Rater, and the scores are being compared with ophthalmological diagnosis.

"Development of special devices was undertaken at the request of other branches of the Service, as follows:

"Permanent Camouflage or Visibility Theatre. After extensive conferences conducted by the Coordinator of Research and Development, BuShips requested that the Medical Research Department, New London, build a large-scale working model of the proposed theatre. Plans for the model have been drawn and submitted to the committee.

"Submarine Identification X-paint. Substantial aid was given to BuAer, BuShips, and other interested parties in the trial of a special identification paint for submarines.

"590-Milli-micron Cut-Off Goggles. At the request of the Experimental and Flight Test Department, U.S. Naval Air Station, Lakehurst, a goggle was developed for checking night lighting installation in blimps. The goggles provide a visual, qualitative check on the presence of non-red light.

"At the invitation of the Aero-Medical Association, convening in St. Louis, an extensive exhibition, made up of charts, instruments and demonstrations, was shown of color vision tests and color standards.

"When requested for specific problems, aid, by way of specifications or materials, was furnished to many activities, including:

"Medical Field Research Laboratory, Camp Lejeune, Specifications for night running lights.

"Camouflage Section, BuShips, Field reflectance scales.

"R.C.N. Medical Research Unit, Toronto, Dichroic filters for tracer goggles.

"National Bureau of Standards, Analysis of Color Vision test scores.

"U.S. Naval Air Station, Lakehurst, Colorimetric transmissions of sample lamps.

"U.S. Naval Air Station, Quonset Point, Filter design re: air-borne search-lights.

"Naval Ordnance Laboratory, Navy Yard, Washington, D.C., Plotting charts, New London RUCS Diagrams #38.

"Army Service Forces, Engineering Board, Ft. Belvoir, Blueprints and filters for testing lantern.'

"In order to bring the report on the Color Vision Section up to date, we quote from the Semi-Annual Report on Activities of the Medical Research Department from January to July 1945:

"The routine testing and research activities of the Color Vision Laboratory were augmented by extensive collaboration with the Camouflage Section of the Bureau of Ships on problems of visibility and concealment. This culminated in a project looking toward the eventual establishment of a Visibility Theater for the study of general problems in vision in addition to those of camouflage and ship design. The building of a large-scale working model was assigned to this department. Good progress has been made, in spite of the delays and difficulties incident to procurement of some of the materials needed. It is expected that the model will be finished in about two months, at which time it will be moved to Washington and set up at the David Taylor Model Basin, where the actual theater is to be built.

"Information and assistance on special color problems were furnished to several nearby Naval activities, and to representatives of the Engineer Board of the War Department, representatives of the Medical Field Research Laboratory, Field Units of the Bureau of Ships, the Navy Ordnance Department, and the Royal Canadian Army Medical Corps.

"In addition to the Model of the Visibility Theater, which has required considerable time and study, the following research projects are in active status:

X-263 (Av-151-C) - The Critical Hue Regions of Transmission of Illuminant A for Deuteranomalous and Protanomalous. Data completed on one of the two hue regions to be studied. Material still not available for completion of second region necessary to be studied.

X-265 (Av-153-C) - Comparative Reaction Times of Submarine Candidates to "Christmas Tree" Signal Lights. Work was interrupted because the subject instrument was required in combat service and procurement problems have prevented further work on this study.

X-266 (Av-154-C) - A Field Test of the Ability of Men with Various Degrees of Color Anomaly to Distinguish Code Colors used Inside of Submarines. Insufficient data taken for report.

X-347 (Av-192-p) - The Critical Hue Regions of Confusion of Pigment Colors Under Illuminant A and Illuminant C for the Color Anomalous. Extensive data taken. Awaits analysis.

X-348 (Av-193-p) - Retention of Discriminable Hue at a Distance for Ten Colors Against the Color of Water. This proved to be a study of color at small subtense and a preliminary report was submitted under date of 20 April 1955 (Interval Report No. 1). Further analysis was made in response to BuShips' request and transmitted as an addenda on 22 April 1944.

X-457 (Av-241-k) - Development and Trial of New London Navy Lantern as a Selection Test for Serviceable Color Vision. Models completely developed and await testing on unselected population.

X-480 (Av-255-p) - Comparison and Evaluation of the Pseudo-Isochromatic Plates for Testing of Color Perception (American Optical Company, Second Edition) with the First Edition of these Plates Now in General Use by the U. S. Navy. Final report submitted under date of 19 March 1945. Request has been made for termination of project and for permission to distribute.

X-502 (Av-315-p) - Effect of Tinted Lenses on Color Vision. This work has been completed and is in process of being issued as Color Vision Report No. 9.

X-613 (Av-315-p) - Development and Trial of Screening Devices for Detection of Anomalous Color Vision for Use in Ophthalmic Instruments. Filters have been examined for use in prospective instrument.

