

MINES

against Japan

NOL

NAVAL ORDNANCE LABORATORY
White Oak, Silver Spring, Maryland

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by

ELLIS A. JOHNSON
and
DAVID A. KATCHER

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MINES AGAINST JAPAN

PUBLICATION NOTICE

This book was prepared by Dr. Ellis A. Johnson as a record of mine warfare activities in the Pacific Theater during the war against Japan. He received editorial assistance from Mr. David A. Katcher. This document was originally prepared in classified form in 1947. Initially the material was outlined in twenty chapters which were to have been published in a two-volume work. Many of these chapters were not completed by the designated authors as planned. In view of this circumstance a second volume is not anticipated. The book here consists of eleven chapters which were fully developed. They have been designated in continuous numerical sequence. The pagination has been made consecutive and charts and figures have been redesignated to show these changes. The original classification has been removed. A few typographical errors have been corrected. Annex G of Chapter 8 has been deleted for reasons of security. Otherwise no alterations in the text have been made. It is believed that the present chapters constitute a significant entity as presented and convey the opinions of the authors. Publication of the book does not, however, constitute Department of Defense endorsement of the opinions, conclusions, and recommendations, nor certification of its detailed accuracy.

The development of influence mines was a miracle of World War II. It resulted from the concentrated application of technology to this mode of subsurface warfare. It was accomplished by the contribution of many prominent scientists and engineers who left their academic and industrial pursuits to provide new strength for the defense of the country against authoritarian aggression. These people were brought together in a sudden enlargement of a World War I organization which has come to be known as the Naval Ordnance Laboratory. They were recruited by Dr. R. D. Bennett for the organization of which Dr. R. C. Duncan was the chief scientist. It was recognized at the outset that the functions of this expanding Naval activity were two-fold. It was necessary to have a group whose responsibilities were primarily concerned with research. It was also necessary to have a group effective in translating a large reservoir of science and technology into effective weapons.

The Research Unit was concerned with the applicability of new scientific principles to the development of modern weapons. In this phase of exploration the ideas of many prominent people were solicited. The immediate activities of the local group were concerned with influence fields of ships which could be used for timely actuation of bottom mines. These early studies indicated the significance of many influence characteristics which have been developed in succeeding years. They included magnetic, acoustic, and pressure fields. Other influences which proved less easily adaptable included Alternating Magnetic (AM), Underwater Electrical Potential (UEP), Optic, Seismic, Gravitational, Chemical, and Cosmic Ray. As a result of these basic studies a program for the defense of ships against hostile weapons, existing and under development, was initiated. The analysis and development of passive countermeasures, such as deperming and degaussing, received extensive attention. Methods of detection for locating targets and hazardous underwater ordnance were investigated and promising approaches were applied in development. The Research Unit was initially headed by Dr. Ellis A. Johnson, the primary author of this book.

Simultaneously, the efforts of the Engineering Unit were directed almost exclusively to the development of influence mines. Dr. R. D. Bennett became the Director of the Unit after his initial recruiting activities were largely completed.

The outstanding achievement of the Naval Ordnance Laboratory during this period consisted of the entire process of inventing, testing, and producing influence mines; and of advancing the technique of operational analysis for their effective use. The Laboratory also organized a technical school and trained Reserve Officers in the effective use of this new ordnance. Officers from this reservoir were subsequently assigned to operational areas as required to meet Fleet needs. In addition, the Laboratory provided technical personnel, skilled in electrical and mechanical engineering and in operations research,

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to support the Mine Modification Unit which was located at Advanced Bases in the Pacific. The Mine Modification Unit was made up of officers, professional civilians, and a naval complement. The MMU was established to study intelligence information concerning the mine fields planted by U. S. Forces; to modify mine firing mechanisms for improved damage capability and improved resistance to countermeasures which were being used by the enemy; to conduct full-scale tests of modified mines; to correct mine component material deficiencies; and to provide technical analysis for use in judging the operational significance of proposed mine modifications.

The use of mines against Japan as described in this book provided an unforgettable demonstration of the overwhelming significance of this low-cost weapon system. The enthusiasm and the imagination of Dr. Johnson in providing technical liaison with ADM C. W. Nimitz, USN, and GEN Curtis E. LeMay, USAAF, were largely responsible for the use and outstanding success of this novel subsurface influence weapon. This book recounts some of Dr. Johnson's experiences and describes the principles of mine warfare by which he was guided.

It is a pleasure for me as Technical Director of the Naval Ordnance Laboratory from 1955 to 1973 to be able to release this prophetic book now for publication and distribution.



G. K. HARTMANN
June 1973

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PREFACE

In this report perfection of form has been consistently sacrificed to the prime object of recording the complete war experience with a significant new weapon in a suitable form before the monies, the strength of conviction, and the sharp details of memory have faded. A preliminary version is first offered so that it may be circulated for comment and suggestion before final imprint is made collating the criticism. A modest operation to begin with, it has been necessary to fall short of the normal goals of mechanical excellence on the theory that an unwrapped loaf is better than none when bread is needed.

It was necessary to edit and print the book without materially interfering with various service activities within the Naval Ordnance Laboratory. So each chapter was handled as a discrete entity; some were printed long before the major part of the material was received. Volume I is being published before all the material for Volume II has been written, but the original chapter order, which was planned when the entire work was to come out as one volume, has been retained because some of the last chapters were printed first and numerous cross references already cast. The unique and unfortunate result is that Volume II has been taken out of the middle of Volume I! This irregularity will be remedied in the final version. At the same time an index, glossary, and bibliography will be added for the convenience of the reader.

The material in several chapters of this book has already appeared in print elsewhere (details are given in Acknowledgments). It was recast and included on the supposition that it is more economical to gather between covers all pertinent material on a subject than to burden a reader with the chore of gathering various reports himself or missing them entirely. In all cases, however, the subject matter has been modified to suit the judgment of the principal author. The contribution of the associate author has been that of rewriting, rearranging, and preparing the material for publication.

Expediency has dictated the form of this report, but its content was distilled by Ellis Johnson from the ideas of many men and culled from more than seven years of intimate contact with mines and their use.



David A. Katcher

June 1947

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ACKNOWLEDGMENTS

First, acknowledgment must be made of the men who made the mine a formidable naval weapon by pitting their wits and their strength against the unknowns of science and of enemy activity. Some paid with their lives to home this weapon on its Japanese target. To them goes a tribute which these words cannot measure and which this volume, by recording the complex of experiences which led to mistakes as well as successes, hopes to make valid in the only way they would wish — avoidance in the future of the insufficiencies of experience, judgment, and material which might have sent some uselessly to their deaths.

Of the individual contributions of the many who gave their waking hours, and in some cases their health, there is no adequate acknowledgement in the chapters that follow. It would have been impossible to do justice to all without increasing the size of the volume beyond practicability. The alternative was to give none their personal due except those concerned with high-echelon decisions whose judgments framed the development of mine warfare itself. Another exception is that the several authors, recounting as they do from personal experience, have been unable to eliminate themselves from the text as completely as they have others. To do so without exception would confuse observation with fact, something which this volume shuns.

But particular mention must be made of Captain Tom B. Hill and Commodore Judge Eller who were responsible for the formulation of mine policy and much of the mine planning on the Staff of Commander-in-Chief, Pacific Fleet. The principal author is especially indebted to Commander Ablie Pratt, USNR, who introduced him to "Sound Military Decision" and the "Estimate of the Situation," and spent a great deal of time in teaching him the elementary facts of military planning. He is also indebted to Vice Admiral C. A. Lockwood, Admiral Mark Mitscher, Captain James Lang, Captain Arleigh Burke, and Commander Bob Isley for many critical and skilled discussions on the part played by new weapons, and mines in particular, in the tactical strategy of naval warfare. In the Army Air Forces particular credit must be given to Colonel E. L. Sykes and to Major A. A. Miller for their successful effort in interesting General H. R. Harmon and General Curtis E. LeMay in the intricacies of mining. The support given by Colonel J. B. Montgomery, who was Operations Officer to General LeMay, was vital to the adoption of the plan for mining the Inner Zone. It was the firm belief in and support of the mining effort by General LeMay himself that made the successful campaign possible at all.

The early operational research seminar held at the Naval Ordnance Laboratory, beginning in January 1942, made extraordinary contributions to the ideas of mine warfare. However, its membership of 40 or 50 persons, with many invited guests from the Bureaus of Ordnance, Ships, and Aeronautics, and the Army, is too large to permit including the names of all the individuals. Similarly, the Operational Research Group, first at the Naval Ordnance Laboratory and later at Chief of Naval Operations, also made important contributions. Particular credit in the operational aspects of mine warfare theories should be given to Professor Lloyd Young, of the University of Pittsburgh, who was in the Bureau of Ships in the early part of the war and also to Dr. Thornton L. Page, first as one of the leading civilian members of the operational seminar (then the Operational Research Group) and finally as a Lieutenant Commander, USNR.

Captain James B. Glennon, Commander K. L. Veth, and Dr. R. C. Duncan provided much of the information on the early history of mine warfare of the United States, supplementing the histories of the Naval Ordnance Laboratory and reports submitted by the Department of Terrestrial Magnetism to the Navy Department at the end of World War I. The latter were pointed out by Dr. J. A. Fleming, then the Director of the Department of Terrestrial Magnetism.

The principal author has profited from discussions with Vice Admiral W. W. Smith (then Captain Smith), Chief of Admiral Kimmel, which were held shortly before the Japanese attack at Pearl Harbor. He is also indebted to Dr. J. W. Greig, of the Geophysical Laboratory of the Carnegie Institution of Washington, for discussion concerning the problems in weapons development. Dr. Greig's experience covers both World War I and World War II and thus was of especial value, since he had been in combat and therefore had first hand knowledge of the use of weapons as well as of their development, and he planned

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for their use while he was at Guam as a member of the Operational Research Group with the Army Air Forces. Finally, the principal author is indebted to long and critical discussions with Mr. Robert H. Park, formerly in charge of mine design at the Naval Ordnance Laboratory. He is also indebted to similar discussions with Commander K. L. Veth, Professor S. L. Quimby of Columbia University, Dr. Thornton L. Page of the University of Chicago, and Dr. L. E. Hoisington of the Mine Warfare Section at Chief of Naval Operations.

The idea for the preparation of a critical report on mine warfare was proposed first by Captain R. D. Bennett, Technical Director of the Naval Ordnance Laboratory, but its writing would not have been possible without the warm support of Dr. Vannevar Bush, President of the Carnegie Institution of Washington, and of Dr. Merle Tuve, Director of the Department of Terrestrial Magnetism, who agreed to the assignment of Dr. Johnson to this report for an extended period during the critical post-war conversion. The Naval Ordnance Laboratory furnished the services of Mr. Katcher. Thanks are also due to Mrs. Ella D. Putnam who worked as Assistant Editor.

Thanks are due Commander C. S. Livermore and Mr. K. C. Hayes for their unfailing cooperation in putting at the disposal of Mr. Katcher the facilities of the Publications Division of the Naval Ordnance Laboratory; to Miss Mary Schaefer for her patient editorial help; to Mr. Albert M. Elksnis for his skilled workmanship in production; to Miss Edna Kinman and her colleagues for their cheerful artistry in pulling illustrations out of the barest sketches; and to Mr. Robert Myers for his standards and skill in printing. Other members of the Publications staff contributed their efforts when called upon to help produce this large volume in the relatively short time of about six months.

* * *

Unless mentioned here a chapter is for the most part entirely new.

- Chapter 1 "Mines Before World War II": A. M. Lowe's excellent popular work, "Mine and Countermine" (New York, Sheridan House, 1940) was liberally used for historical background, as was Margaret Tuttle's article on Mahan in "Makers of Modern Strategy" (edited by E. M. Earl, Princeton University Press, 1943) for the history of concepts of naval strategy. Histories prepared by the Naval Ordnance Laboratory were also used, as were reports of the Department of Terrestrial Magnetism to the Bureau of Ordnance on World War I.
- Chapter 3 "Summary of Mining Operations and Results," is based on the United States Strategic Bombing Survey, "Offensive Mining Campaign Against Japan" (Naval Analysis Division, 1946). This was principally prepared by Commander K. L. Veth, together with Lieutenant W. F. Wallace and Commander E. A. Johnson.
- Chapter 4 In the first part of "Mine Policy During World War II" liberal use was made of facts gathered and presented for the first time by Lieutenant Commander Southgate in his unpublished report on the administrative history of Chief of Naval Operations. Commander Southgate, however, cannot be held responsible for any of the conclusions which have been drawn in this chapter or even for the tone in which the criticisms have been presented. Use was also made in this chapter of the Bureau of Ordnance history of mine warfare development.
- Chapter 6 "Outer Zone Operations," is based on the United States Strategic Bombing Survey mentioned above.
- Chapter 7 "Inner Zone Operations," is based on the 20th Air Force publication, "Operation Starvation," which was prepared by the principal author while he was Director of Mining to General Curtis E. LeMay. In the preparation of the original report particular thanks are due to Major G. Brodsky for layout and production. The criticisms of Lieutenant Colonel Pinkham Smith and Captain Hugh Troy were also of particular value. The original report has been reprinted as Chapter 7 with fewer changes than in the use of other material.
- Chapter 8 "Tactics of Inner Zone Mining Campaign," is based on an unpublished report of the 20th Air Force. This was originally written, under the general direction of Lieutenant W. F. Wallace by Lieutenant James Martin, Lieutenant N. D. Rice, Lieutenant (jg) Retherford, Lieutenant (jg) Witted, and others.

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FOREWORD

A year before World War II began, when the Naval Ordnance Laboratory was beginning an expansion which eventually made it one of the largest research and development laboratories in the world, the written record of mine warfare research, development, logistics, and operations, which had survived the attrition of years, could be loosely tossed into one-half a file drawer. This shocked many newcomers who had to repeat some of the work they knew had been done before. And they felt the loss strongly as they painfully groped, with little guidance, to help revive and reform the military strength of the United States against the day war was to come.

Born of this unhappy situation was the determination to keep a written record of the experience gained in World War II to be readily available if ever needed again. This determination was not unique in the Naval Ordnance Laboratory. Almost everybody who could get pen to paper felt that way. World War II is so well documented, the total paper record would probably sink a battleship. But it is no better to be lost in the jungle than to be lost in the desert. After World War I we had too few records. Now we have too many — at least in the sense that documents are so abundant, essential experience can be lost within them. There is a danger that the lessons, the mistakes, the achievements, and the procedures of scientific research and development in World War II, will be lost in the maze of miscellaneous reports, letters, recommendations, directives, specifications, summaries, pamphlets, articles, section files, etc.

The purpose of this volume is to summarize the experience gained in order to provide a ready source of information for those who in the future will be concerned with weapon research and development in general, and with mine warfare in particular. Most of the material presented is factual, a record of events, of mistakes, of achievements. But if this were all, something of great value would be lost — the considered judgment of individuals who were intimately concerned with every phase in the creation and use of a new weapon.

The difficulty is that any judgment, especially post facto and in criticism, may be controversial. If this volume were an official report by the Navy, it would be necessary to eliminate controversy in order to meet a common viewpoint acceptable to all. The presentation would be necessarily emasculated, bled of its untried and disputable strategic points, for only then could an entire organization be committed to it. This would limit the usefulness of this work because its challenge and constructive criticism in peacetime, when criticism is most acceptable, would be removed. This would risk repeating old mistakes.

So this work has been conceived of as a report for the Navy rather than by it. Its individual chapters are the responsibility of individual authors. They have contributed facts and they have contributed constructive criticism from an individual viewpoint derived from their intimate and often primary connection with the happenings they record. Every chapter has been written by a practising member of the professional group or activity which is discussed. Every chapter has been read and criticized by several colleagues of each author. Thus, though each chapter represents an individual point of view, it also contains distillations from many opinions. No fair criticisms have been advertently avoided when the differences of opinion have been vigorous. A fair attempt has been made to present the varying aspects of the argument. Conclusions and opinions are drawn from data which are presented completely so that anyone who so chooses may draw his own and different conclusions.

It is true that many of the lessons learned and presented here are old or rediscovered, and so are the remedies. The authority for the remedies is the direct testimony of developmental and military personnel who have practised what they preached and who have arrived through hard experience at the conclusions put down here. If the conclusions are old ones, they were learned in the same hard old way. But the hard old way is also an expensive one to the nation because it means mistakes are repeated. The difficult task of writing this volume was undertaken in the hope that the nation's security could be achieved more economically by taking advantage of summarized experience. It is felt that the value of this volume will grow with the years, replacing the teaching and continuity now provided by personnel who went through World War II.

For the most part, the successful achievements are not emphasized nearly so much as the failures. Throughout, a determined attempt has been made to make the criticism positive and constructive. This report has not been planned as a record of credit where credit is due, not because such an effort would be without worth, but because it seems more important to point

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to errors and to attempt to prevent their recurrence. An outstanding exception to this is the criticism of the actual mining operations. Those operations are presented in a rosier light than many of the other activities. The authors of these chapters freely admit this, but were unable to avoid it because this part of mine warfare is so new that a more complete technical military criticism of the campaigns will require much more careful analysis than has been heretofore carried out. Considerable detail is furnished and it is hoped that future critiques of these mining campaigns will provide the criticism that is lacking in this volume.

It will not be hard to find personally disagreeable sections. The reader's patience is begged until he has checked the claims on each point. Let him also remember that much of the book is written from the narrow point of view of those fired with the urgency of one particular mission. Therefore, of necessity, the broad objectives of the higher echelons are not always taken into account. This point of view is a deliberate one and necessary if the detailed evidence is to be presented. These details can be skipped by the reader interested only in the fundamental conclusions. Most of them are summarized in Chapters 2, 10, and 11. The other chapters contain detailed evidence which can be referred to for source material when desired. The Naval Ordnance Laboratory would welcome further study and comment on a constructive basis, as would the individual authors.

This is being written more than a year after the end of World War II. At cessation of hostilities, partisanship, repressed during the war for reasons of necessity, has sprung up and compelled many from each profession or group to advance his claim for the decisive role played by his colleagues. But these same men were willing to share the winning of the war a year and a half ago and it is still obvious that the war was won by a partnership. The Navy, the Army, Science, Industry, Management, Labor, Agriculture, and the vast majority of individual citizens in the United States were in this partnership. It was this partnership, largely voluntary, that proved to be so much more effective than the centralized planning of Hitler. No one can honestly claim to have had a predominant part in the winning of the war or in all of its decisive battles.

In keeping with this spirit and their own beliefs, the authors of this book do not claim that mines won the war against Japan. Mines were eminently successful. What they did do was provide the knock-out blow in the maritime blockade of Japan which had almost been completed by the submarines of the United States Navy. Even at the very end of the war our submarines were unable to penetrate the Inner Zone of Japan and were thus incapable of completing the blockade by themselves. Mines played a very important, though not a decisive, part in the war.

It is the nature of this importance, this success, which gives the authors of this book the right to speak and to be heard regarding the weapons which they developed and whose use they guided. The mines used were in essence a new weapon introduced by Germany, adopted by both Britain and the United States, and used very successfully by all three countries. Most of the problems involved in the development and use of mines are typical of the problems encountered in the development and use of many other equally important weapons, as for example, the VT fuze, radar, rockets, or the atom bomb, all of which played their significant and contributing part in the overall tactics of combat. Mine warfare is therefore a good example for discussion of the general problems of weapons development and it is used as a springboard from which recommendations on the overall organization of naval research are made. Mines were largely developed by amateurs and their final use was guided almost entirely by Reserve Naval Officers who were representatives of these same amateurs. From this development comes one of the most important lessons of the war — a sense of where the boundary line should be between the responsibility of the military and of the scientists for their country's defense.

The scientist Naval Reserve Officers were amazed by the fact that wars are won principally by military skill rather than by new weapons, and that in the actual running of the war in combat areas, civilian scientists, except as expert technicians or observers, are about as useful in operations as are professional military men in running a research or development program. The wrong shoe pinches on either foot. Career officers are not equipped, by nature of their training and psychological orientation, to undertake the intimate and detailed direction of research and development. An attempt is made in this volume to steer a middle course between civilian and military points of view, but not to gloss over the fact that in general neither group can claim honestly to possess proven competence in the practice of other's profession.

When the writer was trying to find some way of contributing to military research in the fall of 1939, shortly after war began in Europe, he asked Dr. Ross Gunn, the Superintendent of Electricity and Magnetism at the Naval Research Laboratory, what would be the most effective way of helping the Navy in research. Gunn gave his opinion that the research which would play a decisive part in the tactics of warfare would be finished before war began, and that research begun later would seldom be of much importance to that particular war, although it might be to future ones. Ross Gunn is an old and valued friend, but the writer did not believe him. This is by way of a public apology.

The writer is now convinced that very new weapons do not win the war during which they are developed. In the Pacific, at least, none of the new weapons, including the atom bomb, played a decisive part. In 1942 and 1943, the critical years, there were no new weapons available in the Pacific. The war was fought on a shoestring and its success depended almost entirely upon military skill of the Army and the Navy. By the end of 1943 almost all of the decisive battles had been fought without the benefit of new weapons and the turning point of the war had been reached. It is true that many serious and important

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battles remained to be won, but there was little or no doubt of the eventual outcome.

That is not to decry, however, the importance of new weapons, one of which is described in great detail in this book; it is rather to decry an overemphasis on the supreme importance of new weapons as if novelty alone established their worth. They still have to be good, they still have to be useful, and they still have to be *available* in quantity, with personnel trained in their use, when they are needed. The weaponsmakers of World War II, who were mostly military amateurs (scientists and engineers) from the universities and industry, *were* enormously productive but, though no fault of their own, they were late. This productivity must be channeled and tapped in peacetime if it is to be economical and useful in war. There is a need to plead the cause of economical development, because the actually useful productivity of the war time laboratories was relatively low. For every useful weapon there were dozens or hundreds that might just as well not have been born.

This report will attempt to show why miracle weapons are exceedingly rare and why they are not often possible. Certainly they cannot be depended upon. There is an immediate military need for a peacetime partnership between the research and developmental professions and the military which will raise the useful productivity of weapons laboratories. Except for liaison personnel, it is argued that the developmental functions should be delegated to an organization that is one hundred percent civilian, but organized inside each service and integrated so that it assures and accepts the primary responsibility of usefulness and economical development, and it is argued that the final responsibility and authority for adoption of the weapons belongs to military personnel — the users.

The writer believes that we now face one other fundamental problem in effective weapon development, and that is to continue the high standard of scientific and engineering competence which prevailed during the war. The best of public, legislative, and financial backing, the best of procedures, will avail little if the group of scientific and development personnel of high caliber, attracted to this work for patriotic reasons during the war years, is dissipated. The writer feels it is evident that the continuing competence of the scientists and engineers working in the Service laboratories will be retained only if their professional status is assured and if they are freed of many of the rules of Civil Service which, in their irksome details, are inapplicable to people with initiative and originality, and drive many of them away.

Two current solutions are offered to meet this problem: one is the detailed domination of civilian research by civilians in civilian organizations, the other is the detailed domination of military research by the military in military organizations. The writer does not for a moment believe that military research should be dominated by civilians, or civilian research by military. He deplores the extensive subsidization of science by the Navy or Army on a large scale during peacetime because of the concomitant danger to scientific freedom. Equally, the writer deplores unguided control of military research by civilians because of its wastefulness in producing a large percentage of unsuitable weapons.

If we cooperate as citizens, whether military or civilian, with equal responsibility in weapons development throughout the peacetime years, then, if war comes again we will not be unprepared. But if we congeal too completely into tight little military empires, ivory-towered scientific priesthoods, and exclusively profit-seeking industries, we may find our common and broader interests endangered. There is a middle course in which each profession attends to and runs its own affairs for the most part, but lends, when need be, a helping hand to its partner. If the writer pleads any cause, it is that our attitude be one of partnership and not of partisanship.

Captains F.S. Withington and R.D. Bennett, of Naval Ordnance Laboratory, with the approval and support of the Bureau of Ordnance, had the foresight to provide the physical means and some of the personnel required to publish this work. A number of the authors furnished their manuscripts on their own time and on their own initiative out of their interest and belief in the worth of such a volume (details are given in "Acknowledgements"). The Naval Ordnance Laboratory shows breadth of vision in its willingness to publish such a critical evaluation of its own contribution and achievement, and it can afford this in view of its superior record. The criticism pulls no punches, but ordinarily an organization does not call attention to any of its own mistakes for fear of the irresponsible use of such criticism.



Ellis A. Johnson
Washington, D.C.
28 April 1947

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1.

MINES BEFORE WORLD WAR II

THE BEGINNINGS

In 1585 Gianibelli,¹ an Italian engineer in the employ of the Dutch, blew up a Spanish floating bridge blockading Antwerp. Parma, the Spanish commander, lost his bridge, some of his bravest officers, and a thousand men dead. His army was thrown into confusion. Mines had made their first known appearance in the history of naval warfare.

Gianibelli had been permitted, by the hopelessly blockaded Antwerpians, to experiment with two small ships crammed to the skins with gunpowder and fitted with clockwork which could operate a flintlock firing device some time after being set. He floated these two ships down upon the bridge at night, masked by 32 fire ships sent forth as a diversion and to deceive the Spaniards into thinking his mine-ships were duds. One was a dud but the other one worked.

Only three years later, a secondary effect of mining — fear of mines rather than actual destruction by them — caused the initial break in formation which sent the Spanish Armada scurrying from Calais and towards its eventual destruction. When the English Lord Admirals sent fire ships down into the Spanish Armada, riding the roadstead off Calais, the cry “Fire Ships of Antwerp” rose from the fleet and struck fear into the Spaniards’ hearts. They lost several ships by collision in their haste to make sail and away. They had been panicked by dummy “mines.”

Thereafter mines had slow development because explosives were so dangerous to handle, and in concentration were often more of a threat to those who employed mines than to the enemy. Furthermore, dependence on the chance help of wind, tide, and current made their eventual contact with the target ships a matter of extreme uncertainty. Bushnell, an American inventor, floated kegs filled with powder and equipped with contact firing devices down on the British in Philadelphia harbor during the Revolutionary War. Though not one struck a ship, the crews panicked. They fired wildly into the water, fighting what a contemporary jingle called “The Battle of the Kegs.” In an attempt

to make more certain contact with the ship’s hull, Bushnell invented the submarine. It was driven by hand power and carried mines linked to an auger which could be screwed into a ship’s hull. Thus, though neither worked well, the first limpet mine was born at the same time as the submarine.

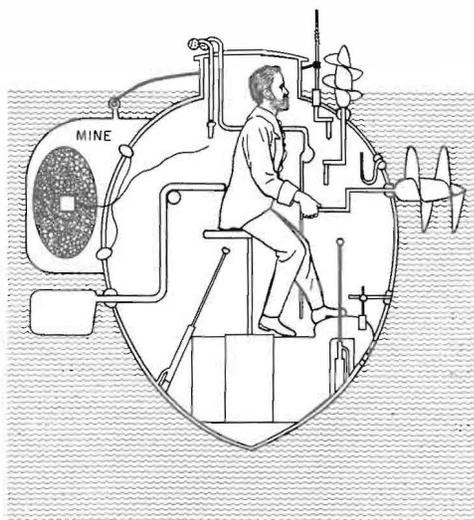


Figure 1-1. David Bushnell's submarine carried a mine papoose-fashion

MINES IN THE CIVIL WAR

It remained for Robert Fulton to develop the spar-torpedo, an explosive put on the end of a long pole and rammed at the hull of an enemy vessel. Later, this method was used during the Civil War when the Confederate ship

¹ A. M. Low, *Mine and Countermine* (N. Y., Sheridan House, 1940).

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DAVID, a small torpedo boat, sank the HOUSATONIC, one of the Union's finest and biggest ships. Actually, at this stage in its development, the weapon was both a mine and a torpedo. The principal development in naval warfare which made this hybrid useful was the change in tactics from fighting land engagements aboard ships — the technique of grappling, boarding parties, and ship capture — to fighting the ships themselves, in which the aim was the destruction of the vessel itself. Gunfire was a perfectly acceptable means of accomplishing this and the greater vulnerability of a ship below its waterline was not exploited simply because the underwater ordnance had not reached a readily useful state.

The weaker belligerent is often forced to the greatest ingenuity. Facing superior Union naval forces, Confederate engineers were pressed to keep their harbors inviolate. They developed defensive mines, demijohns filled with gun-powder and ignited by a friction primer. The cases were laid in pairs connected by a wire passing to friction tubes; when a ship struck them, it pulled the wire and exploded the mines. The Confederates also developed a contact mine which did not have to be carried against a ship (that weapon developed into the torpedo) but which waited and exploded when the ship came upon it. The "Singer" mine contained an air chamber for buoyancy and a friction firing device which was set off when the mine was jarred. Another mine was horned, as many as five fuzes jutting out at various angles; when broken, the horns spilled sulphuric acid on chlorate of potash mixed with powdered sugar. This generated enough heat to set off the charge.

At Mobile, in 1864, a mine field of 80 mines was laid, a spectacular number for those days. The mines were laid in a triple line, staggered so that if a ship passed between mines in one row it would meet a mine in the very next row. The existence of this mine field was a powerful psychological weapon. The threat of ships' guns was often disregarded, whereas mines aroused terror. Admiral Farragut, however, scorned the danger. When the command was given for a squadron of his vessels to attack Mobile, the TECUMSEH led the way. Before she was near enough to the shore to use her guns, she struck a mine. After a great explosion, the hull tilted forward. She sank. Officers and most of the crew were lost. Another ship saw more mines in the water and began to signal and also to alter her course. This angered Admiral Farragut. He shouted, as quoted by Low,² "Damn the mines! Captain Drayton, go ahead! Jowett, full speed!" Mines bumped against other ships but none exploded. Too many had corroded to be effective, although others must have been operative. When this mine field was cleared, there were a number of casualties.

The Confederates' total for the Civil War was 32 Union ships mined, of which 27 were sunk. Only 9 Union ships were sunk by gunfire.

MINES IN THE RUSSO-JAPANESE WAR

The next important use of mines occurred during the Russo-Japanese war. The success of mines during the United States Civil War was a pointed lesson to all naval powers. Widespread development by the European powers and by Japan had ensued. The Russians used mines purely defensively. They laid a field of about three hundred to protect the Port Arthur roadstead after a successful Japanese attack. The Japanese later attacked, anyway, but only as a ruse for laying their own mines. Soon after, they lured three Russian battleships and four cruisers out of Port Arthur through this field. The Russians steamed right through without casualty but, on sighting Admiral Togo's main squadron which came up over the horizon, they turned back towards Port Arthur. They had used up their luck. The Japanese mine-trap then was sprung and the Russians had grave losses.

Later, when the Japanese approached Port Arthur from the land, the Russians withdrew by sea. They had to go through their own mine field which they were unable to sweep themselves, and paid the consequences in casualties. (This was a terrible example of a faulty tactical application of a new weapon.) In order to mine Japanese shipping, the Russians laid mines in the open sea. This indiscriminate sowing of contact mines brought protests from the western powers. Occasionally it appeared that a Japanese ship struck two mines at once, which gave rise to the rumor that the Russians had a new and more powerful mine. They were however using the usual type of electromechanical mine which sometimes was able to explode a ship's own store of ammunition.

During the Russo-Japanese war, mines restricted freedom of action in the fleet engagements. It is significant that many ships were mined, but not one was sunk by a torpedo. The following table shows the Japanese losses in 1904-5:

Type of Ship	Total Sunk	Sunk by Mines	Sunk by Other Means
BB	2	2	0
CA	6	5	1 (collision)
DD	9	4	5 (gunfire)
Total	17	11	6

² Low, *op. cit.*, p. 64.

MINES AGAINST JAPAN

MINES IN WORLD WAR I

By 1914 mines had become firmly established as a major *defensive* weapon. They played a major part in one of the most disastrous campaigns of World War I, the British attempt to force the Dardanelles. The crucial action which caused withdrawal of the British naval forces is described by Mr. Low in detail, and it is summarized here because, together with the great North Sea Barrage and offensive sorties by German submarine minelayers, it marks the extent to which mines had changed their status from dangerous and ingenious playthings to naval ordnance of heavy potential.

The Turks had planted defensive mine fields and covered them with heavy shore artillery. They used anchored contact mines set at different depths, mines controlled from shore, and drifters, which they set in the strong currents of the March flood. Sailing against the Turks, the British Fleet sent their sweepers out at night, but Turkish searchlights picked them up, shelled them heavily, and made sweeping almost impossible. This action, together with the bombardment of the shore, took place over a period of days. In covering destroyer and trawler sweepers the cruiser AMETHYST sustained heavy damage from shell fire.

The mine fields, first regarded as a nuisance obstacle to the main naval mission, finally proved insurmountable. As the British were relieving the French squadron, the battleship BOUVET, coming out of the line, struck a mine which exploded her magazines. She split wide open, turned over and sank, still going ahead, the water closing over the twisted, shredded mass of steel 175 seconds later. Then the IRRESISTIBLE was struck, then the INFLEXIBLE, both British battleships. The INFLEXIBLE got off to Tenados where it was found that she had flooded twenty compartments and had a hole in her bottom 30 by 26 feet. The IRRESISTIBLE was holed by another mine as she drifted helpless, her engines stopped. The battleship OCEAN, coming to her aid, received a hit in her steering gear, and while running out of control struck a mine. Both ships, now subjected to merciless bombardment, sank during the night. The Allied forces withdrew. Churchill said of this action in *The World Crisis, 1915*:

The operation of sweeping the area from which the ships were to bombard . . . was the indispensable preliminary to any naval attack upon the forts. This was not achieved because the sweepers were inadequate . . . and this fact led directly to the losses in the attack of March 18, and indirectly to the abandonment of the whole naval enterprise.

While this was, perhaps, the most dramatic use of mines in World War I, it was by no means the only one. Between 1914 and 1918 the Allies laid enormous fields to

bottle up German submarines. In antisubmarine barrages, like that in the North Sea, mines were anchored at such depths that surface vessels could pass safely over but submerged submarines would run into them. The construction of the North Sea Barrage was so deep and the barrage so long that a great number of mines and minelayers were needed. The waters adjacent to Norway left a loophole for German submarines, but Allied vessels were able to keep close watch. One of Britain's mine laying operations was the Coast Barrage, two lines 40 miles long, which were laid 12 miles off the coast of Belgium. In the German Bight another mine field was laid. A total of 172,000 mines was laid in the Channel and the North Sea.



Figure 1-2. Assembling mines at Inverness for the North Sea Barrage (Sept. 1918).

The Germans conducted extensive mine operations, using both surface raiders and submarines for laying mines in two ways mainly: they defended their ports with mine fields, and they set groups of mines where they could most harm the British on the high seas. These groups were of an indeterminate number of mines scattered at indeterminate distances in order to make sweeping harder. As the weaker naval power, the Germans used mines offensively and, by their determination and effort, made it apparent they considered mines an important weapon. The German raider WOLF laid mines successfully in areas as separated as off the northern tip of New Zealand and along the route of the Atlantic liners. It was near Tory Island that the AUDACIOUS, a new and powerful superdreadnaught, struck a mine. In four hours she sank. A German mine near Marwick Head caused the disaster of the cruiser H.M.S. HAMPSHIRE in June, 1916. During a severe gale she struck the mine and sank in 20 minutes. All but 14 of the 600 men aboard were lost, including Lord Kitchener, the Secretary of War. In 1917 the liner LAURENTIC

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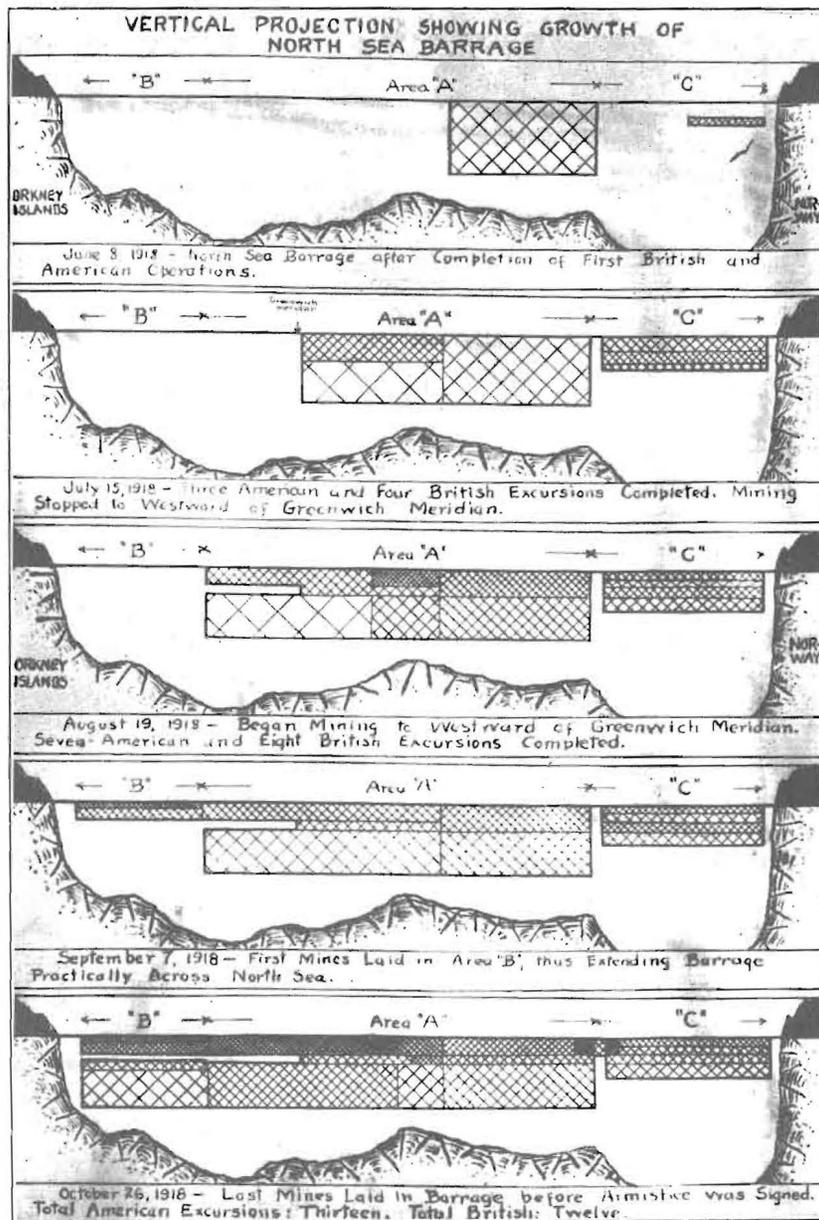


Figure 1-3. Growth of the North Sea Mine Barrage

encountered a mine and went down with three-fourths of her complement.

British submarine minelayers were credited with sinking a hundred enemy ships between 1915 and 1918 in the Heligoland Bight, but it was in the latter days of the war that mines became most useful. Between 1914 and 1917 the

British lacked effective mines. Only about one in twenty was reliable in firing or stayed at the proper depth. The primary electric cells ran down, the contacts rusted, and the explosive deteriorated with damp. Beginning in 1917, the situation improved, for a new mine, the Mark H, was developed and was manufactured in quantity. Both the

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United States and Britain had also improved mine tactics by using 30-foot antennae which rose vertically (and streamed horizontally as well from the British mine). A ship scraping an antenna (or little floats attached to it on the British mine) would operate the firing device electrically. This reduced considerably the number of mines needed in a barrage.

The moored mine had reached a stage of development in World War I that has since been improved only in detail. In general, all moored mines consisted of an anchor and a mine case which were planted locked together. When the combination was dropped into the sea it floated. A plumb bob unreeling from the anchor to a length equal to the distance below the surface the mine was to set. Then the mine and anchor unlocked, the mine floating on the surface and the anchor descending, unreeling a cable attached to the mine as it went down. When the plumb bob, hanging down below, touched sea bottom, the anchor locked the cable and pulled the floating mine down below the surface the length of the plumb bob line. Then the combination came to rest.

The mine fired on contact with one of its elements in all cases. This was done mechanically, by jarring the case and, for example, setting a vibrating bar in motion which closed an electric circuit; or it was done chemically, by crushing glass vials within lead horns jutting out from the mine case, which then poured their fluid out to make a wet cell; or it was done electrically, when antennae passed minute electric currents from the galvanic action which occurred upon scraping a ship's hull. Some antennae carried floats with horns, galvanic action occurring when a copper disk was bent against an iron cup.

Besides the moored mines, whose main use was defensive though they could be laid offensively by surface and subsurface raiders, drifting mines, which originated with Gianibelli and Bushnell, were used offensively. International Law limited their life to one hour, but early in World War I the Germans disregarded this. Allied retaliation to this violation was necessarily limited by the fact that the Allies had freedom of the seas and had no desire to fill them with live drifters.

In summarizing the use of mines in World War I, the following figures are indicative: 43,636 mines were laid by

	War Vessels	Auxiliaries	Merchant
German losses	102 (including 40 submarines)	42	—
British losses	44	225	—
Allied losses	—	—	586 (over 1,000,000 tons, gross)

Germany. The United States laid 56,000 in the North Sea Barrage and the British laid a total of 128,650 mines, of which 40,000 were in one area off the German coast.

MINES A WEAPON FOR THE WEAKER BELLIGERENT

In reviewing the 330 years between 1585 and 1918, it can be seen that technological development of underwater weapons made them a dominant factor in naval warfare. The well-known history of German submarine warfare during World War I made clear the great offensive strategic possibilities of mines for blockading merchant shipping. This overshadowed the use of surface vessels and other means to impose a sea blockade. Mines, however, were substantially employed defensively throughout the entire period. Every major use of mines was carried out either by the belligerent who was the weakest from the naval point of view or in order to counter enemy action which could not be solved by more orthodox means.

Because Antwerp possessed no naval forces, Gianibelli invented a new and extraordinary means to raise the absolute blockade imposed by the Spaniards. Again, in the American Revolution, the rebellious colonies had no naval forces with which they could seriously coneract British sea power. This led Bushnell to the first serious attempt to develop both the submarine and the mine in their modern forms. In the Civil War the Confederacy had no resources as a sea power and lacked orthodox naval means of countering Northern blockades or the attacks made by Union gunboats supporting land invasions. Confederate inventiveness brought moored mines to a thoroughly practical stage of development and constituted the Confederates' only serious means of attack on Union men-of-war. Since the mines were developed during hostilities they did not have a decisive effect even though 75 percent of Union naval casualties were due to Confederate mines.

Again, in the Russo-Japanese War, mines were used principally by the Russians after their decisive naval defeats and when they were most seriously threatened by the Japanese. That is, mines were used defensively to fend off direct Japanese naval attacks. The only serious Japanese naval losses were due to mines which accounted for all of the battleships and most of the cruisers and destroyers lost.

In World War I, defensive mine fields reached tremendous proportions. The North Sea Barrage and the other numerous British mine fields were clearly defensive, an attempt to counter the German offensive use of submarines. Thus, although the Allies had control of the seas, mines were used where the orthodox means of attack and defense were inadequate. The Central Powers also made extensive defensive use of mines. Their defensive mine fields made direct naval attack on their prepared land positions difficult if not impossible, as proved by the Turks at

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the Dardanelles. Mines alone caused the only serious casualties to Allied capital ships during the entire war.

The offensive use of mines was initiated during World War I by the Germans in their use of submarine-laid attrition fields. This offensive use, although minor, had grave implications for the future, recognized only by the Germans. It is probable that their successful experience resulted in their decision to make extensive use of offensive mining in World War II.

OBSTACLES TO USING MINES FOR OFFENSE

All of the facts summarized above lead to the conclusion that primarily because of their operational characteristics mines were a defensive weapon through World War I. Up until this time, surface vessels continued to dominate the seas, and the stronger naval power could prevent any mine laying activities by surface vessels, and to a considerable extent by submarines, because a minelayer could not reach waters susceptible to truly offensive mining. Offensive use of moored mines depended upon surface sea power. Therefore the weaker belligerent was unable to use mines offensively except in daring sorties. He could only make defensive use of mines within those waters which were already under control of his land artillery. As at the Dardanelles, even the defensive use of mines was as an adjunct to land defenses. It is in the light of these constraints that the relation of mines and mine development to American naval strategy and to the theories of Mahan must be considered.

MAHAN

United States naval policy before Mahan was extremely limited in point of view. Theories of defense of the coast and commerce raiding hindered the development of a broad naval strategy. Mahan's influence changed this because of his fundamental belief that the most important factor in a nation's destiny is sea power.

Alfred Thayer Mahan, the son of a professor at the United States Military Academy, graduated from Annapolis in 1859. He was on active duty for about 25 years. During his service in different parts of the world, he formed the habit of studying history from the angle of cause and effect in military developments. He felt that the effect of sea power was a factor which had never been thoroughly explored. In 1884, he was invited to lecture on naval history and tactics at the Naval War College in Rhode Island. His lectures, articles, and books during the next 20 years had a far reaching effect. His concepts of sea power and his new theory of naval strategy were advanced in three books, published between 1890 and 1905, *The Influence of Sea Power upon History, 1660-1783*, *The Influence of Sea*

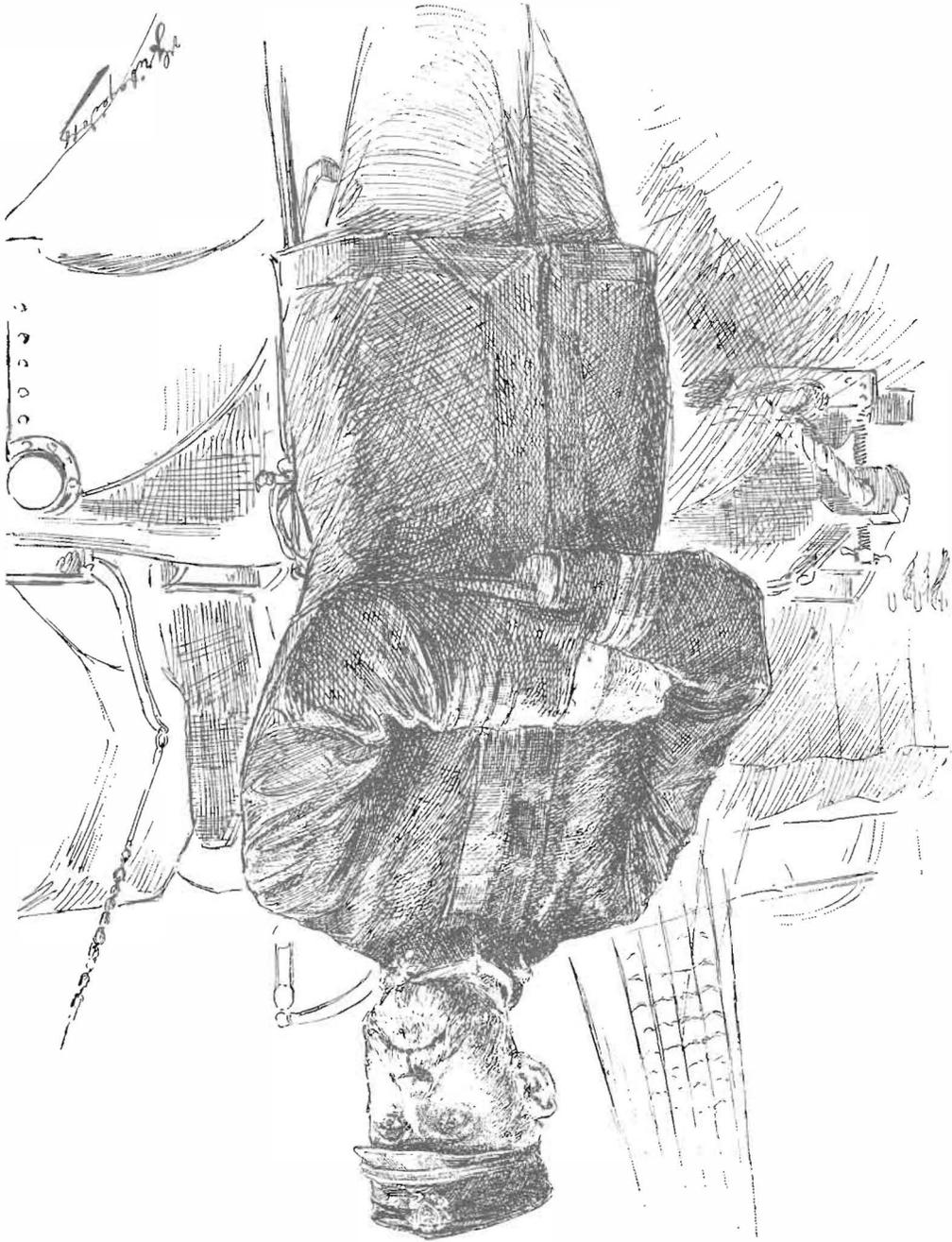
Power Upon the French Revolution and Empire, 1793-1812, and *Sea Power in its Relation to the War of 1812*. His ideas brought about a revolution in United States naval policy. Rulers and statesmen in England, France, and Germany were profoundly influenced by his doctrines, which became the foundation for naval strategy throughout the world. This is fully presented by Margaret Tuttle in *Makers of Modern Strategy*³.