"The staff of this laboratory includes Lieutenant Dean Farnsworth, H(S) USNR, J. D. Reed, PhMlc, USNR, P. Foreman, Y3c, WAVE, and Jerome Nathan, Slc, USNR."

"(d) Ophthalmological Research:

When in October 1944, the Medical Research Department was ordered to undertake the testing of personnel for radar operation, a study of visual aptitudes was required. A project was set up for the purpose of determining the "validity and reliability" of visual screening devices.

"When the visual reliability phase of the work was approached, it was found that ophthalmological research was in a rudimentary state, that clinical procedures were not standardized, and that insufficient data were available with which to evaluate any of the vision tests used in the instruments. Consequently, research and standardization were begun.

"Snellen letter charts were found so unsatisfactory that construction was begun on new ones. Research was therefore directed toward equating the difficulty of letters and discovering natural step intervals.

"As a result of reports before the Army-Navy-OSRD Vision Committee on 10 April 1945, a Subcommittee on Procedures and Standards for Visual Examinations was set up for the purpose of issuing a standard manual of instructions for testing visual acuity and to investigate more reliable test charts for visual acuity, methods of testing phorias, and physical conditions surrounding the tests.

"The writing of the Manual for Testing Visual Acuity was undertaken by Medical Research Department. During the subsequent weeks, a draft of a proposed manual was prepared, and revised at ANOSRD Committee and Subcommittee meetings."

Following the cessation of hostilities, the demobilization process began and personnel losses were heavy throughout 1946. However, in order to compensate for this and insure the continuation of the research program at New London, the civilian complement of the Medical Research Laboratory was increased and additional

civilian personnel were added to the laboratory staff, particularly in the Professional and Sub-Professional classifications. There was some delay while the new members of the staff became indoctrinated and picked up the threads and continued the program; however, as this is being written, in May of 1947, there are six officers, 13 civilians and 18 enlisted personnel in the research activity. Most of the schools have been assigned to the cognizance of the Submarine School, the exception being the Pharmacist's Mates. As an indication of the type of continuing work, the following is the list of projects active as of this date:

X-263 (Av-151-C): "The Critical Hue Regions of Transmission of Illuminant A for Deuteranomalous and Protanomalous",

X-266 (Av-154-C): "A Field Test of the Ability of Men with Various Degrees of Anomaly to Distinguish the Color of Signal Lights at Night".

X-347 (Av-192-p): "The Critical Hue Regions of Confusion of Pigment Colors under Illuminant A and Illuminant C for Color Anomalous".

X-613 (Av-269-p): "The Development and Trial of Screening Devices for Detection of Anomalous Color Vision for Use in Ophthalmic Instruments".

X-721 (Av-377-w): "A Study of the Distribution of Degree of Color Anomaly in an Unselected Population by a Battery of Pass-Fail Tests".

X-729 (Av-318-e): "Investigation of a Method of Physical Specification of Filters in Relation to Perceptual Differentiation of Color".

X-764 (Av-391-k): "Specification of Polychromatic Plates for Use in Screening in the Military Services".

X-423 (Av-277-K): "Variations in Visual Acuity Under Conditions of Low Illumination; Possible Use as Selection Procedure and in Assignment to Duty".

X-493 (Av-263-p): "Comparison of Various Screening Devices with Standard Medical Procedure".

X-638 (Av-330-p): "Field Test of the Use of Filters and Goggles in Penetrating Haze".

X-662 (Av-347-p): "Field Test of Optical Instruments and Auxiliary Experiments".

- X-757 (Av-387-k): "Comparison of Three Measures of Night Vision".
- X-243 (Sub.No.47): "Relationship of Personnel Selection Devices to the Behavior of Criteria of School Performance and Performance on Submarine Patrol".
- X-566 (Sub.No.119): "Analysis of Rejections in Submarine School".
- X-596 (Sub.No.128): "Analysis of Examinations of Personnel Received for New Construction and for Reassignment".
- X-329 (Sub.No.58): "Relationship between the Audiogram at High Frequencies and Proficiency in Sonar Performance".
- X-487 (Sub.No.100): "The Comparative Efficiency of the Whispered Voice and Pure Tone Audiometry for Testing Auditory Acuity".
- X-619 (Sub.No.134): "A Study of the Relationship of Certain Auditory Selection Tests and Proficiency in Sonar Performance".
- X-745 (Sub.No.152): "The Psychophysiology of Loudness Discrimination for Complex Tones".
- X-746 (Sub.No.153): "The Estimation of Percentage Hearing Loss from Pure Tone Audiogram".
- X-747 (Sub.No.154): "The Psychophysiology of Pitch Discrimination in a Noise Background".
- X-761 (Sub.No.163): "The Incidence of Deafness among Navy Veterans".
- X-606 (Sub.No.131): "Preliminary Study of the Effect of Snorkelling on Submarine Personnel".
- X-713 (Sub.No.145): (a) "Investigation of Adrenal Cortical Functions in Relation to Stress Situations".
(b) "Investigation of the Relation of Androgen Excretion to Body Type, Physical Fitness, and Psychiatric Status".
(c) "Investigation of the Relation of Rorschach Scores to Psychological Stress and Tension Factors as Indicated by Urine and Blood Analyses".
- X-752 (Sub.No.155): "A Study of Procedure for Training Personnel in the Making of Free Submarine Escapes".

X-753 (Sub.No. 156): "Field Study of the Effects of Snorkelling on Submarine Personnel".

X-707 (Biodyn.53): "Comparison of Flotation Characteristics of Various Types of Life Preservers".

Special note should be given to the work more specifically related to submarine operational problems. Of primary interest in this field are listed the following:

X-752 (Sub.No. 155): - Study of Procedure for Training Personnel in Making Free Escapes.

A visit of the British Submarine Escape Committee to Submarine Base, New London, in July of 1946 stimulated renewed interest in the practicability of training submarine personnel in the procedure of making "free" escapes from submarines. A review of the finding of the British Committee's survey of all recorded submarine disasters showed that more men have escaped from sunken submarines without the use of submarine escape devices than with the use of such equipment. It is believed that many more could have survived had they been trained in making free escapes.

It had been standard practice for over five years for all instructors at the Submarine Escape Training Tank, New London, to make free escapes from all depths to 100 feet during Tank operations. Over 15,000 such free escapes had been made by trained instructors without a casualty. The method used in making these free escapes had been to slowly exhale during the ascent, these being free floating escapes (without buoyancy apparatus or ascending line), the speed of ascent being regulated by the amount of air exhaled at a given depth.

A project was therefore proposed and approved in August of 1946 for the study of the time required for training submarine personnel in making such free escapes. It was also proposed to study whether or not preliminary "Lung" training would facilitate "free escape" training, and to ascertain the practicability of training all submarine personnel in making "free" escapes, and perfect techniques of making this type of ascent. Volunteer subjects have been used throughout. To date approximately 250 men have received this type of training and results are most promising. Work has been begun on an immersion suit which it is hoped will be suitable for protection to the escapee and will provide added positive buoyancy.

X-753 (Sub.No. 156) - Field Study of the Effects of Snorkelling on Submarine Personnel.

When German submarines fitted with the snorkel (a retractable breathing tube for procuring air from the surface for engines of a submarine remaining submerged) first became available to us at the close of the war, very little information was available concerning the effect of personnel and living conditions within the boats. Some reports had been made of serious difficulties resulting from the use of this device. Since the snorkel is fitted with a head valve which closes automatically to prevent intake of water when the top of the snorkel tube is ducked, and the sudden closure of this main air intake to the boat causes a sudden and violent change of pressure within the submarine, reports of ear pain and even ruptured ear drums were prevalent, as well as some reports of nausea, disturbance of sleep and other difficulties.

Accordingly, a preliminary study of effects on personnel was requested and approved as of 12 June 1945. A parallel study was assigned to NMRI and the investigators cooperated closely in their investigation and collaborated on some of the formal reports.

Members of the crews of the captured German boats were interviewed at Portsmouth, N.H. in 1945. Medical officers making this study rode the snorkel boats on experimental runs.

Some delay was inevitable due to the engineering problems in connection with installation of this snorkel device in U. S. submarines and conversion of several of our submarines. After the completion of two reports, the original project X-606 was terminated and a new, more, comprehensive study outlined and approved as X-753.

Studies so far indicate that the effects on personnel are not as serious as at first anticipated, but due to priority of operational considerations, it has not yet been possible to assign a boat to the exclusive investigation of this problem. It seems likely that with maximum pressure fluctuations continuing over extended periods of time sufficient discomfort may be experienced by sleeping personnel that construction of a pressure constant sanctuary may be necessary.

X-713 (Sub.No. 145) - The so-called "Keto-Steroid project, which has three phases:

- (a) Investigation of Adrenal Cortical Functions in Relation to Stress Situations;
- (b) Investigation of Relation of Androgen Excretion to Body Type, Physical Fitness, and Psychiatric Status;
- (c) Investigation of the Relation of Rorschach Scores to Psychological Stress and Tension Factors as Indicated by Urine and Blood Analyses.

The so-called "17-ketosteroid project" (BuM&S Research Project NM 003 017) was instituted to investigate the 17-ketosteroid excretion and blood lymphocyte changes in connection with stress situations, especially that of the Escape Training Tank. Other areas of investigation such as anthropometric measurements and body typing, physical fitness tests, psychological and psychiatric tests and blood cellular alterations were included in the program. A total of some 400 variables were obtained on each of 120 subjects. For purposes of convenience in handling the large quantity of data, results were grouped into thirteen sub-studies and each area or matrix subjected to a factor analysis in order to reduce the 400 variables to some 10 to 15 independent and significant factors.