According to Mahan, "Sea power in all its ramifications was the royal road to national wealth and prestige for all countries capable of its development." He believed that the development of a nation's sea power was determined by six factors: geographical position, physical conformation, extent of territory, population, national characteristics, and governmental institutions. His point of view on these factors can be indicated by considering what he thought would be the ideal. A nation should be well situated, far enough away from potential enemies for protection yet not out of striking distance. A nation should not have to divide its fleet between two coasts. Its geography would be adequate to support a strong navy but not so rich in resources that the inhabitants would be tempted neither to go to sea nor to develop overseas commerce. The waterways and extent of coast and inland territory should be in proportion to resources and manpower. Apart from the percentage of the population actually engaged in the navy and in overseas commerce, a sufficient percentage should be engaged in the trades and skills upon which shipping and sea power depend. National characteristics should include a keen interest in peacetime commerce, overseas trade, and colonies. The government should have a long-range policy of developing sea power and also should adopt a fundamental strategy which tends to build up a navy. For example, naval strategy should be aimed directly at control of the seas and should not be considered a subsidiary to land warfare. Naval strategy should include the precept "Engage the enemy more closely," rather than "Keep the sea as long as possible but not at the cost of losing ships."

The Swiss, Jomini, laid down the principles of war based upon position, lines, communications, and concentration of force. Mahan was influenced by this approach to seek out the parallels in naval warfare. Mahan taught that in order to be a formidable sea power, a nation needed a better naval strategy than its rivals, more material resources, and in addition, "control of the narrow seas." These are bodies of water which can be dominated from either shore with comparative ease. Mahan studied the significant history of control of the Bosphorus, the Dardanelles, the Sicilian Narrows, the Straits of Gibraltar, and the English Channel. He drew the parallel that since the Caribbean was a "narrow sea," its control by the United States would be

³ Edited by E. N. Earle (Princeton University Press, 1943).

Figure 1-4, Captain Alfred T. Mahan, USN, LL.D.



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as significant as Great Britain's domination over the Channel and the Mediterranean.

Mahan first took a position opposed to territorial expansion and an imperial policy for the United States. He changed, however, because he recognized the need of colonies for trade and overseas naval bases. He urged that the United States Navy be made strong enough to prevent a blockade. His reply to Congressional criticism was that a strategic offensive was not a political offensive, that the aim therefore of the United States should be to command the sea, not to attack another nation. As time went on, his doctrines gained acceptance. The expansions he urged took place and brought about the acquisition of bases in the Pacific and commitments in the Far East which have remained a heavy military burden ever since. A Navy "second to none" was authorized by the Naval Act of 1916.

Several factors have altered the basis on which Mahan formulated his original views on sea power. Complete dependence on sea transportation has been vastly decreased by the growth of air, rail, and highway transportation, although Mahan denied that transportation by water would ever take second place. His analysis of natural phenomena, national policies, and sea power was made when Europe was dependent on British shipping and when the influence of the British Navy was at its peak. The rise of the United States and of Japan as sea powers altered international politics and the balance of power. Another factor was technical development in industry. This led to the manufacture of synthetic products in Europe instead of continued importation of various raw materials. Technical developments in warfare were extensive. Mahan maintained that neither steam, steel, nor torpedoes would interfere with the maintenance of the close blockade, which was of cardinal importance in earlier naval strategy. Later he felt that even the submarine and the new torpedo would not change the earlier principles of strategy. He did not live long enough to join in the debate of ships versus planes.

Mahan's theories continued to be the primary basis for United States naval policy. Therefore control of the seas in all regions of the world was the aim of American naval policy in order to prevent any possibility of invasion of the North American continent. In addition, the national policy of this country anticipated no offensive war, no invasion of foreign territory. Naval tactics were based on control of the seas by surface ships, primarily battleships and their suitable escorts; that is, strong cruisers and destroyer squadrons, and later on, strong carrier forces in which the range of the weapons of surface ships was extended to several hundred miles. These policies did not require the development of mines in view of the known defensive nature of existing types. They could be laid offensively only by a superior sea power or by sneak tactics which might be of

trivial military significance. A superior sea power did not require mines. Therefore the United States Navy had no real strategic or tactical use for mines provided the basic assumptions indicated above were correct. Similarly, it had no important need for strong submarine forces. In order to achieve surface dominance, all appropriations and research needed to be directed towards strengthening surface forces. This policy was pursued. In consequence there was no strong motivation to develop mines, and no strong mine organization was ever built up in the United States Navy.

It is important to consider the relation of countermeasures to Mahan's theories and to naval policy during the period between World War I and World War II. The policy which tended to prevent mine development tended to develop mine countermeasures as a protection against mining by a weaker naval power. Mines had always been used against the stronger naval powers, sometimes very effectively. In order to control the seas, Mahan's theories required the establishment of strong naval bases in appropriate parts of the world. During the course of a war the capture of new bases and the support of landing operations might be necessary. Under these circumstances a dominant naval power might expect extensive use of mines to counteract its offensive naval operations. Even in fleet engagements, the weaker fleet might use drifting mines. These would require clearance in order to preserve the freedom of action of the fleet itself. Although not of the same primary importance as the expansion of the surface forces, development of adequate mine countermeasures was consistent with Mahan's theories and with United States naval policy.

THE MAGNETIC MINE: A WEAPON FOR OFFENSE

The British and the Germans probably held similar ideas on the relation of mining to Mahan's doctrines, and the Germans, whose surface sea power was forced to a defensive position, developed offensive mining as one of their solutions to the problem of control of the seas. The Germans had been especially impressed by the cogency of Mahan's theories and were thoroughly familiar with the importance of sea power to them, even though predominantly a land power. All three nations, Germany, Great Britain, and the United States, possessed the basic ideas necessary to the development of an offensive mine. The idea of a magnetic influence mine occurred almost simultaneously in the three nations, all being experienced in magnetic measurements. The Germans had the longest experience and the best instrumentation through World War I, although American experience at that time was rapidly growing. At any rate, crude models of magnetic mines had been developed by both Germany and Britain. These units were not designed for aircraft use but were primarily for

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use in defensive moored mines or for controlled harbor defense. Their potentialities for offensive use were not foreseen under the prevailing naval doctrine.

In the United States, during World War I, scientists had taken an appreciable part in war developments, especially in the development of antisubmarine devices. Such men as Vannevar Bush, W. F. G. Swann, J. A. Fleming, E. F. Nichols, Professor Zeleny of Yale, J. B. Whitehead, and E. Merritt worked on magnetic methods of detecting submarines. The group at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, working under Dr. L. A. Bauer, included Fleming, Swann, H. W. Fiske and Nichols. In the process of their antisubmarine developments, Swann worked out theories of the magnetic fields of ships. Experimental measurements of the ships' magnetic constants were made by Fiske and Fleming.

Stimulated by this work, Nichols, who was a professor from Cornell University working at the Department of Terrestrial Magnetism during the war, conceived the idea that a mine firing mechanism, which would respond to the magnetic field of a ship, could be developed. Most of Professor Nichols' early development work on this mine, which was made for the Bureau of Ordnance, was carried out at the Standard Magnetic Observatory of the Department of Terrestrial Magnetism. Professor Nichols was employed after the war by the Bureau of Ordnance to perfect the design of his device.

In order to find out how sensitive the device should be, a series of measurements was made on a battleship and on a submarine to determine the magnetic constants of these ships. Since the proposed firing device utilized only changes in the horizontal field,⁴ no attempt was made to measure the ships' total fields. Measurements were obtained by the Department of Terrestrial Magnetism by setting up a number of magnetometers around a drydock and measuring the magnetic field at these points. The ship to be measured was then brought into the drydock and the magnetic fields at the same points redetermined. Thus the changes produced by the ship's presence were found. The extensive reports prepared by the Department of Terrestrial Magnetism were missing from Navy archives at the beginning of World War II. Negligence in their preservation undoubtedly slowed down United States' development of the magnetic mine during the following decades. The general result of the measurements was a decision that the desired sensitivity of the magnetic firing device should be such that a change of plus or minus 0.01 gauss would operate the mechanism.⁵

The Nichols device, known as the M-1 device, was based on geophysical magnetic instrumentation and was patented. In principle it consisted of two magnetic needles, one several times as strong as the other, mounted co-axially on individual pivots. If such needles are very far apart, they both point north; if they are close together, the stronger one points north and the weaker points south (that is, to the north pole of the stronger needle). Somewhere between these two extremes is a critical zone at which the relative position of the needles is highly sensitive to the strength of the surrounding magnetic field. The needles in the M-1 device were set at this critical distance. When the field around it changed, the weaker needle swung around and the fine platinum wires it carried made contact which closed an electric circuit and could fire a mine.

Theoretically it appeared feasible to design a device which would have the desired sensitivity and in this Professor Nichols succeeded. A thousand were built by the Bureau of Ordnance. Practically, the mechanism was a laboratory toy. The forces involved were so minute that it was found necessary to reduce the friction on the pivots by submersing the whole unit in kerosene and buoying the individual needles with small pieces of cork. This was one of many practical difficulties. Also, no provision was made for automatic change of adjustment with latitude. The mine, adjusted for planting in the latitude of Norfolk, would fire if planted in the latitude of Washington.

In 1918 another type of magnetic mine was proposed to the Bureau of Ordnance by Captain Jules James, USN. This was applicable only to ground mines because it depended upon the change of direction of the magnetic field at the mine rather than upon the change of strength. In principle, it consisted simply of a horizontal magnetic needle whose motion in either direction would close a contact. Lieutenant Palmer, USNRF, made a similar suggestion to the Bureau and conceived certain additions and improvements not included in the James device. The Bureau of Ordnance had Lieutenant Palmer detailed to the Bureau, put him in charge of the new Mine Building in the Navy Yard, and authorized him to perfect a mechanism. Only six of these mechanisms were ever built and, so far as known, they were never tested. The officers in the Bureau of Ordnance with whom the problem was discussed were not, at that time, interested in ground mines, so that when Lieutenant Palmer left the service further development of the device ceased.

⁴ *Since a magnetic field is a "force" which has both strength and direction, it can be resolved into horizontal and vertical components. Magnetometers, instruments which measure the strength of magnetic fields, can measure either the total value of the field at a given point, or its strength in a particular direction in a horizontal or a vertical plane.*

⁵ *This is less than two percent of the strength of the earth's total field.*

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No further work on magnetic mines was done until just before World War II. A thousand M-1's were kept in stock with the hope that a type of automatic latitude calibration could be devised. Some consideration was given to mine cases made of nonmagnetic stainless steel as a substitute for earthenware cases which broke too easily, but the small force available at the Mine Laboratory found themselves fully occupied with the job of keeping up to date the large stock of World War I contact mines.

OTHER MINE TYPES

The moored contact mine, described previously, was the only mine which saw extensive combat use prior to World War II. Between World War I and World War II, a number of different types of mines were designed and partially developed. They are difficult to distinguish, one from the other, because of poor records, confused nomenclature, and the thrifty habit of borrowing major components of one mine to use with another. Drifting, moored, and ground mines were designed using mechanical, chemical, galvanic, and magnetic firing mechanisms. Most of them never got beyond the design stage, or, if they did, like the magnetic mine, they never had service use. Some were manufactured in small lots and used for drill. Of historical interest only is the fact that an acoustic firing mechanism was conceived, but work never progressed beyond the stage of collecting some of the equipment necessary to build the first model.

MINES AT THE OUTBREAK OF WORLD WAR II

When World War II broke out, Great Britain immediately commenced a defensive mining campaign using moored contact and antenna mines of World War I basic design. She laid mines in the English Channel and obtained enemy casualties soon after the mines were laid. Later a mine barrage was laid along the English East Coast which proved adequate to discourage enemy submarines. The ends of the Irish Sea were mined. This proved effective in excluding enemy submarines from that area. A very large mine field was laid extending north of England. The effect of this field on enemy submarines is not known, but the field is credited with causing the BISMARCK to take a route through an unmined but patrolled sea area which led to her being discovered and tracked down. This field may have had some influence on the German decision to run the SCHARNHORST, GNEISNAU and PRINCE EUGEN through the Channel rather than north of the British Isles.

All of the above instances are good examples of defensive mining in World War II, a continuation of the established policy. It remained for Hitler to open the world's eyes with his offensive use of mining. At the beginning of the war the Nazi dictator had bragged of a secret weapon which he said would win the war for him. One day in September a vessel was sunk while steaming out of what

was thought to be a swept channel. The channel had been swept thoroughly by a wire sweep. Soon another ship was sunk under similar circumstances. The British suspected a new type of mine that rested on the bottom and avoided sweeping. Reports began to come in of enemy aircraft parachuting long cylindrical objects into harbors and channels. The British were then convinced that the enemy was laying a new type of ground mine by parachute, but needed a specimen for analysis. One day a fisherman reported an unusual object on the beach in tidewater and a party of mine experts from the Admiralty rushed to the scene and saw what they decided was the new German mine.

Lieutenant Commander J. G. D. Ouvry removed all metal objects from his pockets and, equipped with tools, left his friends at a distance as he proceeded to the mine. As he worked, he informed his associates of each intended step so that if he went up with the mine the next person would not make the same mistake. He was successful. When the mine was examined after the detonator and booster were removed, a bomb fuze was discovered which was to explode the mine if it landed ashore or in very shallow water. Fortunately this fuze had failed. The mine was rushed to a laboratory for analysis. It contained a magnetic unit. Intense efforts to work out countermeasures proceeded day and night. How could it be swept? How could a ship be rendered safe from it? As a result of these studies degaussing was developed and seemed to offer partial protection for a ship against the mine. It was later perfected as far as was operationally practical. After some bad starts and a few months' time, a magnetic sweep using buoyant cable was devised which gave good results.

Meanwhile the Germans continued to drop their magnetic mines in British ports in comparatively small numbers. Ship casualties were very high in proportion to the number of mines dropped. Over one weekend, 45,000 tons of shipping were sunk by mines in Bristol Channel. Luckily the Germans did not start to lay mines in really large numbers until April 1940. By this time a reasonably successful magnetic sweeper was fairly well developed. When the mine blitzes came in the spring of 1940, the British were ready and managed to keep their ports open.

The fact that Hitler dropped his magnetic mines in dribbles over the period of September 1939 to April 1940 is considered by many high-ranking naval officers to be one of his most vital mistakes of the war. This period gave the British an opportunity to recover his mines and work out countermeasures. The Germans had made the same error as in their use of gas in World War I. They violated what should by now be understood as a fundamental axiom of warfare: *Much of the value of a new weapon lies in its surprise introduction and large-scale use before the enemy can develop countermeasures.* If Hitler had saved his magnetic mines until April 1940 and then used them in all-out raids on British Isles ports, it is probable that shipping would

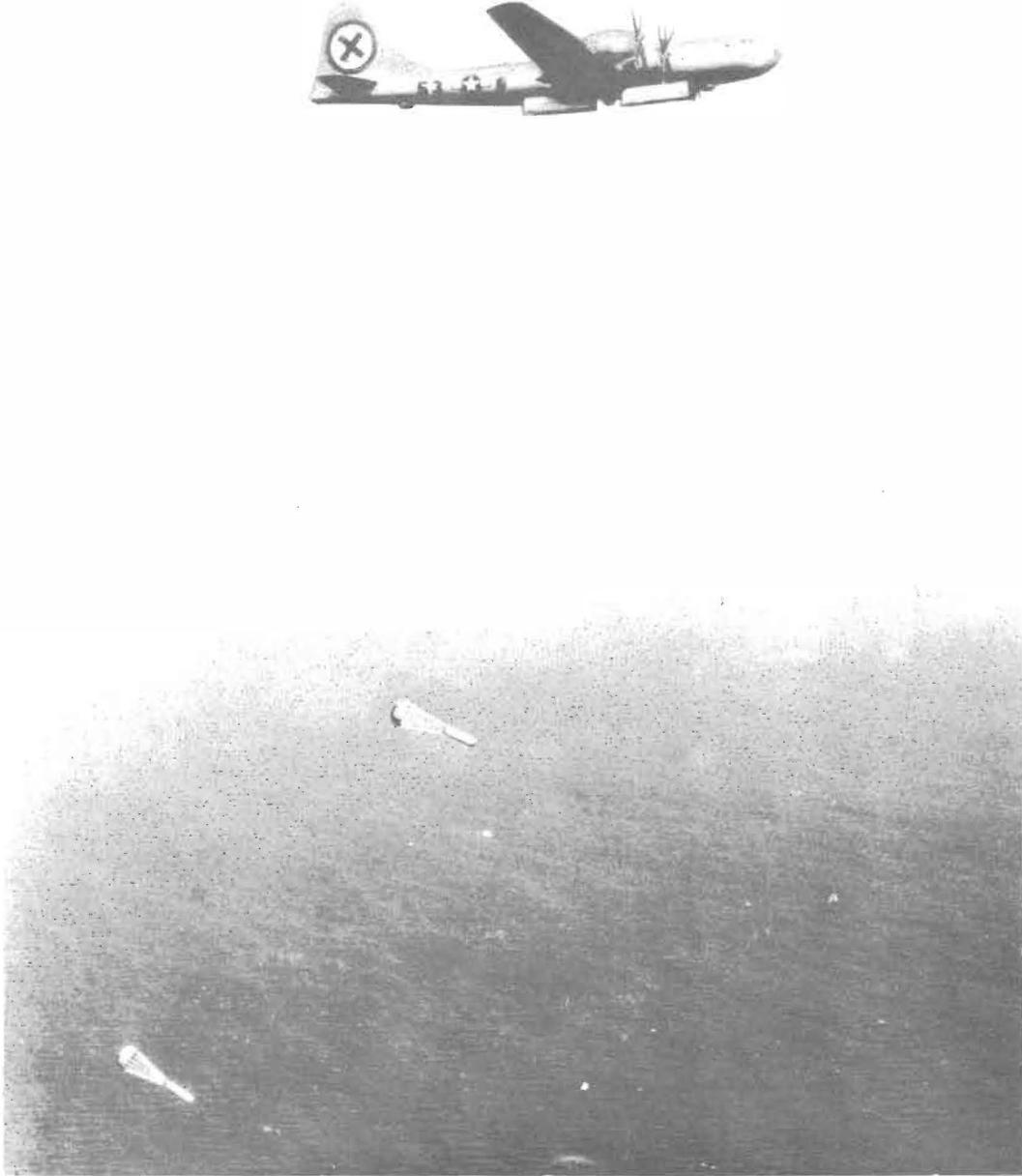
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have been completely tied up for a period of one to three months. This would have been disastrous and might have necessitated British capitulation at that time.

Britain had considered aircraft-dropped influence mines in 1935. German use first forced countermeasures, and then mine development by the British. United States Naval Attaches in London provided the United States Navy with the details of the new weapon from the very beginning of the war. The stage was set for the United States Navy to

develop the new weapon, the influence mine, as well as the even more essential countermeasures. The lasting importance of this "first" of Hitler's secret weapons was that it provided at last, to the disadvantage of surface-oriented sea power, a major means of using mines offensively. In its effect on sea power, the combination of mines-with-aircraft is similar to the combination of torpedo-with-submarine, but possibilities of even more revolutionary effects on naval tactics have unfolded.

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Blockade

Figure 2-1. Mines Being Dropped From a Superfortress Over Japanese Home Waters

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2.

SEA BLOCKADE FROM THE AIR

MINES ARE WEAPONS OF STRATEGY

Recent and potential developments in influence mines and in moored homing torpedo-mines have provided very long range strategic aircraft with weapons which make it possible for them to dominate shipping, submarines, and surface-borne sea power. The significant fact emerging from a study of source data on the use of mines in World War II (Chapters 3 through 8) is this: On a basis of the effort required to produce one enemy ton casualty, attacks on shipping using air-borne influence mines were about ten times as economical as submarine attacks in World War II. This advantage will grow in the future.

The economy and war potential of all existing nations of the earth are still greatly dependent upon sea and land transportation. There appears to be no prospect that the great bulk of commercial and military freight will be carried by air during the foreseeable future. The ability to invade and conquer foreign territory is also still dependent upon the traditional forms of transportation. The defeat of a future enemy of the United States will require the strategic destruction of that enemy's industrial potential and economic resources. These two tasks are complementary and may overlap. If both are successfully completed, the enemy will be defeated, although he may still possess intact armies of great size.

The two tasks, which have the same strategic purpose of denying all raw and finished supplies to all enemy activities, both civilian and military, therefore constitute one strategic mission. The general effect on enemy civilians will be to reduce employment and their supply of food, clothing, shelter, and other necessities. This lowers morale and the will and ability to wage war. The general effect on the enemy military organization will be to reduce its supply of food, ammunition, equipment, and the ability to transport its forces. This will reduce an enemy to a strictly defensive position. The ultimate result for the urban enemy civilians will be starvation, exposure, and widespread disease; the rural population may also starve. The ultimate result for the enemy military organization will be such an acute lack of supplies and transport that it will have no freedom of action to undertake an offensive campaign and

no ability to withstand a prolonged attack. In some instances, therefore, the successful accomplishment of the strategic mission may be able to achieve the surrender of the enemy without a decisive battle. Thus Japan surrendered in World War II with her main army forces essentially undefeated, but impotent because of the destruction in industrial cities and the effect of blockade.

One of the most important links in the transportation system of every nation is its combined maritime and inland waterway systems. Island empires such as Britain and Japan are completely dependent on seagoing ships and can be defeated by destruction of this shipping. Continental empires such as the United States and Russia are crucially dependent upon seagoing and inland waterway shipping as part of their transportation system. The destruction and blockade of this shipping, if not decisive, would still be essential to the strategic mission. The Dardanelles and inland waters, especially the Volga, are very important to Russia; to her satellites, the Danube has a similar importance.

MINES CAN CONTROL THE "NARROW SEAS"

Mahan emphasized the importance of controlling the "narrow seas" and the necessity for a close and continuous blockade. He regretted the fact that modern technology had improved defense against blockade so that these aims were more and more difficult for surface vessels (and submarines), and forced them to impose a less perfect blockade from a distance. The accelerated effect of technological factors, especially air power, has deprived sea power of its dominance in the "narrow seas" adjacent to enemy territory and its ability to impose blockade.

Thus in World War II the United Nations (Allies), although clearly possessing naval superiority in Europe, were unable to blockade the Mediterranean, the entire coast of Europe, or the Baltic, using sea power alone. All of these are "narrow seas." On the other hand, the British were themselves, at times, almost blockaded by air power alone, as for example at Malta. The German attempt at counterblockade using submarines was eventually prevented by land-based aircraft more than by any other single means. Land-based

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aircraft are credited with 326.5 kills compared with 285 by ships and submarines, and 44 by carrier aircraft. United Nations sea power was supreme on only those high seas which were distant from enemy air bases. Blockade in these areas was effective because of British ownership of refueling bases permitting the navicert system, as much as for any other reason.

Although sea power had been forced from the crucial "narrow seas" of Mahan, the ordinary air weapons — torpedoes, bombs, and gunfire — were also inadequate to obtain continuous blockade. On "narrow seas," night passages close to shore with daytime refuge in ports provided a means of avoiding strict and continuous blockade, and daytime passage with local fighter protection was possible. Direct air attack at night is difficult and so far has been ineffective even with guided missiles, especially near shore or island-surrounded channels.

The German introduction of aircraft-laid influence mines (on an experimental basis) provided aircraft for the first time with a weapon which *permits air power to impose a continuous blockade*, one of the important requirements of Mahan. Thus, by using mines, air power can reinstate the blockade of the "narrow seas," lost by sea power, provided these seas are within its radius of action and provided the aircraft are actually able to lay the mines. It is important to

recognize that a blockade imposed on a large port by mines is similar to that imposed by a naval squadron. A very small squadron — say one ship — may be incapable of obtaining a blockade if many ships attempt to run the blockade. Similarly, one mine capable of sinking one ship cannot seal a port against a sensible and courageous enemy. A blockading squadron must be strong enough to seal the port against all or nearly all ships attempting passage. A blockading mine field must be dense enough, and properly dispersed, to defeat the most determined enemy efforts. Both blockading ships and blockading mines await enemy ship passage, but the blockading ship (which may be a submarine) must await the enemy attempt to run the blockade and then fire its weapons. The mine is a weapon laid in anticipation which fires only when the attempt to run the blockade is actually made. It does not require the continual presence of a ship.

The tactical concepts of Mahan may have been weakened by modern technological developments. These on the one hand have reduced complete dependence on sea transport through extensive use of other forms of transportation and the use of technological substitutes, and on the other hand have radically altered naval tactics in an unfavorable way. But Mahan's strategic concepts have hardly been invalidated. His stress on the control of the "narrow seas" and the necessity for continuous blockade is



Figure 2-2. Areas Susceptible to Strategic Mine Blockade

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still as valid as his main strategical doctrine. It is therefore highly desirable to employ the new technological means which make it possible to develop new tactics. These will permit full realization of Mahan's basic strategy. This strategy should obviously be extended to include control of air as well as ship commerce.

During World War II, Germany, Britain, and the United States each used aircraft-laid influence mines of primitive and simple types on a small scale. All of these campaigns were successful in proportion to the effort expended but failed to achieve a complete blockade because of the meager effort. The German mine offense against Britain terminated only when British night fighters drove the Luftwaffe from Britain. But what happened was that air power, using a naval weapon — the mine — had demonstrated its ability to gain negative control of the seas at less cost, more efficiently, and in a greater variety of circumstances than surface or subsurface craft.

By gaining negative control is meant denying the seas to enemy shipping. Positive control of the seas means the safety of one's own lines of sea communication is assured, as well. This requires negative control, but the reverse is not true. Therein lies both the threat and the limitation of mine warfare. Mine warfare can achieve negative control without a fleet, but it cannot achieve positive control which requires, in addition, the traditional strong naval forces and naval strategy. Negative control is sufficient for land power when opposed by sea power; positive control is essential to sea power under all circumstances. The relation of these two forms of control has a direct bearing on the relative strategy of the great nations which depend predominantly upon land power and those to whom sea power is also essential. The emphasis which this places on the problem of countermeasures for the United States cannot be overstressed, and Chapter 10 has been devoted to it after the full meaning and ramifications of this new weapon of strategy have been expounded.

EARLY INDIFFERENCE TO MINING IN WORLD WAR II.

The new tactics introduced by Germany in 1940, in which they used influence mines to threaten the very existence of sea power from the air, were not popular with either the British or the United States Navies. The reason for this negative attitude lay in the traditional use of mines. In accordance with Mahan's doctrine, they had been used as a defensive weapon of minor importance to United States and British strategy. This strategy placed the emphasis on offensive action in which defensive mines were advantageous only to the weaker adversary. Improper use of defensive mines by a strong fleet could result in a costly reduction in its own freedom of action. Therefore the concept of using mines in an offense in the enemy's home

waters to obtain blockade at a minimum cost was not one that would occur naturally to a dominant sea power, since it involved the invention of an entirely new type of mine and the use of land-based aircraft of unprecedented range.

Early in World War II, staff studies showed that the offensive mining campaigns by the German Air Force and the Royal Air Force had been highly successful for the small effort expended. These studies also indicated that offensive mining could be carried out effectively in force only by very long-range heavy bombers. Since the Navy possessed few suitable aircraft and since submarine attack presented a more acceptable and orthodox means for destroying shipping, the Navy high command gave mining no strong support either in development or operations. This resulted in a lack of priority in development, and consequently in tardy development and production of mines. Submarines and air attacks (including mining) accounted for most shipping losses in World War II. In the Japanese campaign submarines were the principal strategic weapon used against Japanese shipping. For lack of a policy to use mines as a weapon of strategic offense, with the consequent lack of plans and logistics for mining, the United States did not lay aircraft-type mines on a full scale, although it used them increasingly towards the end of the war. Even in the Inner Zone Mining Campaign against Japan, because of a lack of mines, the 21st Bomber Command was able to lay only one mine in the shipping channels for every ten ship passages, compared to the estimated requirement of one mine per ship passage.

To summarize the principal reasons for the failure to use mines on a large scale before 1945, mining cognizance was assigned to the Navy for historical reasons and the Navy did not possess the aircraft suitable for a major strategic mining effort and made no strategic mining plan. Navy strategists preferred the alternative use of submarines to attack Japanese shipping. This was orthodox and its effectiveness had been proved by the Germans in both World Wars. No strategic mining plan was submitted to the Joint Chiefs of Staff until the last year of the war.

In operations, Admirals William F. Halsey, Jr., and Marc Mitscher both opposed the extensive use of mines by carrier-based aircraft, in spite of modest successes in one carrier mining operation. This opposition was justified insofar as it was restricted to the carrier air arm, because carrier aircraft are unable to carry sufficiently heavy mine loads, and the carriers themselves do not have adequate mine capacity to make a mining attack in force feasible. The use of carrier aircraft in direct attack on shipping is in general undoubtedly much more profitable than a less direct mining attack. Carrier aircraft, however, are also much less able to impose continuous blockade by direct air attack than are land-based aircraft and will have difficulty in reaching some of the "narrow seas" and inland waterways. In any event,

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blockade entirely by means of direct carrier aircraft will be even more expensive than submarine blockade.

From the beginning of the Pacific War, Admiral Chester W. Nimitz gave strong support to the tactical use of mines and limited support to the strategic use of mines. It was difficult to give full support in view of the opinions held by his own air staff. Since there was no plan for a strategic mining campaign, Nimitz had not been provided with the means to carry out mining on a large scale. This was especially true of aircraft. He did, however, make use of mines to support his own tactical operations. This was done at the earliest possible opportunity and whenever the use of mines was profitable. The supply of new mine types behind the operational needs. Nimitz was unable to initiate a full-scale mining campaign within his own command partly because he lacked suitable mines but principally because he lacked appropriate aircraft. These were in an independent command under Army cognizance. Convinced by the success of tactical mining operations, Nimitz formulated the plans for the strategic mining of the Inner Zone of Japan. He asked the Army Air Forces to carry out this plan as soon as B-29's were available in the Mariannas.

Navy cognizance, and early lack of operational and technical mining personnel on the staffs of Army Air Forces commanders, prevented early Army familiarity with the potentialities of mines. Contacts with Army Air Forces by mining personnel were at first made on a limited and sometimes informal basis. The open-minded attitude of many Army Air Forces personnel towards new strategical and tactical concepts eventually made them receptive to mining proposals. Although late, this led to an increasing and widespread Army use of mines, which was finally limited by the Navy's inability to deliver sufficient mines of the right kind to the 21st Bomber Command (later the Twentieth Air Force). Generals Le May, Stratemeyer, Chennault, and Arnold, in varying degrees, gave strong support to mining. Generals Norstad and Kenney, on the other hand, were opposed to the extensive use of mines at the expense of bombing operations.

MINES PROVE THEMSELVES

A total of 21,000 United States mines were laid in the Mine Offensive against Japan, of which about 3000 were laid by the Navy. A total of 4323 sorties were flown by all kinds of minelaying aircraft which ranged from Navy PBY to Army B-29. Of these, 2078 were flown by the Army Air Forces, 1128 by Royal Australian Air Force, 631 by Royal Air Force, and 486 by the Navy. It is significant that Royal Australian Air Force aircraft were PBY with a load capacity of two to four mines, whereas the Army air-

craft were partly B-24 but mostly B-29 with a load capacity of seven to twelve mines. Thus 1424 B-29 sorties out of a

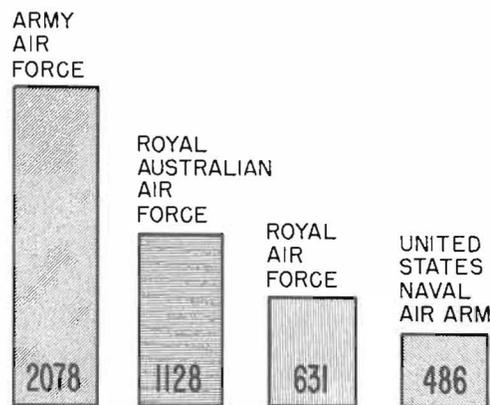


Figure 2-3. Mining Sorties by Each Service

total of 4323 accounted for over 12,000 out of a total of 21,000 mines laid. That is, 34 percent of the sorties accounted for 63 percent of the mines laid.

The result of this campaign was the mining of 961 ships of which 484 were sunk. This amounted to 2,000,000 tons sunk or damaged of which 650,000 tons were sunk. Casualties included 147 men-of-war, consisting of 2 battleships, 8 cruisers, 2 escort carriers, 7 submarines, 46 destroyers and destroyer escorts, and 82 others. In the Inner Zone mining carried out by the 21st Bomber Command, a total of 606 ships were sunk or damaged. Of these 283 were sunk and 137 were damaged too severely to be used for the rest of the war. *This amounted to 1,250,000 tons sunk or damaged in a period of four and one-half months by the average effort of one single Bomb Group of 40 aircraft.* This is to be compared with 4,780,000 tons of casualty produced by United States submarine attack over a period of three and one-half years by a force of about 100 submarines.

The strategic attack by United States submarines on Japanese shipping was in major force. The Inner Zone Campaign by the 21st Bomber Command was not in force, but was on sufficient scale to indicate experimentally the effect that can be achieved by a mining attack in force. These mining results are typical. The conclusions would be substantially unchanged by consideration of the two European campaigns by the German Air Force and Royal Air Force or of the other smaller operations in the Pacific. The contrast between the submarine campaign and the 21st Bomber Command Inner Zone Mining Campaign is shown by the following very approximate data:

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ECONOMIC COST PER ENEMY TON CASUALTY

	Inner Zone Mining	Submarine Campaign
Duration of campaign in months	4-1/2	44-1/2
Number of craft employed	40	100
Number of crew per craft	11	85
Total craft lost	15	52
Total crew lost	103	4,000
Cost of one craft	\$500,000	\$5,000,000
Ship casualties to enemy in tons	1,250,000	4,780,000

THE RELATIVE COST OF THE TWO CAMPAIGNS

	Inner Zone Mining	Submarine Campaign
Enemy casualty rate in tons per month	280,000	110,000
U.S. ship investment per enemy ton casualty	\$ 16	\$100
Tons of enemy casualty per crew member required	3,500	560
Tons of enemy casualty per crew member lost	12,000	1,200
Cost of U.S. loss per enemy ton casualty	\$6	\$55

These figures do not of course include the enormous expense of capturing the bases in the Mariannas from which the air operations were carried out. These bases were used for all staging operations against Japan, both Army and Navy. Earlier decisions would have permitted mining operations from Chinese bases when these were still available. In any case, the significance of capturing new bases would have to be divided among the various arms and services which depend on them for assigned missions. If possession of the necessary bases is presumed in predicting future costs of mining campaigns, the low figures given are accurate; it would be fallacious to include the costs of the military campaigns leading to the capture of the specific bases used in World War II operations.

The United States' investment in ships and personnel for the two campaigns may be taken as a relative measure of the logistic cost, although the accurate figures would require a more complete analysis. An accurate analysis would include reserve crews, crews in training, repair organizations, fuel and ammunition logistics, etc. It is probable that the final ratio of costs and losses would not differ widely from the crude estimates obtained above. These data indicate that the logistic cost, including personnel, ships, ammunition, and other supplies, will be about one-tenth as much per enemy ton casualty, if very long-range land-based aircraft instead of submarines are employed to attack enemy shipping.

These data also indicate that one single Bomb Wing composed of 200 B-29 aircraft would be able to sink and damage enemy shipping at a rate of 1,400,000 tons per month, or more than ten times the average rate achieved by

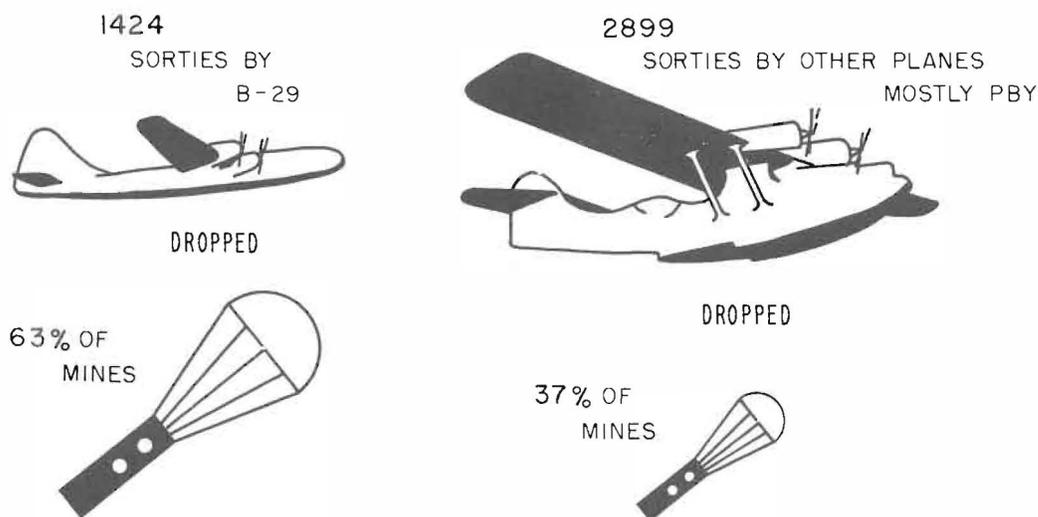


Figure 2-4. Capacity for Mines

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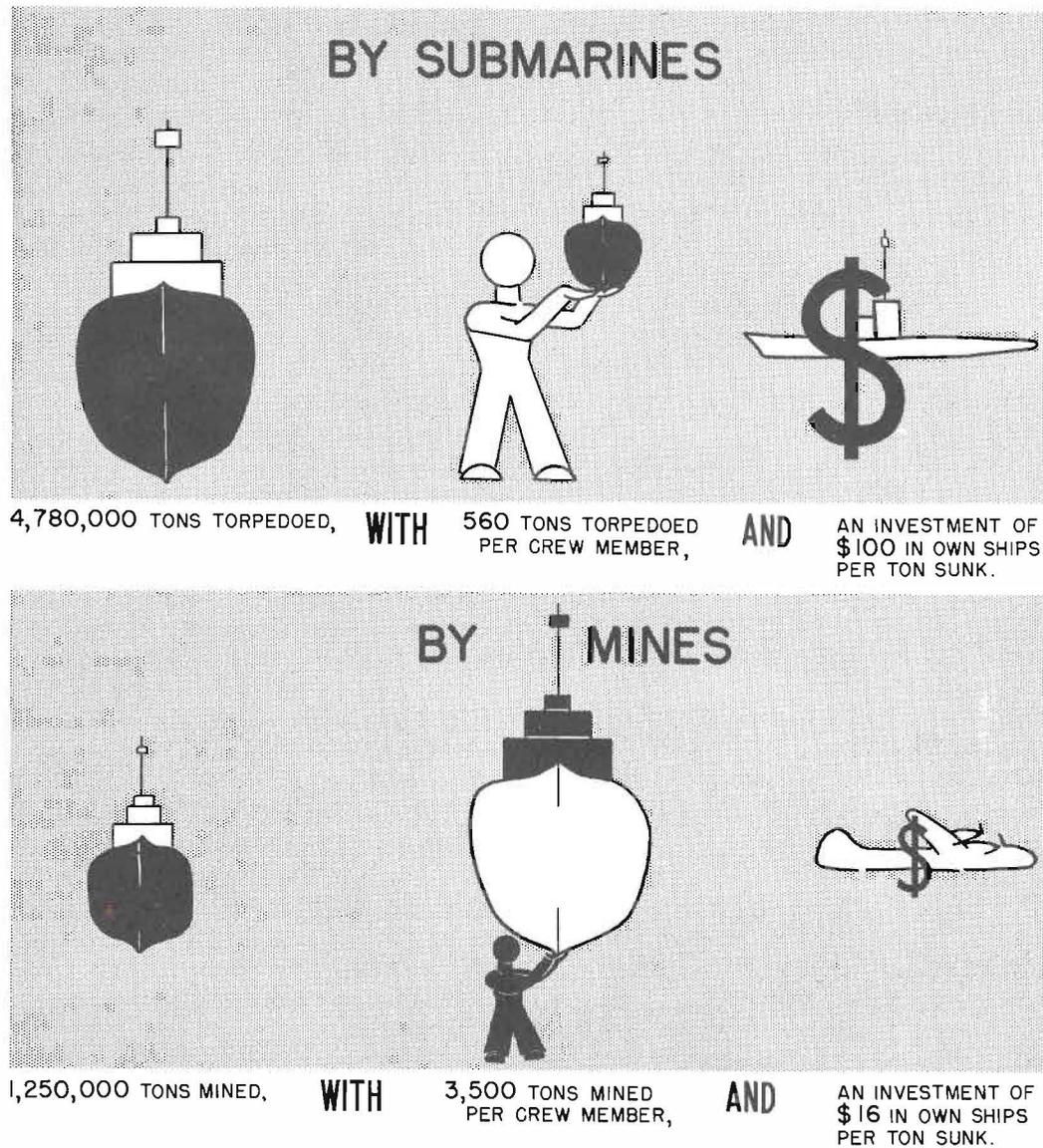


Figure 2-5. Relative Cost of Mining and Torpedoing

United States submarines during World War II. This rate is so great that the complete blockade or destruction of an enemy fleet of 6,000,000 tons could be obtained within six months. In order to achieve this, a prewar stockpile of 200,000 mines of sizes ranging from 100 to 8,000 pounds would be needed. Production data for World War II indicate that at least one year would be required before new mine production could reach combat areas. Therefore the prewar stockpile would have to be large enough to last the first year of the campaign.

An important tactical characteristic of mines is the fact that once planted in the target area they remain a threat to shipping until swept, cleared individually, or self-sterilized. Ground mines embed themselves in the sea-bottom in nearly all targets so that clearance is extremely difficult. A well-designed field of modern mines is substantially unsweepable—for example, United States forces were unable to sweep their own minefields in Japan for many months. A mine attack is much less exacting than direct forms of attack in that it does not require the transitory

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presence of the target during attack and *does not require the immediate and detailed intelligence required for direct attack*. Mining intelligence requires only a broad knowledge of shipping routes, ports, ship sizes, and density of shipping. It does require a knowledge of specific kinds of enemy countermeasures. Intelligence of a day-to-day nature is desirable but not essential. High planting accuracy is not required, a median accuracy of two miles is adequate.

The mine attack is prolonged in time since the mines, unless cleared, remain a threat for six months or more. This makes it profitable to attack minor routes and ports and thus to establish a complete blockade. Such minor targets are unprofitable for direct attack, unless there is an excess of antishipping forces plus very exact and timely intelligence information. This prolonged nature of mine attack also makes it possible to anticipate and to prevent enemy diversion to previously unused routes and ports, thus reducing his freedom of action. Finally, the long life of mines makes the attack continuous so that short gaps in mine laying, although undesirable, need not be crucial.

A mine attack by air has the important advantage of being able to blockade interior river or inland sea arteries and both sea and inland ports. These targets cannot be attacked by submarine. In World War II, the 21st Bomber Command produced a complete blockade of Shimonoseki Straits and the Inland Sea Route of Japan, the main industrial inland trade artery of Japan, by a heavy local attack. Ship traffic was reduced from 520,000 tons per month in March to a rate of less than 8,000 tons per month in the first two weeks of August 1945; that is, to less than two percent. Similarly, even though the attack was light, mining was principally responsible for reducing the traffic to all of the industrial ports of Japan, most of which were then in the Sea of Japan, from 820,000 tons a month in March to a rate of 175,000 tons a month in the first two weeks of August 1945 or to about 21 percent. This traffic had been substantially invulnerable to submarine and direct air attack.

Although the Japanese had planned a sortie of fleet units at Kure, no capital ship left Kure after its approaches were mined, and the only ship to make the sortie was the YAMATO, which was outside of the mine fields and unable to reenter Kure after the mining. The YAMATO was forced to use unmined Bungo Suido and an unfavorable approach rather than to attempt the passage of Shimonoseki Straits. No capital ship attempted passage of Shimonoseki Straits after it was mined. It is also important that Japanese use of Kure as a submarine base was discontinued after mining. Transfer to the west coast of Honshu was made. Inner Zone mining, therefore, produced a tight blockade of Japanese capital navy units and restricted the freedom of action of other men-of-war. These effects were largely incidental to the merchant ship blockade which produced two-thirds of all Japanese ship casualties after March.

These results were not unique. The Fourteenth Air Force obtained a substantially complete blockade of the Yangtze River in China with mines, as did the Tenth Air Force and Royal Air Force of the Irrawaddy River in Burma. In Europe the Royal Air Force obtained a 50 percent blockade of the Danube for about four months with a small mine attack, and the German Air Force mining of the Suez on a very small scale was reasonably effective. During the Inner Zone Campaign all except 3 out of 22 ship repair yards were blockaded and out of commission.

Toward the end of the Inner Zone Mining Campaign, the Japanese attempted a limited amount of dispersion of their shipping as countermeasure against mining. Ships were anchored offshore along the west coast of Honshu and cargo was lightered ashore. This type of countermeasure is costly and inefficient but could not be countered because an impractical number of mines would have been required. The Japanese also anchored these ships in water too deep for existing influence-type mines. Dispersion of shipping can be expected in the future as a defense against atomic bomb attacks as well as against mines.

PORTENTS

Technicians of Britain, Russia, and Japan are in possession of the basic ideas of influence mechanisms and familiar with all United States mines. At the end of World War II the United States possessed four mine mechanisms and two mine sizes, both employing parachutes. The mine mechanisms are similar to German types manufactured for Russia by the Hugo Schneider works at Leipzig during 1946. (The Germans were the first to introduce all of the new mine types, except the very low frequency mine.) Russia has undoubtedly examined numbers of each type of United States mine taken from Korean ports where they were laid during the last month of the War.

The necessity for economy, her geography, and the difficulty in training large naval forces, will probably predispose Russia to conclusions similar to those presented in this chapter. Russia can be expected to open any major war against the principal sea powers with an aircraft-mining blockade. Such an attack has a high probability of success unless a majority of the actual mine-laying aircraft or missiles can be intercepted and destroyed. Probably the British, as well, on the basis of operational studies of the European mining campaign, will eventually reach conclusions similar to those presented above and may incorporate them as part of their basic naval policy.

At the present time the United States is unprepared for effective sweeping of heavy and continuously laid mine fields. An effective defense may be possible, but it requires an important policy decision to initiate the extensive and close operational and technical cooperation necessary if the mine clearance problem is to be practically solved. And added to the present lack of preparedness is the hazard

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which will be posed by mines of the future, for United States influence mines and those of all other nations are still in a primitive state of development compared to the eventual possibilities (see Chapter 9). Further development can provide mines which are ready ammunition, have trajectories similar to bombs, and which are basically unsweepable when laid in combination. Mines can be provided which can be laid by any means adaptable for using bombs, including rocket and guided types. Dispersion of shipping can be met by the development of moored homing torpedoes which could home on a target from depths up to 1000 feet and from distances up to 3000 feet. This mine would make it possible to close all enemy shorelines to shipping and most open sea routes as well. Only the high seas would be relatively immune and even these could be mined by using a floating homing torpedo.

CONCLUSIONS

One of the controlling factors in the strategy of the United States must be the selection of the most economical means of obtaining military security. Now, as in ancient times, the economic cost of waging war will largely determine the ability of the nation to protect itself, to survive, and to prosper. Prolonged and intolerable military expense can weaken both the nation's war potential and morale and therefore its security. This military expense should be minimized as far as is consistent with the accomplishment of the military mission. The control of the seas is one of several important military missions. Several alternative means can be used to achieve this control, including aircraft-laid influence mines. These appear to be both the most suitable and the most feasible means of achieving the mission, and to be the most economical as well. Mines utilize most fully the strength of the United States and capitalize upon a unique weakness which it would be difficult for any enemy to avoid.

The following conclusions are drawn: (1) World War II experience shows that control of the seas, in the sense of denying their use to the enemy, can be obtained by moderate air effort using very long-range aircraft laying mines. (2) Aircraft mine laying can achieve attrition of merchant shipping at about one-tenth the economic and logistic

cost required by submarines. (3) Mine laying can blockade interior waterways and harbors and clog ship repair and construction facilities. (4) Strategic mine laying requires very long-range heavy bombers and is adapted to the type of training, facilities, experience, and psychology of the Army Air Forces. (5) Mine development must meet the tactical needs of the future in respect to expected ship dispersal by the enemy, the need for wide target areas in open sea lanes, and new methods of placing weapons in enemy territory. Mines must also be developed so that mine fields are basically unsweepable, taking into account enemy knowledge of our present mines, and mines should be developed as ready ammunition. (6) A prewar mine stock of 200,000 mines is required to permit immediate blockade of an enemy — one year is required for new production. Blockade is most effective in the first part of the war. (7) Destruction of enemy air power and enemy aircraft using mines is essential to prevent imposition of a counter mine blockade.

On the basis of these conclusions, the following general recommendations are made: (1) United States military policy should establish the use of aircraft-laid mines as a primary means for control of the seas and blockade of interior waterways. (2) Cognizance over strategic mining operations should be transferred to the Army Air Forces. This service should make mine plans in addition to the personnel and logistic preparation for strategic mining operations. (3) The present status of Navy mine development should be surveyed very critically to determine whether or not it meets future tactical needs of both the Navy and the Army. If necessary, other agencies should help develop appropriate mines. (4) The United States should have a reasonable submarine force for supporting attack on enemy shipping on the high seas as well as for Fleet duties. (5) Strong defensive naval forces should be provided for the United States' own mine clearance. (6) The mining attack should be coordinated with the attack on other parts of the enemy's interior communications system; i.e., railroads, bridges, tunnels, and his road systems in general. Mining as one aspect of the strategic attack on an enemy's entire communications system should not be isolated from the others.

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3.

SUMMARY OF MINING OPERATIONS AND RESULTS

JAPAN'S VULNERABLE PERIMETER

The offensive mine laying campaign against Japan began in October 1942, when the perimeter of Japanese conquest formed roughly a circular arc of 3000-mile radius, centered at Tokyo. It extended from Kiska in the Aleutians through the Marshall, Gilbert, and Solomon Islands in the Pacific, through Java, Sumatra, and the Andaman Islands in the Indian Ocean, to Akyab in India. In acquiring this vast empire Japan took on the double burden of supplying her numerous overseas troops and of attempting at the same time to exploit economically the rich resources of her new territory. More than seven million tons of Japanese shipping were engaged in this essential effort. These ships were under constant danger, first from Allied submarines, then from aircraft, and finally from mines which denied them safe anchorage at either end of their journey.