It was hoped that on the basis of this study it might be possible to establish a simple selection battery consisting of the primary physical, physiological and psychological data which would then be validated on a second large independent population. The results of this second study, simpler in design and consequently larger in scope, could then be employed as the means of selecting future candidates for Submarine School.

It is believed that this is the first time in research history that such data has made available the possibility of inter-relating in a single population measures from a number of related but distinct scientific fields - the medical, the anthropometrical, the psychological, the psychiatric, the physiological, and the biochemical, and we are proceeding carefully and cautiously with the first comprehensive examination of the interrelationships in these areas.

From the basic measurements obtained on a population of 120 enlisted submarine candidates, some 57,630 correlation coefficients were possible. Since many such comparisons would be of little interest, the variables were broken into natural sub-divisions in an attempt to find the number of basically different, yet reliable, types of measurements within each sub-division or area, and to study the interrelationships among these more stable measurements. The basic measurements were divided into 8 sub-sections, 3 of which were in turn sub-divided again to provide a total of 13 sub-sets of data which were in turn sub-divided again to provide a total of 13 sub-sets of data which were adapted for handling by I. B. M. methods. The areas of study selected were:

- | | |
|-----------------------------|-------------------------------|
| 1. Physical Fitness | 8. Blood Data |
| 2. Ketosteroid | 9. Blood Ratios |
| 3. Psychiatric | 10. Blood Mean Percentages |
| 4. Physical Characteristics | 11. Absolute Blood Count |
| 5. Anthropometric | 12. Blood Differential Ratios |
| 6. Rorschach (1) | 13. Psychological Tests |
| 7. Rorschach (2) | |

It is planned to devote a separate report for each of the thirteen areas into which the data have been divided.

IX RECOMMENDED ORGANIZATION FOR ANY FUTURE EMERGENCY

Following the close of the war the Medical Research Laboratory, Submarine Base, New London, in compliance with a request from the Navy Department, wrote a chapter on "Submarine Medicine" for inclusion in 'SUBMARINE WARFARE INSTRUCTIONS, 1946,' in which recommendations were made concerning the organization believed to be essential so far as the medical needs for any future emergency are concerned. This chapter is included in its entirety and in exactly the same form as submitted to the Navy Department. We believe that it serves as a fitting climax and summary to this history and in addition outlines the organizational setup which will function most efficiently for routine peacetime operation, as well as in case of any future emergency.

SUBMARINE MEDICINE

(As submitted for Chapter XI of Submarine Warfare Instructions 1946)

1100 Organization

Submarine Medicine is a distinct medical specialty, requiring special selection and training of medical personnel. The submarine medical officer works in close unison with the entire Submarine Force, therefore, the medical facilities require special treatment and separate organization from the general medical department organization of the Navy.

1101 The Submarine Force

The Submarine Force should include one qualified submarine medical officer and one Hospital Corps officer qualified in submarines. Either or both of these officers might be carried in additional duty status, with their primary duty being on a Base or Tender.

1102 The Submarine Squadron or Division

One qualified submarine medical officer should be attached to the staff of the squadron, serving aboard an operating submarine, with additional duty on a Tender or Base serving the Squadron. The Division should have one Hospital Corps officer qualified in submarines attached to the Division staff, or with additional duty to the

staff and primary duty on a Submarine Tender or Base serving the Division.

1103 The Submarine

The experience of the recent war indicated that the ideal medical organization for a submarine should be composed as follows:

- (a) One well qualified submarine pharmacist's mate should be aboard at all times;
- (b) One additional pharmacist's mate should be carried whenever possible, for purposes of training and indoctrination;
- (c) One qualified medical officer should ride one of the submarines of the Squadron, for purposes of training;
- (d) The medical equipment of each submarine should be standardized as supplied by the Naval Medical Supply Depot and as augmented by the desires of the individual medical officer or pharmacist's mate.

1104 The Submarine Tender

The Medical Department of a Submarine Tender is the facility from which the submarine derives all medical aid, medical personnel, and medical equipment. It should be organized as follows:

- (a) The squadron medical officer shall have additional duty on a tender. The light of our war experience has shown that the squadron medical officer must be a qualified submarine medical officer and not simply the senior medical officer of the Tender;
- (b) A pool of pharmacist's mates qualified in submarines shall be maintained aboard each submarine tender, so as to allow rotation from submarines to surface craft tender duty. This rotation of duty allows for continuous training, keeps qualified men with the Submarine Force, and makes them available for assignment to submarines by the squadron medical officer.
- (c) The Submarine Tender shall carry additional medical supplies for issue to submarines;
- (d) The Submarine Tender shall maintain sick bay facilities and other medical and dental services.

1105 The Submarine Base

The Medical Department of a Submarine Base should be organized as follows:

- (a) The Submarine Base shall have at least one qualified submarine medical officer attached;

(b) The Submarine Base shall maintain a pool of qualified pharmacist's mates, so as to allow rotation from sea to shore duty, thus keeping well qualified men within the Submarine Service, and integrating the training and assignment program with that of the Squadron;

(c) The Submarine Base shall act as a supply depot for medical supplies and equipment, as replacements for the original allowance;

(d) The Submarine Base Dispensary shall furnish hospitalization for patients transferred from submarines or from tenders, and any other medical or dental service required.

1106 The Submarine Escape Training Tank

The medical problems to be expected during training of submarine personnel in the use of the submarine escape appliance are such as to require:

(a) Two qualified submarine medical officers attached to the Submarine Escape Training Tank, or with additional duty to the Submarine Escape Training Tank;

(b) One of these qualified submarine medical officers shall be present at all times during operation of the pressure chamber;

(c) One of these medical officers shall examine candidates prior to training and determine their fitness for training at that time. He shall supervise the giving of the 50-lb. pressure test, which is one of the requirements of the physical examination specified in the Manual of the Medical Department, Par. 211334. He shall be present during the actual "lung" training and be responsible for the treatment of any casualties which may occur; and observe the performance of candidates under training, in order to determine their emotional stability under stress conditions and shall review, or refer for review and possible disqualification any candidate showing questionable emotional traits, as brought out by lung training.

(d) The experience of the last war clearly indicates that because of the numerous responsibilities under medical cognizance in connection with submarine escape training, it is advisable to have this activity under the jurisdiction of a qualified submarine medical officer. Such an arrangement worked ideally at the Submarine Base, New London, Connecticut, throughout the war period.

1107 Submarine Medical Research

Submarine medical research proved to be of such value, prior to and during the war period, that it is imperative that it be continued during the peace in such a way as to allow easy expansion during any possible future emergency. The organization of the Medical Research Department at the Submarine Base, New London, Conn., could be used as an example and, based on its experience, it is felt that any active

submarine medical research unit should include the following personnel:-

(a) Three qualified submarine medical officers, the senior of whom could be the staff medical officer for the Submarine Force of that area, and the other two could have additional duty at the Submarine Escape Training Tank, if the unit were based near such a tank.

(b) A medical officer specializing in ear, nose, and throat.

(c) A medical officer specializing in psychiatry.

(d) Two Hospital Corps officers, qualified in submarines,

These officers could have additional duty in a Division, if indicated.

(e) Hospital (Specialists), Civil Service employees, and technical specialists, as necessary to conduct the research program.

(f) As many Pharmacist's Mates as may be necessary for the specific research program, --25% of whom should be qualified in submarines.

1110 Medical Personnel, Their Qualification, Training and Duties

As noted in Paragraph 1100 under organization, submarine medicine is a distinct medical specialty, and therefore the special qualifications and training required to carry out the duties of submarine medical personnel are herein defined.

1111 The Submarine Medical Officer

The submarine medical officer shall meet the following qualifications:

(a) He shall be qualified in accordance with the Bureau of Naval Personnel Manual, Par. E-1314 (rev.). In addition to this, the experience of the last war demonstrated that it is highly desirable for him to serve at least twelve (12) months "attached to and serving aboard" an operating submarine. He would then be well qualified as both a submarine and diving medical officer.

(b) The training of a submarine medical officer is outlined in the listed qualifications for entrance into the Navy Medical Corps and for his designation as a qualified submarine medical officer.

1112 The Submarine Medical Officer's Duties.

In addition to the duties of a medical officer of the Navy, as outlined by the Manual of the Medical Department and Navy Regulations, the submarine medical officer shall comply with the following:

(a) He shall keep himself fully informed of the progress of current research and developments which may have medical significance applicable to the Submarine Service.

(b) He shall carefully examine and determine the fitness of officers and men for the Submarine Force, in accordance with existing regulations and standards prescribed by BuPers and BuMed. It is highly desirable that only a qualified submarine medical officer shall determine the fitness of officers and men for submarine duty.

(c) He shall conduct physical examinations of divers and candidates for training in diving and supervise the administration of the 50-lb. pressure test in accordance with the Manual of the Medical Department, Par. 21134. He shall be present at diving and salvage operations as prescribed in the Diving Manual.

(d) In addition to the regular duties described above, the submarine medical officer shall have certain special duties as outlined below:

(1) When serving on the staff of the Submarine Force, --duties as outlined by BuMed directives and as organized by the Force command.

(2) When serving with the squadron, --as outlined by BuMed directives and as organized by the Force and Squadron commands.

(3) When attached to and serving aboard a submarine, --either on practice war patrols, or actually on combat patrols, he shall act as an observer for the purposes of his further training and indoctrination, and in order to establish complete liaison and coordination between the submarine line officers and the medical officers.

(4) When assigned special research projects, he shall carry out the investigation assigned.

(5) He shall constantly observe and report upon conditions of a medical nature requiring investigation or change.