During 1942 mine warfare officers of the Navy had visualized and planned a coordinated strategic mining attack on the Japanese outer defense zone. The objectives of this mining campaign were to disorganize the enemy maritime supply system, deny him safe ports and shipping routes for the transport of essential war and economic materials, sink and damage as many of his ships as he would expose to mine risk, and impose upon him the military and economic burden incident to the establishment and maintenance of a defense. Much of this planning eventually was fruitful. Mines were laid by the United States Army and Allied Air Forces as well as by United States naval aircraft, surface vessels, and submarines. All United States mines were prepared under the supervision of United States naval technical personnel. Mine Warfare Officers directed or collaborated in the planning and execution of all operations. The cooperation between personnel of the different United States and foreign services in the logistic support and operational direction of mine warfare was exemplary in all war theaters and contributed much to the success of the campaign.

Essentially the campaign was divided into two major parts. The first was a widespread and persistent attack on enemy ports and shipping routes in the Japanese Outer Zone. From 1942 until the end of the war, nearly 13,000 offensive mines were laid in over 150 enemy harbors and locations by submarines, surface layers, and aircraft. This was, in effect, a campaign of attrition against enemy shipping in the fringes of Japan's new empire. The final portion of the campaign was a large scale aerial mining attack concentrated on the Japanese Inner Zone. B-29 aircraft laid over 12,000 mines in every important enemy harbor in the Japanese homeland between March 1945 and the end of the war. The unprecedented number of mines laid in such a short period resulted in the virtual blockade of shipping through the Shimonoseki Straits and in the Inland Sea of Japan.

The mine laying attack against Japan sank or damaged 1075 ships (including at least 109 combat vessels)¹ totalling over two and a quarter million tons of enemy shipping, a volume representing about a quarter of the pre-war strength of the Japanese merchant marine. Prince Konoye estimated that in the final months of the war the mining attack was just as effective as the bombing of Japanese industry. Admiral Nimitz described the results as "phenomenal" in his commendation of the execution of the campaign.

THE OUTER ZONE MINING CAMPAIGN

The first offensive mine laying undertaken by United States forces against the Japanese was in the Central Pacific Theater. Operations there included a coordinated use of all types of minelayers ranging from small landing craft to B-29's, a widespread and prolonged attack across the wide expanse of the Pacific in which early mines were tested and proven, and tactics devised for planting offensive mine fields of all types. The Central Pacific campaign was inaugurated by surface-laid tactical mine fields in the

¹ In making comparisons with forms of attack other than mining, the most conservative estimates have been used; in discussing what mining has done, the higher, more probable figures are used. Chapter 2 gives 147 (rather than 109) as the number of combat vessels mined, including some ships for whose damage credit was disputed for other means of attack. But Chapter 2 gives 961 (rather than 1075) as the total casualties to mines, using the conservative figure when making comparisons with other means of attack. The figures used here are CNO (used in the United States Strategic Bombing Survey, "Offensive Minelaying Campaign Against Japan," Naval Analysis Division, 1946) and include mining casualties for which all data were not available. In the tables which follow, these are distinguished by being set in parentheses.

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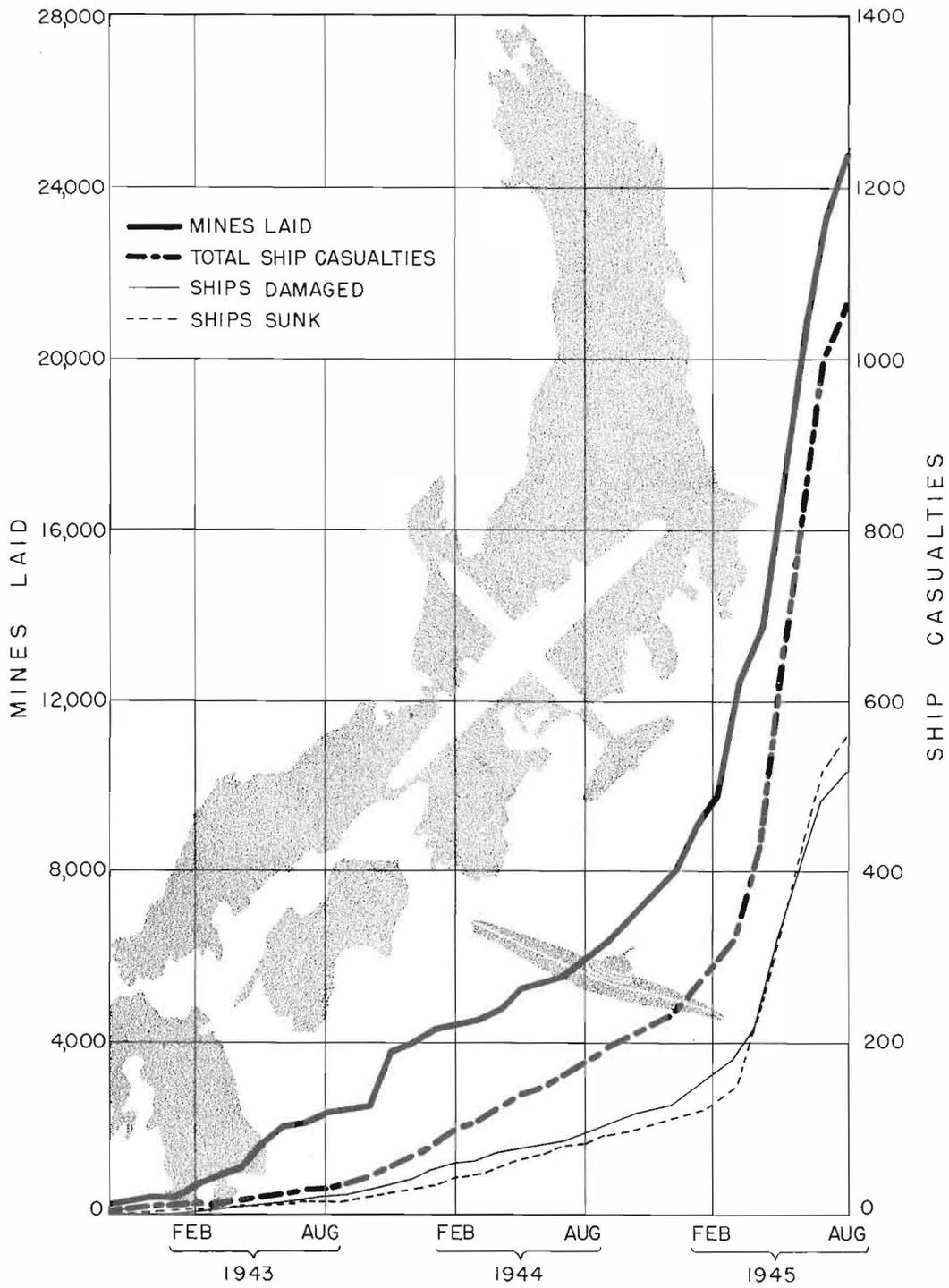


Figure 3-1. Offensive Mining Attack on Japan and the Occupied Territories

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Solomons and submarine-laid fields in Japanese home waters. These were followed by a series of tactical mining operations, carried out mainly by aircraft, in conjunction with the advance of United States naval and amphibious forces across the Pacific. The campaign culminated in the large scale strategic attack on the Inner Zone by B-29 aircraft (discussed in the next section) which established an effective blockade of Japan in the closing days of the war.

In the South and Southwest Pacific Theaters and in the operations based in India and China, mine laying followed the global strategy of the Allies in the early years of World War II: an accelerating harassment of Japanese outposts on the periphery of her gains. The attacks, though occasionally concentrated on particular targets, were spread over a huge area. It was this attrition mining which helped the submarines and bombers force Japanese shipping back to the protected waters of her Inner Zone where the shortest sea routes to China were based. Table 3-1 summarizes the effort expended and the results obtained in the Outer Zone mining operations for all Pacific Theaters. All figures on casualties are based on available Japanese records and questioning and are considered a minimum.

In 1942 few aircraft or bases were available for aerial mine laying, therefore submarines started the offensive of the Outer Zone Campaign. Seventh Fleet submarines based in Australia took extremely long cruises to the dangerously shallow waters of the Gulf of Thailand and the Gulf of Tonkin in the South China Sea where they placed mine fields along Japanese shipping routes. Submarines from Pearl Harbor conducted similar mining operations off the

Coast of Japan and of China. This mining continued intermittently throughout the war until a total of 658 mines had been laid in 36 mine fields during 33 patrols. Because United States submarines were so profitably engaged in hunting enemy ships with torpedoes, the scale of mine laying effort was never large, but it offered a constant threat at a large number of widely separated points and so presented a grave problem to the Japanese. At least 27 ships were sunk and 27 damaged as a result of this submarine campaign. These figures represent a bare minimum of results because of the likelihood that many explosions in out-of-the-way mine fields were attributed to other causes.

Early 1943 marked the start of offensive mining by surface layers. Between February 1943 and May 1944 (with the exception of one operation in August 1942) DM's and LCI's laid 2817 moored contact mines and 12 magnetic ground mines in 17 offensive mine fields through the south and southwest Pacific areas. Ship casualties include at least eight vessels sunk and three damaged though proximity to some fields laid from the air makes credit doubtful. A majority of the operations were conducted in support of tactical operations.

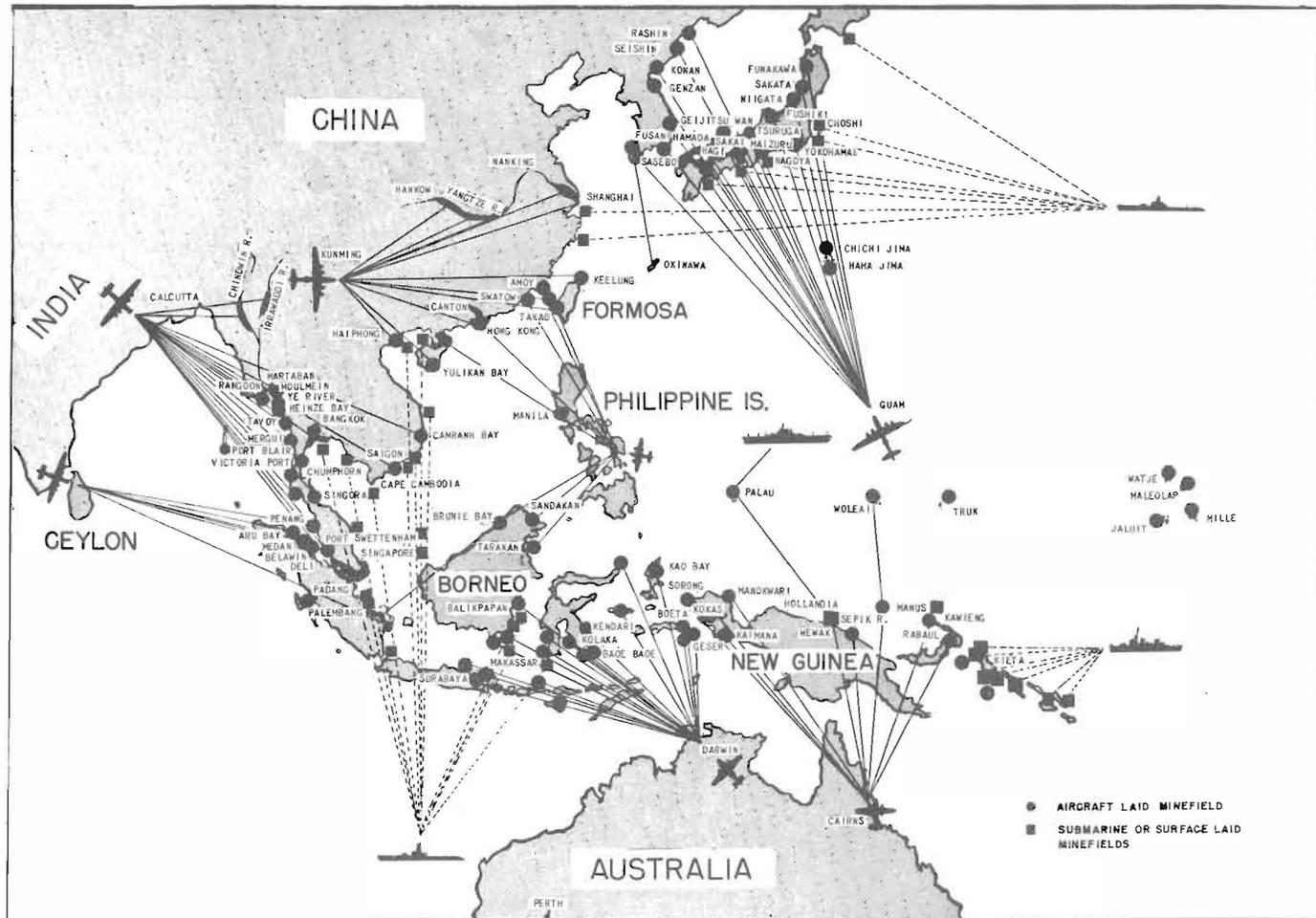
Also beginning in early 1943 was the aerial mine laying offensive which continued throughout the war, mounting in intensity. In the Outer Zone a total of 3231 aircraft successfully laid 9254 mines in 108 targets within the area included by Rangoon, Palembang, Surabaya, Kavieng, the Marshall Islands, and Shanghai, sinking 186 ships and damaging 154. Figure 3-2 shows the envelopment of Japan by mines as the attack was pressed to the Japanese

TABLE 3-1. SUMMARY OF OUTER ZONE MINE LAYING

Mine Layer	Number of Mine Fields	Patrols/ Missions/ Sorties	Total Mines Laid	Ships Sunk	Ships Damaged	Remarks
Submarine	36	33	658	27	27	Records from only 21 of 36 mine fields.
Surface	17	49	2829	8	3	In support of tactical operations and often in collaboration with A/C.
Aircraft	108	3231*	9254**	186	154	Includes RAAF planting US mines in SWPA and AAF using British mines in CBI.

* Mining A/C airborne includes 40 planes lost and 335 unsuccessful missions.

** Mines in target: 9829 were expended.



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Figure 3-2. Offensive Mine Laying Campaign Against Japan - October 1942 to August 1945.

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homeland. Because it was aerial mine laying which revealed the potentialities of the weapon, these operations will be summarized in some detail. Table 3-2 shows the Outer Zone aerial mining effort by theater and command. A statistical analysis of aerial mining operations will come later in the chapter.

On the nights of 22 and 23 February 1943, while the submarine and surface mine laying campaigns were in full progress, United States aircraft laid their first mines (British) against Rangoon. A month later the first United States mines were planted from United States aircraft in the Buin-Kahili region of Bougainville. The operation was aimed at closing down enemy supply lines to Japanese outposts in the Solomons and was carried out in collaboration with surface layers. At least six enemy warships were hit. In the Southwest Pacific, the first aerial mining was to prevent the development of a major base. From late April 1943 until early June, Royal Australian Air Force PBV-5's planted mines near Kavieng, New Ireland, in a proposed Japanese anchorage and its approaches. The one entrance

which was too deep for ground mines was closed by a field of moored mines laid by a United States submarine. The Kavieng field, reinforced in late June and early July, sank one survey ship and five large cargo vessels, damaged several others, included two light cruisers and one destroyer. The Japanese finally abandoned the anchorage completely.

Thus by early 1943 aircraft mining was being conducted in all major theaters of operation in the Pacific. South Pacific mining, on the edge of the farthest Japanese advance, lapsed when the Japanese were forced back from the Solomons. All mining in the Southwest Pacific Theater, subsequent to initial operations, was carried out by the Royal Australian Air Force which conducted a strategic mining campaign against the principal harbors and shipping routes throughout the Netherlands East Indies. In this, as in the submarine campaign, a relatively few mines planted in relatively small fields over a large area offered a constant threat to enemy shipping. Between the summer of 1943 and 1944 about 400 United States and British mines were planted in 21 harbors of the Netherlands East Indies and

Table 3-2. AIRCRAFT MINING IN THE OUTER ZONE BY THEATER AND COMMAND

Theater	Command	Aircraft Airborne	Successful Sorties	Aircraft Losses	Mines in Target	Targets
CBI	10 AAF	167	143	2	505	
	14 AAF	279	232	4	1092	
	20th BC	176	162	0	987	*37 (1B)
	RAF	697	631	7	3235	*10 (C)
South Pacific	Com Air Solomons	292	251	13	251	4
South-west Pacific	5th AAF	4	4	0	24	49
	RAAF	1215	1128	11	2498	
Central Pacific	7th AAF	129	110	1	226	8
	Fleet Air Wing One**	188	157	1	358	
	CTF58	84	78	1	78	
Totals		3231	2896	40	9254	108

* 4580 mines laid in India-Burma and 1239 in China.

** Of these, 94 sorties (88 successful) to lay 186 mines in target around Southern Korea were conducted as part of Phase IV of the Inner Zone Campaign.

MINES AGAINST JAPAN

the Bismarck Archipelago with Surabaya, Java, as the major port taken under attack. The ship casualties and delay which resulted from this mining cost one aircraft in nearly 200 sorties. Japanese development of important sources of raw materials was seriously hampered by the mining as it increased. It is estimated that in the Netherlands East Indies vicinity 90 percent of the ships over 500 tons were lost to Allied attack. Forty percent of these losses were caused by mines. Balikpapan, Borneo, which contained the only high octane gasoline refinery nearer to Pacific bases than Palembang, Sumatra, was mined. Palembang itself was mined on 10 August 1944 by eight B-29's, used for the first time in anything but high altitude bombing. Some aircraft bombed the oil installations at the same time. Seven ships were mined and the river was closed to important enemy tanker traffic for nearly a month. Although aircraft staged through Ceylon in order to carry out this operation, the flight is on record as the longest bombing and mining mission executed during the war.

In the Central Pacific in early 1944, as the Pacific Fleet began to rush the enemy's island defense ring, mines began to be used more extensively as tactical weapons. The first mining specifically in preparation for an amphibious attack was directed against the Marshall Islands in late December 1943 and early January 1944 when groups of heavy bombers from Tarawa and Apamama placed over 100 mines in the entrance to those atolls which were to be bypassed during the invasion of the islands. On 30-31 March 1944 the first mine laying strike carried out by United States carrier-based aircraft was directed against the enemy stronghold of Palau. All principal passages into and out of the atoll were mined. Thirty-two ships were bottled up in the harbor, later to be sunk by bombers. This mine laying denied the use of Palau to the enemy for at least 20 days and led to its abandonment as a forward operating base for Japanese naval ships and aircraft.

In April, Truk and Woleai were mined to prevent (with Palau) their use by any enemy fleet units which might endanger the Hollandia invasion and other movements then being carried on. In June and July Palau was again mined by aircraft to insure its neutralization during the capture of the Mariannas and the westward sweep toward the Philippines. In November and December 1944, B-24's of the Seventh Air Force heavily mined the Bonin Islands, which were being used as forwarding points for enemy supplies going to the Volcanoes and other advanced bases, in support of the attack on Iwo Jima. A marked decrease of enemy shipping in the mined areas resulted from this mining.

During the same period there was a rapid expansion of attrition mine laying in the China-Burma-India Theater. Though United States aircraft had mined Rangoon in February 1943, they used British mines. The first United

States mines arrived in India in July 1943 and had been used to extend the mining attack from Rangoon to Bangkok, Siam, and the railway ferry crossing along the route between those two places. In Burma-India the Royal Air Force, the Fourteenth Air Force, the 20th Bomber Command, and the Tenth Air Force flew over 1000 sorties to lay more than 4500 mines in 37 different regions along the coasts of Burma, Thailand, and the Malay Peninsula to hinder the flow of enemy supplies to the Burma front.

Earlier than this, in October 1943, aircraft mining was introduced into the China Theater when the Fourteenth Air Force dispatched two B-24's to mine Haiphong. Two ships were sunk and six of a 10-ship diverted convoy were sunk by direct air attack. The Japanese abandoned Haiphong as a port for anything larger than junks. Mining by the Fourteenth Air Force in China was done under more difficult conditions than in any other theater. Not only did the mines and equipment have to be flown over the Hump but the loss of forward air fields to the Japanese greatly curtailed air operations during the latter part of 1944. Nevertheless, there were over a thousand mines laid along the coast and in the rivers of China as well as around Formosa in a small but enthusiastic mining campaign. Hong Kong and Takao were mined, and so was the Yangtze River. This disrupted Japanese lines of communication between the North and the South. General Chennault, who gave high praise to mine laying in China, stated that it was one of the major factors contributing to the abortive campaign of the Japanese in South China. Testimony of Japanese military officials supports this opinion.

January 1945 found Japanese shipping in a critical condition. The continued attrition of ships had weakened the Japanese transportation system. Air patrols from the Philippines were threatening to cut off the southern half of the Greater Asia Sphere. The Japanese saw this threat and were making desperate efforts to transport the most vital materials from the Outer Zone to the homeland for a last stand. To thwart this, India-based B-29's engaged in their first large-scale mining effort on the night of 25-26 January 1945, planting several hundred magnetic mines in the approaches to Singapore, Saigon, and Camranh Bay. The Royal Air Force B-24's of the Strategic Air Force operating from India augmented the efforts of this raid. Within a week these aircraft mined nearly every useable port along the Malay Peninsula, as well as centering their campaign against every target within range of bases in both India and Ceylon. Over a dozen major targets were mined more or less continuously with more than a thousand mines during the first quarter of 1945. The third mining of Singapore was carried out by these Liberators in March; they flew a round trip of more than 3000 miles from Ceylon to plant their mines successfully.

The mining of other China Coast ports previously done by the Fourteenth Air Force was taken over by the

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Royal Australian Air Force Catalina squadrons operating from bases in the Philippines as they became available, in addition to continuing their attack on the Netherlands East Indies. No mineable waters were safe for shipping except those in North China, Korea, and the Empire itself.

During this Outer Zone Campaign no Allied submarine or surface vessel was lost while mine laying. In 3231 aircraft mining sorties, 40 planes failed to return. The campaign netted more than 275,000 tons of shipping sunk and more than 610,000 tons damaged. Even more important was the fact that vital shipping was greatly hampered in its movements and delayed for varying periods ranging from a day or two to a month. By the end of March 1945, the Japanese had been forced by submarines, air attack, mines, and the westward advance of United States forces across the Pacific to withdraw most of their remaining 2,000,000 gross tons of shipping to the Inner Zone. Operating in the comparatively shallow and well-protected East China Sea, Yellow Sea, and the Sea of Japan, the remnants of the Japanese merchant fleet shuttled back and forth between the Asiatic continent and the home islands, relatively safe from attack by submarines or heavy bombers. Most of this shipping, which was adequate at the time to supply Japanese needs within the Inner Zone, passed through the strategic Shimonoseki Straits to industrial ports located on the Inland Sea of Japan.

THE INNER ZONE MINING CAMPAIGN

The Inner Zone Campaign undertook to blockade Japanese waterborne commerce and thus sever the lifeline

to the Asiatic continent. B-29's newly based in the Marianas undertook, beginning in late March 1945, a mining campaign of unprecedented intensity to saturate Japanese home waters and make them unsafe for enemy ships. On the first night of the mining effort, just before the landings on Okinawa, Superforts of the 21st Bomber Command carried nearly 1000 magnetic and acoustic mines to Shimonoseki Straits and the Inland Sea, thus denying to the Japanese the use of sea lanes on which they depended heavily to rush reinforcements to the Ryukyus and to bolster their homeland for the impending invasion.

This mining attack on the Inner Zone continued until the end of the war. More than 12,000 mines were laid in the important channels and harbors of Japan and Korea producing an almost complete blockade of the Shimonoseki Straits and of all important industrial ports. Hundreds of ships were delayed, sunk, or damaged. Traffic vitally needed in industrial and populated sections was diverted to northern Honshu ports where it had to be hauled to its destination in spite of the overloaded transportation system. Figure 3-3, based on official Japanese shipping records, shows the decrease in shipping through the Straits. This decrease to less than two percent within four months was almost entirely due to the mining. Figure 3-4 shows the decrease in Japanese shipping to industrial ports (80 percent reduction in four months) and the overall effects of the blockade.

The mining campaign against the Empire was divided into five phases. The first phase was planned in support of the Okinawa operation. The Shimonoseki Straits and the

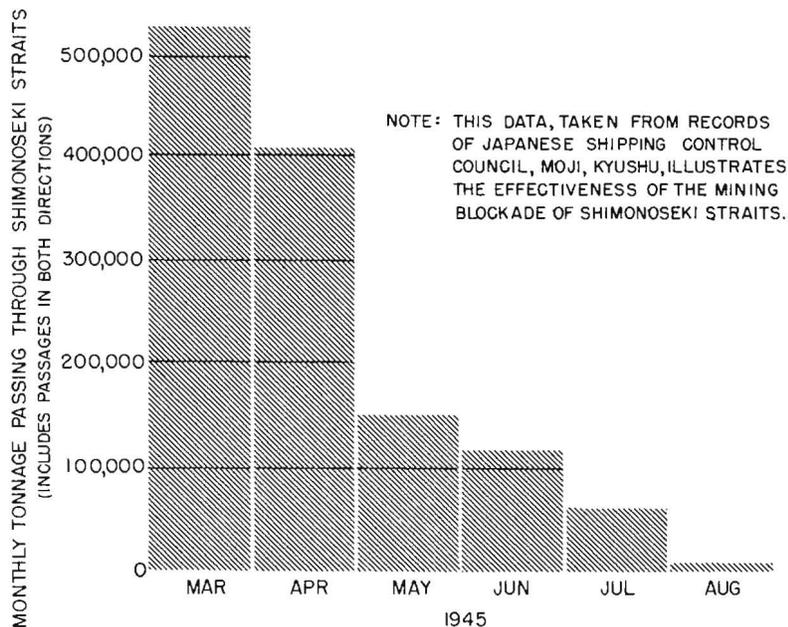


Figure 3-3. Effect of B-29 Mine Laying on Ship Passages Through Shimonoseki Straits

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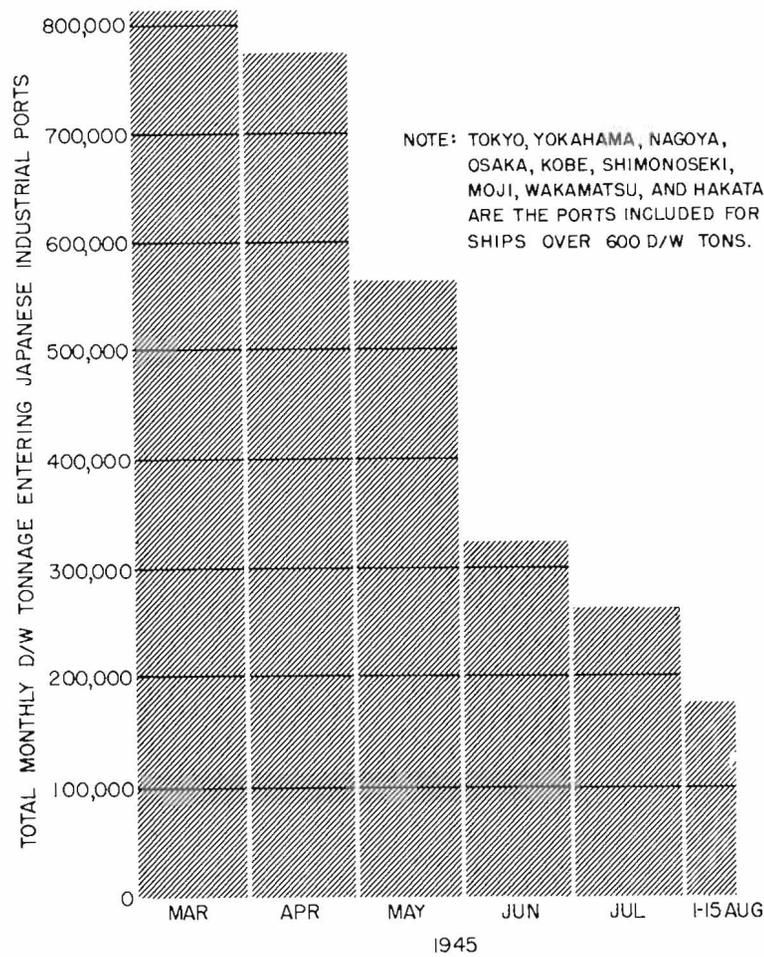


Figure 3-4. Total D/W Tonnage Entering Japanese Industrial Ports During Period of B-29 Mine Laying

naval bases of Kure, Sasebo, and the military port of embarkation at Hiroshima were hit with 2030 mines² in order to endanger movements of Japanese naval units in those places. It was particularly desired to prevent the sortie of the Japanese fleet through the Shimonoseki Straits whence they could speed to the defense of Okinawa under cover of Western Kyushu. In this the mining was successful. The only Task Force which did sortie attempted to slip out of the Inland Sea via the Bungo Suido (east of Kyushu) where United States units lay in wait. At that moment the battleship YAMATO was intercepted and sunk. No capital war vessel left Kure after it was mined. No capital war vessel even passed through the Shimonoseki Straits after it was

mined. The Japanese fleet was blockaded. Its vessels were immobilized for later attacks by carrier bombers near the close of the war.

The second phase, called the "Industrial Center Blockade," was begun on 3 May. The purpose of this attack was to destroy the seaborne communication routes between the great industrial zones of Japan by maintaining the blockade of Shimonoseki Straits and by mining the ports of Tokyo, Nagoya, Kobe, Osaka, and the main shipping lanes of the Inland Sea. This phase marked the introduction of the "unsweepable" pressure mine, the most potent under-sea weapon developed during the war. A total of 1422 mines of all types were used. Ship sinkings and damage

² The figures on mines laid in target during each of the five phases of the Inner Zone Campaign are taken from "Operation Starvation," a Twentieth Air Force publication, and total 12,053. These differ from those in the United States Strategic Bombing Survey (op. cit.) which were supplied by CNO and total 12,135 without any breakdown into phase. This minor discrepancy could not be eliminated at this preliminary stage of the book. Except where noted, all figures in this chapter are CNO (from USSBS), and all figures in Chapter 7 are from "Operation Starvation."

MINES AGAINST JAPAN

immediately increased. Shipping at all ports began to fall off rapidly and much of it which formerly passed from Korea and Manchuria through the Straits to industrial ports on the Inland Sea was diverted to northwest Honshu ports and Kyushu.

The third phase began on 13 May. The purpose of this attack was to blockade the bulk of enemy shipping moving from the Asiatic mainland to Japan by continuing the blockade of the Shimonoseki Straits and by mining all the major harbors of northwest Honshu and Kyushu. A total of 1313 pressure, magnetic, and acoustic mines were dropped. This phase saw the introduction of another purportedly "unsweepable" mine, the low-frequency acoustic mine. Initially unsweepable, it was to confound the Japanese in their feverish attempts to develop mine countermeasures. Shipping continued to decrease in Shimonoseki Straits and the industrial ports. There was a correspondingly slight rise in shipping in the northwest Honshu and Kyushu ports, but the new-laid mines resulted in many casualties among ships which had been sent to these ports.

The fourth phase, beginning on 7 June, was a greatly intensified attack. Efforts were made to complete the blockade of northwest Honshu and Kyushu by mining the secondary and tertiary harbors in these areas, and also to maintain blockade of Shimonoseki Straits and the primary ports of northwest Honshu and Kyushu. The important port system of Kobe-Osaka was also mined repeatedly during the fourth phase. A total of 3542 mines of all types was laid in this expansion of activity. Ship losses increased in the Honshu and Kyushu ports. Shimonoseki Straits and the industrial ports were almost completely blockaded.

As part of this fourth phase, Navy PB4Y-2 aircraft based on Okinawa conducted an attrition mining attack against shipping from the Yellow Sea skirting the southern coast of Korea. Between 10 June and 1 July, these planes of Fleet Air Wing One planted 186³ mines in the archipelago along the south coast of Korea, which forced shipping to abandon routes around the many islands in the area and to move out to open water. There it was vulnerable to direct attack. Finally the movement of shipping over 1000 tons was altogether eliminated.

The fifth phase was planned to carry the blockade to remaining enemy shipping at every point possible by mining all the ports of Korea while maintaining the blockade of Shimonoseki Straits and the entire northwest Honshu-Kyushu area. A total of 3746 mines was dropped in target areas. The effect was continued shipping loss and a falling off of traffic in all ports. The closing days of the war found Japan ringed with ports polluted with aerial mines. Shipping through the Shimonoseki Straits and in important

industrial ports had been reduced to a trickle. The Japanese were not able to clear any of their shipping lanes efficiently, but preferred to take abnormally high losses rather than stop completely. Ships were using the diversionary ports on northwest Honshu and Kyushu only as a desperate measure to get supplies to the mainland which accomplished but little, for the limited inland transportation facilities prevented final delivery of the necessary food and materiel to the industrial, populated sections in the Inland Sea.

The cumulative effect of mining left Japan little hope of continuing the war. Resultant shortages of coal, oil, salt, and food contributed to paralyzing industry. Shortly before the surrender, leading industrialists indirectly informed the militarists that industry could not continue. They estimated further that 7,000,000 Japanese would have starved to death if the war had continued another year.

The complete B-29 attack on the Japanese Inner Zone had used 12,135⁴ mines in only 1529 sorties (1427 successful). This was 6.7 percent of the Twentieth Air Force's total effort. Bombing occupied the other 93.3 percent. In the 1529 sorties, 15 aircraft failed to return, a loss of less than 1 percent.

Records kept by the Japanese show that at least 1,398,156 tons of shipping were mined in the Inner Zone (see Table 3-3). The casualties were 670 ships, including 65 men-of-war. Of the total, 294 were sunk and 137 damaged beyond repair for the duration of the war, and 239 damaged. During the Inner Zone Campaign, mines accounted for 63 percent of *all* Japanese merchant ship casualties from *all* causes. In addition to the great effect of blockade, all except 3 of the 22 ship repair bases were blockaded (most were in the Inland Sea area). This meant that ship casualties were substantially irreparable during the last two months. A complete evaluation of all intelligence available on the results of mine laying leads to the conclusion that it was accomplished with minimum effort and made an extraordinary contribution to victory.

RESULTS AND EVALUATION

Considering the entire campaigns in both the Inner and Outer Zones, about 25,000 offensive mines were laid against the Japanese. Of these, 21,389 were aircraft launched in target in 4323 successful sorties with a loss of but 55 planes (see Table 3-3). The cost was an insignificant portion of the overall effort against Japan. The results were proportionately very high. Over two and a quarter million tons of enemy shipping were sunk or damaged by mines. This represented nearly one quarter of the prewar strength of the Japanese merchant marine. Combat vessels mined included 2 battleships, 2 escort carriers, 8 cruisers, 38 destroyers and destroyer escorts, 5 submarines, and 54

³ These mines, planted in 94 sorties, are included in Outer Zone statistics (see Tables 3-1 and 3-2).

⁴ These figures differ by a slight amount from those given in Chapter 7 (see footnote, p. 28).

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Table 3-3. THE MINE OFFENSIVE AGAINST JAPAN

	Fields	Patrols/ Missions/ Sorties	Mines Laid in Target	Ships Sunk		Ships Damaged		Remarks
				No.	Tonnage	No.	Tonnage	
Outer Zone Operations	108	33 Sub. 49 Surf. 3231 A/C ¹	12,741 ⁴	201 (20) ²	253,365 (24,000)	154 (30)	522,895 (90,000)	This includes 94 sorties by Fleet Air Wing One in July 1945 in support of Inner Zone Mining Operations.
Inner Zone Operations	26	1529 A/C ³	12,135 ³	283 (11)	396,371 (15,400)	323 (53)	854,885 (132,500)	Damaged ships include 137 so seriously damaged that they were knocked out of the war.
Subtotal				484 (31)	649,736 (39,400)	477 (83)	1,377,780 (222,500)	Ship Casualties: 1075
Total	134	33 Sub. 49 Surf. 4760 A/C	24,876	515	689,136	560	1,600,280	Tonnage: 2,289,416

¹ Mining aircraft airborne. Total includes 55 planes lost and 437 unsuccessful missions.

² () indicate ships of unknown tonnage. They are confirmed sinkings for which all data were not available from Japanese records.

³ According to records in CNO. Twentieth Air Force records give 12,053 mines in target (Chapter 7), 1528 aircraft airborne, and 1424 successful sorties.

⁴ Includes 1,791 British mines and 106 dummy mines.

other vessels. (See footnote, Page 21.) Of these, 9 destroyers, 4 submarines and 36 auxiliary craft were sunk.

In a consideration of the accomplishments of the mine laying campaign, ship losses should be recognized as only one objective of mining, which also includes the delay and disruption of enemy shipping, disorganization of his maritime supply system, and the consequent deprivation of essential military and economic materials. These effects cannot be evaluated directly because they are too closely integrated with results from all other forms of attack on shipping and transportation. Sufficient information is available, however, to indicate that the mining made a significant contribution towards this end.

The mining campaign, although carried out with a small effort, was a very effective supplement to submarine and direct air attack on shipping and to strategic bombing of ports, industries, and rail and road transportation systems. The spectacular success of the mining operations during the later part of the war was undoubtedly magnified by the fact that enemy shipping had been so depleted by submarine and air attack that additional losses were very keenly felt. Casualty data indicate, however, that mine laying has been the most economical in both men and materiel of all types of attack against shipping. The indirect effect of mining on military and economic supplies is nec-

essarily omitted in such data, which serves to emphasize the conservative nature of this comparison with other forms of attack.

It is difficult to determine accurately the number of ships sunk and damaged by mines. Most of the Japanese data were burned. The official lists prepared by the various agencies in the United States vary considerably in accordance with their sources and the standards of validity they accepted. It is probable that even the most liberal figures are incomplete, since many ships were sunk or damaged without any record having been made of either the sinking or the cause. Often mines have not been suspected in an area, and the sinkings were credited to some other cause. In fact, some official Japanese opinion was that ships sunk by mines were probably attributed, in many cases, to other agents, such as torpedoes.

According to a compilation of the most reliable data available (see Table 3-4), approximately 1,067,963 tons of Japanese shipping have been credited as sunk or damaged irreparably by mines. In addition to this, more than 1,221,453 tons have been damaged. It is estimated that the totals for mine casualties will be increased by at least 10 to 15 percent when final evaluation is completed. So it is probable that the final total figure will exceed 2,300,000 tons.

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Table 3-4. SUMMARY OF JAPANESE SHIP CASUALTIES TO ALLIED MINES
(BASED ON JAPANESE RECORDS)

OUTER ZONE CASUALTIES

Target	Sunk		Damaged—OW		Damaged		Total casualties	
	Number of ships	Tonnage	Number of ships	Tonnage	Number of ships	Tonnage	Number of ships	Tonnage
Aru Bay.....	2	2,814					2	2,814
Babo.....	1	2,913					1	2,913
Balikpapan.....	5	18,063			5	11,415	10	29,478
Bangkok.....	10	7,764			(1)	(3,000)	(1)	(3,000)
Banka Str.....					2	6,425	18	14,189
Belawan Deli.....	(1)	(1,200)			2	9,729	2	9,729
Berhala.....	8	7,622			(1)	(3,000)	(2)	(4,200)
Blackett Str.....	(1)	(1,200)			1	1,945	9	9,587
Bonin Is.....	4	5,845	1	1,953	1	8,000	(1)	(1,200)
Buin-Kahili.....	(1)	(1,200)					6	15,798
Canton.....	3	4,950					(1)	(1,200)
Cape Padaran.....	3	420			2	2,831	5	3,251
Cape Selatan.....					2	4,390	2	4,390
Chumphorn.....					(1)	(3,000)	(1)	(3,000)
Geser.....	(1)	(1,200)			1	1,079	1	1,079
Guadalcanal.....	2	11,626					(1)	(1,200)
Hainan Str.....	1	2,165			1	2,156	3	13,782
Haiphong.....	.1	100			1	100	1	100
Hong Kong.....	(1)	(1,200)					1	2,165
Kaimana.....	1	100					1	100
Kau Bay.....	5	13,500					(1)	(1,200)
Kavieng.....	5	8,233			2	10,170	4	14,700
Kega Point.....	1	639			(1)	(3,000)	(1)	(3,000)
Kiirun Ko.....	(1)	(1,200)					5	9,261
Koh Sichang.....	10	4,586			(2)	(6,000)	(2)	(6,000)
Kolaka-Pomalaa.....	(5)	(6,000)			12	47,035	22	51,621
Kula Gulf.....	1	575			(3)	(9,000)	(8)	(15,000)
Lai kang Bay.....	1	2,500			1	1,255	2	1,830
Laut Str.....	5	13,500			(1)	(3,000)	(1)	(3,000)
Malacca Str.....	1	5,457			6	9,393	11	22,893
Manila.....	5	8,233			(1)	(3,000)	(1)	(3,000)
Mergui.....	1	639			5	14,701	5	22,934
Mille-Jaluit-Maloelap.....	(1)	(1,200)			(2)	(6,000)	(2)	(6,000)
Moulmein.....	1	5,300			3	21,825	4	22,464
Otua Island.....	1	2,500			2	10,112	(1)	(1,200)
Pakchan River.....	1	2,500			(1)	(3,000)	3	15,548
Palau.....	1	2,500			2	10,112	1	2,500
Palembang.....	1	3,098			2	10,112	2	10,112
Pare-Pare.....	1	2,219			(1)	(3,000)	(2)	(4,200)
Penang.....	1	2,219					1	3,098
Phan Rang Bay.....	1	2,219			2	9,416	3	11,635
Port Blair.....	1	2,219			(1)	(3,000)	(1)	(3,000)
Pulo Gambir.....	1	5,457					1	5,457
Pulo Tenggara.....	2	1,093			2	4,528	2	4,528
Rangoon.....	1	4,000			1	100	3	1,193
Saigon.....	12	2,141			2	4,000	3	8,000
Satahib Bay.....	1	500			(1)	(3,000)	12	2,141
Seeadler Harbor.....	1	500			1	20	1	500
Shanghai.....	1	500			1	20	(1)	(1,200)
Shortland Island.....	1	500			3	12,347	3	12,347
Simpson Harbor.....	1	500			4	6,560	7	8,328
Singapore.....	7	12,011			1	6,435	1	6,435
Singora.....	1	30			3	290	6	2,218
Sittang River.....	1	30			(2)	(6,000)	(2)	(6,000)
Sorong.....	1	30					(1)	(1,200)
							1	50
							1	6,925
							(1)	(1,200)
							2	14,554
							11	12,206
							1	1,000
							(3)	(7,200)
							2	2,799
							(2)	(4,200)
							46	109,545
							(3)	(7,200)
							1	750
							1	100
							17	124,620
							(2)	(6,000)
							(1)	(3,000)
							1	30
							1	5,832
							(1)	(3,000)

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OUTER ZONE CASUALTIES—Continued

Target	Sunk		Damaged—OW		Damaged		Total casualties	
	Number of ships	Tonnage	Number of ships	Tonnage	Number of ships	Tonnage	Number of ships	Tonnage
Sunda Strait	1	1,002			1	250	2	1,252
Surabaya	7 (2)	2,497 (2,400)			11 (1)	36,887 (3,000)	18 (3)	39,384 (5,400)
Swatow					1	96	1	96
Takao	3	12,999			8	15,668	11	28,667
Tana Keke	1	50					1	50
Tanjong Aru	2	3,120					2	3,120
Tavoy					(1)	(3,000)	(1)	(3,000)
Tioro Strait	1	100					1	100
	2	1,528			1	4,180	3	5,708
Yangtze River	36	25,087	1	870	9	9,894	46	35,851
					(1)	(3,000)	(1)	(3,000)
Yuliokan Bay	1	4,000			3	12,042	4	16,042
Total, Outer Zone	201 (20)	253,365 (24,000)	2	2,823	152 (30)	520,072 (90,000)	355 (50)	776,200 (114,000)

INNER ZONE CASUALTIES

Beppu					2	34,000	2	34,000
					(1)	(2,500)	(1)	(2,500)
Fukuoka-Karatsu	12	13,314	3	9,337	1	1,000	16	23,651
					(2)	(5,000)	(2)	(5,000)
Funakawa	1	1,778					1	1,778
Fusan	6 (1)	1,142 (1,400)	4	13,685	3	5,537	13 (1)	20,384 (1,400)
Geijitsu Wan			1	881			1	881
Genzan	2	1,738			1	7,000	3	8,738
Hagi			1	4,025	3	2,645	4	6,670
Harima Nada	11	21,113	3	3,143	4	7,856	18	32,112
Hiuchi Nada	5	5,900	2	9,723	4	13,154	11	28,777
					(5)	(12,500)	(5)	(12,500)
Imubo Zaki	2	8,055			2	2,986	4	11,041
Iseno Umi					1	4,216	1	4,216
					(1)	(2,500)	(1)	(2,500)
Kii Suido	2	5,000			2	3,373	4	8,373
					(1)	(2,500)	(1)	(2,500)
Kobe-Osaka	31	47,524	16	38,119	10	17,085	57	102,728
Konan					(2)	(5,000)	(2)	(5,000)
Kure East Aprt.	2	6,452			3	2,558	5	9,010
					(2)	(5,000)	(2)	(5,000)
Kuro-Hiroshima	4	12,990	2	3,095	7	43,227	13	59,312
					(2)	(5,000)	(2)	(5,000)
Maizuru-Miyazu	13	20,105	3	6,047	5	22,247	21	48,399
Masan			1	887			1	887
Nagoya	2	2,096					2	2,096
					(1)	(2,500)	(1)	(2,500)
Nano-Fushiki	8	10,984	12	39,437	12	28,898	32	79,319
Niigata	16	14,170	2	3,416	13	15,981	31	33,567
	(1)	(1,400)			(1)	(2,500)	(2)	(3,000)
Rashin	1	2,225			5	20,586	6	22,811
					(1)	(2,500)	(1)	(2,500)
Reisui			1	3,601			1	3,601
Sakai	1	3,825	4	5,378	2	9,261	7	18,464
					(4)	(10,000)	(4)	(10,000)
Sakata	2	604					2	604
Sasebo	4	3,527					4	3,527
Seishin	2	2,286					2	2,286
Senzaki-Fukawa-Yuya	1	15	1	6,527	9	19,138	11	25,680
					(1)	(2,500)	(1)	(2,500)
Shimonoseki-East	70 (8)	85,839 (11,200)	22	52,421	51 (17)	104,496 (42,500)	143 (25)	212,756 (53,700)
Shimonoseki-West	74 (1)	117,427 (1,400)	51	150,473	34 (5)	83,126 (12,500)	159 (6)	351,026 (13,900)
Southwest Korea	4	2,500			2	1,086	6	3,646
					(3)	(7,500)	(3)	(7,500)
Tokyo	1	799			1	1,000	2	1,799
					(1)	(2,500)	(1)	(2,500)
Tsuruga-Obama	4	4,704	4	8,657	3	8,144	11	21,505
					(2)	(5,000)	(2)	(5,000)
Yertimo Zaki	2	199					2	199
Unknown locations			4	17,152	6	20,231	10	37,383
					(1)	(2,500)	(1)	(2,500)
Total, Inner Zone	283 (11)	396,371 (15,400)	137	376,004	186 (53)	478,881 (132,500)	606 (64)	1,251,256 (147,000)
Total, Outer Zone	201 (20)	253,365 (24,000)	2	2,823	152 (30)	520,072 (90,000)	355 (50)	776,200 (114,000)
Net total	484 (31)	649,736 (39,400)	139	378,827	338 (83)	998,953 (222,500)	961 (114)	2,027,516 (261,000)
Grand total	515	689,136	139	378,827	421	1,221,453	1,075	2,289,416

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Statistics furnished by the Japanese show that the time required for repairing large ships damaged by United States mines was 95 days (average for 21 ships) and that required for small ships was 70 days (average for 16 ships). Towards the end of the war, the limited number of dry docks and the scarcity of materials for repairs prevented even the beginning of repair on many damaged ships. Such ships were effectively sunk insofar as usefulness to the Japanese was concerned. The best data available show that at least 400,000 tons of damaged enemy shipping were in this condition at the end of the war. This figure, added to over 690,000 tons actually sunk, gives a total of more than 1,000,000 tons which might be considered sunk in contributing to the embarrassing situation in which the Japanese found themselves in August 1945.

Another objective of mining is to force upon the enemy the military and economic burden of maintaining a defense. This may require mine sweeping or clearance, mine spotting, special treatment and modification of ships, and various measures to prevent mine laying operations. The enemy's concern over these matters was demonstrated by his degaussing of naval vessels and auxiliaries even though handicapped by serious shortages of electrical equipment and technical personnel. In the latter part of the war, anti-aircraft guns were moved from important industrial cities to locations where they strengthened defenses in mining target areas. As a last resort, scientific and technical personnel were diverted from other work to that of the development of mine countermeasures. By the end of the war, defense against mining was given top priority over all defense measures in Japan.

In some cases the effort expended on countermeasures may well exceed in cost and labor the effort required to lay the mines. For instance, the United States was forced to spend millions of dollars to build and maintain a fleet of minesweepers because of the mere threat of German mining in the Atlantic, and when the Germans did finally mine the East Coast, their effort was insignificant compared to the effort the United States expended in countermeasures. German mining forced the British to man and equip over 1000 minesweepers; the cost of the latter in money alone probably exceeded what it cost the Germans to execute the campaign. Similarly, British mining operations against the Germans forced the latter to develop and maintain a large mine sweeping force. It has been estimated that by the end of the European war, the Germans had more personnel engaged in mine countermeasures than would be required to man the entire British Navy in peacetime.