(6) When attached to a Squadron or a Submarine Base, with additional duty to a Submarine Tender or Base, he shall perform the primary medical duties as outlined or assigned for a Squadron medical officer. He shall be responsible for the Sanitary and Safety inspections and for First Aid and Venereal instruction

for the submarines of the Squadron. He shall be responsible for the training of the pharmacist's mates of the Squadron and for the proper conduct of the Medical Department. He shall keep the squadron commander informed concerning the detailing of the pharmacist's mates.

(e) Rotation of Duty. An attempt should be made to keep qualified medical officers in the Submarine Force by rotating them to one of the following duties: Submarine duty; Submarine Base dispensaries; Deep Sea Diving School; Experimental Diving Unit, Washington, D.C., Naval Medical Research Institute, Bethesda, Md.; Research Division, Bureau of Medicine and Surgery; Medical Research Department, U.S. Submarine Base, New London; and to Submarine Tenders and to Diving and Salvage units.

1113 The Submarine Hospital Corps Officer.

The qualifications of the Submarine Hospital Corps Officer and his duties are outlined below:

(a) The Submarine Hospital Corps Officer shall have been a qualified Chief Pharmacist's Mate with at least two years' service in submarines.

(b) Duties: Wartime experience demonstrated that it was highly desirable that one HC officer be assigned to each Submarine Force and to each Submarine Tender and Base. In addition to those assignments, they are required in research units in such numbers as may be indicated by the volume of the work assigned. Their duties in all of these promulgated in the Manual of the Medical Department or as directed by other competent authority; and they shall in all cases act as the assistant to the Submarine Medical Officer of that activity to which he is attached.

1114 Qualification of the Submarine Pharmacist's Mate

The Submarine Pharmacist's Mate must have the following qualifications:

(a) The submarine pharmacist's mate must meet the requirements set by Bu-Med and PhM's on independent duty and in addition be specifically trained for duty in submarines, after having passed the entrance examinations for enrollment in the School for Pharmacist's Mates Entering the Submarine Service.

(b) Training: The submarine pharmacist's mate must successfully complete the School for Pharmacist's Mates Entering the Submarine Service; or have previously served on an operating submarine for at least a year. He must successfully com-

plete the Basic Submarine School, Submarine Base, New London, Connecticut; or have previously served successfully on an operating submarine for at least a year. He should have at least a week of special instruction in the use of the submarine escape apparatus and related safety appliances, including some knowledge and treatment of caisson disease.

1115 Duties of the Submarine Pharmacist's Mate

The duties of the submarine pharmacist's mate shall be as follows:

(a) The submarine pharmacist's mate shall be responsible for the care of the sick and injured and for the institution and observation of all safety regulations. He shall work closely with the Squadron Medical Officer, his immediate medical superior, keeping him informed on medical problems. He shall keep complete records; make proper entries in the Health Records, and complete such records to BuMed and Force commands as required. He shall be responsible for the immunization, vaccination, and prophylaxis, of officers and crew, as required. He shall make sanitary inspections and keep the Commanding Officer advised as to conditions, --in galleys, heads, washrooms, refrigerator spaces, etc. He shall make necessary safety inspections. He shall be responsible for maintenance of the "lungs", oxygen, etc. in proper working order and that the crew are familiar with the method of escape and the handling of the necessary locks and equipment. War experience demonstrated the desirability of the pharmacist's mates performing general submarine operational duties and such special duties as were assigned, such as sonar operator, radar operator, day or night lookout, etc.

(b) Rotation of Duty. Pharmacist's mates should be kept within the jurisdiction of the Submarine Service by rotation to a Submarine Base, either in the States or foreign shore, to Submarine Tenders and to Research activities.

1120 Medical Aspects of Submarine Operation

Due to the highly technical nature of the medical aspects of submarine operation, a detailed discussion is presented below:

1121 Medical Aspects

The purely medical activities may be considered under the heading of medical treatment and medical records.

(a) Medical treatment shall be conducted as laid down in the Manual of the Medical Department and the various BuMed directives, and in accordance with the best medical and surgical judgment of the medical personnel involved. Due to the

limitations of space, and problems of ventilation, air purification, etc., patients should be transferred for treatment and/or hospitalization to a Tender or to the nearest Base or Naval Hospital whenever possible.

(b) The Commanding Officer shall include in the patrol report pertinent information concerning all illnesses and injuries and shall be responsible for the admission to the Sick List of the personnel involved (even if no Sick Days are involved), and shall see that suitable entry is made in the Health Record. Appropriate entry shall also be made in the Ship's Log concerning all such occurrences.

1122 Medical Examinations

Various special physical, psychological and psychiatric examinations and evaluations are required by the Manual of the Medical Department, Par. 21133 and 21134, and by Bureau of Personnel directives, and these shall be conducted under the supervision of a qualified submarine medical officer.

(a) He shall determine the fitness of all candidates for Submarine Service in accordance with Bureau of Medicine and Surgery directives.

(b) Special examinations shall be conducted, as required by E-1306, BuPers Manual, to determine the physical fitness of officers for qualification in submarines.

(c) Wartime experience has indicated that pre- and post-patrol physical examinations of all officers and men are highly desirable. These examinations should be carefully conducted and should include a psychiatric examination in order to determine the necessity for treatment or rest. Before and after each patrol, the squadron medical officer shall submit a written report to the Squadron Commander concerning the physical fitness of the Commanding Officer and all officers and men of each submarine crew.

(d) Any submarine personnel referred by the Commanding Officer or by other medical activities, or by any competent authority shall be examined for fitness for retention in the Submarine Service.

(e) Physical examination for entrance into, or continuance in deep-sea diving shall be conducted in accordance with existing instructions.

(f) Physical examination shall be conducted prior to submarine escape training, particular reference being made to otological, circulatory, and respiratory conditions.

1123 Dental Aspects

The dental aspects of submarine medicine may be considered under the following heads:

(a) It shall be the duty of the dental officer to assist the submarine medical officer by conducting the dental part of all of the various examinations mentioned above and authorized by existing directives.

(b) Experiences of the recent war demonstrated very clearly that it is imperative that each man going to sea on a submarine have all necessary dental work accomplished, and his mouth in as perfect a condition as possible, prior to his departure. The dental officer shall exert every effort toward taking the proper care of submarine personnel immediately prior to a war patrol.

(c) The dental officer shall assist with the training of submarine pharmacist's mates so that they will be qualified to diagnose and treat any dental conditions that may develop at sea.

1124 Hygiene and Sanitation

In each Submarine Force activity, the assigned submarine medical officer and the submarine pharmacist's mate shall be responsible for seeing that all hygiene and sanitary regulations which are promulgated by competent authority are strictly complied with.

(a) They shall be especially responsible for seeing that proper conditions exist in regard to: water supply, food and food storage; heads and general toilet facilities; galley; living spaces; including bedding; and noxious gases.

(b) They shall familiarize themselves with the medical problems of the geographic area in which the Submarine Force is operating and bring to the attention of the proper authorities any necessary facts contributing to, or hazardous to, the health and comfort of the men. (See Manual of the Medical Dept. Section IV, Par. 35D14 and 15, Page 425).

1125 Special Submarine Problems

Special submarine problems may be considered under the following heads:

(a) Air Purification. The submarine medical officer and the submarine

pharmacist's mate will determine that the proper conditions and facilities exist in regard to: oxygen supply, carbon dioxide removal, temperature and humidity control, control of noxious gases, such as chlorine, carbon monoxide, etc., and will report any deficiencies to the proper authorities. They will conduct a program of education for officers and men in the problems of air purification and the physiology of air pressure. Lectures and literature should be utilized.

(b) Submarine Escape, Rescue, and Salvage. The medical officer and the pharmacist's mate on independent duty will take an active interest, and shall participate in all drills, training and educational activity related to submarine escape or "lung" training; shall stand by during pressure test and actual training in the Training Tank. When aboard ship he shall be responsible for indoctrination and training of the officers and crew of the submarine in escape procedures and in the use of the "lung". He shall be responsible for inspection of the "lungs" and oxygen fittings, etc., to see that they are in working condition. All qualified medical officers shall keep themselves completely familiar with all of the literature and techniques and shall be present during the practice drills, and during any actual submarine rescue or salvage operations which may occur.

1126 Submarine Medical Research.

This vitally important subject is presented as a separate unit, as paragraph 1130.

1130 Medical Research.

Submarine medical research will be discussed under the headings of: location, personnel; and the Medical Research Department of the Submarine Base, New London, will be discussed as an example of such a submarine medical research activity.

1131 The Location for Submarine Research.

The ideal locations for submarine medical research are considered to be as follows:

(a) The Submarine Base, New London, is well located for the principal submarine medical research unit, since it is there that most of the personnel enter the service for the first time, and it is there that the new submarines are commissioned, outfitted, and the crews trained for their wartime missions. In order to properly coordinate all of the submarine medical research, it has been shown

to be highly desirable to have the Head of the Medical Research Department of the Submarine Base, New London, designated as coordinator of all submarine medical research activity.

(b) In the recent war, the Submarine Base, Pearl Harbor, proved to be the logical site of various phases of field research. However, the location of this type of research unit would depend upon the sphere of naval operations in any future conflict.

(c) Research of certain types must be conducted aboard the submarine tenders, and submarine rescue ships, and war experience has indicated that more should have been conducted aboard operating submarines, -- even if such work might detract somewhat from the military efficiency of an operating submarine.

(d) Certain types of research work associated with the general submarine medical research program can best be conducted at Naval Medical Research Institute, Bethesda, Maryland; at the Experimental Diving Unit, Naval Gun Factory, Washington, D.C.; and the Naval Research Laboratory, Anacostia Station, Washington, D.C., and other areas as may be indicated by the nature of the situation which may develop.

1132 Personnel.

Due to the uncertainty as to the type of naval personnel envisioned for the peacetime Navy, the following discussion of personnel will be patterned after the organization during the recent war.