In the Pacific the mine sweeping effort expended by the Japanese did not compare with that of the United States, Britain, or Germany. Their countermeasures were neither extensive, efficient, nor adequate for the purpose.

The Outer Zone mining campaign was, for the most part, dealt with locally. The high naval authorities in Japan neither comprehended nor were well informed of the details or results of this widespread attack. As a result they failed to make adequate preparation for an attack in Japanese waters and the large scale Inner Zone campaign executed in the few closing months of the war gave them little opportunity to divert a substantial effort to this new menace. It can be concluded that lack of foresight was a major factor in accounting for the relatively small effort expended by the Japanese on mine countermeasures, though Japanese, in the Inner Zone alone, spent 35,715,340 yen and employed more than 20,000 officers and men in connection with mine countermeasures.

By the end of the war the Japanese had developed fairly effective sweeps for all United States mines except the pressure mine. But the sweeping equipment available was insufficient and, as a result, they were poorly prepared to meet a large scale attack in any one area. Generally, magnetic mines were cleared by a sweeper towing either magnetic bars or an electrically energized cable or loop. Acoustic mines were swept by noise bombs dropped into the water. Additional countermeasures, partially effective against all types of mines, were the use of drag nets drawn over the bottom and the location and disposal of mines by divers. The Japanese had set up extensive mine-watch organizations in practically every port or area mined during the campaign. In this way they hoped to discover the extent of the mine fields and obtain some idea of the number of mines dropped.

It has been stated that a major purpose of mining is to delay and disrupt shipping, and that ship casualties are only incidental to that purpose. An analysis of intelligence information on the Outer Zone mining campaign bears this out as far as can be determined. The delays and disruption of shipping traffic brought about by this attritional mining campaign were significant, and greatly complicated the enemy's logistic problems. The situation in the Inner Zone was somewhat different, although the overall effect appears to have been much the same. Because of the mining blockade of the Shimonoseki Straits and important industrial ports, the shipping in those areas was finally reduced to a trickle. A large portion had been diverted to northern Honshu ports, where cargoes waited for passage on an already overloaded rail system in order to reach the industrial and populated section of Japan. The effect of this diversion cannot be accurately evaluated in comparison to ship sinkings. It should be noted, however, that because of the desperate shipping situation in Japan during the closing months of the war, the Japanese often ran ships through mined waters even though the danger was great and little time or effort had been spent to clear a channel.

The effect on Japanese shipping summarized above was accomplished with relatively minor effort. The number

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of mines required per ship casualty for the various types of layers, computed from the estimates on ship casualties, is approximately 21 per casualty for aircraft, 12 for submarines, and 250 for surface layers. Counting 1075 casualties, for all types of layers in the Pacific campaign, the number of mines per ship casualty is about 23 (based on mines in target) and 25 (based on mines expended). Table 3-5 lists the type mines expended in each theater.

The aircraft-laid fields achieved favorable results compared with the aerial mine laying undertaken by other belligerents in World War II. This was mostly attributable to the fact that the Japanese were not technically on a par with other belligerents in influence-mine countermeasures, while at the same time their national economy was such as to make them extremely vulnerable to mine attack. An analysis of the aerial mining campaign in the Inner and Outer Zones discloses that about 23 mines per casualty were obtained in the Outer Zone, while approximately 19

mines per casualty were obtained in the Inner Zone. This difference is traceable to the fact that many of the Outer Zone fields were directed against areas where there was little traffic, so that fewer casualties resulted per mine expended. Also, the Outer Zone attacks lasted over a period of almost three years and were not heavily concentrated, so that the Japanese had an opportunity to develop countermeasures locally and in most cases could delay the sailing of ships until such countermeasures had been taken. These delayed sailings compensate for the lower casualty rate.

In the Inner Zone the attack was very concentrated in place and in time, many new mine types were introduced in rapid succession, and there was comparatively heavy traffic through the mined areas. Moreover, the desperate shipping situation at the time forced the Japanese to sail their vessels through unswept waters regardless of the risk. All these factors contributed to the attainment of the remarkably efficient 19 mines per ship casualty in the Inner Zone.

Table 3-5. AIRCRAFT MINES EXPENDED, BY TYPE AND THEATER

	Theater	Magnetic	Acoustic	Magnetic Acoustic	Pressure Magnetic	Low Frequency	Contact (Drifting)	Dummy	Total
Outer Zone	Central Pacific	575	34	—	33	20	—	—	662
	South Pacific	237	14	—	—	—	—	—	251
	Southwest Pacific	1933	465	124	—	—	—	—	2522
	India-Burma	4192	246	—	—	—	36	106	4580
	China	825	182	—	—	—	232	—	1239
	Total	7762	941	124	33	20	268	106	9254
	Percent	84.0	10.1	1.3	0.4	0.2	2.9	1.1	100
Inner Zone	Central Pacific	4291	3507	—	2959	748	—	—	12,135
	Percent	40.5	28.9	—	24.4	6.2	—	—	100

	Outer Zone	Inner Zone*	Mining Campaign
Successful Launchings	9254	12,135	21,389
Total Expended	9829	13,090	22,919
Percentage in Target	94.5	92.7	93.1

*CNO Figures

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TACTICS OF AERIAL MINE LAYING

The airplane has become the most important type of minelayer. This craft can carry its mines into the enemy harbors and repeat operations over an extended period without fear of being endangered by its own previously laid mines. The disadvantage of aerial mine laying is that it can seldom be carried out secretly. This is a minor fault when conducting a blockade. The primary advantage of a submarine is that it can lay mines with great secrecy and at a distance beyond the current operating range of aircraft. But its use is handicapped because it must go into normally dangerously shallow waters to plant ground mines. Once a submarine has mined an area, it must subsequently avoid that area during the life of the mines. The primary advantage of a surface craft is that it can carry a large quantity of moored mines into enemy waters, thus creating a complementary danger to that of ground mines laid by aircraft or submarines. Surface craft are at a major disadvantage since they are easily detected and attacked, and must avoid their own as well as enemy mine fields.

Many types of bombers were employed in mine laying during the war. The most effective aircraft for long-range large scale mine laying proved to be the B-29, which

was used in the attack on the Inner Zone and in the China-Burma-India Theater. B-24's were used successfully in the China-Burma-India and Central Pacific areas. In the Southwest Pacific, PB4Y-2's were suited for the type of attack carried out there, where a few mines had to be laid accurately at each of many and widespread targets. Navy TBF's and PV-1's carried out attacks in the Central and South Pacific areas. These were generally successful, but such aircraft carry too small a load for normal operations. PB4Y-2 aircraft used in the mining of Korean ports proved very well adapted to low and medium altitude mine laying. Other aircraft which saw limited use were B-25's and PB2Y-3's, both of which performed satisfactorily (see Table 3-6).

The tactics varied according to the type of aircraft and mine employed and the operating conditions in the different theaters. The most satisfactory system was for individual aircraft to drop mines by making a course and distance run from a known landmark or pin point. On occasion, mines were dropped by a "down the channel" method. In this, the aircraft flew down a river or channel at low altitude and released mines in the desired locations along the route.

Table 3-6. AIRCRAFT PERFORMANCE

	Type Aircraft	No. Airborne	No. of Aircraft Successful	Aircraft Lost	Mines in Target	Successful Missions	Aircraft Losses	Mines Laid per Aircraft Loss
O Z u o t n e e r	B-24	1230	1077	14	4981			
	B-25	46	43	0	101			
	B-29	176	162	0	987			
	PBY-5	1242	1153	11	2548			
	PB2Y-3	5	4	0	12			
	PB4Y-1	46	31	1	101	89.5%	1.2%	231.0
	PV-1	48	18	0	18			
	TBF	344	320	14	320			
	PB4Y-2	94	88	0	186			
	TOTAL	3231	2896	40	9254			
I Z n o n n e e r	B-29	1529	1427	15	12,135	93.4%	0.98%	809.0
	GRAND TOTAL	4760	4323	55	21,389	90.8%	1.16%	407.0

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With few exceptions, aircraft mine laying was carried out under varying degrees of darkness. Accuracy was not seriously affected by this policy, and it offered greater safety to mine laying aircraft and more secrecy to the location of mines dropped. On occasion, in the China-Burma-India Theater, mine laying was executed in daylight during the monsoon season where heavy cloud cover gave the necessary safety and secrecy to the operations. In a few other instances, most notable of which was the mining of Palau from carrier aircraft, mine laying was executed in daylight to alarm the enemy with mines.

In the Southwest Pacific area PB4Y-2 aircraft were used, but because of the low speed and vulnerability of this plane, the darkest nights of the month were usually chosen for operations. Approaches were made at less than 100 feet to avoid radar detection. Drops were made visually at 100 to 500 feet, usually near 100. In the China-Burma-India Theater B-24's were mostly used. Drops were generally made visually during moonlit nights. Some daylight operations were executed along the Malay Coast during the monsoon season. Some radar drops were made in the China area. Mines were released at altitudes of 200 to 1000 feet, depending to a large extent upon the surrounding terrain. B-29's were used to some extent in this theater. Drops were made visually during moonlit periods, although provision was made for dropping by radar if visibility was bad. Altitudes of 2000 to 8000 feet were used.

In the Central and South Pacific Areas TBF's and PV-1's were used in both daylight and moonlight operations. Drops were made visually from altitudes of 200 to 1000 feet. Formation mine laying was developed and found feasible in tactical mining. B-24's employed visual tactics similar to those used in the China-Burma-India Theater, except that formation tactics were used more often. Pioneer work in radar mine laying was done in conjunction with the Bonins mining, thus preparing the way for later B-29 tactics.

In the Inner Zone campaign B-29's mined at night throughout the month, but preferably on moonless nights and during cloudy or bad weather. Navigation and dropping were primarily by radar. Altitudes were usually 5000 to 10,000 feet. A few Inner Zone operations were carried out by PB4Y-2 patrol aircraft. These also took place at night throughout the month. Drops were made visually from altitudes of 300 to 800 feet. If visibility was bad, drops were made by radar at an altitude at least 1200 feet above surrounding terrain. This usually required dropping from 2000 to 2500 feet.

CRITIQUE: OPERATIONS

Much of the value of a new weapon lies in its surprise introduction and large scale use before the enemy can

develop countermeasures. Offensive mine laying began on a small attritional scale in the Outer Zone in apparent violation of this principle. Circumstances made this necessary, but experience verified the maxim. Locally, the threat of a particular type of mine decreased after it had been used. This, however, did not have the expected adverse effect on the overall mining campaign. Reasons were that there was no good exchange of information among Japanese commands; also the campaign was carried out secretly and the results therefrom were kept from superiors by local Japanese commanders for fear of "losing face." Thus the top authorities in Japan did not become aware of the growing menace of mining attacks. When the large scale mining began in the Inner Zone in March 1945, they were not prepared and could not cope with the blockade. Once the final mining attack started and the Japanese seriously tried to develop countermeasures, the truth of the above maxim was borne out. The value of the simple magnetic mine and the audio-frequency mine fell off after their early use. This effect was minimized by the large scale introduction of magnetic mines with specially adjusted mechanisms. The large scale use of pressure mines and low frequency acoustic mines soon followed. This procedure first rendered Japanese magnetic sweep gear obsolete and then so complicated their countermeasure problem that sweeps for the later types of mines were not developed. As a result, the Japanese never did have practical countermeasures against the Allied attack.

Persistent mine laying over a widespread area was proven valuable throughout the mining campaigns in all theaters. It was desirable to mount a large initial attack on an area and then to drop a few mines at frequent intervals. This procedure had better results than occasional large scale missions, even though the total number of mines was the same. These facts have been verified by Japanese interrogations. The mining of the Shimonoseki Straits shows the importance of diversification. Because of operational considerations, there was a period during the attack in which the two ends of this Strait were mined alternately on successive missions. The Japanese were quick to detect this and each night concentrated all of their minesweepers at the end of the Straits at which the mining attack was anticipated. Thus they could apparently clear channels more quickly than would have been possible had their forces been divided into two groups working at both ends of the Straits. Actually, time delays and ship count mechanisms spread the threat of the mines continuously over the period between mine layings. Frequent dropping of mines in small numbers closed harbors for more total time than when occasional large scale mining took place. The explanation is that a few mines required nearly as much time for sweeping as larger numbers. Even though no mines had fallen in a channel during a small operation, the enemy was forced to

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indulge in time-consuming exploratory sweeping before a passage could be declared safe.

Occasionally it may be desirable to conduct a concentrated attack upon a particular area. Generally in the execution of a strategic campaign it has been found advantageous to spread the effort over the greatest possible area with large initial attacks on the more important ports. Operations should be carried out at frequent intervals against all mineable ports.

Inland waterways are important as mining targets. The best example is the attack the Fourteenth Army Air Force and 20th Bomber Command carried out on the Yangtze from its mouth at Shanghai to its upper reaches. The scale was small but results were particularly good. Many ships were sunk and traffic on this important waterway to Central China was interrupted, which had an adverse effect in Japanese military operations. Similar mining of the long river approaches to Rangoon, Bangkok, and Palembang showed the vulnerability to mines of shipping in confined channels. In Europe the aerial mining of the Danube by British bombers seriously disrupted the ship and barge traffic on that vital waterway. The inescapable conclusion to be drawn from all of these operations is that the mining of inland waterways can be most effective. Serious consideration should be given to both the offensive and defensive aspects of the problem.

CRITIQUE: PLANNING

Generally speaking, the mining campaign was not closely coordinated with other forms of attack on Japanese shipping. In the few instances in which this was done there were gratifying results, as in the mining in the Solomons, the carrier attack on Palau, and other operations mentioned above. For a very brief period submarines of the Seventh Fleet and aircraft of Fleet Air Wing One coordinated their antishipping patrols with mining missions. Mines forced enemy shipping from protected coastal waters to open sea routes where they could be taken under direct attack by the submarines. When direct daylight air attack on enemy minesweepers could be made, it was found to offer valuable support to the night mine laying operations because the sweepers were forced to operate at night, which slowed them down.

There was no general plan for a mining campaign against the Japanese, so offensive mining was not part of the major strategy of the war. On occasions it entered into particular major plans, the most important of which was the mining of Shimonoseki Straits in connection with the invasion of Okinawa. For the most part, however, mining plans were initiated on a low level and sent up the chain of command for approval. Mines, perhaps more than any other weapon of equal accomplishment, were orphans during the war. Even though approval and encouragement were

received from the high commands, much of the initiation and promotion of the mine laying campaign came from a relatively small group of enthusiasts, in lower echelons, who were engaged in the work.

At the beginning of the war, a Mine Warfare Section was established in the Office of the Chief of Naval Operations for the purpose of coordinating all mine warfare activities, but cognizance of mine warfare sprawled over many units, each responsible for individual aspects of mine warfare, none responsible for the whole (see Chapter 4). By the middle of the war the Mine Warfare Section had effected the best possible compromise in a bad situation. It performed its work of centralized coordination by liaison and the assumption of responsibility where none would claim it or use it. By analyzing operational requirements it was possible to guide the Bureau of Ordnance in determining the types of mines needed, their relative priorities, and the quantities and distribution desired. The Chief of Naval Operations controlled the release of mines to service use, thus insuring the coordinated introduction of new mines in all theaters and avoiding premature introduction and consequent compromise of a mine in any one theater. The collection dissemination of operational information and intelligence among all theaters was also effected, so that operations in each area profited by experience gained in others. Close supervision was maintained over the training and distribution of mine warfare personnel, thus providing all commands with the most capable and experienced mining experts available. Army Air Forces liaison officers formed an integral part of the organization. This general coordination of the various phases of mine warfare has been an important factor in the success of the mining campaign.

The cooperation between personnel of the United States Army and Navy and Allied services in the logistic support and operational direction of the mining campaign was exemplary in all theaters and basically necessary to the success of the campaign, for the most effective large scale aerial mine laying was carried out by long range bombers. In the Pacific campaign most of this was undertaken by the United States Army Air Forces, supported in Southeast Asia and the Southwest Pacific by the Royal Air Force, and the Royal Australian Air Force. Much of the planning, the logistics, and the sweeping (because a mine threatens all ships, friendly or enemy, and must be coordinated with possible future naval movements) was a naval problem. Close liaison between the Navy and the Air Forces was imperative.

In peacetime planning for mine warfare, advantage must be taken of the experience gained in World War II. The prime lesson was that there *must* be peacetime planning. Development of mines and other underwater weapons had suffered in the prewar period because there was no

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well-balanced program to guide their research and development, partly because of lack of funds for technical research, and partly because little thought was given to the potentialities of offensive mine warfare. Chapter 11 treats this problem at great length. It suffices here to say that operational needs must be closely integrated with developments rather than forcing a finished development into operational usefulness by superimposing modifications with a consequent hesitation in accepting the weapon.

The importance of adequate intelligence cannot be overemphasized. A mine laying campaign is generally strategic and the mining officer must know the relative economic and military importance of prospective targets. The volume of shipping, the size of the ships and the nature of their cargo are all significant and must be carefully studied and analyzed in the planning stages of a campaign. Mine laying operations are dependent upon the geography and oceanography of the target area, upon the status of the enemy's countermeasures, and especially upon the disposition of the enemy's shipping as it varies throughout the attack. Aerial photographic reconnaissance is an important source of this information. Since the success attained with the use of mines varies inversely with the ability of the enemy to dispose of them, continuing detailed and accurate intelligence on enemy mine countermeasures is most important in the successful prosecution of a mining campaign.

Much of the information needed in mine planning and operations can be acquired during peacetime. Therefore it would be desirable to have files set up at the Chief of Naval Operations for all potential mining targets. Information should be gathered on the economic importance of ports and cargoes, size and number of ships handled at each port, terminal facilities, locations of channels, water depths and currents, character of bottom, etc. These data should be the object of continuous peacetime investigation. All valuable information concerning the development of mine countermeasures by potential enemies should also be obtained in peacetime.

A decision must be made before another war begins, or in its earliest days, on the desirability of a major mining campaign. Only then can the necessary logistics be planned. In the last few months of the war with Japan, the Twentieth Air Force was ready to devote a still larger portion of its effort to mine laying, but mines were unavailable. This was because the decision to carry out a large scale attack was not made until shortly before the Inner Zone Campaign began. In view of the many other logistic commitments in the Pacific, there was a reasonable reluctance to give mines the necessary priority in both production and shipping.

Throughout the mining campaigns in all theaters there was a tendency to underestimate the number of aerial mines required to mine a given location. This was due partly to lack of up-to-date intelligence on the effectiveness of Japanese sweeping measures, and partly to lack of recog-

nition of the fact that a relatively small percentage of the mines dropped by aircraft fall into the ship channels. Estimates should not necessarily be more liberal, but more complete information should be available on the location of enemy channels, the accuracy of planting, and the ability of the enemy to execute countermeasures. It is also essential that experienced mine warfare officers be available to interpret and analyze enemy intelligence in order to recommend the most economical distribution of the mining effort (see Chapter 5).

Despite the relative success of the mining campaign, the attack was "too little, too late." In nearly every area, offensive mining would have produced far greater results if it had been started at an earlier date and on a larger scale. The delay was due to the lack of early development and early indifference to the offensive possibilities of mine warfare. This type of warfare was new and had to undergo a period of proving itself before it was accepted. The development, production, and supply of mines were pushed with particular vigor during the later months of the war. Logistics were superior considering the handicap at the start. As a result the mining campaign progressed with a tempo equal to the general tempo of the war against Japan. A mining attack, however, could have preceded other offensive action to a greater extent and would then have made a far greater contribution to victory.

Most mining was done at night, when true control of the air was doubtful, both enemy and friendly aircraft having some freedom of action. This made mine laying easier than most other offensive air action. It allowed aircraft to help when otherwise their operations might have been restricted. For example, though Royal Australian Air Force Catalinas had few offensive uses, they were very effective as minelayers in the Southwest Pacific. Aerial mine laying did not require complete air superiority. Mines can be laid with limited air resources even if a nation finds itself almost stripped of air power, like the United States after Pearl Harbor. Then mine laying may be an effective and economical means of thwarting a seaborne offensive by an enemy power. This means that a nation should not be lulled into a sense of false security by the unlikelihood of attack by another nation weak in air power. It could still mount a very effective mining attack against a stronger power.

In the chapters that follow are given the source data of the mine warfare campaign conducted by the United States. The story is unfolded in most of its details beginning with a history of the formulation of mine warfare policy and continuing through research, development, production, preparation, and the operational use of mines. What happened with mines, what should be done differently should the United States be required to wage war again, and what must be done in peacetime — including the major problems of countermeasures and weapons development — is

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gathered in this one book. The remarkable and economic results attained by the intensive campaign against Japanese shipping has made of mine warfare a major means of nailing

another power to dry land. This offensive potential could be unleashed against the United States. Good heed must be taken.

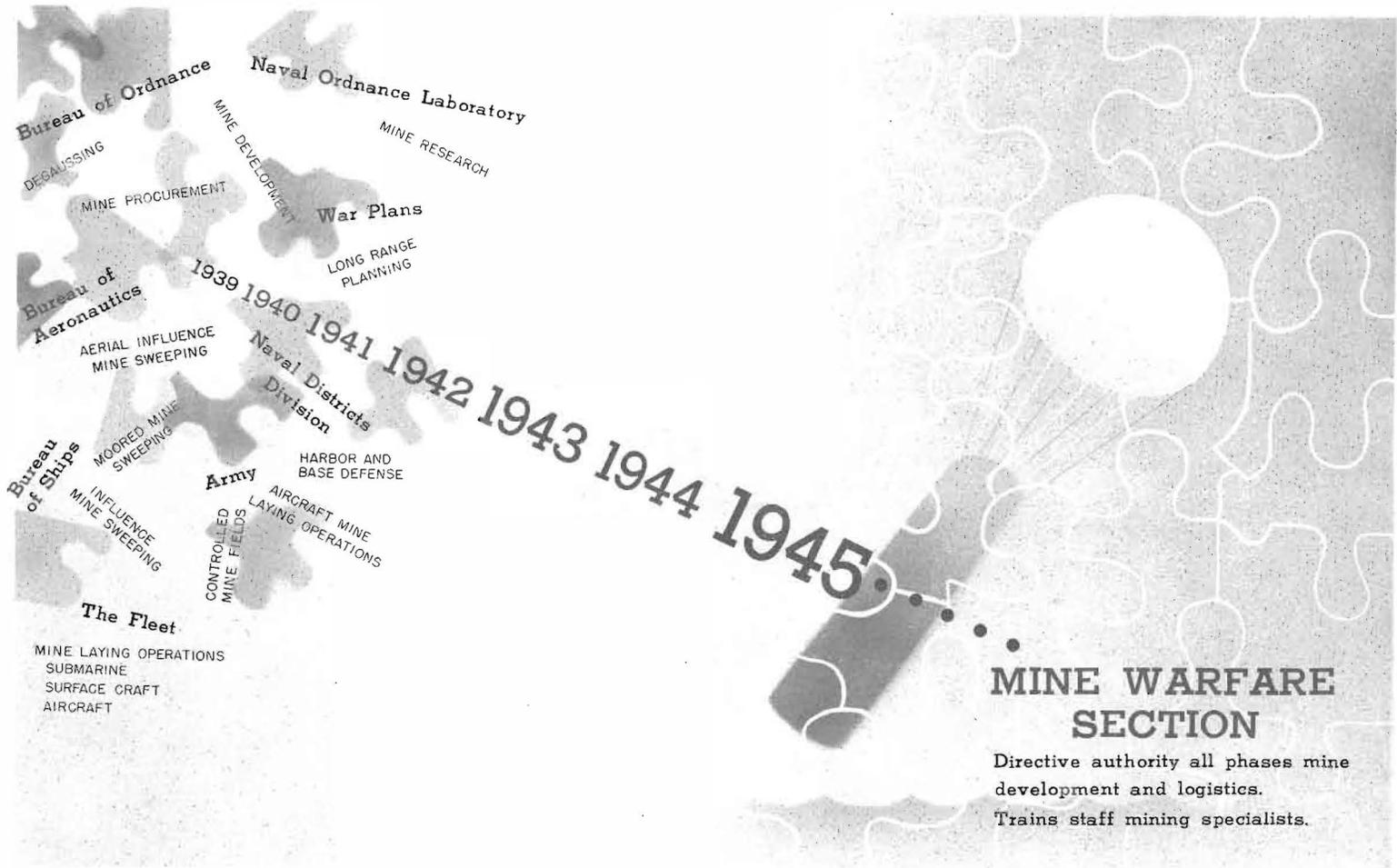


Figure 4-1. Growth of Control of Mine Warfare Policy

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4.

MINE POLICY DURING WORLD WAR II

DIVIDED COGNIZANCE

Early mine policy in World War II was vague and uncertain, and what there was of doctrine was completely outdated. Policy formulation belonged to no one specifically and so its history is one of divided cognizance, of a series of compromises involving established procedures and divisional policies which fundamentally had nothing whatsoever to do with mine development and use. Much of this is to be expected in a large organization whose procedures are set along tried lines, but the saving grace of a subordinate section which would act to formulate and then advocate a new doctrine was absent as a cementing force until very late in the war.

The responsibility for development of mines and countermeasures fell largely on the materiel Bureaus with only general assistance from the Divisions in Operations. In a sense this was in accordance with naval custom, since the problem was one of research and development of material, but it was complicated by the absence of central direction. The absence of a clearly delineated cognizance between Bureaus forced the Chief of Naval Operations to take more and more responsibility even though cognizance was not clear within Operations itself. Under prewar organization it might have rested in any of four Divisions: War Plans, Fleet Training, Fleet Maintenance, or Naval Districts. Three of the four Divisions were interested only in specific aspects of mine warfare: Fleet Training in distributing new doctrine, not originating it; Fleet Maintenance in maintaining mining and countermeasures gear, not initiating developments; and Naval Districts in mining and mine sweeping for the defense of continental bases, not in possible offensive use. War Plans alone could be expected to take cognizance of the field as a whole, but since that Division served as a planning rather than as an administrative unit, and since its interests were spread over all fields, mine warfare received relatively little of its time.

Naval Regulations gave jurisdiction over *moored* mine sweeping to the Bureau of Construction and Repair, and within Operations, the Naval Districts Division had responsibility for base defense, of which moored mine sweeping was an accepted function. As a result of this and of its early

activity in this known form of mine warfare, the Naval Districts Division became the natural point towards which the other aspects of mine warfare gravitated. In this Division a desk was finally provided specifically for mine warfare just before the United States entered the war. Around this desk grew the entire Mine Warfare Section, which, by the end of the war, had cognizance over mines, sweeping, degaussing, mine and bomb disposal, and operational research.

But naval regulations made no provision for Bureau cognizance over countermeasures against *magnetic* mines. Responsibility for appliances to destroy mines and torpedoes was recommended for the Bureau of Ordnance in an early memorandum intended to centralize the supply of all defense nets and booms in one Bureau. The Bureaus of Engineering, and Construction and Repair objected to the assignment of such magnetic mine countermeasures to Ordnance (whose cognizance of mining had never been questioned), apparently holding that because of their responsibility for mine sweeping, they should have cognizance of other countermeasures as well. As far as can be ascertained their stand was taken entirely on legalistic grounds and not on the basis of any technical study of this problem.

The Bureau of Ordnance, however, considered the development of the magnetic mine and its countermeasures too closely related to be split between the Bureaus. After thorough discussion in late March 1940, the Research Council assigned cognizance of magnetic mines and the measurement of magnetic fields of ships to Ordnance and defense measures requiring power other than explosives to the Bureau of Engineering. On paper this was a sensible solution, for degaussing required power and the generation of power was a function of the Bureau of Engineering. Furthermore, the Bureau of Construction and Repair would necessarily be responsible for the installation of equipment in a ship. This solution ignored the fact that Ordnance had already begun degaussing as a part of its general investigation of magnetism when, spurred by events in Europe, it had directed the Naval Ordnance Laboratory to institute active research on magnetic and acoustic mines and their countermeasures in December 1939.

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On this score the solution by the Research Council was questioned, and in May 1940 the Secretary of the Navy decided in favor of the Bureau of Ordnance because their experimental work on degaussing was progressing satisfactorily. But the following month the Bureaus of Engineering, and Construction and Repair, while admitting Ordnance cognizance over degaussing, claimed cognizance over magnetic sweeping, except magnetic sweeping by aircraft which was under the Bureau of Aeronautics. Then for the first time in the long controversy the Chief of Naval Operations took an active part. The complexity of the problem brought about by divided cognizance was fully recognized, but no attempt was made to combine the various elements into one jurisdiction. Magnetic sweeping was stated to be under the Bureaus of Engineering, and Construction and Repair, with mine sweeping by aircraft tentatively assigned to the Bureau of Aeronautics.

In August, The Chief of the Bureau of Aeronautics requested that the Chief of Naval Operations prescribe the coordination of the aerial mine sweeping development with the Naval Research Laboratory, the USS HANNIBAL (a test ship whose operation was the responsibility of the Chief of Naval Operations), the Bureau of Ships (a consolidation of the Bureaus of Engineering, and Construction and Repair), and the Bureau of Ordnance. The Chief of Naval Operations endorsed Aeronautics' request. But Ordnance strongly dissented, since it was currently working on both mines and degaussing, and contended that coordination with Ordnance only was necessary for work of this character. In reply, Ships stated that it should have cognizance on the basis of development of magnetic sweeping which was well under way.

Thus it became necessary for higher authority to determine cognizance once and for all. Accordingly the Director of the Naval Districts Division began a review of the entire problem. He had two very germane reports on hand from London, one from the Naval Attaché Captain Alan Kirk, the other from two Bureau of Ships representatives in London, Captain (then Lt. Comdr.) E. C. Craig and Captain (then Lt. Comdr.) R. E. Wilson. Kirk, noting the close interrelation of mines, degaussing, mine sweeping, and mine recovery, suggested "that the departmental organization for handling these closely related activities be a single organization with field officers." He further suggested that there be three divisions, degaussing, sweeping, and mine recovery, plus two service sections, one for research and one for procurement. Craig and Wilson reached much the same conclusions. The basis of their proposal was their examination of British experience during the previous year. While these officers preferred the plan to place this division under the Bureau of Ships, they recognized this would probably not be feasible. Therefore they recommended combining personnel from the Bureaus in the closest possi-

ble liaison. They further recommended that the mine sweeping and degaussing sections be fitted into the Naval Districts organization with a Director in Operations and operating personnel in the Naval Districts.

The Chief of Naval Operations then recommended certain specific assignments of cognizance which were duly promulgated by the Secretary of the Navy in September 1940. Since Operations declared that "at this critical time" it was undesirable to make changes in procedure, all sweeping except aerial sweeping was assigned to the Bureau of Ships. Degaussing was assigned to the Bureau of Ordnance. The Bureaus were ordered to keep the Research Council informed on mine developments by potential or actual enemies of the United States. Operations declared that for many reasons the British mine organization was considered inapplicable to the Navy Department organization of Bureaus, and therefore, to effect closer cooperation, it was recommended that the cognizant sections of the Bureaus be placed in close proximity to one another and that there be a free interchange of information to coordinate the action of the interested divisions of the Bureaus to insure that the "needs of war plans, assignment of ships and personnel for tests, experiment, and training which will contribute to the effective defense against magnetic mines and torpedoes be given the necessary support."

This action by the Chief of Naval Operations did clarify cognizance. But the basic problem, the relation of weapon development to countermeasure development, remained unsettled. Liaison on countermeasures was never very close and at certain stages of the war fell down lamentably. Reorganization of cognizance came too late, and Operations' incomplete assignment of Bureau cognizance was paralleled within its own organization. No unit of the Office was responsible for all the aspects of mine warfare. Since the Naval Districts Division had assumed responsibility for countermeasures, it was involved in the controversy between both Bureaus, but it was neither interested in mining nor qualified to handle the subject. Having a responsibility limited to defensive measures, particularly mine countermeasures, the Division was satisfied with any workable solution of the vexing problem of Bureau cognizance without attempting to analyze and solve the more general problem. Yet it became by default the center for mining as well, since no other Division in Operations claimed such cognizance.

MARSHALLING THE SCIENTISTS

The use of the magnetic mine by the Germans in the first weeks of the war and the havoc it created in British shipping brought the United States Navy face to face with a new weapon for which it had no countermeasures. The Naval Ordnance Laboratory had begun its own investigation of magnetism and the magnetic measurement of ships, but

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its prewar scientific staff was not familiar with the subject of magnetism and, through fear of violating security, was unwilling to explain the problem to scientists outside the Navy. As a result very little was accomplished during the late months of 1939. Through the efforts of Rear Admiral W. R. Furlong and Dr. Vannevar Bush of the Carnegie Institution of Washington, a meeting was arranged early in January 1940 with Dr. J. A. Fleming, Dr. A. G. McNish and the writer, all of the Department of Terrestrial Magnetism. Commander J. B. Glennon, Officer in Charge of the Naval Ordnance Laboratory, explained to the Carnegie group the measurement problem and its fundamental importance for further research on magnetic mine countermeasures. Glennon stressed security and pledged the group to secrecy, but he showed complete confidence in the scientists and did not allow this security pledge to impede the exchange of information. As a result of the conference, McNish and the writer were lent to the Naval Ordnance Laboratory the writer remaining with the Navy throughout the war in mine warfare. McNish, after a very brief period, transferred to other war work at the Department of Terrestrial Magnetism.

At the Naval Ordnance Laboratory it was necessary to develop adequate methods for measuring ships' magnetic fields before means of countering the ships' magnetism could be devised. New measuring instruments were needed and were developed during the early months of 1940 for the first full scale experiments carried out in March on the USS VINCENNES. At the same time every effort was made to get from the Naval Attaché in London adequate information on the countermeasures which the British were known to have developed during the winter. This necessary information was not officially received until May. But in March the unfinished liner QUEEN ELIZABETH arrived in New York with a great degaussing girdle for all to see. A fairly complete description of the gear was obtained from the QUEEN ELIZABETH and from other British merchant vessels in American ports. In April the Laboratory received a piece of degaussing cable from the Commandant of the Third Naval District with the somewhat startling information that more than 100,000 feet per day was being manufactured in America for the British. From measurements with the new instruments developed during the spring, degaussing coils like the British coils were installed on the USS OMAHA, USS BARRY, and USS GOFF early in June. The results were considered highly satisfactory. In June, the Chief of Naval Operations directed the installation of coils on all United States naval vessels.

During the first half of 1940 the mine warfare forces gradually expanded both in the Bureau of Ordnance and in the Naval Ordnance Laboratory. Commander S. P. Fullinwider, who had been chiefly responsible for the design and development of the Mk 6 mine in World War I,

had been recalled to active duty in December 1939. The section in Ordnance (Re6b) responsible for mines and mine countermeasures had been expanded considerably. Since no regular naval personnel had influence mining experience, it was decided to recall to active duty Captain (then Lieutenant Commander) L. W. McKeehan, Professor of Physics at Yale, and Captain (then Lieutenant Commander) R. D. Bennett, Professor of Electrical Engineering at the Massachusetts Institute of Technology and, at the same time, to enlist the services of Dr. Francis Bitter, a Professor of Physics at the Massachusetts Institute of Technology. McKeehan, who had been Glennon's assistant at the Naval Ordnance Laboratory in World War I, reported in May to the Bureau of Ordnance. Bitter, reporting about the same time, was soon sent to England as the first of the Ordnance mine warfare representatives there. Bennett reported to the Naval Ordnance Laboratory in July where, after a year spent in recruiting technical personnel, he directed technical development throughout the war. Through the efforts of Commander Glennon and his staff of civilian or erstwhile civilian scientists, the group at the Laboratory grew enormously until nearly 1000 scientists were working at the Laboratory. By all standards the group was highly representative of American science. This was due in part to the missionary work done by the early recruits among their scientific brethren, in part to constructive direction of the research staff by the commanding officer.

EARLY ORGANIZATION FOR COUNTER-MEASURES

In September 1939 Admiral (then Captain) Alexander Sharp was assigned to the planning desk in the Naval Districts Division. His activities faced apparently hopeless competition, for mine sweeping was merely one aspect of the Division's many base defense duties. And then the number of minesweepers in the Navy was wholly inadequate; existent gear was antiquated. Ships had to be built or converted and satisfactory sweeping gear developed for them; adequate base facilities were needed and personnel trained. The Districts Division surveyed facilities, canvassed commercial vessels available for conversion, and searched for small yards which could be used in conversion.

At about the same time Sharp took over the mine warfare desk in the Districts Division, Captain (then Lt. Comdr.) E. C. Craig was assigned the mine sweeping desk in the Bureau of Construction and Repair. In view of the variety of activities which the Naval Districts Division was forced to undertake, and the small number of officers in the Division (only six were listed as of 15 January 1940), the responsibility for the development of adequate sweeping gear fell largely to the materiel Bureau, the Bureau of Construction and Repair. Similarly, for development of Fleet mine sweeping gear, the Bureau took action in the

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absence of Chief of Naval Operations direction. Later, as the Naval Districts Division became increasingly active with the Bureau in mine sweeping development, the close relationship between District mine sweeping and Fleet mine sweeping was continued. The Districts Division took the responsibility in Operations for Fleet as well as for District craft. This was natural since mine sweeping in practice is not an easily divisible subject. Here was another link which eventually chained the whole field of mine warfare to a Division which originally dealt only with District affairs and base defense.

The real beginning of the development of high-speed moored mine sweeping was in 1939. Since this was a Fleet problem, development resulted from direct cooperation between the Bureau of Construction and Repair and the Fleet in testing high-speed moored mine sweeping gear, both American-designed and a modification of the British type. They were highly successful, and despite the small number of ships converted to the new gear and the need for improvement in details, the groundwork had been laid for future development. This signal achievement was due to the joint efforts of Craig and to two destroyer division commanders engaged in the tests: Admiral (then Comdr.) R. S. Berkey and Vice Admiral (then Comdr.) G. F. Hussey, Jr. In January 1940 the Bureau had reported that the low-speed gear used by the Fleet was virtually worthless; it was of World War I vintage, heavy and cumbersome. Only one draftsman was working on the new gear, and the ultra-limited objective of equipping low-speed commercial craft had been stated. But further effort was committed, and by the middle of August 1940, the development and standardization of new type-O gear, similar and of equal or superior performance to foreign gear, was an accomplished fact.

The development of moored mine sweeping gear took place independently of the new development in weapons. Magnetic sweeping, like degaussing, followed the introduction of the magnetic mine and was therefore nearly a year later than the moored mine sweeping gear in its development. Nor did the new sweeping gear develop as quickly as degaussing. This was natural, for degaussing was a more pressing problem than mine sweeping to a neutral nation. As a neutral the United States could not sweep mined waters, but the events of May 1940 changed all this. The failure of the Allied Forces in Norway and the invasion of the Low Countries changed both Britain's and the United States' approach to the war. Britain, increasingly aware of her need for United States help, showed a new willingness to exchange information, and the German success brought the possibility of war closer to the United States. In May work was begun on magnetic sweeping gear.

The question of cognizance over magnetic sweeping had been raised during the controversy over degaussing. In May 1940 after some months of confusion, Admiral H. R.

Stark gave to the Bureau of Construction and Repair cognizance over magnetic sweeping. Craig collected information and proceeded with development. During the early part of 1940, the scientists at the Naval Ordnance Laboratory were investigating methods to detonate safely enemy magnetic mines, paralleling their work on degaussing. Lacking detailed information on the German magnetic mine they had made general investigations, but, though their conclusions were quite sound, better liaison with the British was obviously needed in order to take advantage of the experience gained in the first part of the war. In July, Craig, Wilson, and Bitter left for England. During their absence experimental work on the development of magnetic mine sweeping gear proceeded. In September Craig's return from England was followed by increased activity in both the Bureau of Ships and Chief of Naval Operations. On the basis of British data the Bureau of Ships issued detailed specifications for the work on magnetic sweeping gear at Norfolk. The work of the Bureaus of Ships and Ordnance and the Navy Yards proceeded rapidly. Ships issued the first of its Pilot letters to the Fleet in October, explaining in detail the principles of magnetic countermeasures. Magnetic sweeping gear was still confined to experimental ships. While the initial work on magnetic mine sweeping was getting under way, moored mine sweeping gear had reached the production stage in the Navy Yards under Bureau of Ships guidance. Tests with live mines were performed late in March 1941 and the Commanding Officer of the unit expressed great satisfaction with the new type-O gear, suggesting only minor improvements. This was United States naval officers' first actual operational experience with live mines since World War I.

In February 1941 the Bureau of Ships reviewed the entire mine sweeping program. A total of 270 ships was listed for district use, of which 66 were being converted and 64 constructed, and 140 were authorized for construction. All but 17 of these were to be equipped with both magnetic and moored sweeping gear. Of the 117 ships planned for fleet use, only 14 moored sweepers were in commission. The remainder, equipped for both magnetic and moored sweeping, were under construction or authorized. Furthermore, the Bureau had ordered gear for 143 more sweepers in order to meet the Chief of Naval Operations' specifications for wartime needs. War Plans had considered that a construction program of such magnitude would adversely affect other constructions, but Admirals Sharp and Ingersoll stood for it. Later Fleet Maintenance drew up the Operations letter to Ships declaring that the program was adequate and no further gear need be obtained.

The difficulties experienced by the Bureaus of Ordnance and Ships in procuring adequately trained personnel for the expansion of their program made it clear quite early that without a training program it would be

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impossible to man the new ships and bases reserved for mine warfare. At a September meeting held by Admiral Sharp with Ships and Ordnance representatives it was decided to set up a mine warfare school. Ground was broken at Yorktown on 16 October 1940. The student quota was placed at 50 officers and 175 enlisted men. Upon taking charge as prospective Commanding Officer, Captain (then Lt. Comdr.) A. W. Ashbrook set a schedule for the first four months' course to begin 6 January 1941. In the meantime, an informal course in mine sweeping was given by Craig at the Bureau of Ships.

EARLY ORGANIZATION FOR MINE DEVELOPMENT

Countermeasure development was well under way by the summer of 1940, but mine development was only beginning. This resulted from pressure of events rather than from planning. Degaussing came first, then mine sweeping. Mining necessarily had to wait. The old moored antenna mine Mk 6 was deemed quite satisfactory for purely defensive mining of the coasts and harbors of the United States. Since this nation had general air and surface control of its coastal waters, the mine was safe against sweeping. The magnetic ground mine, on the other hand, was of value primarily as an offensive weapon. This was the considered opinion of Captain H. E. Fischer of the Bureau of Ordnance after a thorough survey made early in 1940. The necessary impetus for the active development of new and original influence type ground mines could come only from an operational plan for offensive mining. The lack of such a plan was the cause for the slowness of development and absence of originality in design.

The Bureau had directed the Naval Ordnance Laboratory to make a study of magnetic mines on the basis of information on hand and to develop such mines concurrently with the necessary countermeasures. The research group at the Laboratory was hampered by lack of information and, in early 1940, was so occupied with measurements that they did not have time to begin to create a magnetic mine. Upon the arrival of a German magnetic firing device sent by the British in May, and the increase in the research staff at the Laboratory, work in earnest was begun on a copy of the German device. This became known as the Mk 12, a needle-type magnetic ground mine which could be planted by submarines, surface vessels, or aircraft. It was anticipated that production would begin on an order from the British Navy. Ordnance waited for the War Plans Division or the General Board to set the number of units desired by the United States Navy. It seemed that the materiel Bureau did not intend to take responsibility indefinitely for setting policy.

As a result of the availability of an influence mine and the activity in the Bureau of Ordnance, the War Plans Division wrote a long memorandum on mine laying, taking

up the whole question of offensive mine warfare. This reflected the Navy Department's increase of interest in mine development. The memorandum's review of the bibliography on the subject showed that general mine warfare thinking was completely out of date. The latest Fleet tactical publications were ignorant of influence mines. Even the War Instructions confined their remarks to defensive and evasive tactics, ignoring the offensive. The memorandum urged the same offensive use of mines that the Germans had made so effective against Great Britain. A farsighted program was outlined, concluding with the recommendations that: (1) forces afloat should study the great offensive possibilities inherent in the magnetic mine launched from submarines, surface ships, and the air; (2) all strategic studies should consider the use of air and submarine laid mines; (3) the nuisance value of offensive mining should be exploited, where even a few mines might entail great loss of time and expense to the enemy in sweeping; (4) the Bureau of Ordnance should actively prosecute the development of improved influence mines; and (5) the Office of Naval Intelligence should obtain data abroad on all aspects of mine laying.

Unfortunately this program was carried through only in part. The War Plans Division, originator of the memorandum, was responsible for virtually every aspect of national defense and military planning within the cognizance of the Navy, but as a planning division it was not intended nor equipped to carry out details of the plans. It brought the mining program to the attention of other Divisions and finally in June urged its submission to the General Board. But once conclusions were reached by the General Board, the matter was allowed to rest. It was a pity that the War Plans Division did not see the need for a specific unit in the Office of the Chief of Naval Operations which could take the responsibility for implementing general plans once they had been initiated. Because there was no such specific unit, strategic mine laying was dropped by the way, as if of no interest. The only apparent result was action taken by the Naval Districts Division on defensive plans, and the focusing of attention on mine developments. The responsibility for operational planning was presently passed to the Fleets, but the Commander in Chief, Pacific Fleet, showed little interest in the development of strategic mining. The Fleet's attitude was that depth charges and bombs, not mines, were really needed. It was stated that due to the great distances in the Pacific it would seldom be desirable for aircraft to use mines instead of bombs.

In March 1941, the Bureau of Ordnance made an exhaustive report to the Chief of Naval Operations on the production program for submarine and aircraft mines, forwarding the information to find out whether the program was adequate. According to the Bureau the Mk 12 had gone into production, 3000 on order, the first to be ready about 1 June 1941. The Mk 12 Mod 1, a parachute version of the

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Mk 12, was to be ready at the same time. One thousand parachutes were on order, leaving 2000 mines for submarine use. The Mk 13, a lighter weight, induction type ground mine was to start production about 1 May. An order of 3000 was contemplated. Work had been undertaken to modify the old Mk 10 Mod 1 for air, but the Bureau questioned its desirability and asked for instructions. The Mk 19, a drifting contact mine, was to be ready for production about 15 April, and an order of 1000 was contemplated. Prospective mines included acoustic and magnetic moored mines. As to the supply of moored mines, 23,092 Mk 6 were on hand and the plans were to order up to 35,000. It was significant that the earlier production estimates had not been met and research and development still had a long way to go. The Bureau, however, had had little or no encouragement from the rest of the Navy. The General Board's estimate of needs in November 1939 for aircraft mines of all types had been only 3500.

The Director of the War Plans Division took immediate action on the Bureau letter, sent a careful analysis of it to the Fleet Training and Fleet Maintenance Divisions, and suggested that the Fleets be informed of the new types. The Bureau letter was forwarded to the Fleets by the Chief of Naval Operations with a request for recommendations. In the meantime, so that the Bureau of Ordnance might proceed with development and production, the War Plans Division recommended that the Secretary of the Navy be requested to submit the subject again to the General Board. At the same time Admiral R. E. Ingersoll, the Assistant Chief of Naval Operations, requested a report on the progress of mine development. The Director of Fleet Maintenance also made a report to the Assistant Chief of Naval Operations after reviewing the memoranda and suggested that the War Plans Division prepare an estimate of the situation regarding the uses and number of types of mines required. But for the work that the War Plans Division normally passed on to other units for execution, no proper unit of mine warfare existed. The General Board would not go further than a consideration of material presented and certainly would not take up operational matters. Both the War Plans Division and the General Board apparently looked to the Fleets for the statement of operational needs. When it finally came, the only recommendation from the Fleet, that of the Commander in Chief, Pacific Fleet, made it clear that the Fleet's interest in mining was extremely limited.

The General Board meeting, in June 1941, agreed with the Bureau of Ordnance that a broad general directive was needed which would give the Bureau freedom to develop new types of mines, with enough mine orders authorized to hold the manufacturers to mine production without forcing the Navy to accumulate stores of mines that might become outdated. This was the best policy that could have been evolved for production. The War Plans Division was

satisfied with opening the subject and stressing a very broad point of policy by insisting on aircraft and submarine mines. The follow-through on operational planning was not made, and the Division apparently accepted no responsibility beyond recommending that the Commander in Chief and the War College study the question.

In the summer and fall of 1941 the Bureau of Ordnance proceeded with the development and production of the mines Mk 12 and Mk 13. The Bureau had promised that the Mk 12 would be ready for service use about 1 July. In August, Ordnance had to change its estimate. The explanation of the new date, 1 October, was that production and design difficulties had delayed receipt of many essential accessories. The first shipments of the Mk 12 finally left the United States early in November for Cavite and Oahu. The shipment arrived at Cavite before the Japanese attack, but the mines were not used. This was not an impressive record. By the time of Pearl Harbor, the Navy had the Mk 12 and the Mk 12 Mod 1 in production, with the delivery of the Mk 13 expected in February. The latter was the only mine beyond the stage of research. No original American mine had been produced. Little interest and no pressure came from the shore establishment or the Fleet; therefore, mine development and production could not compete with other fields of ordnance, especially since the Bureau received no direction beyond the report of the General Board meeting of the previous summer.

THE MINE WARFARE ORGANIZATION EXPANDS

By 1941 the Chief of Naval Operations' entire sweeping program was being directed by the Naval Districts Division. The Division had also taken on the responsibility for degaussing, which had become less a matter of change in ship design and construction and more a matter of testing and maintaining proper standards by degaussing and deperming stations. As the emphasis gradually spread from naval vessels to merchant vessels degaussing was clearly recognized as a District or base problem. Beginning with harbor mining, where the Districts Division's responsibility was clear, the Division gradually assumed responsibility for *all* mining even though many aspects were most remote from their authority, but no other Division had clear responsibility or even interest. Defensive mining of continental waters presented no serious problems in development or production. The Mk 6, with certain technical alterations developed by the Bureau of Ordnance, was satisfactory and enough were on hand for harbor defense purposes. Only the First and Third Naval Districts indicated that they considered mines, apart from harbor defense, necessary on the coasts under their jurisdiction.

But even the one well established branch of mining, harbor defense, was not free of conflicting authority. Army cognizance over controlled mine laying and fields was

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bound sooner or later to conflict with Navy responsibilities for harbor defense. In April 1941, a dispatch from the United States Naval Attaché in London recommended that the United States profit by British experience and place mining under unified control. The Bureau of Ordnance stressed the difficult position in which minesweepers were placed by the dual control of defense mines. The Navy was responsible for all sweeping activities and yet had no supervision of the controlled mines. The mines themselves, according to the Bureau, were of limited effectiveness as an antisubmarine weapon. The offer was made therefore that the Bureau use its large scientific staff to adapt the superior British controlled mine. In conclusion the Bureau strongly recommended that cognizance be transferred to the Navy.

Despite the soundness of the Bureau of Ordnance position, the Naval Districts Division advised against unified control for procedural reasons. The Director admitted that the principle of unified underwater control was fundamentally correct, but he felt that the practical difficulties more than offset the advantage to be gained. The Army would object, the Navy would need additional personnel, and confusion would occur during the transition. The Director stated that the Army was working on a new and effective controlled ground mine and at the same time had been receptive to the Division's views on mine sweeping problems. The attitude is characterized by the opening line of the letter, "Regardless of the merits or demerits of the question . . . it is believed inexpedient . . ." The settlement shows the absence of any desire on the part of the Naval Districts Division to indulge in empire building, but, as in the solution of the degaussing controversy the year before, a lack of strong convictions about mine warfare was evident. A little empire building might not have hurt.

In September 1941, the Underwater Defense Section of the Naval Districts Division was expanded to five desks creating a specific Mine Warfare Desk, Op-30-C3, to which was assigned Captain (then Lt. Comdr.) R. D. Hughes. Mine warfare at last had the recognition of a desk in the Office of the Vice Chief of Naval Operations, but its duties were limited to defensive mining and sweeping. Hughes had general cognizance of mining and mine sweeping, the location of mine fields, the type and number of mines, other problems involved in laying the fields, and the apportionment of minesweepers to various areas. Through liaison with the Bureaus, Hughes had cognizance of development of mines and mine sweeping gear and the construction and conversion of vessels.

The desk developed mainly because of Hughes' personal interests and background. He was an Academy graduate and a graduate of the Mine Warfare School in its first class. After his resignation from the Navy he had taken a PhD in biology. He was professor of biology at the University of Richmond prior to his recall to active duty. His interests extended beyond the scope of Admiral Sharp's

memorandum largely because he went to England to study the British mine warfare organization and its activities after completing the Yorktown course. The British were acutely mine conscious. From hard experience they knew the value of offensive mining. Hughes, like most of the officers who went to England, became thoroughly imbued with the value and importance of mine warfare in all its aspects. He saw his task as that of a promoter of mine warfare. Although the United States Navy was far from mine conscious in 1941, Hughes faced a situation not altogether unfavorable. In the Bureau of Ordnance the mine warfare section had expanded and was extremely active. In the Bureau of Ships the organization headed by Commander Craig was doing excellent work. Whereas Hughes' own Division did not completely share his enthusiasm, he was supported at every point by the senior officers responsible, Op-30, Admiral Alexander Sharp, and Op-30-C, Commodore (then Capt.) R. W. Cary who succeeded the Admiral as Op-30 in January 1942.

With the United States' actual entry into the war the activities of the Mine Warfare Desk naturally increased tremendously. It became a Section (Op-30M) when the Naval Districts Division was changed to the Naval Districts and Bases Division and then to the Base Maintenance Division by March 1942. Captain S. P. Fullinwider of the Bureau of Ordnance joined as Liaison Officer. An officer was assigned to handle personnel problems and liaison with the Bureau of Personnel.

To cope effectively with rapidly expanding duties and responsibilities, Hughes urged the assignment of a Captain as head of the Section. In May Captain P. L. Meadows replaced Hughes as head, and Hughes became his executive assistant (a post which he filled until the autumn of 1945). Captain C. C. Miller replaced Meadows in June, holding the post for two years, after which it was taken by Captain H. W. Fitch. In providing necessary continuity, in handling a large part of the personnel work of the office, and in active promotion of offensive mining, Hughes' contribution cannot be overestimated. As a graduate of Annapolis who returned to active duty in the Navy as a reserve officer, he was able to appreciate the validity of two viewpoints which unfortunately differed at times. Reserve officers on the staff were so convinced of the necessity of promoting mine warfare that they frequently tended to overlook regular naval procedure. Without the impetus which the thoroughgoing enthusiasm of these reservists provided, the mining program would hardly have got under way. On the other hand, without the sound judgment and wide naval knowledge and experience of Captain Miller less might have been accomplished in the end. The history of the Section's personnel during the war furnishes an exceptional example of the fine interplay of reserve and regular elements in the Navy.

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Commander (then Lt. Comdr.) R. H. Bennett who held the underwater detection desk in Op-30, also had a desk in Op-30M as degaussing officer. This was later made into a separate Section but was reincorporated into Op-30M less than two years later. By the end of the summer of 1942 there were 12 officers in Op-30M, the exact number in the entire Naval Districts Division when the Mine Warfare Desk had been set up.

In July the Bureau of Ordnance set up an Operational Research Group with Dr. Francis Bitter as its head, operating under Captain (then Comdr.) L. W. McKeehan in the Bureau as Officer in Charge. In three months the Group increased from 7 to 22 men. To gain closer cooperation between the Army and Navy in regard to both controlled mines and the use of Navy influence mines by the Army Air Forces, Colonel D. Luce reported to the Mine Warfare Section in October to serve as liaison. The last major organizational change of the war period occurred in November 1942. Army liaison continued as a separate Sub-Section MA. The remainder of the Section was divided logically into four Sub-Sections, M1 Mines and Mining, M2 Mine Sweeping, M3 Mine and Bomb Disposal, and M4 Operational Research. With the addition of M5, Degaussing, the same month, the Section took the form it kept until the end of the war. The degaussing Sub-Section, formerly Op-30-E, was set up on the same plan as M1, M2, and M3, handling its personnel in the field and relying upon the Operational Research Group for necessary research.

According to the place of the Mine Warfare Section in the Chief of Naval Operations, the chain of command went from the section head to the Assistant Director Base Defense, to the Deputy Director Base Maintenance, to the Director Base Maintenance, to the Assistant Chief of Naval Operations for materiel, to the Subchief of Naval Operations, to the Vice Chief of Naval Operations. At any point along the way a document might be signed, endorsed or turned back. On mine warfare documents important enough to reach them, the signatures of the officers in the higher echelons were necessary. But a great number of the papers had little to do with either Base Defense or Base Maintenance. At times great delay and inconvenience resulted from the necessity of going through these desks to reach the correct echelon. It was only in May 1944, when the Director of Base Defense (in the reorganized Base Maintenance Division) increased his assistant directors to five, that one for mine warfare was included. He was authorized to sign or release "routine mail and dispatches . . .;" letters on policy, important dispatches, and all directives were to be routed to the Director for release.

CENTRALIZATION BY DEFAULT

The possibility of a unified mine warfare organization in the Navy was first considered in 1940 in the final stages of the controversy over the cognizance of degaussing and mine sweeping. Aside from the activities within the Naval

Districts Division in 1941, culminating in the creation of a Mine Warfare Desk in September, no action was taken by the Chief of Naval Operations to establish a center of responsibility for mine warfare, except that the Districts Division was responsible for the "coordination of the various divisions of the offices of the Chief of Naval Operations with the Bureaus towards 'effective defense against magnetic mines and torpedoes'." So, in the months that followed, the Division took increasing responsibility only for the defensive aspects of mine warfare. Mine development was left wholly to the Bureau of Ordnance. The War Plans Division showed general interest in the problem and in offensive aspects, recognizing the need for detailed operational planning. It did not, however, take this responsibility to itself. Its assumption seemed to be that direction should come from the Fleets and that the proper authority to relate the Fleet plans to the materiel Bureaus was the General Board. Interest shown by the Division in the spring of 1941 had no result other than the General Board's increase of the mine allowance that summer.

Early in 1942 Rear Admiral R. K. Turner, Assistant Chief of Staff (Plans), advocated the offensive use of mines by the Fleets. In response Readiness pointed out that the mine program should be comprehensively reviewed and a specific program should be imposed on the Bureaus to facilitate procurement. This was the core of the problem. The materiel Bureaus could not develop mines without operational direction because of the tremendous competition in the field of ordnance between guns, torpedoes, depth charges, etc.

The old Bureau opposition to interference by the Chief of Naval Operations was largely dissipated by the exigencies of war. It was not possible for a Bureau to know the plans and needs of the operating forces, and without them development and production were pointless. Hence, contrary to the prewar tradition of Bureau versus Operations, the Bureaus were willing and anxious for direction from one part of the naval organization, not from several possibly conflicting sources. Admiral W. A. Lee (Readiness) pointed out that far too many agencies had cognizance over matters pertaining to mining. Plans of Commander in Chief was responsible for strategical planning; Readiness was responsible for tactical technique; Operations for broad operational control of Sea Frontier operations; War Plans of Vice Chief of Naval Operations for long range-planning and procurement of mines; the Bureau of Ordnance for actual procurement; the Bureau of Ships for design and procurement of sweeping gear; and the Chief of Naval Operations, the Bureaus, and the Commandant, Fifth Naval District, for the administration of the Mine Warfare School. A conference of all interested units was called in March. The consensus of opinion was that the existing organization for handling mine warfare in the Navy Department was inadequate and that a Mine Warfare Section should be set

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up, probably as a section of Chief of Naval Operations, and that mine warfare officers should be assigned to the Staffs of the Fleets. No action resulted. The pressure of events and the amount of work that had to be done was so great that little time could be devoted to formal considerations of cognizance, but an informal arrangement did result in which the Mine Warfare Section of the Base Maintenance Division was to be responsible for the "coordination of all mine warfare activities." This was given some basis in the appointment of a Mine Warfare Officer in the Plans Division of Commander in Chief — an apparently contradictory step because it might have been taken as an attempt to take over mine warfare planning. Actually, this officer acted in liaison. He transmitted mine warfare problems arising in Commander in Chief to the Mine Warfare Section of Vice Chief of Naval Operations for solution, and he arranged for the approval of plans solved by or arising in the Mine Warfare Section.

For a time this was a satisfactory solution largely because of the close personal relationship between Admirals Farber and Lee under Vice Chief of Naval Operations and Commander in Chief, respectively. But the informal arrangement did not meet with the approval of Admiral Edwards, who became Chief of Staff in September 1942. A detailed memorandum was prepared for his signature which carefully defined the mine warfare cognizance of the various Divisions under the Commander in Chief. This was the assignment of responsibility: to Plans Division, offensive employment of mines and review of Fleet plans; to Readiness Division, readiness of operating forces, particularly training for offensive air and subsurface operations, and coordination with the Vice Chief of Naval Operations; to Operations Division, specific directives for offensive employment of specific types of mines for immediate tasks and areas; to the Mine Warfare Section, supply and production of materials, plans for defensive mine fields, supervision of the Mine Warfare School, coordination of mine sweeping matters, mine and bomb disposal, degaussing, and coordination of the activities of the Bureaus, Coast Guard, and Army in mining activities.

Admiral Farber's comment was that this would create a situation "similar to that which obtained prior to the war namely, divided responsibility for the employment of a type of weapon with great potentialities." He suggested that the Mine Warfare Section retain its responsibility for coordination of all mine warfare activities and that liaison officers from Commander in Chief be added. Though the memorandum was issued in spite of this, it was never fully implemented, which was fortunate, since it would have brought confusion and duplication. The Mine Warfare Section continued to act on the basis of the original Commander in Chief — Vice Chief of Naval Operations verbal agreement (see above). During December 1942 and January 1943 the question of cognizance between Commander in

Chief and Chief of Naval Operations again came to the fore. Several proposals were drawn up in the Mine Warfare Section, and mention was made of a new directive to be drawn up.

Nothing might have come of the discussions had it not been for the proposed visit of Captain Cowie, R. N., a senior mine warfare officer from the British Admiralty, to effect greater coordination between British and American mining in all phases. Difficulties were so apparent in any effort to coordinate British mine warfare, with its unified organization, and American mine warfare, with its complete lack of centralization, that Commander H. P. Smith prepared a memo for the Assistant Chief of Staff (Plans) pointing out that the proposed visit was embarrassing to Op-30M for several reasons. No mining policy had been enunciated by the Joint Chiefs of Staff or by Commander in Chief. The only plans were for submarine mining, issued by Commander in Chief, Pacific Fleet. Furthermore, Op-30M had so little information that it could not initiate programs for mine development and production.

Commander Smith stated that Admiral E. J. King had indicated very strongly his interest in the development of mine warfare planning. On an intelligence report on British Mining successes King had written, "I want this followed up and followed through, submarines, aircraft, training, etc. Expedite!! K." Smith therefore recommended that it be taken up as a matter of urgency by the Future Plans Section and that a committee of the Joint Staff planners be appointed to formulate policy directives and broad strategic plans for mine warfare. At the same time he originated a mine warfare directive which Admiral King signed on 30 January 1943.

In substance, the Mine Warfare Division in the Office of the Chief of Naval Operations was to (1) coordinate the development, production, and supply of mines, minelayers, mine sweeping, bomb and mine disposal, and degaussing; (2) formulate logistic requirements, including area allocation; (3) plan defensive fields; (4) supervise training and coordinate mine warfare intelligence; (5) make analytical studies for mining operations; and (6) establish a repository which would record mine lays and damage to the enemy. With the exception of submarine mine warfare, the Plans Division was assigned the responsibility for preparing policy directives, broad strategical plans, joint planning with the Army, and review of Fleet mine warfare plans. Readiness was given the duties of preparing tactical methods for surface layers, submarines, and aircraft, training Fleet forces and coordinating readiness of men and equipment with the Mine Warfare Division.

This directive did not achieve the unified and autonomous organization so long advocated, although it did achieve much that Admiral Farber had sought. Without proper information and intelligence, without analytical studies based upon this information and upon technical

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research, without the facilities for records and studies of operations, broad plans could not be made, nor could joint Army-Navy plans; in fact, planners could not begin. The Mine Warfare Section was not specifically authorized to proceed with plans nor given a place in Commander in Chief commensurate with the importance of mine warfare. Obviously the final decision covering plans, the fitting of these plans into the broad strategic pattern, had to be the work of those who made the broad pattern.

Upon the reorganization of the Office of the Chief of Naval Operations in October 1945, the Mine Warfare Section's designation was changed from Op-30M to Op-415E2. It retained its position as a unit of the Base Defense Subdivision of the Base Maintenance Division. In March 1946 it was transferred by Chief of Naval Operations directive to the Readiness Section of the Operations Division as a subsection (Op-34B). Its duties as specified by the Commander in Chief memorandum of January 1943 were to remain unchanged.

A HALF-FORGED LINK

The mine development policies of the Mine Warfare Section are so closely related to the activities of the Mine Warfare Operational Research Group, that a consideration of the one inevitably involves the other. The Mine Warfare Operational Research Group had its origin in the Naval Ordnance Laboratory. The writer, the first scientist added to the Laboratory staff in the early stages of research on degaussing and technical director of the Laboratory's Countermeasures Unit, had gone to Pearl Harbor in November 1941, to inspect degaussing installations. He was on the waterfront the morning of 7 December 1941. When he returned to Washington, determined to speed up the work at the Laboratory, he believed the most vital need was closer contact between the Laboratory and the operating personnel of the Navy. His own experience during the past two years had demonstrated the ineffectiveness of technical work without operational guidance. He was equally convinced of the corresponding weakness in operational planning which lacked close liaison with technical developments. It seemed most feasible to attack the double weakness by developing the interest of the technical staff in operational problems, therefore, the writer formed a seminar group of scientists from his Countermeasures Unit at the Laboratory. It was the only group in the Navy whose interest encompassed both mines and their countermeasures. The men were divided into teams, one working out a mining attack and the other a defensive plan for the same area, all on the most abstract and hypothetical basis. Projects included the mining and sweeping of Japan, of Port Darwin, and of Pearl Harbor. Representatives of the Mine Sweeping Section of the Bureau of Ships and members of the Mine Unit at the Naval Ordnance Laboratory participated in the meetings. The seminar was looked upon with

some suspicion by officialdom but was tolerated largely on the basis that it was held outside regular working hours.

By the first of March 1942 the value of the work became apparent and the writer requested Dr. W. C. Michels, Professor of Physics at Bryn Mawr, and a member of the seminar, to organize an Operational Research Group to function as a regular section of the Laboratory. The members were to spend full time in a study of mining problems, the tactics and techniques of countermeasures, and in the analysis of the characteristics of weapons to meet operational needs. Dr. Michels' group produced in the next two months a large number of memoranda. These were of two kinds, a continuation of the type of work begun in the seminar, and more technical studies on the characteristics of mines and procedures in sweeping. These were later summarized and issued as FTP 159A. Although substantially sound, they suffered naturally enough from a slightly academic approach to the mining problem.

Operational research received a tremendous boost upon receiving an account of British mine warfare operational research written by Dr. S. L. Quimby, Professor of Physics at Columbia and originally a member of the seminar at the Naval Ordnance Laboratory. The dependence of the Navy upon British mine warfare development has already been indicated. In this field the close relation between the two countries had begun with the previously mentioned visits of Craig, Wilson, and Bitter to London in the summer of 1940. Because the United States Navy had much to learn, these men collected information on the technical developments, training methods, operational research and organization, and field operations of British mine warfare. Of special significance was the visit of R. D. Hughes and Commander (then Lt.) Kenneth Veth in the spring of 1941. When Quimby joined Veth in London in the fall of 1941, he, like the writer, became involved in the operational aspect of mine warfare while seeking solutions for technical problems. Quimby's mission was to get technical information, but the British mine warfare organization, with its lack of departmentalization, allowed him to move freely from technical investigation to operational research and later to the field of operational planning itself. His intelligence report of February to the Navy Department analyzed the work of British operational research, stated its broad general objective, and gave specific examples of the work performed.

The major objective of the British was very similar to that for which the seminar was formed at the Naval Ordnance Laboratory; i.e., to bring the technical scientific personnel closer to operations by interpreting practical considerations to the technical people and the technical possibilities to the operational staff. At the same time the operational staff learned the analytical methods of the scientist in order to assess correctly the probability considerations in a given operational plan. A further function of

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the group was to collect, analyze, and disseminate information to the various fields of operations. Finally, the group entered actively into the question of weapon design, performance analysis, and operational use, which made it a vital link between the field and the laboratory. This data reached the interested units in the Navy Department by the regular Office of Naval Information report and by personal accounts. Captain McKeehan of the Bureau of Ordnance, on a brief visit to England in the winter, learned of the British Operational Research development and returned with a copy of Quimby's report in the early spring. This and the later reports of Quimby were received with enthusiasm at the Naval Ordnance Laboratory and resulted in general discussion of the advisability of expanding the Laboratory Group in the Bureau of Ordnance or directly under the Chief of Naval Operations. Dr. Bitter proposed that the Group's functions be to gather information, to evaluate actual and proposed operations, and to specify operational requirements on the basis of which materiel should be designed and procured.

However, the initiative of the Laboratory Operational Research Group was regarded unfavorably by the Bureau of Ordnance and the high command when the extent of its activities was brought to light in peculiar circumstances. An attempt had been made to obtain information on the size and routes of Japanese shipping. This information was essential if the sensitivity and endurance of mines, as well as other technical characteristics, were to be intelligently determined. It was in full pursuit of this data that an enthusiastic civilian cut some well-regarded procedural corners and came a cropper. The coordination of operational information with technical development was considered to be too secret for study by such a low echelon and by civilians to boot. The Bureau of Ordnance therefore took action in July 1942 to disband the Laboratory Group. It was ordered to restrict its discussions to unclassified information only. It was also directed to make no further attempt to obtain or use operational information except with the specific consent of the Bureau.

Yet the success of the British approach and the obvious need for guidance in the mine program made it desirable to find some way of using the Group within the existing naval establishment. The Bureau was the logical agency to sponsor the group, but did not desire to incorporate it until its value as a semi-permanent organization was definitely established. It should be borne in mind that the Vice Chief of Naval Operations was responsible in general for the logistic support of operations, not for the military operations themselves. Hence, even if the Operational Research Group were placed in the Vice Chief of Naval Operations, it would lose much of the value of its British prototype since the latter had close association with actual operations at headquarters and in the field. The Vice Chief had only a vague idea of the work of such a group either in England or

in this country, and he took a conservative view of the scientist's value to the war effort. He misunderstood the fact that direct access to the data is required in the scientific method. To quote the concluding paragraph of his letter, "The question of operational information arises in the employment of civilian scientists comprising this unit, but properly handled, their research need not encroach on the security of current or future operations. Problems may be presented on a hypothetical basis or as a type of operation totally unrelated to prospective employment as to time or place. It is possible that some of the production of this unit may be of little practical value, but it appears desirable to determine to what extent their services can be utilized in this field." The Vice Chief was finally willing to let the group prove its worth, having recognized that work previously done by certain members of the scientific staff of the Naval Ordnance Laboratory of a kindred nature had been exceedingly helpful.

The Bureau of Ordnance had a better understanding of the problems, its Chief protesting the limitation of the size of the group and dissenting strongly on the question of security risk. While the Bureau agreed that security of operational information was vital to free and efficient use of the proposed unit, it stated that it did not understand why the question of security was rendered any more difficult by employment of civilian scientists, properly chosen, since disclosure of operational or other information to trustworthy persons of all categories was permitted by the naval regulations and it was expressly stated that officers, as such, had no special privilege of access to secret documents. This opinion is not surprising in view of the Bureau's wider experience with civilian scientific personnel. But the Bureau did not oppose the separation of the Operational Research Group from actual operations, in contrast to the close relationship between the British research group and operations. From the Bureau's point of view any contact whatsoever between the Research Group and the operative units of the Navy marked an advance over the Group's previous isolation, even at the cost of isolating the Group from the technical realities of mine development. In June the Mine Warfare Operational Research Group became an official unit in the Navy Department. It remained under the direction of the Bureau of Ordnance with Captain McKeehan in nominal charge and Dr. Bitter as actual head. Although an attempt was made to assign operational problems to this Group and weapons analysis to the Naval Ordnance Laboratory Group, much of the work was duplicated and the latter was therefore disbanded in the late summer. Beginning in November 1942 when the group left the Bureau, operational research in mine warfare was entirely under the jurisdiction of Op-30M.

In staffing his Group, Commander Bitter chose but a few members of the Laboratory Group to serve as a nucleus. The majority was newly recruited from outside the

Navy. These men were distinguished mathematicians and scientists, many of national repute. He included mathematicians, a statistician, a social scientist, and even a lawyer, in accordance with the broad policy of the British. Unfortunately they had had no opportunity, unlike the scientists at the Naval Ordnance Laboratory, to gain a grasp of the technical side of mine warfare. They also lacked operational experience and the training of the Laboratory seminars of early 1942 which had generated real interest in operational problems. During 1942-43, the Group's work spread over many fields. Commander Bitter anticipated an extensive mining attack by the Germans against American shipping. With the organization of the United States coastal convoy system, and the great increase in United States antisubmarine forces during 1942, the Germans were expected to use mining instead of torpedo attacks. Whenever enemy mining attacks were made, as occurred sporadically during the fall, a member of the group was detailed to the scene. All available data was studied to ensure that the Navy possessed the fullest possible knowledge of German mines, tactics, and strategy, in an attempt to keep the United States from being caught unprepared. That the attack did not materialize in force in no way detracts from the soundness of the planning.

Defensive action was only one phase of the work of the Operational Research Group. They investigated a vast range of topics, some operational, some extremely technical. Studies included geography, oceanography, economics, meteorology, mine performance, operations of the United States, the British, and the Germans, and plans for various theaters of war. The topics were assigned haphazardly and much of the work was of little practical value because the scientists had little background in mine warfare problems and the Group as a whole lacked contact with the field of operations. Offensive mining on a large scale was thought to be out of the question. Early in 1943 the group began to diminish in size. By September, the Operational Research Group had been reduced from twenty members to seven, Commander Bitter had left to join the target analysis group in the Joint Chiefs of Staff, and Dr. W. C. Michels became the new head. Though it failed in its original ambitious purpose of duplicating the work of British operational research, it was most successful as a functional unit within the Mine Warfare Section. The Group's studies of special projects which were directly related to the tasks of the subsections increased during the first year and became an integral part of the Mine Warfare Section's activities. The Section profited by the Group's analyses which were forwarded to the field or to the materiel bureau.

It is difficult to assess the contribution of the Operational Research Group and its influence on the Mine Warfare Section. Indubitably the Group's efforts achieved rational guidance in a technical development situation which had become completely chaotic. Thus its organiza-

tional effect was fundamentally important. On the other hand, many of its judgments tended to be academic in both the technical and operational aspects of mine warfare because it was too far removed from practical experience in either field. Thus serious mistakes in judgment were made.

Against the good resulting from the Group's attempts to filter field experience and to translate it into development directives must be balanced the failure to push the development of a magnetic-sonic combination, the pressure unit, a combination magnetic-subsonic unit, and arming clocks, sterilizers, and other smaller mine features. These developments should have proceeded in 1943 when there was a chance of completion in time to meet the needs of the Fleet. In effect, the Operational Research Group partly undid the early constructive work of Veth and Quimby.

The mine development program might have fared as well had it been directly dependent upon the decisions of the Mine Warfare Section of the Chief of Naval Operations, which were based upon the recommendations from the field. The Operational Research Group did help to lay the groundwork for the Empire mining, and for its logistics in the United States, although Colonel Alfred McCormack and Captain J. W. O'Boyle of the Army probably had the most important part in promoting the Empire mining amongst the Washington echelons. The idea and formation of the Operational Research Group were sound, but to function successfully it required a staff of experienced operations personnel who were not available.

MINE POLICY FOR DEFENSE

Antedating the Operational Research Group and the creation of the Mine Warfare Section itself were the first mining plans for defensive fields. These plans never developed since harbor defense fields were traditionally controlled fields under Army jurisdiction, but after the United States entered the war serious consideration was given to defensive fields for the major East Coast ports especially Boston, New York, and Chesapeake Bay. The New York and Boston mine fields were postponed indefinitely because they offered more disadvantages than advantages. A defensive field was laid in the entrance to Chesapeake Bay early in 1942 because the expanse of shallow water at its mouth made access to its vast inner reaches a simple matter for enemy submarines. An antisubmarine net was impracticable because of its width and the Army controlled fields did not offer sufficient protection. A contact mine field was a logical solution and proved extremely effective. Throughout the war Chesapeake Bay provided an inland sea free of the threat of enemy submarines and invaluable for training activities of the Navy and for normal merchant shipping.

A barrier field along the full length of the coast on the continental shelf behind which merchantmen could proceed unmolested was proposed to meet the submarine

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attack on shipping in United States coastal waters. With the increase in convoys in the summer of 1942 the barrier scheme became a weak alternative to a highly successful system. However, a series of anchorage fields was established along the coast to serve as places of refuge for merchantmen and as convoy assembly points. Actually, they served the latter purpose only because the convoy system precluded the necessity of coast-hopping by day and hiding by night. Such fields were established at Key West and Cape Hatteras and Cape Charles.

The Key West field was particularly valuable. The Florida Keys were the focal point for all northbound Gulf and Caribbean traffic and all westbound East Coast traffic where reforming convoys would wait for several days. Convoys under jurisdiction of all four of the Sea Frontiers in the east (Eastern, Panama, Caribbean, and Gulf) safely merged and reformed at Key West throughout the war within this mine-protected assembly point. The field off Cape Charles was little used because it was located near the mouth of the Chesapeake where ample anchorage existed, and the Hatteras Field was a decided hazard to navigation, yet offered little benefit.

The inauguration of the coastal convoy system in May, and its expansion during the summer, radically changed the defensive mining picture. New York and Norfolk harbors, and the Key West anchorage field, were used with no need for intermediate anchorages. Although the defensive mining program never developed on the anticipated scale, it played an important part in the extremely effective coastal convoy system and made available to convoy planning at Key West a vitally needed assembly point where none had existed.

INDOCTRINATION FOR OFFENSE

As the need for defensive mining decreased, possible offensive operations claimed attention but neither the opportunity nor the means was at hand. In the late spring of 1942 Captain Hughes worked with Lieutenant Colonel Younger of the Army Air Forces Staff on a general project for aerial mining in the Mediterranean Theater. Their informal talks resulted in the Army Air Forces request in May that the Navy provide mines and personnel to service them. Veth, who had just returned from England, did not favor the use of the Mk 13 mine, the only one available for the projected mission, because of its limitations. It was the first original mine developed by the United States in World War II, a lightweight (1000 lb.) magnetic bomb mine which, lacking a parachute, could not be planted from an altitude over 200 feet or at a speed above 150 knots. In attempting to make the mine less easy to sweep, the designers had made it extremely insensitive. As a result it was useful only in shallow water. Veth concluded that the Army flyers would oppose aerial mining when they learned these

limitations which made operations suicidal in an area heavily protected by anti-aircraft like the Mediterranean.

Even so, it was decided to send over the mines and their servicing unit. In August two mining officers reported to Army Air Forces Headquarters in the Middle East, but the project was a failure for the reasons Veth had foreseen. Unsuccessful attempts were made to use British parachutes. Of the 500 mines shipped only 14 were used as mines and 27 as bombs. The remainder, together with a much larger shipment which had gone to England, were later sent to the China-Burma-India Theater where large areas of shallow mineable water plus inadequate anti-aircraft defenses made them very useful to the British and to the Army Air Forces. The significance of the Mediterranean mine detail lay in its experiments with the mine. The reports from the unit stressing the absolute necessity for parachutes gave Veth valuable support from the field. His prior efforts to have the Bureau of Ordnance design the new Mk 26, a 1000-pound aerial magnetic mine, as a parachute mine had been unsuccessful.

After three years of war opportunities for aerial mining in Europe, no adequate mines were available. This was a grave reflection on naval mine development. Of the available American mines only the Mk 12 Mod 1 and Mk 13 were aerial mines. Neither was wholly acceptable for aerial mine warfare, for both long range bombers and carrier plane operations required highly dependable mines which were relatively unsweepable to make mining worth the time and risk. The distances between bases and mining objectives in the Pacific area as well as in Europe made the long range bomber the ideal plane for mining. Navy amphibious craft were too slow for heavily defended areas. The Navy's only alternative to the bomber was the carrier-based plane.

In the summer of 1942 the mining enthusiasts harshly criticized the materiel Bureau for its failure to develop and to produce the necessary mines. Captain McKeehan wrote that he was "tired of being told that we have not quickly enough passed from the stage when nobody wanted any aircraft-laid mines — to the stage where abundant mines of various special types are ready to plant from all possible places." His indignation was justified, but the cause of the complaint was not the fault of the Operations officers who brought pressure to bear on the Bureau. The airmen in the Navy had displayed no interest whatsoever in mining, either before the war or in the months since Pearl Harbor. The Army Air Forces knew nothing of mines and showed interest in May 1942 only as the result of Captain R. D. Hughes' missionary efforts. Aerial mining had been discussed in fairly high echelons since 1940, but the only talk which went beyond the most general terms was in the lowest echelon where a few officers and scientists in Operations, the Bureau of Ordnance, and the Naval Ordnance Laboratory were spurred on by letters from officer and

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civilian observers in England. Before such talk could bring results, the indifferent Navy airmen or the equally indifferent Army Air Forces had to be convinced. This educational work was a long uphill struggle because of the position of the Mine Warfare group in the naval hierarchy. Equally important, mining advocates had to have mines which they could unqualifiedly recommend to the Naval airmen or the Army Air Forces. Yet without the demand for mines on the part of the air forces, the materiel Bureau had little incentive to develop them. The activities of the Mine Warfare Section in the summer and fall of 1942 reflected two general aims: to produce mining plans which would convince the air forces of the value of aerial mining and to convince the materiel Bureau that certain mines, if developed, would be used.

A major project undertaken by the Mine Warfare Section and directed by Hughes consisted of three parallel educational programs in aerial mine warfare training. The first was an aerial mine warfare course for both naval and army aviators at the Mine Warfare School. The second course was in the technical and operational aspects of mining at the Naval Air Operational Training Command, Jacksonville, Florida, and later at other naval air training fields. The third was a comparable course at the Army Air Forces School of Applied Tactics, Orlando, Florida. The courses at Jacksonville and Orlando were continued throughout the war, but their net effect on the conduct of the war was hardly noticeable. The reason for failure was that the Air Forces gave only half-hearted support to the project. In both the Naval Air and Army Air Schools the courses were merely superimposed on already overcrowded curricula. Both officers and men were exposed to the courses, but the naval officers were very junior and had no part in planning. That the program should have been undertaken is hardly open to question, but without sufficient interest in high echelons, it was inevitable that the results of the Mine Warfare Section's program should be largely futile.

The training given to naval aviation ordnancemen was wasted because of the small amount of mining by Navy planes. When Navy planes did mine, the technical details were handled by regular mining rates who had a far more thorough training. The actual servicing of the mines for the aerial bombing campaign in the Army, as in the Navy, was done by surface mine specialists working under the supervision of officers sent out by the Mine Warfare Section. Had the aviation ordnancemen been needed, they would have been hard to find since the Bureau of Personnel never attempted to keep track of them as mine specialists, whereas the Bureau and the Mine Warfare Section did cooperate in listing surface mine specialists. The same problem existed in the Army. The men trained at Orlando were lost in the general pool as were the naval aviation ordnancemen trained at Jacksonville and elsewhere.

The only tangible achievement of the entire program was that the Army flyers and technicians were given a general acquaintanceship with mines and mining. Captain (then 1st Lt.) G. A. Grossman, an early convert to the value of aerial mining, did succeed in creating an awareness of the potentialities of mining among the officers at Orlando, Florida. Since this made less arduous the indoctrination later necessary at the operational bases, it was a distinct advantage. The training program therefore was by no means a complete loss. Whether it was worth the great expenditure of time and effort on the part of the Mine Warfare Section is debatable. In the early stages of the war, if the top airmen of the Navy and the Army Air Forces had had a modicum of interest in aerial mining, they could have used the opportunity, and both air forces would then have included officers and men qualified like the British airmen to make full use of the great potential in mining.

THE CUPBOARD WAS BARE

The Mine Warfare Section was more successful in making developmental plans than in implementing them. The Mine Warfare Operational Research Group made studies of background for mining operations and of actual area operations. The studies and proposals which were of practical importance were based on actual experience in mine warfare. Veth and Quimby worked independently of the Mine Warfare Operational Research Group and prepared memoranda on offensive mining potentialities demonstrated by English operational experience and of the mine types required. From these proposals the necessary characteristics of mines were determined and directions were given to the Bureau of Ordnance. The first general directive to the Bureau, issued in June 1942, reviewed the mining needs and made general recommendations covering all aspects of mine design, but with no reference to specific mines. The Bureau's reply a month later was equally general, referring specifically to surface laid mines only. Through its contact with personnel at Naval Ordnance Laboratory and Bureau of Ordnance, the Mine Warfare Section came to the conclusion that development of new mines was not proceeding as rapidly as it should.

In August, Captain C. C. Miller, then head of the Mine Warfare Section, called a meeting of representatives from the Laboratory and from his Section to discuss the operational characteristics of mines. Definite conclusions on mine requirements had already been reached within the Mine Warfare Section and they were accepted by the Bureau representatives at the meeting. A directive to the Bureau from the Vice Chief of Naval Operations was drawn up specifying the characteristics of two aerial mines, one of 1000 pounds and one of 2000 pounds, to be used interchangeably with Army-Navy bombs of comparable size. Parachutes were specified. Magnetic, acoustic, and

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magnetic-acoustic firing devices were recommended. From the point of view of a materiel Bureau, the directive was a model. It was reasonable; it was general enough to allow the Bureau to meet special problems that might arise, yet it was very clear in the specification of essentials. This directive was a realistic appraisal of the needs of the Fleet and it provided all of the guidance which should have been necessary in the years that followed. Unfortunately Veth and Quimby, who had initiated this action, soon left for the Pacific thus withdrawing from Washington the only people with actual mine warfare experience.

The Bureau had already begun to redesign the Mk 13, which, as the Mk 26 Mod 1, could fill the specifications for a lightweight parachute mine. Original research devoted to a submarine mine, the Mk 17, was turned to a new heavy-weight aerial mine, the Mk 25. In view of the dependence of possible operational plans upon rapid mine development and production, the Mine Warfare Section followed very closely the activities in Bureau of Ordnance and Naval Ordnance Laboratory. Liaison should have been excellent, because the Operational Research personnel were still technically under the Bureau and worked in Bureau offices until November, and because several mining officers in the Section were still attached to the Bureaus. But the Mine Warfare Section found it quite hard to keep well informed of development and production. What was revealed was not hopeful; development was too slow. Initiated by Veth, an Operations letter to the Bureau of Ordnance was therefore drawn up requesting that the Bureau hold monthly mine development meetings to be attended by all interested personnel, or else that the Bureau furnish Operations with a monthly summary of the progress of mine development and production. The Bureau chose the first alternative. In November 1942, the first monthly meeting on mine development was held with representatives from the Vice Chief of Naval Operations, the Commander in Chief, United States Fleet, the Naval Ordnance Laboratory, and the Bureaus of Ordnance, Ships, and Air in attendance. Meetings were held thereafter every four or five weeks through 1944.

The early meetings were valuable in making possible the direct exchange of ideas. The meetings covered all aspects of mine warfare and kept the Chief of Naval Operations informed of the status of technical work in the Bureaus, making it possible for the Bureaus to inform themselves of operational needs. After the first few months, however, the meetings began to resemble those of the Mine Warfare Operational Research Group of the same period with discussions centering around reports and technical details. The operational aspects were not stressed and the meetings failed to exert pressure for speeding up development and production. One reason was the absence of Veth and Quimby, the only members with a practical operational knowledge of offensive mining, and another reason was the

direction given them by the Chairman, Captain McKeehan, whose interest in technical details was carried over too completely.

Beginning in 1943 the major activity of the Mine Warfare Section was the development and production of the mines for the general mining objectives worked out first in Washington and then in the field by Mine Warfare Section personnel. This task was the result of increasing pressure from the field through the reports of Quimby from the Southwest Pacific, Veth from the China-Burma-India Theater, and the writer in the Central Pacific. Traditionally, the responsibility for the development and production of new weapons rested with the materiel Bureau subject to guidance from the Fleet. But Fleet interest in mining was almost nonexistent until it was roused by the missionary efforts of the mining officers sent into the field. Since their influence was not strongly felt until well in 1943, the Bureau of Ordnance could rightly claim that it lacked guidance during the first year of the war. However just this claim, the fact remained that the necessary mines were not in production. After the early spurt in research and development in 1939-41, lethargy and diffusion of interest characterized the Bureau until well into 1943. The cause, no doubt, was lack of guidance and general lack of interest in mining.

The Bureau of Ordnance had been the chief promoter of mining during 1940 and 1941. From the Naval Ordnance Laboratory had come most of the significant developments in mine warfare and the key personnel for the Chief of Naval Operations and the field. To carry out the ideas originally evolved in both these organizations, it was clear in 1943 that strong direction from outside was needed. The leadership was assumed by the Mine Warfare Section in 1943. Research, development, and production of mines in the Bureau was directed, rather than guided, by the Office of the Chief of Naval Operations. This step was not altogether out of line with the Chief of Operations' growth during the war period as the great logistics agency of the Navy. The Mine Warfare Section coordinated with the Bureaus in development and production. When the Mine Warfare Section was further strengthened early in 1943 with the appointment of a Mine Warfare officer in the Commander in Chief's Office who acted as liaison, it also gave unofficial guidance to the Commander in Chief, United States Fleet, instead of being directed by that organization, and performed many operational functions by coordinating directly with the fields of operations.

In March 1943 one of the major weaknesses of the mine materiel program became evident. It attempted to cover far too wide a field. Certain major items illustrate this. The two most desired mines were the Mk 25 (the 2000 lb magnetic ground mine for air) and the Mk 26 Mod 1 (a 1000 lb magnetic ground mine for air), both parachute mines. The Mk 26 Mod 1 had been expected in early 1943,

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but was then estimated for 1 June and later for 1 August. The estimate for the Mk 25 was 1 September, but in April it was postponed to 15 November. The urgently needed sterilizer, SD-4, due on 1 April, was not released until November. This the Vice Chief of Naval Operations wrote in a review of the status of mine development and production. For almost two months the Bureau did not answer the Vice Chief of Naval Operations' request for the verification of dates and apparently regarded as compliance the reports on the Mk 19 and Mk 31 mines made at the mine development meeting on 24 March.

Pressure increased. Early in April, the Chief of Staff of the Army stated to the Navy his prospective mining requirements. The list included all the important aerial mines under development as well as those already in production, the estimate having been a result of consultations with the Army liaison officers in the Mine Warfare Section. The estimate was apparently wishful thinking of officers, all of whom were concerned with promoting aerial mining and desirous of speeding up production and development by bringing pressure to bear on the Bureau. This is just what happened. The Commander in Chief ordered the Chief of Naval Operations to direct the Bureau of Ordnance to take steps to make certain the schedule of dates requested by the Army was met. This did give the Mine Warfare Section directive authority over its counterpart in the materiel Bureau.

The efforts of the Mine Warfare Section to bring pressure to bear on the Bureau were apparently without result. The Section was determined, however, to get at least a clear schedule of development and production, in order to hold the confidence of the operational forces. In April, six weeks after the original request to the Bureau of Ordnance, Admiral Wright, Director of the Base Maintenance Division, wrote that "radical steps must be taken because progress towards some of the stated objectives was already so unsatisfactory." Captain McKeehan stated the Bureau's case in a memorandum read to the mine development meeting but not incorporated into the minutes. Briefly, he said that the estimates used were based on informal conferences with Bureau and Laboratory personnel and from the monthly mine meetings, and were based frequently on wishful thinking. Since research was involved, intangible obstacles were bound to arise and the estimates should never have been considered definite commitments. McKeehan objected strongly that Mine Warfare Section personnel were using their technical background and their connections in the Bureau and the Laboratory to embarrass the Bureau. In the fall of 1943 the official Bureau apologia maintained this point of view and a later corollary that such connections were actually delaying research and development at the Laboratory. In view of the far from directional tone of the Vice Chief of Naval Operations letter, the Bureau could

easily have corrected whatever error arose from the natural assumption that data received via the mine development meetings were official. Instead the Bureau waited until pressure from the Commander in Chief forced action. Some confusion evidently existed in the Research Section of the Bureau at that time. A clear answer was not forthcoming because a clear picture did not exist.

The chief trouble in the Bureau and at the Naval Ordnance Laboratory was a diffusion of effort. The research staff, lacking military guidance, was spreading itself over too many projects, most of which had no real relation to the needs of the Fleet. The Bureau complained that production was very badly hampered by conflicting reports from the field which again and again held up production at crucial times. This was a just complaint because there were no experienced operating personnel in Washington who could evaluate the varying requests and criticisms. But it was the duty of the field to report deficiencies in equipment, thus the criticisms did not hamper production but were themselves caused by faulty or hasty research and development. Items had gone into production before they were ready. Equipment was given inadequate tests. All this came from the failure to foresee the need for the items, which went back to the Fleet's and the Chief of Naval Operations failure to plan in the years when there was time.

In 1942-43 the Bureau of Ordnance proved unable to cope with the problem. Indeed, as a materiel office it was not qualified to choose between the demands received from the field and then formulate a directive policy. The solution was for the Vice Chief of Naval Operations, which, of the Washington groups, had the best available knowledge of operational requirements, to establish priorities for mine development and production. But it was exceedingly difficult to decide the priorities. Operational factors did not coincide with the research and production factors, nor was there unanimity of opinion on the priority of operational needs. As a compromise, a simple formula was evolved, placing at the top those items which were nearest completion and also most urgently needed. From the beginning it was understood by the Bureau and by the Vice Chief of Naval Operations that the system would be changed from time to time to keep pace with operational needs and technical and production problems.

The system of priorities, however, failed to solve the development and production problem. Therefore the Bureau in July 1943 began to consider a general priority system to include all underwater ordnance. Commander W. H. Albach, who had taken full responsibility for mining in the Office of the Commander in Chief, considered such a system would be fatal to the items which received a low rating, in which category mines might fall. The Mine Warfare Section, at Commander Albach's suggestion, prepared a review of the entire mine program. This memorandum,

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prepared by Dr. H. M. O'Bryan, pointed out that since 1941 only two new types of mines had been made available for service use: the Mk 12, which was only recently modified so that it could be used satisfactorily in the Pacific, and the Mk 13, which was still limited to shallow water mining. The status of each mine under development was reviewed. The steady retrogression of estimated dates of production was shown, for example, by the Mk 25 which on 1 May had an estimated delivery of November 1943; on 2 June the estimated delivery was November 1943; on 7 July it was December 1943; on 14 August it was January 1944; and on 16 September the estimated delivery was March 1944. Not one Mk 25 was available for service use in October 1943, although in a letter of 29 June 1943 the Vice Chief of Naval Operations with the concurrence of the Commander in Chief had placed this mine in the highest priority group. Other mines and the sterilizers had a similar record, which was exceedingly poor, regardless of the troubles faced by the Bureau. The estimates from which the record was tabulated were official Bureau estimates which could not be impugned as optimistic guesses made at informal meetings.

The Commander in Chief directed the Vice Chief of Naval Operations to take immediate action. The assistant Chief of the Bureau of Ordnance analyzed the weaknesses in the various sections. He stressed the need for experienced operating personnel in the Mine Research Section (Re6b) and at the Naval Mine Warfare Testing Station at Solomons, together with the desirability for greater interest and emphasis on mines in the Planning Section. These were wholly constructive steps. But he placed greater emphasis on two other points which were not altogether constructive. One was a recommendation to return the Mine Warfare Operational Research Group to the Bureau. The other point was a condemnation of the close informational liaison between the Operational Research Group and the Naval Ordnance Laboratory. The old controversy was brought out and aired thoroughly. Finally a compromise was worked out. It did clip the wings of the Mine Warfare Operational Research Group. It forbade any attempt at direction of technical research and development or the obtaining of information concerning the progress of development and production by the Section except through the Bureau. Relations between Mine Warfare Section personnel and the Naval Ordnance Laboratory were not prohibited but they were to be confined to general educational matters. The Chief of Naval Operations would "specify the essential performance characteristics, qualities required, when required, and the allocation, of mines and nets." The Bureau, in Admiral Blandy's words, would be responsible "for working out the 'how' for meeting the above defined 'what, when, and where'."

The Mine Warfare Section through its increasingly close relations with the field of operations was able to give

definite direction to the Bureau. The Section had a more accurate estimate of operational needs and placed unneeded developments on a low priority. In contrast to the period ending in the summer of 1943, the next two years were marked by the release and production of many new mines and mine devices, although all of these had been initiated and their development problems substantially solved prior to 1943. Indicative of the new position of the Mine Warfare Section was the release of materials for service use by the Chief of Naval Operations, with the approval of the Commander in Chief, instead of by the Bureau of Ordnance. From the fall of 1943 to the end of the war, relations between the Chief of Naval Operations and the Bureau of Ordnance were excellent.

HARVEST

The most creative period of mine *development* in the Bureau of Ordnance Laboratory was during 1940-1942. These were also the most turbulent years because of the lack of early guidance. The resulting differences of opinion were reduced by excising the early and aggressive leaders. Thus after 1943 relations were much smoother and at the same time the results of the earlier and more creative period were harvested. The departure of R. H. Park who had been in charge of mine development at the Naval Ordnance Laboratory, for example, had serious consequences in reducing the technical quality of some developments. Controversy was avoided at the expense of competence. Without the early period of turbulence with its dynamic activity, there would have been no harvest. Indeed, since 1943 the Naval Ordnance Laboratory has not been creative in *new* mine development but has merely perfected the older designs.

The establishment of mine development and production on a sound working basis under the Chief of Naval Operations direction in 1943-44 was necessary to future operations. This parallel between the logistic and operational aspects continued throughout the war. In this phase, which partially overlapped the preparatory phase, development and production were focused on the new mine devices suitable for mining the Japanese Empire, while specific plans were being evolved for the operation itself by the Commander in Chief, Pacific Fleet. When activity changed from planning to operations, problems of transportation and servicing were substituted for those of development and production. Veth and Quimby returned to the Mine Warfare Section where for the first time the Section could be continuously guided by realistic experience based on combat operations.

The first of the new mines, the Mk 13 Mod 5, an acoustic version of the lightweight Mk 13 aircraft mine, was declared suitable for service by the Bureau of Ordnance in September 1943, but it was not immediately released for use because of the accepted United States policy of issuing mines for service use only when adequate sweeping

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methods had been devised. This policy was reconsidered because, though the Bureau of Ships was experiencing difficulties in developing countermeasures, the Mk 13 was needed for immediate use against wooden Japanese ships. The Chief of Naval Operations finally decided that the offensive mining could not be held up indefinitely (the Mk 13 Mod 5 lacked sweeping instructions until the summer of 1944). The mine was released in November 1943 subject to the condition that only the fine sensitivity settings be used — a restriction that was probably unwise since it limited the usefulness of the mine and did not hasten the development of countermeasures. The mine had a limited life and would be used in areas where American surface vessels were not expected for some time. The action was of primary importance as a precedent for the later release of important mines, like the Mk 25, with the stipulation that sterilizers be used. The release of mines before adequate sweeping methods were devised became an increasingly serious problem in the next two years.