(a) Medical Officers.

The majority of medical officers assigned to any of the submarine medical research activities shall be qualified submarine medical officers; others should be specialists in psychiatry, ophthalmology, otology, etc., in such proportions and numbers as necessary for the conduct of any particular type of experimental work undertaken. These medical officers should be furnished by the Bureau of Medicine and Surgery.

(b) Hospital Corps Officers.

Hospital Corps officers should be supplied in numbers required to handle the billets as personnel officers, property officers, and general administration officers, as well as to serve as officers in their technical specialties.

(c) Hospital (Specialist) Officers.

H(S) officers, (a wartime designation which may or may not be retained), shall be assigned in sufficient numbers to each submarine research group to handle such special duties as required in the fields of physiology, chemistry, physics, bacteriology, statistics, etc.

(d) Pharmacist's Mates.

At least 25% of the pharmacist's mates should be qualified submarine pharmacist's mates.

(e) Civilian Personnel.

Special civilian technicians and clerical assistants in Professional, Semi-professional, and CAF classifications should be provided as necessary for the conduct of various types of special research. Wartime experience indicated that this type of research assistant was highly desirable.

1133 Medical Research Department, U. S. Submarine Base, New London.

This outline of the wartime functions of the Medical Research Department of the U. S. Submarine Base, New London, Connecticut, is presented as a guide for planning any central submarine research unit which may be required. During the war this department was charged with the selection of all submarine personnel, and was responsible for the development and standardization of a battery of special selection tests. In addition, research was conducted in the following fields: Day vision, night vision and color vision; hearing and auditory problems; personnel selection techniques; and research on problems of a more specific submarine nature. All of the above activities are now in operation and it is contemplated they will be continued into the peacetime.

(a) Submarine Selection Activity. Selection procedures are subdivided as follows:

(1) Selection of personnel for entrance into the Submarine School and the Submarine Service is accomplished under Bureau directives, by various physical, psychological, psychometric and psychiatric evaluations.

(2) Physical examinations are conducted for the designation of officers as "qualified in submarines".

(3) Physical examinations are conducted for entrance into and continuance in deep-sea diving.

(4) Special examinations are conducted for continuance in Submarine Service.

(5) Special examinations are conducted for various designated tasks:-- night vision for lookouts; visual examinations for radar operators; auditory and psychometric examinations for selection for sonar school, etc.

(b) Research in the following fields is assigned by directives and is financed by funds from cognizant Bureaus:

(1) Personnel Selection. Tests for selection of officers and enlisted men were developed, validated, and put into routine use. This work was done in cooperation with the Bureau of Naval Personnel.

(2) Visual research was conducted at all levels, --scotopic, mesopic, and photopic, including field trials of various visual aids; and special work in color, including color perception and camouflage.

(3) Auditory research. Tests were developed for the selection of sonar personnel and work was done in connection with the training program for sound operators. A treatment was used experimentally (using radium) for men who were unable to "clear" their ears under increased atmospheric pressure. This enabled the utilization of hundreds of desirable candidates who otherwise would have been lost to the Submarine Service.

(4) Research was conducted in problems of a more specific submarine nature, such as: air purification, water supply, submarine safety and salvage, submarine escape, snorkelling, etc.

(c) Various School and Training Activities were conducted during the war period, as follows:

(1) School for Pharmacist's Mates Entering the Submarine Service. This consisted of eight weeks special course preparing carefully selected and trained pharmacist's mates for duty aboard submarines.

(2) Submarine Escape Instruction. The medical aspects of the operation of the Submarine Escape Training Tank have been clearly defined in Par. 1106, but it seems wise to point out again the desirability of medical jurisdiction over the operation of an escape tank. Under medical supervision of lung training at New London during the period of war, 46,809 escapes were made with only two minor cases of air embolism. The training in the Tank proved to be sufficient as a stress

situation to reveal such conditions as claustrophobia and emotional instability, and thus was used as a part of the medical selection.

(3) Lookout Training School: Because of the close relationship of this training to selection and experimental work in night vision, operation of this school was assigned to the Medical Research Department. This arrangement was highly satisfactory, since new techniques could be readily tried out, modified as necessary, and then put in regular use.

(4) Telephone Talkers School or Interior Voice Communication School. This school came under the cognizance of the Medical Research Department because of its relation to the problem of the selection of interior voice communicators; the school was organized and administered by this department during the entire war period.

(5) School for Second Class Divers. This school was organized because of local need and administered by the Medical Research Department during the war period, because the various medical officers attached to that department were also all qualified deep-sea divers.

1134 Field Research Stations.

It is highly desirable to have field units available for undertaking projects as necessary in communication with the various activities previously enumerated, as indicated in Par. 1131 and 1132. It has been amply demonstrated that field conditions cannot be duplicated exactly in the laboratory. Field units are proving stations for techniques developed in the laboratory.

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