The Operational Research Group mistakenly supported the early and fallacious arguments against development and release of the unsweepable pressure and vibration mines. This retarded their development from 1942 to 1944, and reconsideration of this policy was forced by the action of other belligerents. The isolation of the Operational Research Group from new data, i.e., from direct contact with field operations and with technical developments at the Naval Ordnance Laboratory, led it to a conservative attitude. It often acted to help rationalize decisions (using analytical arguments) based on poor assumption rather than to present bold, independent, and perhaps unpopular conclusions. In July 1944 Commander Michels proposed that, since the Germans and the British had begun using the pressure mine, and since the long range mining of Japan was now practicable, steps be taken to push the development and production of the low frequency and pressure mechanisms. The Bureau of Ordnance approved this after consultation with other interested agencies in the Department, and Michels was appointed project manager.

The project was not one of developing a new mine. Instead, the Mk 25, the 2000-pound parachute mine already released, was to be converted from a magnetic to either a low frequency or a pressure mine by the use of conversion kits. After a careful review of the situation the Bureau agreed that it could meet a schedule whereby 500 pressure conversion kits a month would be released beginning in March 1945, and 500 low frequency conversion kits a month would be released beginning August 1945, or possibly earlier. The Chief of Naval Operations in reply requested the Bureau to procure 3000 each of the two types on the schedule set. To meet this difficult schedule, several variants on the usual procedure were adopted. It was arranged for the Naval Ordnance Laboratory and the Mine Warfare Test Station to collaborate on all tests, thus

overlapping the design and service tests. The Production Section of the Bureau of Ordnance, through the Naval Ordnance Laboratory, arranged to assist contractors in procuring critical materials. A Laboratory representative was authorized to permit changes in production during the early stages of manufacture. As a result of the fusing of research, testing, and production, delivery of the new pressure and vibration conversion kits began in December and January. The progress had been so good by November, that the Bureau was requested to advance the release date of the vibration kit (Mk 25 Mod 1) to March 1945, to coincide with that of the pressure kit (Mk 25 Mod 2) and to expand production from 3000 of each mine at 300 per month to 4500 of each at 750 per month. The schedule was met and the Mk 25 Mod 2 was available for use in the field in April, and the Mk 25 Mod 1 in May. The Bureau of Ordnance was commended by the Chief of Naval Operations for its outstanding performance during this critical period in exceeding the scheduled requirements originally set. At no time between July 1944 and May 1945 was there a failure to reconcile the widely differing requirements of research and production. But the action came too late to meet the kinds and volume of mines required for the B-29 operations.

Towards the end of the war the Mine Warfare Section was able to function effectively in relating operational needs to the problem of development and production because of the long uphill struggle of the officers of the group against severe administrative handicaps. Intelligence and information is one example. Officers in the field kept the Section reasonably well informed of operations. The information needed for the total mine warfare picture was extremely varied involving general operational plans and also detailed knowledge of enemy shipping, enemy countermeasures development, and possible future bases for Allied operations. Potential sources of this information were almost unlimited. The operating forces, at the same time, needed to be kept abreast of new developments in materiel and in solutions to operational problems reached by individual units scattered all over the globe. Such information depended on Bureau directives and various Fleet bulletins. In meeting this desperate need for coordination, the Mine Warfare Section was always handicapped by its lowly place in the administrative hierarchy and by the traditional responsibility of the materiel Bureaus in keeping the Fleet informed of new developments.

A greater handicap was the organization of Commander in Chief, and Chief of Naval Operations. They had been reorganized almost entirely on functional lines, with a vertical basis only in antisubmarine warfare and in mine warfare. In antisubmarine warfare the problem of organization was solved by the arbitrary establishment of the Tenth Fleet, directly under the Commander in Chief himself. (The Tenth Fleet had the only other Operational

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Research Group.) The Mine Warfare Section on the other hand had continual struggle with other parts of the Commander in Chief—Chief of Naval Operations organization because of the crossing cognizance of intelligence and of logistic and operational planning. In addition the Section, which was a vertical type organization, had to operate in a functionally horizontal organization. Further, the machinery for the transmission of information proved time and again undependable. To reach the Mine Warfare Section documents passed through so many offices that the papers could be delayed or halted permanently. This plagued the Section throughout its existence and was never satisfactorily solved. The Section did an effective job largely because individual members personally saw to it that necessary information was made available. Like many aspects of the Section's activities, this was not administratively ideal but it worked.

Soon after his return from the Pacific in 1943, Michels proposed a series of monthly mine information letters to the operating forces. To fill a need observed in the field he felt the letters should discuss both materiel and operational information. But the Bureau of Ordnance claimed cognizance over materiel information, whereas divisions in the Chief of Naval Operations and the Commander in Chief had cognizance over operational information and intelligence. In December 1943, nine months after the proposal, Letter Number One was issued and stated the purpose of keeping the addressees informed of new mine developments, new techniques of employing mines, operational experience from all theaters, etc. The letters were given top secret classification, thus avoiding restrictions in content. They were issued each month through April 1945 and proved valuable for Fleet planning.

THE GUARD WAS DOWN

During 1944 the remainder of the mines and devices which had been given continuing high priority ratings were released by the Vice Chief of Naval Operations for general service use. The delay until 1945 in releasing the mechanisms to convert the Mk 25 to pressure and subsonic mines, though initial development had been finished by the Naval Ordnance Laboratory in the spring of 1942, was due to the low priority given. Countermeasures for these mines were lacking and it was feared that they would be used against the United States if the enemy discovered and duplicated them. This appeared a very grave risk to the British, and almost as grave to the Americans. Though the concept of the pressure mine was as old as the war itself (the fields of influence had been investigated at the Naval Ordnance Laboratory in 1940) planners in England and in this country would not believe that an enemy with technological and industrial skill like Germany's would normally have a weapons development parallel to that of the Allies.

The Bureau of Ships, with cognizance over all countermeasures involving sweeping, had full knowledge of the research done and of its future possibilities. The reason for the United States Navy's lack of satisfactory countermeasures goes back to 1939-42. In this period of great expansion and development of mine countermeasures in the Bureau of Ships, a policy was followed which was successful at the time. The Bureau made full use of early British gear, improving it by using American power units. Thus the American minesweepers were equipped with highly satisfactory gear for sweeping moored contact mines, magnetic ground mines, and the early types of acoustic ground mines. This result was attained with a minimum of research because development had reached its late stages in the British prototypes. The major problems were those of production. Thus the Bureau of Ships did not develop a research organization for mine warfare countermeasures comparable to that organized for mine development. No attention was given to countermeasures which future weapon development might demand, the full effort being applied to weapons already in use. Research was never a strong point of the Mine Countermeasures Section and was not prosecuted energetically.

The Bureau of Ships was not consistently challenged in its failure to provide for future possibilities in weapon development. With the exception of one member of the Operational Research Group who acted as technical assistant to the sweeping Subsection making general sweeping surveys, drawing up mine sweeping instructions, and analyzing enemy countermeasures, the Group had nothing to do with mine sweeping and no contact with the Bureau of Ships. The mine sweeping desk in the Mine Warfare Section was flooded from the beginning with problems in no sense of its own making. The routine business of defensive sweeping, together with the related logistics problems, was vast. As offensive fleet operations got under way with the attendant increase in the needs of the sweeping forces, the duties of the Subsection were trebled. It was not a planning agency in either an operational or a technical sense, and performed its primary task as a logistics agency. And the Bureau of Ships without a mine warfare laboratory, lacked the technical personnel to provide the challenge which the Operational Research Group found at all times in the Naval Ordnance Laboratory. Had the Mine Warfare Section been set up as a strong responsible unit in the Chief of Naval Operations or Commander in Chief, planning for countermeasures, as well as for weapons and operations, would have been coherent and thorough. Instead the Section was created on the lowest echelon and grew almost by chance, performing the duties assigned or being pushed into new fields by the insistence of individual officers. Under these circumstances the Section could not be blamed for the

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Navy's sins of omission. It was a wonder that so much was accomplished with so little support.

The Chief of Naval Operations informed the Bureau of Ships as early as December 1943 (when the Mk 13 Mod 5 and the Mk 26 Mod 1 were released without sweeping instructions) that he was not satisfied with countermeasures progress. But this was not made a major issue, like mine production with the Bureau of Ordnance. Unfortunately, without conflict there are none of the fruits of conflict. The Bureau continued on its even course, understaffed and lacking the barest essentials for countermeasures testing. The Naval Mine Warfare Test Station at Solomons had only two minesweepers available for tests and these had to take care of torpedo countermeasures as well.

The failure of the Navy to develop countermeasures for the new pressure mine was serious. The pressure devices were finally given high priority in January 1944, and the highest in May. This stimulated research on countermeasures, but though concentrated efforts had not ended by the time the German mine appeared in June, results were very poor. The Germans used a magnetic-pressure mine during the Normandy Invasion which was followed almost immediately by an acoustic-pressure mine. Since thus far the Allies had not planned to use either mine and hence had not reached the production stage for either, it could be claimed that countermeasures should not be expected. Had Germany resorted to the use of the new mines earlier, rather than in retreat and hampered by a failing air force, the results would have been disastrous. Ironically, she did not use them lest the Allies analyze the mine and turn it against her!

When the German pressure mines appeared in June 1944, the Chief of Naval Operations called a meeting of experts from the Naval Ordnance Laboratory, the Bureau of Ordnance, the Bureau of Ships, the Taylor Model Basin, the Commander in Chief, United States Fleet, and the British Admiralty Delegation. A directive was issued assigning the highest possible priority to the development of suitable countermeasures. The Bureaus of Ordnance, Aeronautics, and Yards and Docks were requested to make available to the Bureau of Ships all practical assistance. Under the general direction of the Bureau of Ships, work was started at the David Taylor Model Basin, at the Naval Ordnance Laboratory, and by the Bureau of Yards and Docks. The Model Basin, a research unit of the Bureau of Ships, which had responsibility for general explorative research, had begun active research on a deep-draft steel barge, later known as the "egg crate." The Naval Ordnance Laboratory was requested to prepare prototypes of the German mines. The Chief of the Bureau of Ordnance authorized the Laboratory to work directly with the Bureau of Ships, merely keeping him informed of developments. The Bureau of Yards and Docks undertook the construction, with standard pontoons, of another type of barge later called the

"cube steak." This, the "egg crate," and an affair resembling a large water balloon which the Naval Ordnance Laboratory developed and called the "Loch Ness monster," were the three major pressure mine countermeasures undertaken in 1944.

The situation was considered acute, for in July the first three "egg crates" were ordered sent to Norfolk, Boston, and New York for emergency use against possible German submarine mining of the coasts. This was an impressive achievement, if the effectiveness of the "egg crate" is not questioned. But had the Germans chosen to use their new mines along the East Coast, they could have bottled up American shipping during the crucial period of the Battle of Normandy. The new German mine was not a straight pressure mine. It was a combination, first of pressure and magnetic principles, and then of pressure and acoustic principles. The operating forces in Europe concentrated on sweeping methods based on weaknesses of the magnetic and acoustic features and were able to minimize the danger from these mines. Further, the stock of German mines proved limited.

Since the Navy's pressure mine, then being readied for production, was more difficult to sweep than the current German type, development of the United States pressure mine countermeasures was emphasized to sweep effectively both United States and German pressure mines. Although the "egg crate" model swept only one mine in the European Theater, in favorable circumstances the sweep proved able to explode the German pressure mine without disintegrating or sinking to block the channel. At this time the British version of a similar sweep was an indestructible barge of concrete construction. It was not ready for service use when the "egg crates" were shipped to Europe, and it was later found to be unsatisfactory. But British research on the effects of sea and swell upon pressure mines and on the effectiveness of limiting speeds of vessels in dangerous waters was very valuable to their countermeasures development and that of the United States.

The difficulties of shipping "egg crates" in sections and of assembling the sections in a suitable drydock made these sweeps impracticable in the Pacific Theater if any other sweep as effective and easier to ship was available. Progress on the Loch Ness monster development was promising in September 1944. In October, 50 were ordered procured if current tests showed acceptable effectiveness. Thirty-five Loch Ness units, which tested well under favorable conditions, were later shipped to the Pacific area for use in mine clearance. But since the United States mine fields were sterilized, and their locations were known approximately, these mine fields were avoided by United States occupying forces until after the sterilizing date. So the Loch Ness, like the "egg crate" in Europe, was not given a thorough test against known live pressure mines in the field. On the basis of general operational experience it appeared ineffective as

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a sweep, because of its extremely narrow sweep path and ineffectiveness in the presence of large waves, as well as the danger to the towing vessel. The "cube steak," as a standby sweep, was about as effective as the "egg crate" but would withstand the explosion of only one mine. It was not needed, but was available.

After the Chief of the Bureau of Ordnance had permitted the Laboratory to work directly with the Bureau of Ships on pressure mine countermeasures during 1944, it became increasingly apparent that the Bureau of Ships was leaning more heavily on the Bureau of Ordnance's Laboratory than on its own organization. This had given rise to suggestions that the Bureau of Ordnance was better qualified to take cognizance of countermeasures. Early in 1945 Captain H. W. Fitch, of the Mine Warfare Section, suggested to the Bureau of Ships a transfer of countermeasures of all influence type mines to the Bureau of Ordnance. A conference was held between the Chiefs of the two Bureaus to which no representative of the Mine Warfare Section was invited. Strangely, the proposal considered was to transfer only the countermeasures for United States type mines which the Bureau of Ordnance was developing. The Bureau of Ships took the position that countermeasures against enemy mines were so closely related that gear and ship-board installations would be similar. Ordnance agreed with Ships' recommendations that instead of a change closer liaison be developed.

As the date approached for the first use of the American mine, the comprehensive review of pressure mine countermeasures was depressing. The Bureau of Ships reported that the Loch Ness, the "cube steak," the "egg crate," and the pressure wave a ship made by stopping a high speed run or by turning sharply, were methods undergoing tests and improvements, but the Bureau did not suggest that research might produce anything new or, in fact, that any research was under way. The Chief of Naval Operations several days later, in a letter to the Bureau, pointed out that the limited progress on countermeasures was unsatisfactory. A comparison was made with British development to date and the Bureau was asked to comment on the British countermeasures program. Finally, the Bureau was requested to investigate the possibility of using explosives as a countermeasure. The pressure mine was not used in the first weeks of the large scale aerial mining operations begun against the Japanese Inner Zone in late March 1945, but its early use was considered necessary to the success of the campaign and was requested by the Area. So, the Commander in Chief, United States Fleet, and the Chief of Naval Operations authorized the use of this mine, provided it was equipped with a sterilizer.

Since countermeasures development by the Bureau of Ships did not show any marked improvement, in April the Chief of Naval Operations sent a second letter, virtually an ultimatum and comparable to the letters of the Commander

in Chief, and the Vice Chief of Naval Operations to the Bureau of Ordnance in the fall of 1943. The Chief of Naval Operations also stressed the necessity for a countermeasures organization paralleling the Naval Ordnance Laboratory and capable of effecting solutions without recourse to outside agencies. The Bureau of Ships objected to the unfavorable comparison with British developments, answering the first letter point by point. The second letter was answered in more general terms. It stressed the physical magnitude of the problem and indicated that any suggestion made by the Chief of Naval Operations on procedure would be welcomed. The Bureau considered it undesirable to form a research organization comparable to the Naval Ordnance Laboratory because it was claimed that countermeasures gear should be coordinated not only with gear for other types of mines but with the sweeping vessels themselves. Thus they considered that the countermeasures organization should be an integral part of the Bureau organization rather than a separate laboratory. Here was a basic misconception of the nature of developmental projects. In any project involving principles as complicated and unknown as pressure fields, research could not be effective if hampered by attempts in advance to coordinate its results with other types of gear and existing types of ships. Research and development, if subordinated to such coordination for production, is bound to be sterile. Nothing but modification of existing gear could be expected. Had the Bureau of Ships held to this misconception in other fields, the Navy today would lack its finest electronics gear.

The Bureau pointed out the inadequacy of its research technical staff, which permitted work on only about 50 percent of the first and second priority projects, and then asked for fifteen officers and ten physicists of medium to low experience. Here again the Bureau's point of view is hard to fathom. Scientists were requested of only P-3 to P-5 Civil Service rating, but they were expected to cope with a problem of such magnitude and complexity that after ten months of intensive work by men of comparable caliber, no solution was in sight. By May 1945, the country's top ranking physicists were obviously needed to solve the problem. The Bureau's estimate of \$100,000 for increasing shop and laboratory facilities reflects the same limited thinking. Evidently the Bureau did not fully appreciate the scope of the problem.

The Bureau estimated that it would succeed in strengthening its countermeasures section within 60 days after receiving the additional personnel and facilities. Marked activity in the Bureau of Ships continued up to V-J Day. Suitable scientists were hard to find but some progress was made in building up the countermeasures organization which was weakened only after V-J Day when a number of its most experienced countermeasures men were sent to the Pacific to assist in mine clearance. Work continued at the Solomons, Maryland, Mine Warfare Test Station, and at the

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Panama City, Florida, Countermeasures Station, but by early 1947 the countermeasures program had not yet caught up with current mine developments. Efforts to build the organization were offset by demobilization and by the release of large numbers of scientists.

A transfer of Bureau cognizance of influence mine countermeasures during the war with consequent disruption of work was undesirable unless it could not be avoided and unless it was strongly supported by all concerned. But there were questions in the minds of some administrative offices regarding duplication of effort in research and development which appeared unavoidable if the closely related problems of influence mine development and countermeasures were conducted by two separate agencies. After conferences with the Bureau of Ordnance and the Naval Ordnance Laboratory, Captain Fitch of the Mine Warfare Section determined once again to press for the transference of countermeasures to the Bureau of Ordnance. The theory for the transfer was not sound, although much of the work on pressure mine countermeasures was being done by the Naval Ordnance Laboratory of the Bureau of Ordnance. The Naval Ordnance Laboratory countermeasure studies and developments on pressure mines had been failures. Competition is essential to healthy development programs. This had been well illustrated within the Naval Ordnance Laboratory where a smooth running but less effective organization had been achieved by eliminating interlaboratory competition.

The Bureau of Ships was opposed to the transfer because those developing "invincible weapons" would find it unattractive to develop countermeasures to them which would be a form of "self-nullification." In another point, the Bureau contended that countermeasures placed under the same jurisdiction as weapons would be developed to counter those weapons rather than enemy weapons. Third, the whole countermeasures development was so closely related to other Bureau activities that taking it away would cause confusion. In view of the Bureau of Ships' strong opposition to the transfer, the Bureau of Ordnance expressed unwillingness to proceed with the change. This left the Chief of Naval Operations with the choice of acting against the wishes of both Bureaus or of accepting the status quo with insistence on very close liaison between the Bureaus. The latter course was chosen.

CONCLUSION

During World War II, in mine development, administrative steps were taken too late to meet the full requirements of the Fleet. The Chief of Naval Operations' early directive requested a magnetic acoustic mine, but instead the development of the simple A-3 sonic mechanism had been forced. This compelled its use, for the unsweepable types were not available. The priorities set on the basis of Operational Research studies could hardly have been worse. Because of expediency or faulty reasoning, the development of poor mines was pushed and the development of the unsweepable types was retarded. This was contrary to the early urgings of Commander Veth. The extensive use of the A-3 in the Inner Zone proved it an operational failure.¹ This verified the technical judgment of Mr. R. H. Park of the Naval Ordnance Laboratory who had been severely criticized for his opposition to release of this mine. Later, the practical guidance of Commanders Quimby and Veth, based on operational experience, helped greatly in the last minute effort, but this was too late.

The problems of mine warfare organization, development, and operations were those expected from the unplanned introduction of a new weapon. In mine warfare these problems were accentuated because the early evaluation of the offensive capabilities of aircraft influence mines was confused with the cogent judgment against the use of defensive mines. Further, offensive mine warfare was an alternative, not the only means of producing sea blockade. Relative effectiveness was hard to estimate prior to the results obtained during World War II.

Many individuals made appreciable contributions to the policies of mine development and to the development of the Mine Warfare Section. In a complete evaluation, considerable credit must be given to Commander K. L. Veth for developmental policies and to Captain Roscoe D. Hughes for administrative policies. Excellent progress in mine warfare organization was achieved in a very short period. Although not yet able to meet the complete requirements for intelligent development, logistics, and long-range planning, this organization made a real advance in the office of the Chief of Naval Operations during World War II. So that the future organizational problems in the complex guidance of weapons development can be evaluated, the remainder of this report includes the detailed aspects of mine warfare research, development, and operations.

¹ *The statements of Captains Tamura, IJN, and Rokuemon Minami, IJN, have direct bearing on this judgment. These passages are selected from numerous others which may be found in the United States Strategic Bombing Survey on the mining campaign against Japan. Tamura said (USSBS Nos. 34, 103, 285), "I think you should have tried to develop something to prevent those spontaneous explosions and sympathetic explosions. I tried to work on it but could not find out why so many of your mines exploded for no apparent reason." Minami said (USSBS No. 256), "The number of premature explosions of American mines puzzled the Japanese and they established a research section to investigate the possible causes. No definite answer was arrived at, although it was noted that the number was greatly reduced during the last weeks of the war."*

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5.

STAFF ASPECTS OF MINING OPERATIONS

PROVING A NEW WEAPON

A new weapon introduced in the heat of a campaign often runs into a solid wall of suspicion. It is untried in combat and is bound to cause unexpected difficulties which disturb all levels of planning. Uncertainties in logistics, training, special intelligence, and in operational procedures snowball until they appear almost insurmountable. Staff planning is normally exceedingly complex, so it can be efficient only if tried procedures are followed and if all personnel who must work in close cooperation have the same essential knowledge of the weapon's servicing and use. If most of the staff lack this knowledge, it is difficult to give a weapon a fair chance to prove its value. This was true of mines in the Pacific during World War II.

A weapon cannot prove itself without being used, and a weapon will not be used on a large scale unless it has proven itself. During a campaign there is seldom a surplus of time, men, or equipment, and each new weapon competes with other new weapons and with older weapons and tactics for the attention of the command. Risk is nothing new in war, and while a commander and his staff always weigh the possibilities of a weapon against the potentialities of a given operational situation, uncertainty in a commander's knowledge of a new weapon is tantamount to limiting its use because the total uncertainties are greater than normal. This charmed circle — no proof, no use; no use, no proof — is difficult to break.

Therefore during World War II practically all new weapons, even those which later proved quite effective, were adopted but slowly. This lag can never be fully eliminated even with peacetime proofing of weapons. In World War II, the lag was often lessened by sending out a staff officer specially trained in the technical and operational characteristics of a new weapon. Besides reporting to Washington on weaknesses revealed by operations, he had two main functions. He assisted in planning the use of the new weapon, and he attempted to convince other staff officers of its effectiveness.

Persuading other staff officers of operational effectiveness was the most difficult task, because definite operational proof is almost always absent for some time after initial small-scale use. Secondly, the nature of combat

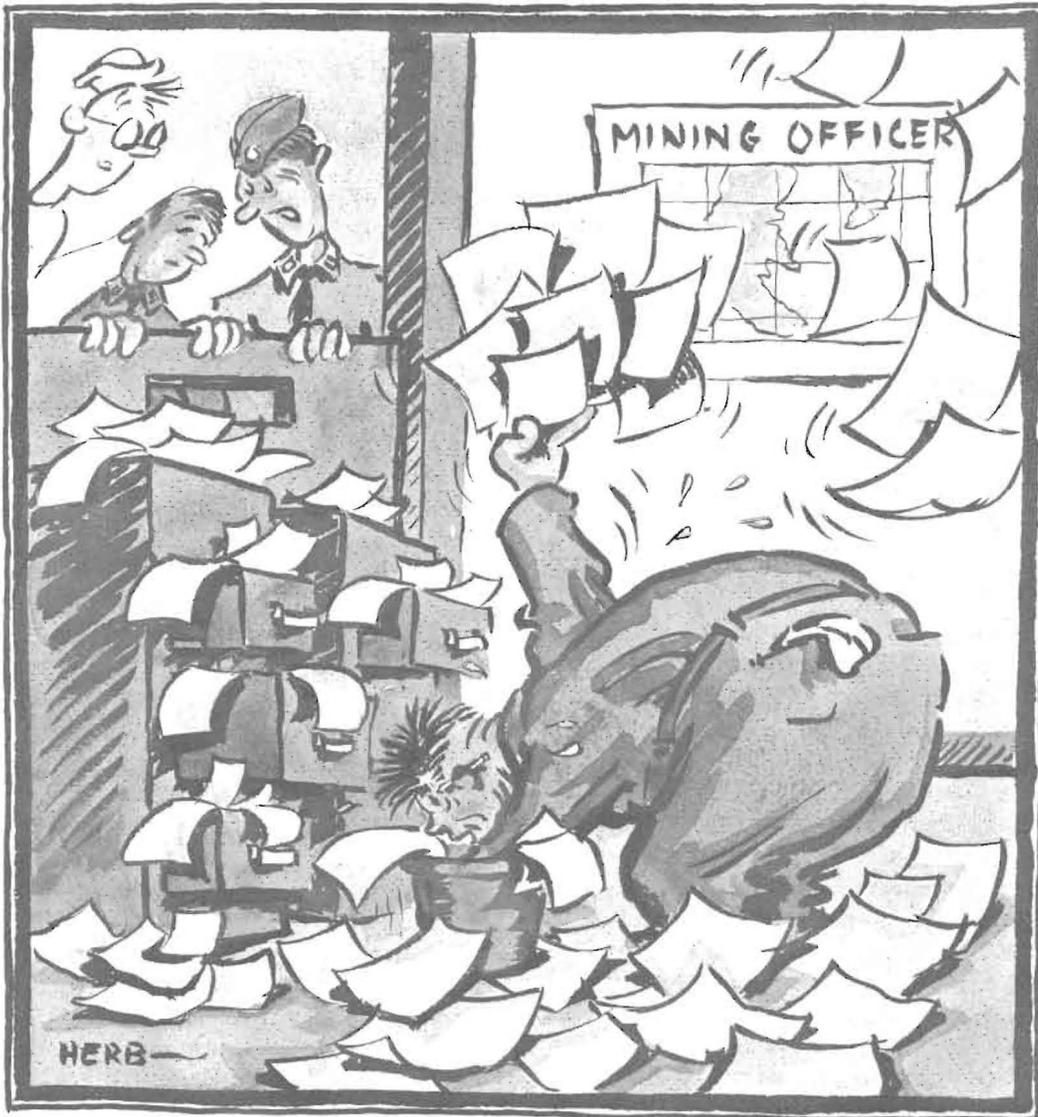
operations often makes it difficult to distinguish between the innate superiority or inferiority of the weapon and the degree of skill of the men who use it. Thus, unless a new weapon is extraordinary, its superiority will not be evident from a few small operations. Eventual proof depends upon a statistical assessment. This requires wide use of a weapon, except in an extraordinary case like the atom bomb whose value was made immediately evident by common sense.

The usual opportunity to prove a weapon is in small-scale operations, because a commander will rarely risk a major operation on the widespread use of a single weapon untried in previous combat. Thus, although the surprise introduction of a new weapon would have advantages, it is generally impossible in the midst of a war because results are so uncertain. Surprise introduction on a large scale may be highly desirable and very effective if the weapon is new only to the enemy; that is, if it has been tried and proven by peacetime tests in war games and by test agencies so that its characteristics under operational conditions simulating combat are well known to the user.

Thus a special staff officer normally finds himself more salesman than planner at the beginning of his duty. Weapons already tried, already proven, will be preferred to his new and unproven weapon. His main attempt at the outset should be to obtain a reasonable small-scale use of the weapon in order to reveal its effectiveness to the planning staff and to discover those operational aspects which can be shown only in combat. But early operations must be appropriate for a particular weapon so that some direct measure of its effectiveness can be obtained. Judgments on the basis of estimates made by the users are inadequate. They have a wide scatter and are difficult to weigh because participants are apt to be strongly prejudiced. Quantitative data is needed. Then the Area or Fleet Commander can be presented with a numerical evaluation for comparison with alternate means for accomplishing the same ends. Otherwise the weapon must be so obviously superior that its merits are evident by common sense, but this is rare.

Proving a new weapon's effectiveness is generally a slow process, and the special staff officer will find it very difficult to hurry. In fact, high-pressure persuasion is usually undesirable. The special staff officer must be

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—CINCPAC JUST ACCEPTED ONE OF HIS PLANS AND NOW HE CAN'T FIND THE BLUEPRINT...

Figure 5-1. A Staff Aspect

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impartial. If the facts demand it, he should be the first to recommend that a weapon be abandoned. If the weapon is proved sufficiently effective to warrant retraining and establishing new maintenance and logistics, then he must work for its increasing use until final full-scale use is realized.

The most favorable time for staff planners to accept a new weapon of great promise is during a desperate campaign situation, but this may not be the best operational situation for the introduction. If the weapon is not obviously a great improvement, the disappointment will be correspondingly great, and it will be denied even its lesser worth. Under ordinary circumstances, where there is no tendency to grasp at a straw, the special staff officer must still be very careful not to be overly optimistic in his early discussions, and he must emphasize all factors which are required for a weapon's successful operation such as training and use only in appropriate circumstances. Most important of all, he must not promise a greater logistic supply than is available, nor base his arguments on the newest super-models, which are being developed in the laboratories, but which could not reach combat for months or even years. This is an easy pitfall which can arouse unbreakable prejudice against a weapon so that a later and more effective model will be given no operational trial. Special staff officers assigned to the Fleet in World War II were sometimes overly optimistic about the new and marvelous mines which they thought would soon appear. They based their opinions on knowledge of the developments in progress at the time they left Washington, forgetting Washington's difficulties in decisions, in development, testing, and production. Sometimes the new mines were not available for years.

All of this emphasizes the need for unity in thought and in action between the development and Fleet personnel concerned with the use of a new weapon. The special staff officer must know exactly what operational characteristics to expect and what new changes. Conversely, the development engineers must clearly understand what weaknesses have appeared in the weapon they developed and all the reasons for a rejection of the weapon if this occurs. Logistics personnel must also be given all pertinent information. On both sides every attempt must be made to put aside personal bias which may result in a stubborn refusal to accept the facts proven by experience. Experience in one operation or in one area is not conclusive, because of the wide variety of special circumstances which may have prevailed, such as poor preparation, training, logistics, or actual deficiencies of the weapon. Washington personnel must use the best experience from all combat areas.

THE SPECIAL STAFF OFFICER

The link between the development and logistics personnel in the rear echelon and the Area or Fleet Commander is the special staff officer. He must know the

features of a new weapon ranging all the way from a comparison of its effects with those of alternate devices down to the details of training and logistics. In fact he must know almost anything that may affect the feasibility of an operation. As if that were not enough, his second general qualification is a broad training in the normal aspects of staff work, because an officer who is skilled only in the specific details of a new weapon cannot introduce it into the general planning of the staff.

This puts the special staff officer astride several normal staff functions, such as planning, logistics, and training, usually separate compartments, each of which involves a multitude of decisions. Many decisions can be made, of course, only in consultation with the staff members under whose overall direction a specified action will lie, but all the diverse, detailed knowledge involving planning on a new weapon must be centralized in one person. Since a special staff officer is handling a weapon unfamiliar at first to the other members of the staff, he must be especially diligent in translating his knowledge into operational doctrine, as soon as experience permits, in a form simple enough to be readily understood by all staff members who lack his specialized knowledge. Otherwise the specialized status of the weapon will tend to limit its use.

The function of a staff member is to do the detailed reasoning for his commanding officer in a particular area of his activities, and to present the results of his thinking and planning to the commanding officer for an ultimate decision. Normally the plan would be previously discussed with the other members of the staff to coordinate all aspects and eliminate all the trivial weaknesses or disagreements. The situation is quite different from that of direct command where an officer is given a task to perform and takes all action on his own responsibility. The staff officer does not act upon his own authority when he issues an order as directed, but upon the authority of his commanding officer whom he becomes in person in all minor actions.

It is none too easy to smooth out staff differences before presenting a plan to the commanding officer for decision on normal operations with normal weapons. The special staff officer must therefore be chosen with more than ordinary care. He should be more personable than average because he will be involved in controversial discussions on a new weapon, and he must be politic and objective and neither be carried away by his own enthusiasm nor lose confidence in his weapon. This objectivity and impartiality should not be *neutrality*. The impartial judgment on operational effectiveness of a new weapon must still be definite, once sufficient data is available, because a staff member's thinking for his commanding officer must be without ambiguity. He must present a definite recommendation with all of the facts bearing upon the situation clearly represented. Usually, it will be very difficult to

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make the total assessment and it should not be arrived at too hastily. Early judgments may be understood to be preliminary, not necessarily final. A weapon need not be condemned or completely approved within the first few weeks or months. However, each separate judgment should be definite within its limits.

This process gives time for each judgment to settle and for the staff to receive a gradual education in the possibilities of a new weapon. This also gives the special staff officer time to feel his way and to compile data for a justified final judgment. To show how one limited judgment led to another which depended on it, and the way in which a special staff officer can function, witness the problem of submarine torpedoes in the Pacific (see also Chapter 11). Torpedoes developed between World Wars I and II by the Bureau of Ordnance had a magnetic exploder and an impact exploder to back it up. They had been insufficiently tested in peacetime for reasons of economy and security, and in combat their poor design was unfortunately fatal. A disproportionate number either exploded prematurely or failed targets.

Neither the Commander of Submarines, Pacific Fleet, nor the Gunnery and Readiness Officer of the Pacific Fleet, had on their staffs an officer familiar with the operational characteristics of the exploder. By chance the writer, who had been in charge of new torpedo development at the Naval Ordnance Laboratory, and who was familiar with the problems of magnetic firing devices and magnetic fields, was in Pearl Harbor. In his opinion the uncertainties in the running depth of the torpedo and the target areas of Japanese ships, together with the insensitivity of the exploder when set to prevent prematures, were such that the exploder could not be effective. The recommendation that use of the magnetic exploder be discontinued was accepted, and a command decision was made jointly by the Commander of Submarines, Pacific Fleet, and by the Readiness Officer of the Staff of the Commander-in-Chief, Pacific Fleet.

Then a high dud percentage showed up when only the impact exploder was used. Operational evidence was very clear. A number of submarine commanders had surfaced and fired torpedoes at relatively shallow depths into targets which were stationary or just under way. The torpedoes had been seen to hit, but had not gone off. On the recommendation of the writer simple tests were then run simulating impact conditions by dropping torpedo heads from a height sufficient to give the required velocity. Moving pictures showed the rate at which the heads crushed. The time for the firing pin to hit the detonator was calculated from its equation of motion, using measured weights and spring strength at the height of travel when released vertically to determine the constants in the equation. It was discovered the firing pin was often crushed before it could reach the detonator. Engineers of the submarine command found a

production method of lightening the pin and shortening its firing time. The torpedoes were made fit for use within a few weeks. If a special staff officer had not been in the field a greater delay would probably have occurred. The torpedo was a weapon which could not be abandoned, but there is no doubt that if there had been a good alternative it might never have been used again. As it was, there was no choice but to find out what was wrong, since torpedoes usually operated satisfactorily in the Atlantic, at least those fired by German submarines.

Mines offer a second example of the kind of problem faced by a special staff officer. Early proposals included the possibility of mining from aircraft carriers. The first mining from aircraft carriers took place in the raid against Palau (see Chapter 6). Mines were planned to extend the duration of attack and to prevent the escape of Japanese ships through the channels of Palau by bottling them up in the harbor and enabling other aircraft from the carrier task force to bomb sitting ducks. The mines were not only to block the channel, they were to sink all ships attempting passage. They accomplished these missions, a success partly responsible for improving the opinion which staff officers of the Fleet held on the general use of mines. However, although the operation proved the feasibility of mining by carrier forces, it also provided complete data on the cost, and so mining could be quantitatively compared with direct attack.

Cost was roughly evaluated by Admiral Mitscher, Commander of Task Force 58. He decided against widespread mining from carriers because it was less economical than direct attack. The decision was based upon the proven effectiveness of direct attack as well as on morale, publicity, etc. The writer arrived at an identical conclusion based on an operational study of the relative effectiveness of the two methods of carrier-based attack. He studied the number of mines that could be borne by a particular carrier, the time between rearming the carriers in a particular mining sortie, the number of ships which would be sunk by mines by one aircraft sortie or one sortie of the carrier force. These figures were compared with those for direct attack. When the analysis was completed, it was very clear that it would be unwise to use mines from carriers for any general attack on enemy shipping if the targets were available for direct attack.

If it was assumed that the carriers would be used in a bold manner and would only attack where there were targets, then mines should not be used at all except where there was some tactical purpose as at Palau. And on the basis of this study, the writer recommended that carriers not be employed in future mining operations except in very special circumstances. This recommendation was very unpopular with most of the mining personnel in the Central Pacific Area, but it was based on cogent reasoning, and it is probable, since it did indicate open-mindedness, that it

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eventually affected favorably the further use of mines by the Fleet.

Another problem arose when operations showed that insufficient information was available on the operational characteristics of the mines, especially acoustic mines. They were arriving in quantity, but target areas, position of firing in relation to a ship, countermining, and various other characteristics were not nearly so well known as its technical characteristics. When pinned down the writer found it difficult to state with any certainty what the mines would do under circumstances dictated by particular needs. Therefore much testing was done by Fleet personnel at Pearl Harbor to discover operational characteristics of mines. This had an unfavorable effect on the staff officers in the Fleet since it indicated ignorance. Yet the results of these tests had immediate effect. They showed weaknesses of the acoustic mines and correction was attempted by the development staff in Washington, though remedy for defects was not completed before World War II ended.

The A-3 acoustic mines laid in large quantities at Shimonoseki Straits by the 21st Bomber Command prematured, many of them in relatively short time. This prematuring, and the simultaneous sweeping by Japanese sound bombs (on which the Fleet had intelligence), reduced the effectiveness of the acoustic mines to little or nothing. The writer recommended to General Le May complete cancellation of the acoustic-type mines, since planting them brought no return, yet it was paid for in casualties. This recommendation was accepted and the mines were cancelled. Such a decision was not easy because of the great shortage of mines of any kind and especially because latter types were made suspect in spite of the good performance of the older magnetic mines. Because of distance, and the difficulty of communicating all the details, this decision was not well received by either the logistics or the development personnel in Washington. Subsequent intelligence obtained by interrogating Japanese after World War II proved that the mines had been useless and should not have been employed in actual combat.

It has sometimes been argued that if lucid information on the operational characteristics of a new weapon is provided, together with personnel trained in its preparation, then no special staff officer is required. This is indeed the case where the weapon has been made familiar through peacetime testing and Fleet training, but experience in World War II does not bear out this viewpoint when the new weapon is first introduced in time of war. For one thing, new weapons usually evolve with extreme rapidity and there is a continuous flow of information on operational characteristics, sometimes of a conflicting nature. The usual staff officer who has a multitude of other duties cannot always evaluate these conflicting data. Thus he either distrusts the weapon completely or he may misuse it. It is far better to provide a special officer who understands

both staff functions and the special operational and technical characteristics of the new weapon.

For example, in the early use of mines in the South Pacific, they were sometimes laid in water that was too deep for them to be effective and sometimes with very heavy losses to aircraft, flying in formation during daytime. Although the men who had developed the mines did not claim an average effectiveness at these great depths, and although use under the loss conditions which prevailed in daytime was not economical for mining, the staff officers without any special knowledge of mining had so directed. They had available a badly organized mass of conflicting information on mines and their conclusion was that mines were probably effective to some unknown extent in water under 25 fathoms. This was actually far from true, but because the information was vague and was not evaluated by someone who actually knew the characteristics of mines, the mines were badly misused, resulting in heavy losses, particularly in the mining of Rabaul. The unusual prejudice developed by the high casualty rate was increased because the mines were ineffective. It was not until favorable results were obtained in later operations that the handicap of this early and unfavorable misuse of mines could be overcome.

Where special staff officers for mining were available in the other theaters, these mistakes did not occur. Mines were used intelligently and under myriad circumstances where their use proved highly profitable. Yet if mining had been judged solely on the early experience in the South Pacific and the successful but inappropriate test at Palau, mines would not have been used widely in the Pacific campaign.

THE ESTIMATE OF THE SITUATION

The first and most important duty of a special staff officer is to prepare an Estimate of the Situation covering the general use of a new weapon as well as each proposed operation. An Estimate of the Situation is an analytical survey leading to a proposed plan of action. It is very important because it is presented to the commander for decision and is his basis for action. It must be backed up with the minutest detail and although the commander himself may not be interested in the details, a special staff officer must be prepared to present them at a moment's notice if any question arises while the commander is making his decision.

No effort should be spared in preparing the Estimate. Its form is familiar to most staff officers and they will appreciate the fact that a great amount of detailed information supports the material actually presented. Often an Estimate which has taken a month or more to prepare can be presented in a one or two page memorandum for final decision. It should not be much longer. The commander must be able to integrate it readily into his general knowledge and to arrive quickly at a decision.

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In time of war, detailed reports or arguments in support of the details of a plan are unnecessary. That part of the thinking is the special staff officer's duty. It is assumed he will do this competently and present to a superior only those factors which require choice between alternative courses of action. The Estimate for the Inner Zone Campaign originally contained several hundred single-spaced typewritten pages. But the summary, as presented to Major General Le May for decision, was typed on a single page. This was accompanied by about 15 minutes of explanation in order to clarify minor points.

Involving all the usual considerations in military planning, the Estimate must have broad scope. The special staff officer must be trained in military planning and have knowledge of military operations as well as of all operational and some technical characteristics of the weapon (usually of minor importance). Explicit details for each step are taught by the War College and are available in its publications, and so are not given here. The form for the Estimate used in mining operations in the Central Pacific is given in Annex A. The form is merely one example of how thinking can be formalized to help arrive at an intelligent decision. The particular form has no special significance and may be worked out differently to meet particular operational conditions. It will differ with individuals or weapons.

The Estimate of the Situation is in itself a changing thing. Once it has been made, and a plan formulated and put into operation, the Estimate must be maintained on a running basis throughout an operation or campaign. As new data comes in from actual operations, the basis upon which the original plan was made must often be revised. Therefore numerical values on results obtained from Intelligence on effectiveness of enemy countermeasures are of special importance; so are losses. These two factors may require drastic alterations in the general tactics or strategy.

In the Inner Zone Campaign, for example, the very first operation showed the difficulty of using full Wings in a raid; planning and execution were both so complicated. Full Wing Operations were later abandoned and mining was conducted by Groups. It was also found that losses over certain areas were especially heavy, and to reduce them alternate mine fields were planned. During the latter part of the campaign a careful analysis was made of losses with altitude of operation. The Japanese had introduced a high-altitude automatic weapon at specific targets. But the crews had attained sufficient skill to operate from higher altitudes without greatly affecting the accuracy and therefore the effectiveness of a plant. Thus it was found feasible to reduce losses without appreciably affecting accuracy.

It will be necessary to set up a procedure for quickly entering changes or additional data from which the running Estimate of the Situation can be taken without delay. Again, the individual solutions will vary; only the principle of providing an up-to-the-minute Estimate is of importance.

In the Inner Zone Campaign, it was hard to visualize clearly the changing Japanese situation by merely scanning Intelligence reports as they came in. So a type of Operations Map was made which showed all shipping routes around Japan and in the Sea of Japan. Pins represented individual ships sighted and reported by Intelligence; their colors represented successive weeks. This gave a continuous evaluation of the changes in the Japanese shipping. Pins more than four weeks old were removed as new data came in. This map revealed many of the Japanese shipping channels, though they often took as much as four weeks to emerge clearly. It could not have been done very easily and continuously by any other method since the number of sightings and other shipping reports were numerous, and many were of no consequence until a very careful numerical analysis had been made.

On the basis of this continuously shifting shipping situation, it was possible to predict the trends based on decisions made by the Japanese Shipping Control. Since routes were shifted gradually, because ships move slowly, mining could sometimes be planned before a traffic shift could be completed. This proved accurate and naturally was invaluable.

The Area or Fleet Commander needs the Estimate as well as the staff officer who is actually conducting details of the campaign. He must confirm his original decision from time to time or alter it as circumstances may require. In the Inner Zone mining, General Le May reviewed the mining decision on a monthly basis and altered the forces assigned to meet the varying requirements of the campaign and other operations of the Air Force.

THE OPERATIONS ORDER

The decision based on the Estimate of the Situation is the basis for operations orders. Annex B, "Planning Detailed Operations," shows how the Estimate of the Situation is used to devise a particular operations plan. As soon as it has been approved by the Area or Fleet Commander, directives are issued which involve all aspects of Intelligence, logistics, and training, and which cover specific orders for combat. Thus the main plan, which is derived from an Estimate of the Situation, leads to a number of subsidiary plans, all of which must be executed before or concurrently with the actual combat operations (see Figure 5-2).

The operations order gives all the principles and some specific instructions which the subordinate commander must follow. All details not stated are left to his discretion. An operations order should give the lower echelons all possible Intelligence plus a running Estimate of the Situation. To provide this information may not always be possible if it is highly classified, but the more data the subordinate commander is given, the better he can do his job.

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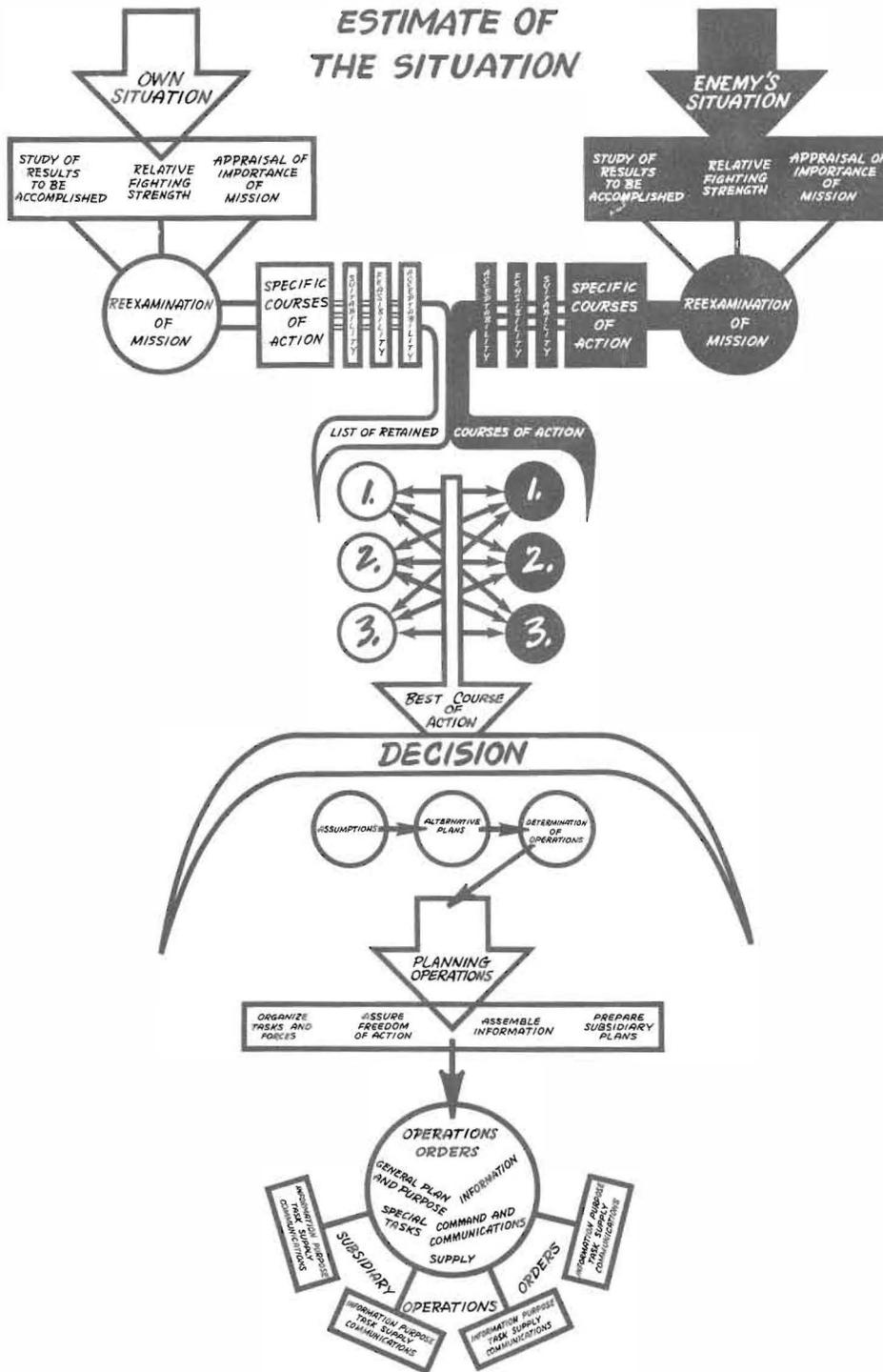


Figure 5-2. Planning A Campaign

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Annex C shows the general form for stating an operations plan and for the operations order used by most of the commands in the Pacific Area. It covers most of their essential points but should not be followed blindly. The principle only is important. Annex K of Chapter 8 typifies the operation orders given by the 21st Bomber Command to the 313th Bomb Wing in the Inner Zone Mining Campaign. The targets were always specified, so were the magnitudes of effort, the general preparation of the mines, and sometimes specific tactics, for example, how mines should be laid in certain areas. The Bomber Command made the broad decisions, leaving most of the detail to the echelon actually carrying on combat. Thus each subordinate command carried out its appropriate function. It was often necessary to coordinate mining operations with other Bomber Command operations, like a particular incendiary attack, for which specific orders were issued by the Bomber Command. This coordination could not be carried out on a Wing level because the entire Command's operations were involved.

In writing operations orders and in designing specific mine fields a set of running rules is needed which has been proven by experience or which will serve until experience provides a better guide. The rules form a standard set of operating principles which channel useful thinking by avoiding the waste of reconsidering familiar problems to which no new data has been added. The rules are not permanent because conditions do change. For example, the acceptable risk at one stage in a campaign may differ from the acceptable risk in another stage, or the percentage of delayed arming mechanisms to be included in a mine plant varies with enemy countermeasure effort and other factors, etc. The running rules provide the best answer at the moment and prevent the hesitation in answering command requests which would result if fundamental calculations had to be repeated as each question arose. The current manual or handbook on mine field design will show basic treatment, but the rules themselves involve specific operational factors and so must be made on the spot.

EVALUATION OF PERFORMANCE

Specific decisions in operations are always more difficult with new weapons than with weapons whose characteristics are familiar to all military personnel. Even the designer of a new weapon cannot be sure of its actual combat performance, and the men who use it will feel still more uncertain. Therefore each operation should be scrutinized to determine whether weapon failure was due to poor military planning or to poor weapon performance. These two factors are not readily separated from each other or from other operational factors such as training, knowledge, and morale.

The mine Mk 24, a homing acoustic torpedo which was used against Japanese submarines, offers a good example of the difficulty in determining why a new weapon

fails in a particular circumstance. During the summer of 1944, VB-108 and VB-109, based on Eniwetok, had made a series of attacks using the Mk 24 on one particular Japanese submarine. The combat results clearly showed that the submarine was often attacked and had been tracked for a number of days. It finally succeeded in escaping, although injured by an ordinary depth bomb.

The writer sought the reasons for the failure and made an operational analysis. There were many possibilities. The torpedo contained a rochelle salt which was susceptible to temperature damage. The mechanism itself was most complicated and required very careful servicing and adjustment to make certain it was in good operating condition. There were severe restrictions on dropping altitude, release speed, and range. The condition of the weapons was doubtful. Microphones may have been damaged because the torpedo heads had been stored on the hardstand where the temperature of the packing cases could go very high (not negligence, for no other storage was available). Servicing facilities were poor and some of the batteries and other components may have been damaged by storage in the tropics.

Further elements to uncertainty entered in actual operations. The weapon had been so top secret that pilots had been given very limited information — so limited, in fact, that the distinction between knots and miles per hour had not been made in the instructions. Pilots used the top speed, so there was a possibility that the allowable speed had been exceeded and the torpedoes might have failed on impact with the water. It was also very difficult to determine whether the torpedoes had been used soon enough after the submarine submerged; interrogation produced varying answers. In this instance it was honestly impossible to decide if the homing torpedo itself had failed or if it had been used improperly. At any rate this one operation caused the torpedo's effectiveness to be doubted for a considerable time in that area. The new weapon was not condemned, but its performance was not trusted, and under the press of operational necessity it was not used as fully as it might have deserved.

While the writer was aboard the USS LEXINGTON he observed similar difficulties in operational decisions on the use of aircraft rockets. They had been widely advertised by the designers as a solution for all problems of accuracy in direct attack by carrier aircraft. At first these rockets required a very long launcher which slowed the aircraft by 10 to 20 knots, a most serious delay within range of the enemy's guns. Furthermore, during the entire day's operation the launchers had to be left on between the several strikes carried out. Commander Bob Isley of TB-16 designed a detachable launcher with the assistance of the writer, but the whole carrier Fleet had to be turned upside down to find the required parts for one squadron.

The second difficulty with rockets was that the pilot

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usually could not see his target until very close. It was almost impossible to identify and to aim decently at brand new targets, especially if they were on the ground, until the aircraft was so close that a bomb would have had the same or greater accuracy. Since the rocket had less explosive power, it was less effective except when great penetration was required. This was rare, especially with open anti-aircraft installations. The accuracy of rockets, like other weapons, is lessened because of the psychological effect of enemy fire on the crew. The accuracy obtainable under drill conditions could not be achieved in combat, and the older 100-pound bomb proved more effective on many targets. After a long time, operations finally proved the rocket a fine weapon in particular circumstances, but it was not a cure-all. The older weapons were far superior in many cases.

Difficult decisions arise with old weapons, too, when the enemy introduces new countermeasures, but these are bound to happen less frequently because the obvious countermeasures are used early. In the detailed operations decisions on new weapons, there is no history of defensive measures. Careful weighing of all of the available evidence regarding their performance is difficult. For this reason, good Intelligence is highly important.

INTELLIGENCE

The special staff officer requires a full measure of normal Intelligence data so that he can maintain an up-to-date Estimate of the Situation, evaluate results of damage to the enemy, and modify tactics, operating procedures, and training to make the new weapon more effective in combat. But he also has special requirements for Intelligence data so that he can make a concrete evaluation of the operational success of a new weapon for comparing it with rival devices, and so that he can determine particular weaknesses, types of countermeasure being developed by the enemy and, finally, general trends. The derived information is often based on very subtle clues and requires careful analysis.

Four general types of Intelligence are specifically needed by the special staff officer: Target, Psychological, Current Situation, and Specific Results. The last two are treated later in this section. Target Intelligence is information on the geography, economy, industry, and the physical structure of the enemy target or target system. Psychological Intelligence is information on the enemy's civilian, military, industrial, and scientific mental set in attacking their problems. Both Target and Psychological Intelligence must be based on long, careful, and detailed studies, and is best obtained during peacetime or from historical records.

At the beginning of World War II, there were few summaries of such studies readily available to staff officers. A Joint Target Group was eventually formed, but too late to complete many studies in time for use. United States forces usually fought and took an area before the location studies reached the Theater of Operations. This obviously does not

change the need for such studies, and some such information is requisite for the special staff officer, wherever obtained. The geographical information needed for mining is on current velocities, water depth, and the nature of the bottom at all targets. Ambient background, temperature, and marine fouling may be important depending on the limitations of the mine mechanism. The height of all surrounding terrain, essential for operations and the aircraft crews, will also concern the special staff officer in his tactical instructions for laying a particular field.

Information on industrial centers, ports from which particular manufactures are shipped, and other detailed knowledge of the enemy's economy should be available to the special staff officer. In the later phases of the Inner Zone mining, details of this sort obtained from China-Burma-India sources helped anticipate the shifts the Japanese made to meet the disruption of their shipping by mining. The fourth type of Target Intelligence, physical structure, is not necessary for mining, but it has obvious use for bombing raids, where the type of bomb is chosen according to the type of construction attacked, whether shipping, bridges, wharves, wooden houses, skyscrapers, strong points, bivouac areas, etc.

Psychological Intelligence is very important. It was necessary to estimate Japanese reaction to mining operations in the earlier part of the Inner Zone Campaign to determine the stubbornness with which they would run mine fields in spite of sinkings. Loss could be reasonably predicted on the basis of traffic rate and target system, so the mining effort required to achieve blockade at a particular target would depend upon the rate of loss the Japanese would tolerate without stopping shipping. This was a very complex estimate, depending as it did upon the urgency of their need and the status of their shipping; it involved military, economic, civilian, scientific, and psychological intangibles.

Contrary to the opinion of the Chief of Naval Operations Operational Research Group, the writer expected the Japanese to be very stubborn in attempting to run a blockade. On this basis it was felt that attacks in force could not be mounted against all Japanese ports and shipping routes with enough potential left to block Shimonoseki Straits, the most important target of all. This estimate proved right. In general, blockade was not obtained except with the heaviest possible attack, and it was necessary to lay more than half the mines of the Inner Zone Campaign against one single target system, Shimonoseki Straits, to blockade it. It proved very worthwhile (see Chapter 7). The effort was not overdone because Japanese morale was not seriously affected by mining; it took mines rather than the threat of mines to stop them. Disturbance to morale might be much more important with other nations, and a corresponding decrease in mining effort would be permissible. Finally, proper evaluation of scientific competence and the psychology of the scientific profession of a nation will help anticipate their

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ability to develop countermeasures and must be considered along with other Psychological Intelligence.

In the Inner Zone operations, plans for a psychological warfare campaign were first rejected, mainly because of the lack of precedent for open propaganda built around a mining operation. In the past the undisclosed location of mine fields was a major factor contributing to their success. Aerial mining had been used to lay attrition fields, in which it was hoped the enemy would lose ships before discovering its existence, or in tactical operations where the less the enemy knew of the mining the better. But secrecy could no longer be a factor in the Twentieth Air Force operations. First account of the mining invariably came from Japanese home broadcasts which tracked the mine laying craft from the moment they approached the Japanese islands to the time they were well on their way back to the Mariannas. Furthermore, since the objective was *blockade* it would help if the enemy imposed it on himself by refusing to move his ships. Permission was finally granted to conduct a psychological warfare campaign on mining, and over four million leaflets were dropped on the islands emphasizing the depletion in Japanese food supplies, their dependence on seaborne transportation, the effects of mining, the high shipping losses because of government insistence on running ships through mine fields, and the hopelessness of feeding the Japanese after peace came if this policy continued. Hitler's successful use of the medium of psychological attack has made it a phase of warfare which can never again be neglected.

The continuing Intelligence information needed by the special staff officer includes Current Situation Intelligence — the broad estimate of the enemy's military, economic, and scientific situation at the moment. This will certainly have bearing on the use of any new weapon because greatest effectiveness is obtained by taking advantage of an enemy's current weaknesses which are associated with his general condition rather than with a specific target system. For example, targets attacked in strategic mining depend upon supplementary attack on enemy shipping by submarines or bombers. Although the same shipping might profitably be attacked by mines, submarines, and aircraft, the entire effort should be coordinated to obtain maximum effect. Many times it will prove desirable to attack an entire communications system at once, each of the attacking forces playing its appropriate part.

In the Inner Zone Campaign, Shimonoseki Straits was mined not only because it was important economically but because it was important to the immediate military situation. Through these Straits the Japanese were attempting to support their forces at Okinawa and through these Straits their shipping was escaping from the China Sea, driven away by the attacks of United States submarines and aircraft. In the decision to use most of the United States' mining force on Shimonoseki Straits, the current military

situation was most important, though economic considerations were not neglected. Aluminum, coal, oil, and food shipments had to be considered on a week-to-week basis because these changed with loss of shipping. Analysis of Intelligence indicated which ports were most likely to be used and how this would be coordinated with the rail and overland transportation systems which were already affected by disrupted communication centers.

The current scientific situation should also be considered, since not all countermeasures can be developed simultaneously and it is possible to estimate the effort the enemy will summon. This will affect the success of a weapon in a particular operation. At Shimonoseki Straits, the Japanese scientific resources were so meagre that they were not expected to be able to put much force into the development of mine countermeasures. This proved true, even though the Japanese gave a priority to mining countermeasures over all defensive measures at the very end of the war because the mining attack proved so disastrous to them.

The fourth type of Intelligence needed by the special staff officer is the day-to-day information on results of attacks and enemy passive and active countermeasures. In mining this involved a knowledge of the enemy's shipping routes and prediction of change. As already indicated, it included the amount of shipping sunk by each mine field. It included a specific estimate of his shipping situation on a day-to-day basis by counting ship passages in and out of all current mine targets and of possible future targets. It included a count of shipping tied up in each port, and whether it was operative.

All this information had to be digested, coordinated and summarized to predict enemy trends. The Operations Map proved convenient. Not only did channels emerge clearly after the data of several weeks had been grouped on the board, but trends in Japanese shipping movements could be anticipated. It was thus possible to order the mining of ports in the Sea of Japan, both of Northwest Honshu and Korea, with the result that these ports were paralyzed before the Japanese could make full use of them. Rashin and Seishin in Korea were thoroughly bottled up just about the time the Japanese were planning to make the fullest use of them. Successful prediction of enemy traffic shifts was fortunate because the small number of available mines had to be used with maximum efficiency.

As a result of carefully following the changing situation, ports no longer used much were dropped as targets, and ports that the enemy was expected to use more fully were taken on as targets. It was also possible to determine the general methods of enemy countermeasure from reconnaissance and other Intelligence, and to determine the number of operable enemy merchant ships. This, for example, involved a week's special reconnaissance effort in which every ship in Japan and Korea was counted from

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aerial photographs. It was then possible to determine which mines were still effective and which were being too easily countered. This altered logistic demands. This immediate information also made it possible to predict how long a mining attack could continue at its existing strength. Thus some idea of the logistic effort required in the near and remote future could be sent to Washington.

To summarize: Intelligence must range from relatively static data gathered over many years resulting from long-time studies during peacetime, to the day-by-day information gained during combat. All data must be taken completely into account and eventually be reviewed by whoever makes the final decisions in the conduct of the military operation, the Theater Commander or his delegated subordinate.

RECORDS AND REPORTS

Of the many uses and justifications for reports and records, only those which have significance for the special staff officer are mentioned here. The special staff officer should review all accounts by Intelligence and Operations personnel for information before passing them on to higher headquarters, where they will provide a basis for a separate evaluation of a new weapon's performance. Taken together with reports from other areas, the account will disclose performance under different sets of circumstances. Only rarely can the success or failure of a new weapon be proven under one particular set of circumstances, and it is particularly dangerous to base final evaluation upon the opinions of a few individuals, even though they may be highly qualified.

The special staff officer has the responsibility of seeing that well-rounded reports are written on all pertinent military and technical features of a new weapon's performance. Mine lays must be accurately recorded so that mine fields can be cleaned up when hostilities cease — a need which does not exist for most weapons. All weapons, however, can be improved on the basis of current reports, and one of the primary functions of the special staff officer is to transmit them for collation with reports from other areas. The written record is without substitute for the development of future countermeasures based on predicted weapon trends. A full performance record of a new weapon can be compiled from source material and examined in a more leisurely and unbiased fashion after the war. This should not be neglected. It was probably the study of previous mining campaigns which led to the German development of the aircraft mine as an offensive weapon. The record was available to all belligerents, but the Germans saw its great potentialities, developed them and first used mines offensively.

LOGISTICS

If a new weapon is desperately needed, logistics

becomes a crucial problem because the demand may skyrocket and greatly exceed logistic possibilities once Fleet use is decided upon by the Area or Fleet Commander. The special staff officer must be alert to sense the way the wind is blowing and to give warning to those concerned with manufacture so that they may plan large scale production when it is requested on the basis of Fleet needs.

Production needs are decidedly unstable. Should the operation fail in which a weapon is first used, its further use may be cancelled completely by the Area or Fleet Commander, and he is not likely to reverse his position quickly. On the other hand, if the command is convinced by operations that the weapon is successful and is definitely superior to alternate means, immediate use on the widest possible scale will most likely be demanded. If the staffs in Washington are too conservative and await word from the Fleet before taking action on production, they will be caught short. Therefore someone must take a chance on an unproven weapon in war time. The someone should be the Washington logistic staffs.

Especially for mines the World War II record shows very clearly that when chances were taken in production, weapons were provided in necessary quantities when needed, and that conversely, the failure to take a chance found mines in short supply when they could have been used to great advantage (e.g., the Inner Zone Campaign). For this reason the staff officer must keep the Washington staff so informed of actual results and trends of thinking that predictions can be made on the best data available. If special staff officers can obtain permission for the visit of ordnance personnel, including those of development agencies, the trends of staff thinking can be assessed directly by them and will give some basis for Washington's changing production.

Though a Fleet or Area Commander's decision may have a very great effect on new weapons production currently in progress in the United States, it is unlikely that he will provide a firm official basis for long-range logistic planning. It would be unfair to expect him to take this risk. His risks are taken in operations in which his men are engaged and he rightly expects that chances on production, development, etc., will be taken by the rear echelons who support his operations. He expects them to evaluate the needs of the other Area or Fleet Commanders and the needs of the Nation, and to take all the appropriate steps including the prediction of future requirements.

The special staff officer must be thoroughly familiar with the logistics of a new weapon. He will have very little long-range influence on logistics because he is concerned with day-to-day operations, and governing decisions will have been made many months and even years before. He must, however, know logistic possibilities. If he is ill-advised, he may be uselessly planning operations on the basis of some laboratory development which is always just

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around the corner. Unless weapons are actually on hand, or en route, they should be discounted.

Of direct concern to the special staff officer is the request for material to reach him as soon as lines of communication permit. In the Pacific, it usually took about six months from factory to operating theater. Special requests for crucial parts could sometimes be met in less time, but logistic planning should be based on average possibilities. The special staff officer must forecast requirements of operations as far ahead as possible; he must make a guess if necessary. He should be reasonably certain of his ground and not simply order everything he can think of because the competition for space on cargo carriers is so great that he may displace some material vitally needed in a campaign. It is just as serious to order an oversupply of a new weapon which appears to be an imminent failure, as to order an undersupply of a highly successful weapon for which great demand is anticipated.

The special staff officer should maintain close contact with Washington on anticipated future trends, but he can only request what he can persuade his seniors to accept. These concrete requests must be presented in tremendous detail. Here, as in all other staff work, great attention to detail is the secret of success in final operations. Further, to rely upon the experience of the past is not enough; the special staff officer must foresee the difficulties of the future, associating them with new bases, new types of terrain, other weapons, or other means of using new weapons, etc. Planning is the staff officer's job and foreseeing future needs is fully as important as the actual conduct of current operations.

COORDINATION

For a new weapon, it is important to coordinate the specific operations of various commands at all levels, and especially between corresponding staff officers. The staff officer must show initiative in support of his commander's policy, and it is his duty to explore all of a weapon's ramifications which concern other commands. It is obvious that such coordination will be difficult if the relations between commands are strained as sometimes occurs, for example, between the Army and the Navy, or where political problems exist, or a clash of personalities. None of these aspects can be avoided in human relations, and each staff officer must aim at complete coordination between commands in spite of these relations or perhaps by taking advantage of them.

Actual operations often have to be coordinated. Mining operations, for example, carried out by the Army Air Forces, had to be coordinated with direct attacks by Fleet Air Wing One based on Okinawa, and by the submarines of the Pacific Fleet. It was readily accomplished without any political difficulties like those in other theaters or for other belligerents. The Japanese, for example, raised noncoopera-

tion to a fine art. Their Army and Navy each possessed its own mine sweeping service. In several cases, each swept its own separate channel for the ships under its control and sometimes the safety of Army craft was assured but not the safety of Navy craft. This may be an extreme example of lack of coordination, but important instances of a like nature occurred within United States forces.

MORALE

Morale is crucially important for Americans who must always know *why*. For prolonged operations, they must be convinced of two things if they are to use a new weapon effectively: first, that the weapon works and will do the enemy damage, and second that they have a reasonable chance to get back alive. When the need is great, there is no holding back. In the First Philippine Sea Battle, for example, all the aircraft personnel of the carriers were unanimous in their desire to attack the Japanese Fleet although impending darkness made small the chance of their returning without great loss. Considerably less enthusiasm occurred when men were convinced the results did not match the danger in certain operations, and the action was accordingly less effective. The special staff officer must take particular pains to explain a weapon's known worth to the men who actually use it. This is just as important for the lowest subordinate as it is for the senior in command.

When a weapon is first used, all its limitations must be clearly discussed as well as its fundamental theory of operations. This can always be done without endangering security. Expected results, and the importance of these results to the current military campaign, must be evaluated and summarized for the operating personnel. Sometimes this will be very easy, as for example after submarine hits; but it may be very hard, as with mines, where results will not be known for weeks and must be deduced with great difficulty from Intelligence information.

This delayed observation of results is a difficult morale problem and is increasingly important because it will characterize more and more weapons used in modern technological warfare. To meet the morale problem, previous results should be described and weaknesses discussed frankly. They will be known through scuttlebutt anyway, and if they are glossed over, distrust will result. Complete frankness is the only safe way to deal with any peculiarities or weaknesses of a new weapon — including rumors, which to the men are just as important as facts. If they know what to expect, the men will accept these weaknesses as part of their general risk, but nothing is worse than a suspected weakness magnified by imagination. Since personal participation in operations is the best indication of confidence in a weapon, special staff officers should themselves take part in operations, if possible, although this risk is often denied to higher echelons for reasons of security.

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"Mines Away" (see excerpts in Annex D) summarized for enlisted men the Estimate of the Situation on mining Japan. It was a direct effort to enlist the thinking enthusiasm of aircraft crews by informing (and therefore convincing) them of the importance of mining Japan. In so doing, it used the same basic thinking and arguments that went into high echelon planning, and so met some prepublication resistance for reasons of security. But the pamphlet, used in conjunction with movies and group and personal talks paid off. Together, they proved very effective in convincing the operating personnel that the operation would be successful. The staff of the 21st Bomber Command was convinced in part that mining was worthwhile by the enthusiasm of the operating personnel and eventually the competition to participate in the operation between the Groups of the 313th Wing and then between Wings. If the men who may die in using a weapon are enthusiastic about it, their enthusiasm is contagious and will go a long way to convince their superiors.

Morale in a prolonged campaign cannot be maintained by promises alone. Intelligence on results must be passed on as soon as possible, and the men must be convinced that the facts are well based, because they will not be convinced by anything except authentic information. Sometimes it is very hard to provide such information, but every effort must be made to do so and on a day-to-day basis. It must be supplemented in every possible way, and exaggerations must be avoided at all costs because nothing is more dangerous than exaggerating the effects of operations. Eventually results become known, and any exaggeration will be held against the new weapon.

Publicity in home newspapers proved important to morale. Americans seemed to depend upon letters from home for keeping their spirits high and they took special pride in letters which recounted or enclosed clippings about their operations. Publicity should therefore not be neglected when permitted. This is difficult with new weapons for reasons of security, but often these reasons for restrictions on publicity of operations prove trivial on more careful examination, because the enemy certainly knows that the weapon is being used. Publicity which can do no harm always helps morale, and it may have a real bearing on the effectiveness of a new weapon by encouraging all personnel involved in its use, production, and development.

TRAINING

Training is usually one of the very first problems which a special staff officer must consider. The Estimate of the Situation depends upon numerical analysis which can

only be based on the actual use of a weapon in field tests by the men who will later go into combat with it. Thus one of a special staff officer's first duties will be to institute a training program with full attention to minute details in order to develop a Standard Operating Procedure.

Tactics used with other weapons may be adapted to a new weapon. The staff officer should never have a closed mind in regard to operating procedures and should never insist on a particular procedure. In general, it is indeed a wise plan to permit the operations personnel to work out new tactics compatible with their particular means of using the new weapon and with their previous training. Tactics should therefore be worked out in a pilot-model training program. After a time, its effectiveness can be evaluated and plans can be made for complete training of all the men. This training is almost always continual as new personnel is added to the command.

Training in an advanced area is always difficult, is always resented by the operating forces since it conflicts with the actual operations against the enemy, yet it is always necessary with a new weapon, and, whatever the difficulties are, must always be planned and carried out. With sufficient ingenuity, much of the training can be done with devices which simulate combat. Complete explanation invariably should be given in ground training before actual operation training begins.

CONCLUSION

Without attempting to be all-inclusive, the nine factors discussed above give a fair sample of the types of problems and duties of a special staff officer concerned with a new weapon. They do not by any means exhaust them all. He has all the usual functions of a staff officer plus a liberal amount of public relations activity to sell the strange and novel device to other staff members.

Any staff officer would much rather work with a weapon with potentialities well proven by peacetime tests and dependent only upon the normal military factors involved in combat. These alone are difficult enough, and require a high order of intelligence. It is very unreasonable to add to these all the uncertainties of evaluating a new weapon in actual combat. When the Intelligence available on such performance is scanty, it can mislead. Thus, the most sensible procedure to avoid overselling or underselling is to complete the research, development, and tests for evaluating weapons during peacetime, and then to complete all the logistic and other plans so that the staff officer can do what is really his job — to plan the effective use of weapons against an enemy.

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ANNEX A

ESTIMATE OF THE SITUATION

I ESTABLISHMENT OF THE BASIS FOR SOLUTION OF THE PROBLEM

A. Study of the Result to be Accomplished:

- (1) Summary of the situation: This is a statement of known information to serve as a background for visualizing the problem. Broad disposition of forces, the progress of a campaign, orders received, may be included. Details should not be included; these come later. Do not draw deductions. This section merely presents a broad picture of the military situation.
- (2) Recognition of the incentive will be: orders from higher authority, previous decision creating new problems, or demands of the situation.
- (3) Appreciation of the end to be attained: Here break down assigned action into a statement of the result desired. Be sure you understand the immediate purpose to be served by the job which has been assigned to you or which you have determined for yourself. See how this fits into the general plan of your superior, either by analysis of directives, or by deductions. If possible, deduce the results which he is trying to attain. Clarify in your own mind the 'chain of objectives'.
- (4) Statement of the 'Mission': Based on the foregoing sections, state accurately and briefly the job you have to do, and the reason it is to be done, i.e., your 'Task' and 'Purpose'. Normally the 'Purpose' is to assist in carrying out the general plan of your superior. Examples:
 - (TASK) Attack enemy lines of communications between Japan and the Carolines --
 - (PURPOSE) To weaken his defensive strength in the area.
 - (TASK) Deny channel A to enemy destroyers --
 - (PURPOSE) To assist in covering the landing operations at B.

B. Relative Fighting Strength:

- (1) Means available: mines and their characteristics, layers and their capabilities, personnel, supporting forces (ships, aircraft, submarines, and land forces), logistics (material, personnel, and facilities).
- (2) Characteristics of the theater: topography, hydrography (water depths, current, marine growth), weather, daylight and dark periods, relative location and distance, lines of transportation and supply and enemy traffic, facilities and fortifications, and communications.
- (3) Means opposed: enemy defenses (ships, submarines, aircraft, and fixed defenses), personnel, material (sweeping facilities), and logistics.

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- (4) Conclusions on relative fighting strength: Here list deductions based on the facts collected in the preceding three subsections. A good form is a list of own strength and weakness factors in a column parallel to those of the enemy. Note that own strength does not necessarily mean a corresponding enemy weakness.

C. Appraisal of the Importance of the Mission: Since every military endeavor involves some measure of risk, it is necessary to have an idea of the importance of the task in order to decide whether its execution is worthwhile. Some tasks are so important that they require an all-out effort, regardless of consequences; others are less vital and should not be carried out if the risk is great. To form a basis for such evaluation later in the estimate, assess here as best you can the importance of the mission.

II PRELIMINARY DETERMINATION OF COURSES OF ACTION

A. Re-examination of the Mission: Though you have already analyzed your objective, the study of relative fighting strength and characteristics of the theater may lead to the conclusion that your mission should be revised. This is particularly true in cases where the incentive arises from your own previous decision or from the demands of the situation. However, do not be misled into considering here how you are going to do your job; this subsection is devoted to a critical re-examination of what the job is and the further purpose to be served. Then restate the mission.

B. Survey of Courses of Action: Here list possible ways to accomplish your objective. This is to be done in broad terms, not by listing detailed operations. Make them very general, in order to cover all possibilities. For example, if the Task is "To interfere with enemy lines of communication. . .," possible courses of action might be: to lay attrition mine fields in trade routes, to blockade enemy ports, or to mine enemy harbors in conjunction with bombing raids. It is not necessary -- it may even be undesirable -- to specify in the course of action the type of layer or mine to be used. It is clearly wrong to list detailed operations. Try to visualize in very general terms all the different ways that you can accomplish the job you have been given, and set them down. Eliminate only the fantastic ones; do not reject mentally any possibility, even though you doubt that it will work. Sometimes only one course will occur to you; rarely will you have more than four or five. If you think of more than a half dozen, then you are really thinking of detailed operations, not comprehensive courses of action. Start again, and set down only general plans for accomplishing the objective.

C. Testing Courses of Action: Now take each course of action in turn and subject it to the three tests listed below, using as a basis the material accumulated in subsections A, B, and C of Section I.

- (1) Suitability: Is the course of action appropriate to accomplish the objective? Does it completely accomplish the objective? If not, does it assist in its accomplishment? Does it accomplish the objective within the period of time necessary to achieve the purpose of the mission?
- (2) Feasibility: Is it possible to carry out the operations contemplated, with the facilities available, against expected opposition, and in the

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physical conditions existing in the theater of operations? How easy is the operation to carry out? Does the course utilize own strengths and capitalize upon enemy weaknesses?

- (3) Acceptability: What are the consequences as to costs of the course of action? Are the costs acceptable in view of the importance of the mission? Are the costs acceptable in the event of failure?

D. Listing Retained Courses of Action: The foregoing tests may cause rejection of one or more courses. List the ones you have retained as possibilities. You may here wish to combine two or more courses which alone are unsuitable or infeasible but which in combination meet the required tests.

III ENEMY CAPABILITIES

A. Survey of the Enemy's Problem:

- (1) Summary of the enemy's situation: Put yourself in the enemy's shoes. In what sort of situation does he find himself? What problem confronts him?
- (2) Analysis of the enemy's objective: What result does the enemy desire to bring about? You probably will not be able to deduce a mission for him, but you should have some idea of what his general objective is.

B. Survey of the Enemy's Capabilities: On the basis of the foregoing survey, and the list of enemy means, what are the enemy's capabilities which might affect your courses of action? Do not omit any possibility just because it is unlikely. List all the enemy's capabilities; do not restrict yourself to enemy intentions. In mining plans, the enemy's capabilities fall into two classes:

- (1) Preventive measures: use of ships, aircraft, and fixed defenses to stop the mines from being laid.
- (2) Remedial measures: sweeping, avoidance of fields and use of mine-proof shipping to render the fields ineffective after laying. Your list of capabilities need not be so classified; the foregoing is merely a reminder.

C. Test of Enemy's Capabilities: Now apply to possible enemy courses of action the same three tests you used for your own courses of action. Since your information about the enemy is meager, do not be too hasty in eliminating any capability; discard only those which clearly fail to meet the tests.

D. List of Retained Enemy Capabilities.

IV SELECTION OF THE BEST COURSE OF ACTION

A. Comparison of Retained Courses: Execute, in imagination, each of your own courses against each enemy capability. This involves breaking the course of action down into more detailed operations to see how it works out. Re-estimate the enemy's situation if necessary. Make further combinations of your own courses if it seems best. By this process you may or may not decide now to reject one or more of your courses.

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B. Determination of the Best Course: The foregoing analysis should now enable you to compare the courses you have still retained. A tabulation of their advantages and disadvantages may be helpful in picking the best. If you have decided on a combination of two or more courses, be sure to test the combination for suitability, feasibility, and acceptability.

V THE DECISION

State your best course of action as your decision: Couple with it the purpose of the decision, which is the motivating task. List any corollaries to the decision which your analysis has developed, that is any subordinate deductions which limit the scope of the decision or affect the manner in which it is to be carried out.

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ANNEX B

PLANNING DETAILED OPERATIONS

I ASSUMPTIONS

In the 'Estimate' you decided upon a basic plan. This decision was based upon the best information available, but which is probably incomplete. Now determine what conditions must exist if the plan is to be successful. Do not list probabilities or expectations, but the assumptions on which your plan is based--that is the facts or conditions which may or may not exist but which must exist if your plan is to be successful.

For example, if the decision were "To lay saturation mine fields in harbor X, in order to prevent the enemy from developing his base at A," a proper assumption might be that: "Harbor X is not defended by barrage balloons." On the other hand, the statement that: "the enemy will attempt to intercept with night fighters" is not an assumption. Both statements are expressions of what opposition is anticipated; both may or may not be true; but the first one is a condition which must be true if the plan is to be successfully carried out, while the second is not. An assumption then, as used herein, is a statement of a condition whose existence is essential to the successful execution of the plan.

If, however, you are preparing an order, not a plan, then there is no place for assumptions. An operation plan is to be carried out only if the assumptions stated in it are actually true; an operation order is designated to be carried out (subject to the usual exceptions) without qualification.

II ALTERNATIVE PLANS

It may be desirable to devise two or more plans based on different assumptions or sets of assumptions. A typical example of alternative plans would be Plan A based on the assumption that high visibility will exist and Plan B based on the assumption that low visibility will exist.

III DETERMINATION OF OPERATIONS

There are many ways of determining detailed operations. The one here suggested is a proven one, and will tend to prevent omitting any essential element. Any successful military operation has the following constituent characteristics: effective action with relation to correct physical objectives; projection of action from advantageous relative positions; proper apportionment of fighting strength; and ensurance of adequate freedom of action. Knowing the result which you wish to obtain (the decision arrived at in the Estimate), break it down into the following elements.

A. Effective Action with Relation to Correct Physical Objectives:

- (1) What are the correct physical objectives? They may be locations; lines

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or areas; troops, ships, or other forces; bases or supplies.

- (2) What action with respect to these objectives will assist in carrying out the plan?
- (3) Consider the possibilities of concealing from the enemy (e.g. by feints) your ultimate physical objective.

B. Advantageous Relative Position: From what geographical locations can the contemplated action be projected? Is a change in positions or a movement of forces necessary? Here consider time and space factors.

C. Measures for Freedom of Action:

- (1) Provisions for exercise of command, including communications.
- (2) Effective training.
- (3) Security measures.
- (4) Intelligence and counter-intelligence.
- (5) Morale.
- (6) Plans for surprise, if desirable.
- (7) Plans for retaining the initiative.
- (8) Logistics support.
- (9) Measures for cooperation.

This list is not all-inclusive.

D. Apportionment of Fighting Strength.

- (1) Consider own strength and weakness factors. Determine whether to oppose own strength to enemy strength, and dispose of his strong points first, or whether it is better to attack first where he is weak.
- (2) Consider strategical as well as tactical considerations.
- (3) Allocate to each operation adequate forces, from the point of view of suitability, feasibility, and acceptability.
- (4) Now is an appropriate time to test each operation for suitability, feasibility, and acceptability. Make further breakdowns or combinations. Discard operations or measures which do not meet the tests; list or check those retained.

IV ORGANIZATION OF TASKS AND FORCES

In the foregoing section, the decision was broken down into detailed operations, and the forces available were apportioned. These detailed operations should have been stated in terms of objectives: for example, under consideration of measures for freedom of action it might have been decided "To avoid disclosing mine locations." Stated in terms of tasks, this becomes: "Avoid jinking." Frequently, operations can be rephrased as tasks merely by removing the preposition 'to.'

These tasks must be grouped according to the forces which will carry them out, and the forces themselves will usually have to be broken down into units performing the same or similar tasks. No thumb rule is possible; too-great subdivision usually complicates the command set-up, but combining too many units in one group will tend to render effective control more difficult. Some tasks will be applicable to all

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forces; these are grouped in one place to avoid repetition. Complete the organization by noting the commander for each group of forces.

You will now have a list of groups of forces, with the tasks that each is to perform. These must be tested, from the point of view of the subordinate commander who is to carry them out, for suitability, feasibility, and acceptability. This step is very important. It is not a repetition of previous tests, but the final analysis after the specific forces have been assigned to specific jobs.

V ASSEMBLY OF MEASURES FOR FREEDOM OF ACTION

A. Measures Required for Security, for Cooperation, and for Intelligence Activities.

B. Measures for Logistics Support: These cover provisions for procurement and replenishment of supplies, disposition and replacement of ineffective personnel, satisfactory material maintenance, sanitation, battle casualties, and the like.

C. Measures for the Exercise of Command: These include provision for communications, location of rendezvous, zone time to be used, and the location of the commander.

VI ASSEMBLY OF INFORMATION

It is necessary to transmit to subordinates all the information they need to do their jobs properly. Here is the appropriate place to note what items should be furnished to them.

VII PREPARATION OF SUBSIDIARY PLANS

Either the estimate itself, or the determination of detailed operations, may have created subsidiary problems. For example, it may be necessary to prepare training plans, intelligence plans, or, in the field of operations proper, flight schedules, detailed dropping plans, etc. These problems lend themselves to the same treatment as basic plans, discussed above.

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ANNEX C

OPERATIONS PLAN

File Notations

SECRET (or CONFIDENTIAL)

Operation Plan

No. _____

Titles of the Superior Echelons

Title of the Force

Name of Ship

Flagship

Task Organization

- (a) Task Force Title, Task Force (Group or Unit) numerical designation, rank, and name of its commander. Composition of Task Force.
 - (b) Similarly enumerate other Task Forces under (b), (c), etc.
1. Information. Information of enemy and own forces affecting the plan and needed by subordinate commanders. If no further information is available, state "No further information." Distinguish between matters of conjecture and of fact. If desired, indicate the tasks and general objectives of higher echelons and of coordinate forces of the commander's echelon, and of other forces of the command not listed in the task organization. If desired, include general measures prescribed by the immediate superior for cooperation and security. Information may be provided by reference to dispatches or other sources held by the force, or included in an annex.

Assumptions. State the assumptions upon which the plan is based, it being understood that the proposed action is to be undertaken only upon disclosure of the truth of the assumptions.

2. State the general plan and its purpose for the whole force actually under the command of the officer issuing the plan, and if desired the methods of executing it. If additional data is needed to convey clearly the will and intent of the commander, it may be added.
3. (a) Title of Task Force (a) is to be followed by a statement of the principal task, other tasks, and detailed instructions for the particular task force. Tasks may be stated, if preferred in chronological order. If this order is used, the paragraph must contain a statement to the effect that the tasks are listed chronologically. Include directions as to cooperation, security, and intelligence activities.

(b) Title of Task Force (b) is to be followed by a subparagraph of similar substance and arrangements as in (a) above.

(c) Give instructions that apply to all task forces or that pertain to

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the general conduct of the operation. Include, if desired, coordinating instructions applying for more than one task force. Include, particularly, measures for cooperation, security, and intelligence activities. Include statement of the time and/or manner in which the operation plan is to be placed in effect.

4. Give broad instructions concerning logistics measures necessary to the operation, or reference to Logistics Annex, if one has been prepared.
5. State measures necessary for the exercise of command, such as plan of communications, zone time to be used, rendezvous, and location of commander during operation.

(Signature)
Rank,
Title of Command

ANNEXES

- A. (Name)
B. do

DISTRIBUTION

(Authentication)

(Seal)

NOTE: The Operation Order follows this Form except that it makes no provision for assumptions and is effective on receipt unless otherwise provided in the body of the Order.

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ANNEX D

THE 'WHY' FOR COMBAT CREWS (EXCERPTS FROM MINES AWAY)



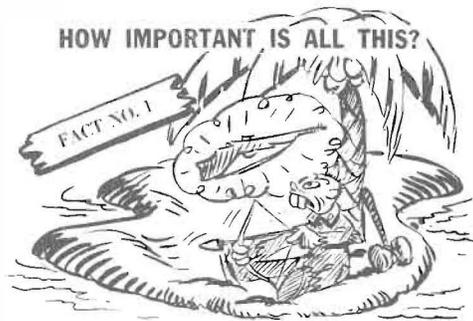
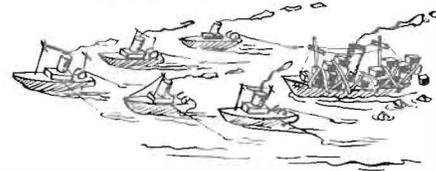
1. KNOCK OUT JAP SHIP TRAFFIC!



2. SINK JAP SHIPS !!



3. MAKE 'EM SWEEP !!!



HOW IMPORTANT IS ALL THIS?

By sealing up important harbors of the Japanese homeland, mines will shut off, at their source, supplies of ammunition and food to millions of Jap soldiers in



China and at the outer bastions of the Empire. Mines watch all the time—day and night—and will sink a submarine trying to sneak into an advanced base with reinforcements as quickly as they will a surface vessel in Japanese home waters. The psychological threat of mined waters has already been demonstrated to be a potent weapon against the treacherous Jap.

Sinking ships in enemy home waters will knock out water borne transport, the main carrier for industry, and will force an eventual breakdown of overland transportation. Japanese railroads are notoriously poor and overcrowded at the present time; they cannot stand further load caused by cessation of shipping. Motor truck transport is practically unknown to the Nipponese. The torturous, winding tracks and roads around the mountainous country are at best unsuited for overland transport.



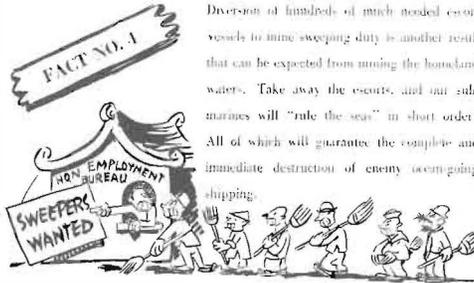
So knock out the shipping, and the home economy takes a blow in its supply and distribution system!

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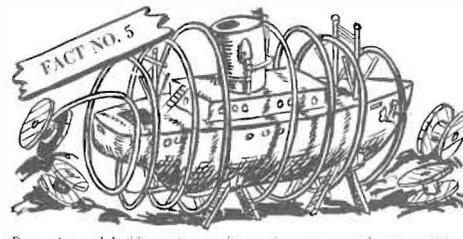
FACT NO. 3

By cutting off imports of critical raw materials, desperately needed to maintain the war economy, mining will cause a serious slump in Jap production. Without raw materials, machines will stand idle. And idle machines are no asset to a production line.



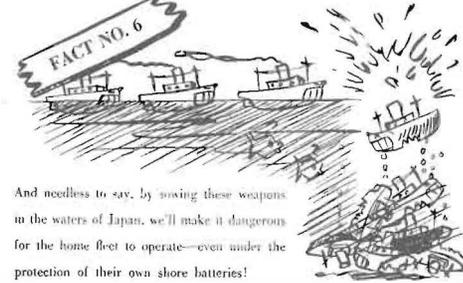
FACT NO. 4

Diversion of hundreds of much needed escort vessels to mine-sweeping duty is another result that can be expected from mining the homeland waters. Take away the escorts, and our submarines will "rule the seas" in short order! All of which will guarantee the complete and immediate destruction of enemy ocean-going shipping.



FACT NO. 5

Degaussing and building minesweeping equipment eat up large quantities of critical copper and rubber. Electrical equipment diverted to sweepers limits the production of radar, radio equipment, and generators for military use.



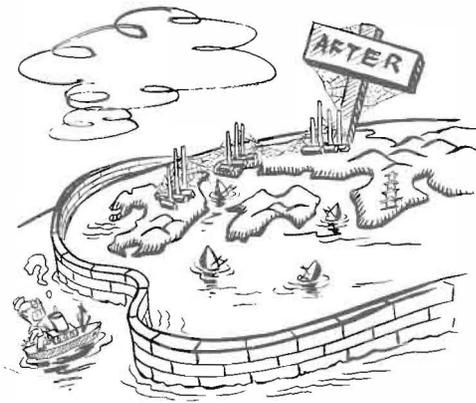
FACT NO. 6

And needless to say, by tossing these weapons in the waters of Japan, we'll make it dangerous for the home fleet to operate—even under the protection of their own shore batteries!

TO SUM IT ALL UP . . .



Japan is an island empire—dependent on water borne shipments for her very life's blood. Millions of tons of shipping pass through her home waters each month, scurrying back and forth from the Asiatic mainland and forward areas, trying desperately to feed the all-consuming machines of war—to fight a nation many times her superior in productive strength . . .



Aircraft mines are going to place a solid wall around that island empire. And no matter how much the enemy disperses his strategic industries, or tries to go underground—he will not be able to evade this attack! Shipping cut off, his atomic home arsenal will shrivel up, leaving the Nip most vulnerable to our other forms of air attack—and—need we say it?—to **EVENTUAL DEFEAT**.

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6.

OUTER ZONE OPERATIONS

BEGINNINGS

Of the three Pacific theaters of operation only the Central Pacific, under Admiral Chester W. Nimitz, had even the beginning of a mine warfare command during the first part of 1942. In the Southwest Pacific and China-Burma-India Theaters, mine logistics was handled by the normal gunnery and readiness sections of the commander's staff, or by A-4 of the Army commands. In the Central Pacific extensive plans for the use of surface minelayers had been prepared. Both Captain G. B. Hull, the first commander of Service Squadron Six, and Captain R. W. Whitmarsh, who later succeeded to the command, were enthusiastic advocates of mine warfare, but both were inclined to use surface minelayers, although with the emphasis on offensive operations. Aircraft mining was impractical until the necessary long-range aircraft became available.

The emergency created by the attack on Pearl Harbor had made necessary the reorganization of the Fleet. The defensive situation in which the United States found itself relegated mine warfare to a very minor role. The strong prewar Minecraft, Battle Force, Pacific Fleet, was reduced to a skeleton and its nominal staff designated as Train Squadron Six. Its ships were dispersed for use in convoy and direct combat duty. Mining was but a minor portion of the duties of Service Squadron Six (then known as Train Squadron Six). It had responsibilities for the establishment, support, and security of advanced bases, mine sweeping, screening for Fleet operations, and services for gunnery training. In the beginning, the Squadron was almost exclusively engaged in furnishing the Fleet with facilities for gunnery training and had administrative control of ordinary vessels, which included the majority of the vessels damaged during the attack at Pearl Harbor. For the lack of a more suitable activity, and with the idea of equalizing the work load, the command was assigned further duties from time to time. With the addition of training of landing craft units, Service Squadron Six resembled a group of Fleet Schools.

In retrospect it is unfortunate that mine warfare in the Pacific developed from a parasitic growth. Although it later enveloped the whole tree, mine warfare to the last suffered from its origin as an extracurricular function, and

mining graduated into a major operation only when conducted by the Army Air Forces (though specialist and logistic support was furnished by an outgrowth of Service Squadron Six, later Commander Minecraft, Pacific Fleet). It is now clear that from the first a specialized Pacific-wide mine warfare command was needed to cut across Fleet lines and to deal only with mining, mine sweeping, and degaussing. But the extent of mine warfare could not be foreseen and was not apparent for some time after hostilities began. Mine sweeping to a large extent was contingent upon the development of the enemy's mine warfare. Mining was contingent upon the development of mines, the availability of minelayers, and proper bases. So this diffusion of effort paralleled that in Washington headquarters, and little else could have been expected.

Mining had not yet become a complicated art. The only available mines were World War I models. Peacetime training for mining was predicated on the supposition that minelayers would accompany the Battle Force to advanced areas, but the losses suffered at Pearl Harbor precluded such movements for a time even if there had been ample supporting craft of all kinds. Mine countermeasure developments were receiving the emphasis early in the war; mine development had to wait. By late 1942 the means for "screening for fleet operations" were largely held by others, and "mobile degaussing" had entered the picture. The mission of Commander Service Squadron Six was expressed as mine sweeping and mine planting, services for gunnery training, and mobile degaussing. Earlier mining activities of this command were limited to moored mines of World War I type. Fields, laid from Alaska to the South Pacific, were mostly defensive.

In March 1943 a program of test, experiment, and training in the use of influence mines was begun. It proved of great value. The Mine Assembly Base, an activity of Service Squadron Six, conducted a school, and a model advanced base was installed at Brown's Camp, Oahu, in order to learn assembly methods and living conditions typical of advanced areas. From these activities developed the Mine Modification Unit, and the Mobile Explosive Investigation Unit No. Four which consolidated all

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Navy disposal personnel in the Pacific, except members of Mine Experimental Investigation Unit No. One of the Seventh Fleet. Teams as needed were sent out to areas to dispose of any unexploded ordnance materials and also to analyze captured enemy ordnance. In August 1943, Commander Service Squadron Six was assigned the duties of setting up advanced mine bases and of caring for, preparing, and issuing all mines for aircraft laying. The personnel for such bases were normally graduates of the Naval Mine Warfare School, Yorktown, Virginia, and of the Naval Ordnance Laboratory. They were given their final training at the West Loch (Pearl Harbor) Mine Assembly Base and at Brown's Camp.

This was in advance of other Theaters. Until the end of 1942 there were no mining officers on the operating staffs of the Pacific areas except for the Commander of Submarines, Pacific Fleet. Mine details had been provided by the Mine Warfare Section in the Vice Chief of Naval Operations, and these were established at Pearl Harbor, in Australia, in the South Pacific, and in the China and the Burma-India Theaters. Mine detail officers were service personnel and could have little influence on the planning officers in higher echelons. Although many staff officers had some knowledge of mining, influence mines were still regarded as an experimental weapon. Thus mining tended to be sporadic and mostly of a tactical nature. The inadequacies of this situation were realized by the Mine Warfare Section in Washington which held in readiness three officers of staff caliber, who were intended for assignment to the area commanders if requested. In February 1943 they moved out to the Pacific. Commander (then Lt. Comdr.) S. L. Quimby went to the Southwest Pacific under General MacArthur, Commander (then Lt.) K. L. Veth went to the China-Burma-India Theater, and Commander (then Lt. Comdr.) E. A. Johnson went to the Central Pacific. They remained representatives of mining on the staffs of the three area commanders and conducted, together with their assistants, the principal mining operations in the Pacific, with one exception, until the end of the war. The one exception was the submarine mining campaign.

SUBMARINE MINING

Like many submarine operations, submarine mining was conducted more or less independently of other operations. The submarine mining officer, Lieutenant Commander George Hern, had been the Commanding Officer of the ARGONAUT, the only United States submarine especially fitted for mining. He had made special studies of the possibilities of submarine-laid offensive mine fields, and with the aid of Naval Ordnance Laboratory technicians he trained his own mine specialists and the submarine crews in mine preparation and laying. Through his efforts the gunnery officer Commander J. O. R. Call and Rear Admiral R. B.

English, Commander of Submarines, both became enthusiastic advocates of mine warfare. This resulted in the initial submarine field planned from Pearl Harbor. The use of mines was also stimulated by the early shortage and poor performance of United States torpedoes. The untimely death of both Call and English removed the support for submarine mine laying. It was revived for a short period in 1943, but the improved performance and availability of torpedoes together with the great and immediate success of torpedo attacks made extensive submarine mine laying attacks unattractive.

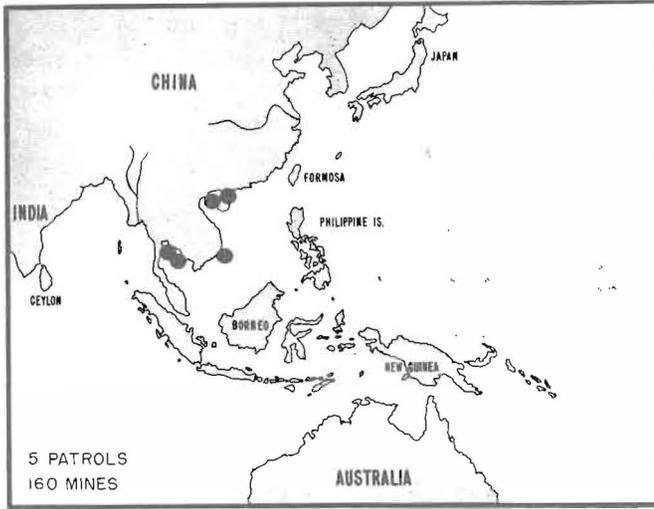
The submarine mine laying campaign of the Pacific Fleet was attrition mining and was directed against shipping routes along the coastal waters of the Japanese homeland and Asia and the shallow waters of the South China Sea. In 33 war patrols between 15 October 1942 and 9 May 1945, 658 mines were planted by the underseas craft at various strategic locations ranging from Hokkaido to Sumatra. Most of these were planted in the course of antishipping patrols in which torpedoes were the major weapon. The mines sank and damaged an appreciable number of ships, however, and played a very important part in forcing shipping out from protected, shallow coastal waters to areas where they were more vulnerable to torpedo attack.

All of the submarine fields were clandestinely laid. There is considerable evidence that the Japanese did not know of the presence of many of these mine fields, including those that claimed significant casualties. In fact Japanese naval authorities have stated that many early mine sinkings were attributed to torpedo attack for failure to recognize that mines were also being used by United States submarines. This limited the intelligence reports of ship casualties in submarine mine fields, with the result that total casualties reported are probably underestimated.

In the Southwest Pacific, the first submarine mine laying was done by boats operating under the Seventh Fleet out of Perth, Australia. Between 15 October 1942 and 2 November 1942 five mine fields were planted in rapid succession (see Figure 6-1), two in the approaches to Bangkok and one each at Cape Padaran, Haiphong, and Hainan Strait, thereby endangering the heavily used route around the Indo-China coast to Siam. The USS THRESHER, GAR, GRENADIER, TAUTOG, and TAMBOR planted mines in the normal route of ship traffic passing through Hainan Strait to Haiphong from the north, or making the circuit around the Indo-China peninsula to Bangkok. Almost immediately after the mines were planted they began to claim significant casualties. Results now indicate that six ships were sunk totaling 22,150 tons, and six were damaged, two of unknown tonnage and four totaling 17,751 tons.

After a few months' delay Seventh Fleet submarines from Perth placed mine fields at Tanjong Aru and Api Passage (shoal area off the northwest coast of Borneo), and a

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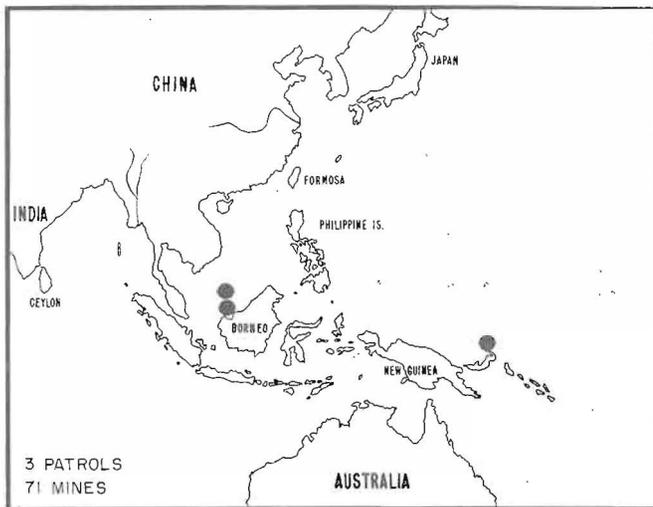


Field	Number of Mines Mk 12
Bangkok Approach.	32
Bangkok Approach	32
Haiphong	32
Cape Padaran	32
Hainan Strait	32

Figure 6-1. Seventh Fleet Submarine Mine Plants, 15 October 1942 - 2 November 1942

moored mine field in Steffen Strait, in conjunction with the aircraft mining of Kavieng, which was designed to block the only deep water entrance to Kavieng that could not be closed by aircraft-laid ground mines (see Figure 6-2). The USS TAUTOG and USS TROUT planted magnetic ground mines at Tanjong Aru and Api Passage. The USS SILVERSIDES planted 24 moored mines in Steffen Strait near Kavieng. Intelligence on results is incomplete, no casualty information having been received from the Api Passage field,

but it is known that the shipping routes in this area changed shortly after the mine laying, which would indicate casualties. It has also been difficult to assess the casualties at Kavieng because the aircraft-laid and submarine-laid mine fields were contiguous. Available intelligence indicates that three ships were sunk totaling 5120 tons; three ships were damaged, the tonnage of one estimated at 6000. Tonnage of the other two is unknown.



Field	Number of Mines	
	Mk 12	Mk 10-1
Tanjong Aru	24	
Api Passage	23	
Steffen Strait		24

Figure 6-2. Seventh Fleet Submarine Mine Plants, 6 March 1943 - 4 June 1943

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After a delay of several months following the Kavieng plant, during which torpedoes were getting very good results, the submarine miners attached to the Seventh Fleet arrived at a scheme for loading 11 mines and 21 torpedoes in each boat. This permitted a reasonable mine field and only reduced the normal number of torpedoes by three. Eight fields were planted between 2 October 1943 and 21 February 1944 (see Figure 6-3). Five of these were along the coast of French Indo-China between Saigon and Bangkok, one was on the east coast of the Malay peninsula sev-

eral hundred miles north of Singapore, and the other two were along the Borneo and Celebes shores of Makassar Strait. All of these fields were of ground magnetic mines and were planted by the USS KINGFISH, POMPON, RASHER, CABRILLA, BLUEFISH, CREVALLE, RAY, and BOWFIN. On the basis of very incomplete reports, they damaged five ships totaling 36,379 tons and sank two, one of which displaced 639 tons. The tonnage of the other is unknown.

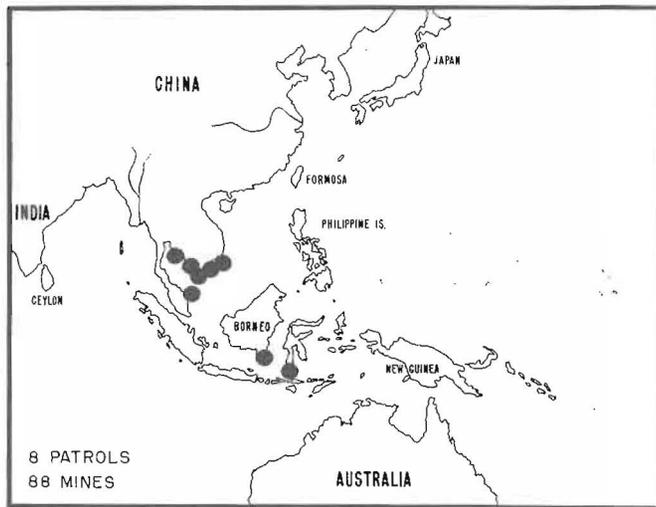


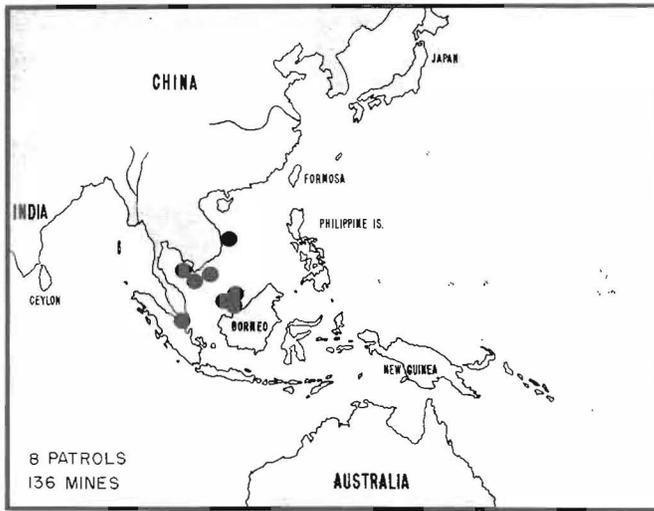
Figure 6-3. Seventh Fleet Submarine Mine Plants, 2 October 1943 - 21 February 1944

Field	Number of Mines Mk 12
Cape Pepe	11
Pulo Condore	11
Saracen Bay	11
Pulo Tenggol	11
Pulo Condore	11
Kega Point	11
Sebuko Island	11
Kega Point	11

In the final phase of the mine laying undertaken by Seventh Fleet submarines they planted eight mine fields between 19 August 1944 and 9 May 1945 (see Figure 6-4). Three were replenishments for the Api Passage field that had been previously laid on the west coast of Borneo. Three more were planted at Pulo Obi, the southernmost point on the Indo-China peninsula. Of the others, one was on the coast of French Indo-China north of Cape Padaran, and the last was on the north coast of Sumatra, opposite Singapore, in Berhala Strait. Again, all of these mine fields consisted

of ground magnetic mines. The USS REDFIN, PARGO, GURNARD, DACE, HARDHEAD, CHARR, BREEM, and GUITARRO laid the fields. Very incomplete intelligence is available on the results. Although heavy Japanese traffic was recorded in the areas where they were planted prior to the operations and practically none after the mine laying, the casualties have been reported from only three mine fields with six ships sunk, two of unknown tonnage and the other four totaling 12,270 tons, and two damaged totaling 9953 tons.

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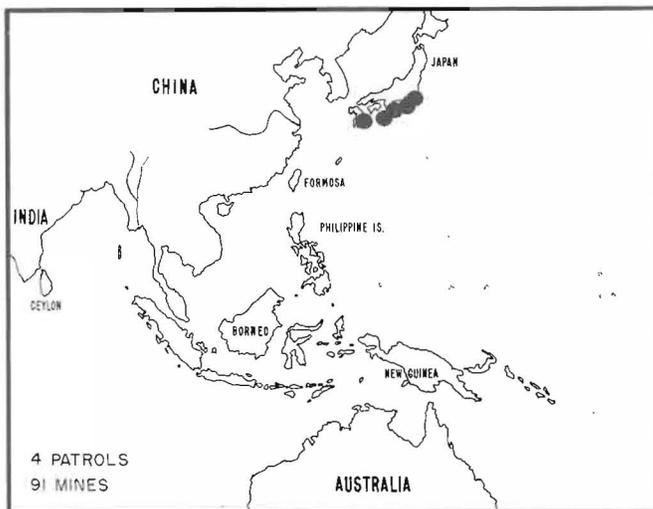


Field	Number of Mines	
	Mk 12	
Api Passage	11	
Koti Passage	11	
Tanjong Datoe	11	
Pulo Gambir Is.	11	
Pulo Obi	23	
Pulo Obi	23	
Berhala Strait	23	
Pulo Obi	23	

Figure 6-4. Seventh Fleet Submarine Mine Plants, 19 August 1944 - 9 May 1945

During this time another submarine mine laying campaign was being conducted from Pearl Harbor. The submarine campaign originating in the Central Pacific was in two phases. In the first, five mine fields were planted by boats operating out of Pearl Harbor between 25 September 1942 and 20 December 1942 (see Figure 6-5). The patrols were all in Japanese home waters, the mine fields being laid in Kii Suido and Bungo Suido, the two Pacific Ocean entrances to the Inland Sea of Japan, and also off Tokyo and Nagoya at Inubo Saki and Iseno Umi Bay. The Kii and Bungo Suido fields were deep water plants and moored mines were used. The remainder were in shallow water and

were planted with magnetic ground mines. The USS WHALE, SUNFISH, DRUM, and TRIGGER conducted these patrols. The mine fields were well situated to interfere with traffic proceeding down the east coast of Honshu to Tokyo, and along the southern coast of the Japanese homeland to Nagoya or the entrances to the Inland Sea. They probably took the enemy by surprise, for available evidence indicates they claimed fairly heavy casualties within a short time after being planted. Three ships were sunk totaling 13,000 tons, and six were damaged, two of unknown tonnage and the other four totaling 9619 tons.



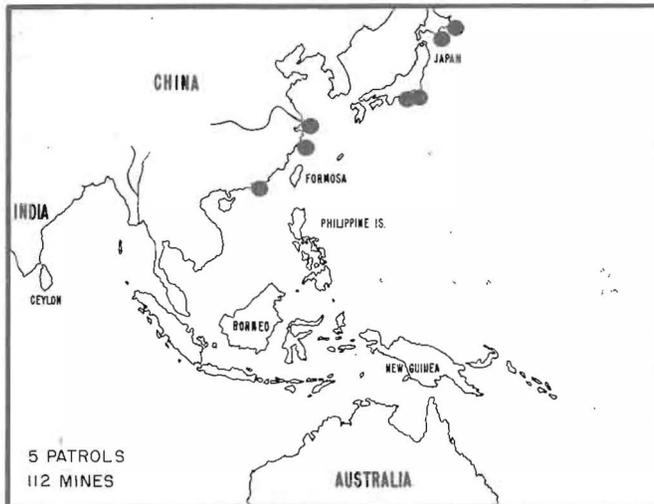
Field	Number of Mines	
	Mk 12	Mk 10-1
Kii Suido		24
Iseno Umi Bay (Nagoya)	9	
(Nagoya)	15	
Bungo Suido		24
Inubo Saki	19	

Figure 6-5. CINCPAC Submarine Mine Plants, 25 September 1942 - 20 December 1942

MINES AGAINST JAPAN

In the second phase, Central Pacific submarines planted seven mine fields between Hokkaido and Hong Kong (see Figure 6-6), thereby exhausting most of the shoal mineable waters along the shipping routes then being used. The first two of these fields were replenishments of the Inubo Saki field off Tokyo on 19 April 1943. On the same day another submarine penetrated the shallow waters off Hong Kong and planted a magnetic ground mine field in its entrance. This was followed two days later by a plant from a third boat in Wenchow Bay, several hundred miles up the China Coast from Hong Kong. On 30 April

1943, a plant was made off Saddle Island in the approaches to Shanghai, and during May two mine fields were planted in the shallow waters off Yertimo Saki, Hokkaido, in the much used northern route to Hakodate. The USS SCORPION, TRIGGER, RUNNER, STINGRAY, SNOOK, and STEELHEAD conducted these operations. This completed the mine laying by submarines out of Pearl Harbor. None of the mines that had been planted had been equipped with sterilizers, and practically all of the shallow water frequented by ship traffic had been mined at this point.



Field	Number of Mines	
	Mk 12	Mk 10-1
Inubo Saki	12	10
Inubo Saki		
Hong Kong	32	
Wenchow Bay	22	
Saddle Island	24	
Yertimo Saki	8	
Yertimo Saki	4	

Figure 6-6. CINCPAC Submarine Mine Plants, 19 April 1943 - 31 May 1943

The ship casualties from this last phase of Central Pacific operations were high, considering that the surprise element had disappeared and that intelligence reports have been far from complete. Thus far no information has been received on the Wenchow Bay field. Also the Shanghai (Saddle Island) field was near aircraft-laid fields in which heavy casualties have been reported, so it is possible that some submarine mines casualties were erroneously attributed to aircraft. Ten ship casualties in these fields are believed a minimum; with six sunk, totaling 2733 tons, and four damaged, one of unknown tonnage and the other three totaling 9454 tons.

Of the 36 mine fields planted by submarines of the Pacific Fleet, intelligence reports have been received giving results in only 21 of the fields. Many of the remaining fields were located in coastal areas that were sparsely settled, or in areas where submarines were also making torpedo attacks, so that it is quite probable that there were additional mine casualties which were not reported as such. Reports to date indicate, however, that the 21 mine fields claimed 54 ship casualties, of which 27 were sunk and 27 damaged.

Tonnages available for 24 of the 27 damaged ships total 56,402 tons, and tonnages for 20 of the 27 damaged ships total 89,136 tons. On the basis of 421 mines that were planted in the 21 mine fields, the number of mines per ship casualty is about 8. If the entire 658 mines are used for this computation, the number is about 12 mines per ship casualty. Eight is probably more accurate and also indicates that submarines obtained a higher average return per mine planted than any other type of layer.

In a consideration of the economy and effectiveness of mine fields, one factor is that no submarine was sunk on a sortie during which mines were laid, although most of the submarine-laid mines were planted on patrols in which torpedoes were the major weapon. Mining is a comparatively safe operation for submarines but it must not be inferred that dangers were not present during the shallow water plants. When the USS GUITARRO laid a field in Berhala Strait, for instance, the nearest she could approach submerged was 70 miles away, and this remaining distance had to be covered on the surface in bright moonlight. The approach, laying, and departure required three days!

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Notwithstanding, the submarine mine laying was carried out with little expenditure of effort and produced excellent results. Particularly in the latter days of the campaign when it was ascertained that mines could be carried without critically affecting the number of torpedoes also taken on a patrol, the potentialities of mines were recognized. So, after the submarines had left their operating areas, the mines they had planted maintained a continuous threat and took a toll of 54 enemy ships that otherwise might never have been brought under successful attack. All through the campaign, the mines were invaluable in forcing ships away from protected coastal waters to areas where they could more easily be brought under torpedo attack. Although the total sinkings and damage caused by submarine-laid mines is but a small portion of the total casualties obtained by the undersea craft, mines established

themselves in this phase of the Pacific war as an important undersea weapon complementary to the torpedo.

AERIAL MINE LAYING IN THE CHINA-BURMA-INDIA THEATER

The organizational problems in the China-Burma-India Theater were complex because the responsibility for mining was split. Mining could be done by British or by United States Army Air Forces. And the mines themselves were supplied by both the British and United States navies. Aerial mines were first laid by United States aircraft on 23 February 1943, when 10 B-24's of the Tenth Army Air Force dropped 40 British mines in the Rangoon River. This was the beginning. The mining program gradually extended to almost every enemy port in Burma, Malay, Siam, Indo-China, South China and Formosa (see Figure 6-7). In 1168 sorties, 5819 mines were laid.¹ Thirteen planes were lost.

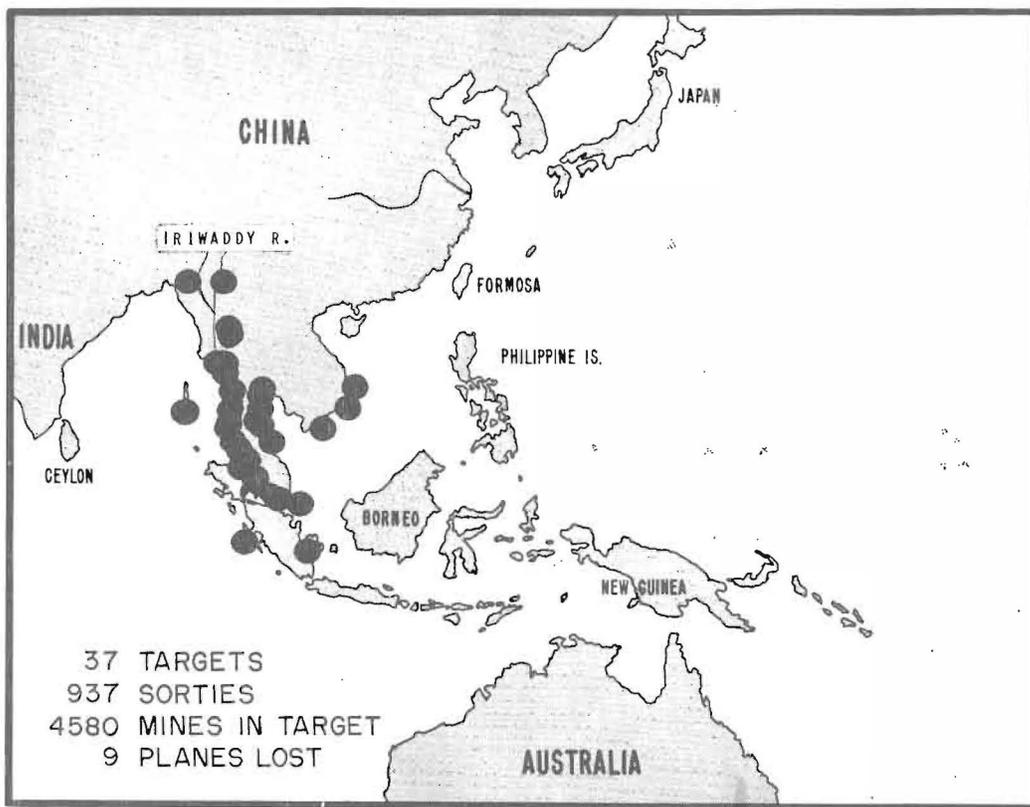


Figure 6-7. Aircraft Mining in the India-Burma Theater

¹ The actual mine field plants have not been charted for the Outer Zone operations as they have for the Inner Zone. Data on the numbers and types of mines laid in each target are available, but it was felt that any beginning study of the effectiveness of a mine field plant would offer less in return if made of Outer Zone operations than if made of Inner Zone operations because of the more limited information on the former. Thus all available statistics are not included here. A reader who wishes to make an area analysis of the Outer Zone operations can find some needed information in the United States Strategic Bombing Survey upon which this chapter was based, and some in the Mine Warfare Section in the Navy Department. In the meantime, by comparison of number and types of mines planted (given in the Figures in this Chapter) and casualties (Table 3-4), a rough analysis can be made.

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Mines in Target

Target	Number of Mines							
	Mk 13	Mk 13-5	Mk 19	Mk 25	Mk 26-1; 36-0; 36-1	Dummy Mines	AMK V Ma.	AMK VII Ma.
Rangoon, Burma	241	12			14	94	164	
Irrawaddy River, Burma							32	
Moulmein, Burma (includes Amherst)	231	30			68		90	
Sittang River, Burma	30						6	
Bangkok, Siam	93	38			84		74	24
Koh Sichang, Siam	109	12			34		24	
Mergui, Burma	122	21			77		71	32
Tavoy, Burma	128	10			24		77	3
Satahib Bay, Siam	16							6
Palembang, Sumatra					14			
Chindwin River, Burma			36		15			
Port Blair, Andamans					25		15	
Packchan River, Burma	100	46		3	56		42	28
Ye River, Burma	68	4			4		35	
Penang, Malay	49	30			171		31	29
Heinze Bay, Burma	12	7			20		31	5
Belawan Deli, Sumatra	38				41		26	18
Aru Bay, Sumatra	41	1			52		22	27
Singapore	4	3		52	356			
Saigon, Indo-China					255			
Camranh Bay, Indo-China					54			
Phan Rang Bay, Indo China					6			
Chumphorn, Malay	38	18			72		36	38
Klang, Malay	16				27		6	4
Meklong, Siam	3	6			9		4	4
Prachuab Girikan, Siam	2	6			9		2	12
Fell Passage, Malay	1				21			30
Kesseraing Is., Malay		2			27		3	32
Puket Harbor, Malay						12		
Tanjung Balai, Malay	15				3			18
Malacca I, Malay	8				20		2	14
Malacca II, Malay					20			
Padang, Sumatra	8							
Singora, Siam	29				3			14
Tachin River, Siam	9							
Bandon, Malay	3				3			6

MINES AGAINST JAPAN

Enemy shipping in some places dwindled to insignificance. Many ships were sunk and damaged. Even more important was the interruption of the sea transportation of men and supplies and its effect upon enemy military operations in the Theater.

In Southeast Asia the first mining of Rangoon was important for it pointed the way to results which might be expected in this new type of warfare against the Japanese. Enemy reaction to mining in Rangoon was immediate. Heavy shipping traffic in the port fell to a negligible amount. For some months thereafter, occasional attempts were made to use this vital harbor, but a loss of at least six vessels sunk and two more damaged discouraged the Japanese. In the last two years of the war shipping was limited to coasters and small boats.

The early mining of Rangoon caused the Japanese to rush the completion of the Bangkok-Rangoon railroad. But in January 1944 the Tenth Army Air Force dropped mines in the river channel leading to Bangkok and at two ferry crossings in Burma where supplies had to be transferred. Over 16 small vessels were sunk and two were damaged in approaches to Bangkok, and numerous ferry boats and small vessels were sunk at the crossings. Much enemy shipping which had previously used Bangkok was diverted to Saigon and still more to Singapore. This greatly lengthened the hauls to which Burma supplies were subjected and made the Japanese more dependent upon their already overloaded rail system in Malaya.

The Japanese began using the relatively safe anchorages along the west coast of Burma. Thence supplies were transported by small coastal steamers as well as by truck and by train to their destinations in upper Burma. So a small but persistent mining operation was started against the Burmese ports and others which might be used for similar purposes. At the same time, British Eastern Fleet submarines laid numerous mine fields in the Malacca Straits. By the end of 1944, the growing danger of mines discouraged the Japanese from bringing into the Andaman Sea area more than a very few of their rapidly dwindling merchant ships.

In 1944 the Twentieth Air Force arrived in India with a chain of command leading directly to Army Air Forces headquarters in Washington. Commander K. L. Veth, the mining officer in the Theater, maintained effective liaison. He found General Stratemeyer very open-minded on the subject of mines, and due to Stratemeyer's interest, a large scale mining attack using B-24's was inaugurated on Japanese-held harbors. Both the Tenth Army Air Force and the British took part in the operations. General Stratemeyer was so convinced of the value of the mining campaign that in May 1944 he personally advocated to General H. H. Arnold the use of the Twentieth Bomber Command's B-29's in mining operations. In August 1944, B-29's carrying Mk

26 Mod 1 mines raided Palembang, the first mine laying by Superfortresses. Penang on the west coast of Malay had been developed as a base for Japanese and German submarines. In October 1944, Royal Air Force Liberators, in a trip of 3000 miles, dropped Mk 26 Mod 1 mines there. Penang was mined regularly in the following months, and finally the Japanese abandoned submarine operations in the area. The Germans moved their submarine base to Batavia which was the only significant mine-free port left.

Early in 1945 the aerial mining campaign was extended to important enemy ports on the Malacca Straits, particularly to some of the oil ports on the northeast coast of Malaya in the Gulf of Siam, when it was learned that the Japanese on occasion were bringing ships in to transport the cargoes across the Kra Isthmus by rail and road and thence up the coast to Burma by small ships. The mining attack from Southeast Asia continued until July 1945, when the amount of enemy shipping left in the area was not enough to warrant further mining effort. A total of 4580 mines was laid from bases in Southeast Asia. Of these, 3443 were United States mines and the remaining 1137 were British. Most of the mining, however, was accomplished by Royal Air Force aircraft which laid 3235 of the mines in 631 sorties. The remaining 1345 mines were laid in 306 sorties of aircraft of the United States Tenth and Twentieth Air Forces, assisted on two missions by planes from the Fourteenth Air Force.

Mine laying from China bases began on 18 October 1943, when a B-24 of the Fourteenth Army Air Force dropped three Mk 13 mines in the shallow approaches to Haiphong. In a second operation, 12 November 1943, a few more mines were laid in the same place. The total effort expended was very small, but the results were good. These mines sank at least two ships and caused the Japanese to abandon Haiphong for any vessels larger than junks for the duration of the war. The excellent results from this initial mine laying effort led the Fourteenth Army Air Force to undertake a small scale mining campaign from China (see Figure 6-8). This was a significant decision in view of the very limited tonnage available to the Fourteenth Army Air Force at that time. With this limitation, they evidently considered aerial mines an economical form of attack offering good results for the effort.

The campaign expanded gradually, taking in important targets from Yulinkan Harbor in the south to the Yangtze River in the north. Hong Kong, Canton, Takao, and Shanghai were kept under continuous attack. The Yangtze River was an important route used by the Japanese to supply their forces in central China. In late 1944 and early 1945 mines were dropped regularly far inland in portions of the river above and below Hangkow. The results seriously affected the support of Japanese armies in the area. More than 40 vessels of all sizes were sunk or damaged, traffic was delayed



Figure 6-8. Aerial Mine Laying in China

Mines in Target

Target	Number of Mines			
	Mk 13	Mk 13-5	Mk 19	Mk 26-1, 36-0, 36-1
Haiphong	22	6		12
Hong Kong	37	18		140
Takao	47	46		5
Shanghai (Yangtze Approaches)	51	25		216
Yulinkan, Hainan	16			
Canton	50	6		20
Kiirun Ko				14
Yangtze-Upper		81	232	148
Yangtze-Taising Reach				36
Yangtze-Yochow				11

MINES AGAINST JAPAN

for long periods, and finally the upper river was completely closed to steel ships. The mining effort in China was small in size but extremely profitable. General Chennault credited mines with being one of the most important factors in stopping the Japanese drive into China in 1944. Enemy military leaders have admitted this.

In the spring of 1945 the allied capture of the Philippines made available new bases from which aircraft mining of Chinese ports could be accomplished with fewer difficulties than from China itself. Therefore in the last few months of the war, aerial mining from China declined. Mining had served a valuable purpose by interfering with enemy shipping at an important time. In addition, the successes helped to prove the value of the aerial mine as an air force weapon. Most of the mining from China was done by B-24's of the Fourteenth Army Air Force, which laid 976 mines in 209 successful sorties. Supplementing the Fourteenth Army Air Force, the remainder of the mine laying was done by B-29's with 263 mines laid in 22 sorties.

Throughout all of the mining operations in the China-Burma-India Theater, the air forces who dropped the mines and the naval services who designed and supplied them showed a high degree of cooperation. Generally, it was found advisable to assign naval personnel and units to air force organizations for duty. A large central mine depot was established at Ondol, India, for the supply of United States mines. A pool of Army and Navy technical personnel was also set up at the depot so that upon request both mines and personnel were readily available to any part of the Theater. British mines were available in Ceylon and were furnished directly to the airfields from which they were to be laid. In general, the mine laying operations in the China-Burma-India Theater were particularly favored in that they were directly encouraged by the Theater Commanders and by their senior Air Force Commanders. These officers attempted to obtain maximum value from the limited aircraft and supplies in the Theater. They recognized the possibilities of aerial mine laying and supported the work enthusiastically. This attitude was significant because it existed when many viewed aerial mining with skepticism.

AERIAL MINE LAYING IN THE SOUTHWEST PACIFIC AREA

In the Southwest Pacific Area Commander S.L. Quimby found that there was a rich field for mining, if only the means were available. Offensive mining by surface craft was out of the question, and mining by submarines was on a small scale at best. Therefore the possibility of a real campaign depended upon the availability of aircraft. The Royal Australian Air Force, because of its British tradition and connections, looked with great favor upon aerial mining. The United States Fifth Army Air Force, on the other hand, knew little of mining and its possibilities and preferred to concentrate en-

tirely on bombing. These two organizations were under the Army Air Force Commander of the Area, Lieutenant General George C. Kenney, who in turn was directly under General Douglas MacArthur. The officers who dealt with mining in the area throughout the war learned that Kenney had a very poor opinion of mining and was unwilling to spare planes for mining if bombing was at all practicable. Neither General MacArthur nor Vice Admiral T. C. Kinkaid shared his views, but the former stated that he would not interfere, having given General Kenney strategic objectives and full authority to carry them out. As a result, except for one mission, all the mining in the area was carried out by the Royal Australian Air Force, and then only when the higher command was willing to free planes from bombing expeditions or air-sea rescue.

Commander Quimby's most important staff achievement occurred when General MacArthur gave authority to the Commander, Seventh Fleet to originate mining programs and to handle all plans directly with the Air Forces. Without this directive it is doubtful if the proportions of the campaign of the next year and a half could possibly have been reached. General Kenney was apparently willing to allow the Royal Australian Air Force to carry out mine plans originated by the Seventh Fleet if mining did not interfere with other duties.

The Naval Air Forces in the area showed no more interest in mining than did the Army's Fifth Air Force. It was not a question of having the right planes, for the Navy flew the same planes used so successfully by the Royal Australian Air Force. Apparently the primary function of the Naval Air Forces in the area, as conceived by the Naval Air Command, was search and air-sea rescue. The Navy considered mining secondary to these, just as the Army placed mining missions secondary to bombing missions.

Aerial mine laying started in the Southwest Pacific Theater in April 1943 and continued until July 1945 (see Figure 6-9). A total of 2522 United States and British mines were laid in 1132 sorties. Only 11 aircraft were lost. The mining was accomplished by the Royal Australian Air Force flying Catalina (PBY-5) aircraft, with the exception of four B-24 sorties by the Fifth Army Air Force. The operations in the Southwest Pacific were widespread and had excellent results. It is estimated that 40 percent of the enemy ship losses in the Netherlands East Indies were caused by mines. Casualty information indicates that about 90 ships totaling 250,000 tons were sunk or damaged in this manner. In addition the supply of Japanese garrisons in the Theater was seriously interrupted, and exploitation of the resources of the Netherlands East Indies was handicapped.

Beginning in April 1943 the first mining effort was intended to prevent the enemy from building up the potential fleet anchorages at Kavieng and Lorengau in the Admiralty Islands. By July 1943 there began the strategic mine laying

MINES AGAINST JAPAN

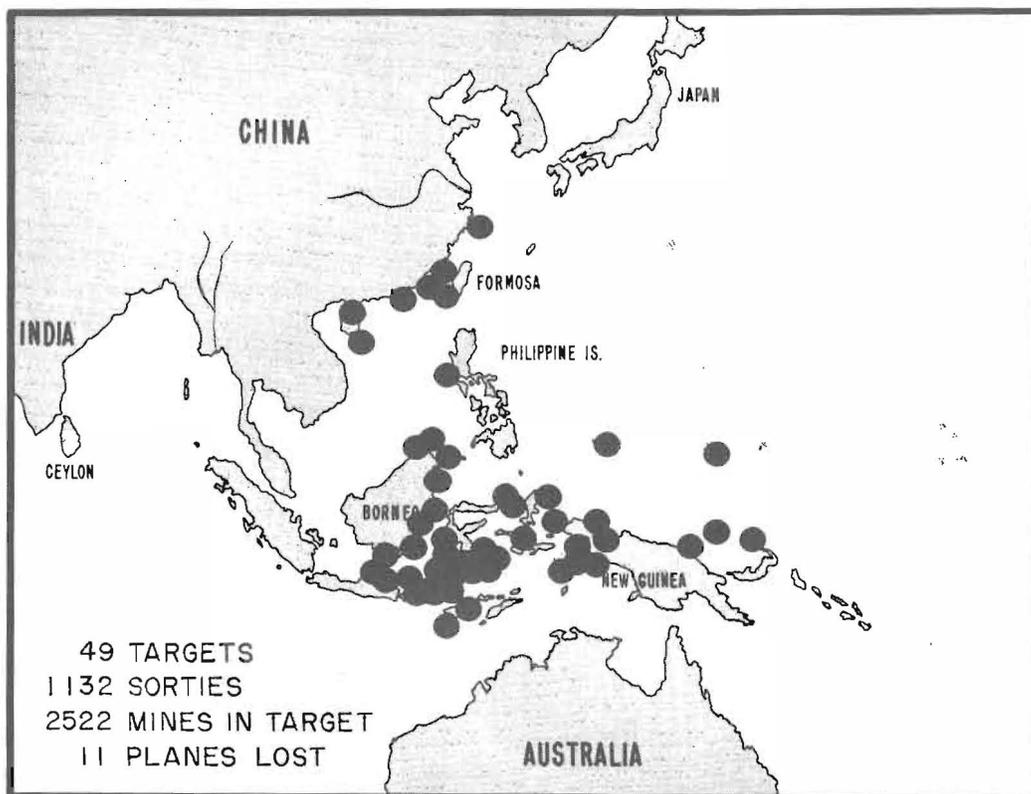


Figure 6-9. Aircraft Mining from the Southwest Pacific Theater

MINES AGAINST JAPAN

Mines in Target

Target	Number of Mines										
	Mk 12-1	Mk 13	Mk 13-4	Mk 13-5	Mk 25-0	Mk 26-1; 36-0; 36-1	AMK IV Ma.	AMK IV Ac.	AMK IV M/A	AMK V Ma.	AMK VII Ma.
Kavieng, New Ireland	64	40									
Seeadler, Admiralties Is.	28	7									
Sepik River, New Guinea		24									
Babo, New Guinea		15					2				
Geser, Ceram	1	8									
Boela, Ceram		12									
Macassar, Celebes	22	14		13	12	26	27	4	18	6	
Sorong, New Guinea	27	2									
Surabaya, Java		55	23	74	6	113			33	43	28
Sekar Bay, New Guinea		8									
Kendari, Celebes	8				8	9	11		8		
Kolaka-Pomalaa, Celebes	6	8		6		24	7		12		
Kaimana Bay, New Guinea	4	4					11				
Manokwari, New Guinea	8						9				
Baoe Baoe, Celebes	12				12	16	2			4	
Waingapu Roads, Sumbo							3				
Kau Bay, Halmahera	23			6		11				22	
Balikpapan, Borneo		33		27		4			8	46	
Woleai Atoll		28								8	
Tioro Strait, Celebes	22				4		18		4	28	
Vesuvius, Soela Is.										8	
Palau Atoll						23					
Bima Bay, Sumbawa	4						4				
Banka Strait, Celebes						12				16	
Tana Keke, Celebes	10			6		2	6		19		
Laut Strait, Borneo (includes Sebuku)		8	14	70		60				49	6
Panarukan Road, Java						8				2	
Probolinggo Road						6				2	
Pasuruan Road, Java		24				8					
Lembeh Strait, Celebes						4					
Wowoni Strait, Celebes					12	6			6		
Laikang Bay, Celebes				4		6			2	20	
Pare Pare Bay, Celebes						8				6	
Tarakan, Borneo				8		7			8	7	
Brunei Bay, Borneo				13		3				4	
Sandakan, Borneo				6		2				4	
Samarinda, Borneo				6						6	
Cape Seletan, Borneo				16		9				3	
Balabac Strait, Borneo					14	40			6		
Manila Bay, Philippines					24	26					
Yulinkan Bay, Hainan				10		34				8	
Hainan Strait				4	53	53				20	
Amoy, China				31		69				4	10
Takao, Formosa					10	4				4	
Mako, Pescadores					2	8					
Hong Kong, China				20	84	26				13	8
Swatow, China				23		7					
Wenchow, China			2	4							2
Banka Strait, Sumatra				18	4	56					39

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campaign against all mineable harbors and shipping routes in the Netherlands East Indies within range of Australian bases. In this campaign a few hundred mines planted in relatively small fields over a large area offered a constant threat to enemy shipping. For a period of two years, mine fields were laid in principal harbors in New Guinea, the Halmaheras, the Celebes, Java, and Borneo as the advance to Japan permitted the use of bases outside Australia.

At Kavieng, the results were particularly good. At least five ships were sunk and seven damaged. More important, the enemy was forced to abandon plans for developing Kavieng into a useful anchorage. Meanwhile the mining attack spread throughout those ports which the enemy was using to supply his bases in New Guinea, the Celebes, and the surrounding islands. Strategic ports like the nickel-exporting city of Kolaka-Pomala in the Celebes were also included in the attack. The net result of these operations was to disperse the Japanese countermeasures effort and at the same time to interfere directly with shipping attempting to use the ports.

In August 1943 the important port of Surabaya was taken under attack. This required particularly long flights by the Royal Australian Air Force Catalinas and necessitated refueling from an aircraft tender at advanced areas. After the first mining the entire port was closed for several weeks and subsequent operations resulted in further closures for shorter periods. A total of at least 9 ships were sunk and 12 damaged. Shipping in this major city of the Netherlands East Indies finally dwindled to insignificance. Balikpapan was another of the more important ports harassed by mines. Large oil storage and refining facilities were located there. It was a key Japanese supply base for oil products. The initiation of mining here in February 1944 was a blow at one of the enemy's most vulnerable spots. Eleven ship casualties totaling 32,500 tons were claimed at this port as the Japanese attempted to keep it in use. Later the attack was extended to additional ports in Borneo. Shipping in the entire Netherlands East Indies was menaced.

A short while before the attack on Balikpapan, Kau Bay, a port of increasing strategic and tactical importance in the Halmaheras, was mined in January 1944. This base was being developed by the Japanese as a supply and staging area and also as an advanced training center. The mining here continued until July and resulted in sinking five and damaging seven Japanese ships of appreciable size. In April 1944 the Royal Australian Air Force undertook their first tactical mining, hitting Woleai in the Carolines in support of the Hollandia invasion. Balbac Strait and Manila Bay were also mined soon after in support of new amphibious moves against the Philippines. Without detailed casualty information on these mine fields it is believed that use of these waters was denied to the enemy at a time when freedom of movement would have been advantageous. During

the latter part of 1944 and the first three months of 1945, widespread targets in the Netherlands East Indies-Borneo area were kept under attack, with Surabaya and Balikpapan remaining the most important objectives.

In March a proportion of the mine laying effort was transferred from the Netherlands East Indies to ports in China, Formosa, and Hainan, operating from bases in the Philippines. These operations were largely carried out in order to neutralize the effect of the loss of Allied air bases in China from which the Fourteenth Air Force had been mining. Several important casualties resulted at Hong Kong and Yulinkan Bay from this effort. By July 1945, however, the Outer Zone of Japan had been so completely cut off and enemy shipping had become so scarce that it was decided to terminate the campaign on 1 August 1945.

During the final months the full time services of three Catalina squadrons were available for mine laying operations. Each of these squadrons was capable of 830 hours' operational flying per month. As each mine laying sortie, including operational travel time, involved an average of no less than 24 flying hours, the three squadrons were capable of carrying out approximately 100 sorties per month. This was later reduced to about 70 sorties per month when it became necessary to operate from advanced bases up to 1500 miles from Australia. In the early days targets of maximum value to the enemy were concentrated on, but during the last year of the campaign almost all ports and anchorages within 1000 miles of existing bases were considered targets.

The complete results of this persistent and widespread mining may never be known, but available information indicates that the number of casualties and port closures was extremely high in proportion to the effort expended. The mining campaign made a direct and valuable contribution to the prosecution of the war in the Southwest Pacific area.

B-29's IN OUTER ZONE MINE LAYING

The B-29 mine laying had begun in August 1944 with an attack on the important approaches to Palembang in Sumatra. Through this channel passed ships carrying oil essential to the Japanese economy. The mining mission was combined with the bombing of the Palembang refinery. It is on record as the longest non-stop mission of its kind. The mining was done at 500 to 1000 feet, a spectacularly low altitude for such large aircraft. The accuracy and success of the operation are indicated by the fact that 3 ships were sunk and 4 damaged from a total of only 16 mines laid. In addition, after the mining, vital oil shipments were held up for nearly 1 month awaiting the opening of the channel. The mission was most significant in that it introduced the B-29 as a mine laying aircraft.

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In January 1945, the B-29's undertook their first large-scale mining in an attack on Singapore, Saigon, and Camranh Bay. Singapore and Saigon had long remained two of the most important ports in the Japanese Outer Zone. Because of their extreme distance from Allied air bases, they had been used by enemy shipping with relative safety. The initiation of bombing and mining attacks by the long-range B-29's served notice on the Japanese that even those ports were no longer free from danger. The mining of Singapore and Saigon and the introduction of the acoustic mines throughout the other ports in Southeast Asia all took place about the time the Allied land drive started through Burma towards Rangoon. The increased interference with shipping just at that time was a serious handicap to the Japanese who were attempting to maintain supplies for their last-ditch stand.

The mining of Singapore was repeated by B-29's in February and again in March 1945, after which Royal Air Force B-24's took over the task. In all, more than 7 ships were sunk and 16 damaged by mine fields at Singapore. After March 1945 no more enemy convoys attempted to make the hazardous trip from Singapore to the Empire. B-29's mined Saigon again in late March. Few casualties resulted from this mine field, the primary reason being that before January it had been abandoned as a convoy stop. At that time a carrier task force raid, followed by a large scale mining attack by B-29's, had convinced the Japanese that the area was not safe for shipping. Similarly, Camranh Bay was not used by Japanese ships after it was first mined in January. This place and Saigon had formerly been important convoy stops and refuge harbors.

In China too the B-29's took advantage of their capacity to carry mines over long distances. They mined the Yangtze approaches to Shanghai twice in March 1945. This large port had been under mining attack by the Fourteenth Army Air Force until forward air bases were lost in late 1944. Then for several months the river was unmolested, and the Japanese again used it as a main supply route in their drive into China. Heavy mining by B-29's soon changed this situation. Enemy shipping was seriously endangered by mines, and the Yangtze was closed for long periods. Preliminary reports show 21 ships sunk and 15 damaged by mines in this area. To supply Japanese troops in central China became a problem.

B-29 mine laying in Southeast Asia and China was done by aircraft of the 20th Bomber Command based in India. In 162 sorties, 987 mines were laid with no aircraft lost. During the first quarter of 1945, the B-29 mining operations were executed about once a month near the full-moon period, and each mission was on a relatively large scale. Most of the mining runs were made visually at altitudes of 2000 to 6000 feet, but they were so planned that radar

could be used if the visibility were bad. Some runs were made entirely by radar with good results.

SURFACE-LAID MINE FIELDS AND TACTICAL MINING

Most of the mine laying operations carried out from the Central Pacific Theater, exclusive of the submarine and B-29 efforts, were tactical operations in support of other offensives. In the drive across the Pacific, few targets were well suited to mine attack, particularly since inferior mines were available when the drive was begun. Limitations in available aircraft also curtailed the use of mines. As it developed, the tactical operations served as a proving ground for aircraft mines and methods of laying them and set the stage for the all-out mine attack on the Japanese homeland with B-29's.

Five series of tactical mining operations were conducted in the Central Pacific: the mining of the Solomon Islands begun in August 1942, the mining of the Marshalls, the Carolines, the Bonins, and finally, in June 1945, the mining of the southern coast of Korea (see Figure 6-10). The logistics support of these operations was extraordinarily difficult because of the size of the area covered; including as it did the area between the Marshalls, the Solomons, the Carolines, Korea, and Nanpo Shoto, it formed one of the largest functional theaters of operations in the War. The difficulty of supplying mines was further increased because mining operations in each of the widely scattered locations were neither continuous nor heavy. Much of the difficulty was obviated by using the USS *TERROR* as a mobile mine supply ship. *TERROR* carried special equipment to Mine Detail Four on Guadalcanal and a complete set of mine depot equipment to Mine Detail Fifteen which was then staging on Guadalcanal for its impending move to Bougainville. *TERROR* also carried complete personnel, mines, and equipment to Mine Detail Nineteen at Tarawa. Mines were supplied to the Fast Carrier Task Forces by *TERROR* on two occasions, and Mine Detail Twenty-Two was put ashore at Eniwetok from this same ship. The mines for the Korean operation were brought to Okinawa by the sea-plane tender, USS *CURTISS*, after *TERROR* had been requisitioned as flagship of Commander, Minecraft, Pacific Fleet.

Much of the tactical mining was in surface-laid mine fields. In some instances, aerial and surface plants were made in support of the same operation. The first and most prolonged of the tactical mining operations carried out from the Central Pacific was the mining of the Solomon Islands. Mines were laid partly by light surface units (DM's) and partly by Navy and Marine aircraft. The surface mining began with the mining of the Japanese forces operating off Guadalcanal beginning in August 1942 and ended with the

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mining of Rabaul Harbor in February 1944. The purposes of these operations were attrition and interference with the enemy's naval forces.

The mining carried out in the Solomons campaign was unique in that it was done in waters continuously disputed by the United States' and the enemy's surface forces. This permitted the United States only offensive surface plants of mines during the Pacific war. The surface mining of an anchorage off Malaita Island, in August 1942, prevented the enemy from using it during subsequent battles by the surface forces. No enemy vessels are known to have been sunk in this mine field. In February 1943 when the Japanese attempted to evacuate their forces from the northern end of Guadalcanal, a mine field was planted by DM's at night off the coast of Guadalcanal and immediately sank an enemy destroyer.

Next Blackett Strait was mined by DM's in May 1943, directly in the normal route taken by the Tokyo Express in coming down the 'slot' for bombardment of United States forces on Kolombangara and Vella Lavella Islands. This field took the Japanese completely by surprise and sank three destroyers shortly after it was planted. The surface mining of the Kula and Vella Gulfs and of the Short-

land Islands followed in a series of operations lasting through November 1943. Thus the blockade of the Solomons' anchorages was completed. The Kula Gulf mine field sank one merchant ship and damaged another. The Shortland fields accounted for two Japanese submarines and a merchant vessel during the Bougainville campaign.

Aircraft mining in the South Pacific was coordinated with the surface mine laying. In the first aerial mine laying operation in which United States aircraft planted United States mines, Navy and Marine TBF's mined Kahili and Buin Harbors on the southern end of Bougainville in March 1943. Replenishment of this field followed in May 1943 concurrently with the mining of Faisi Harbor in the Shortland Islands. Kahili was being used extensively by the enemy in the reinforcement of Bougainville, and the plant of early Mk 12 mines yielded good results. They accounted for one Japanese destroyer and two merchant vessels. A Japanese cruiser and several destroyers were mined either in this field or in the one at Faisi, although complete confirmation is lacking. There is little doubt, however, that this mining, together with that of Faisi and the surface-laid fields at Shortland, eventually provided a complete blockade of the only available

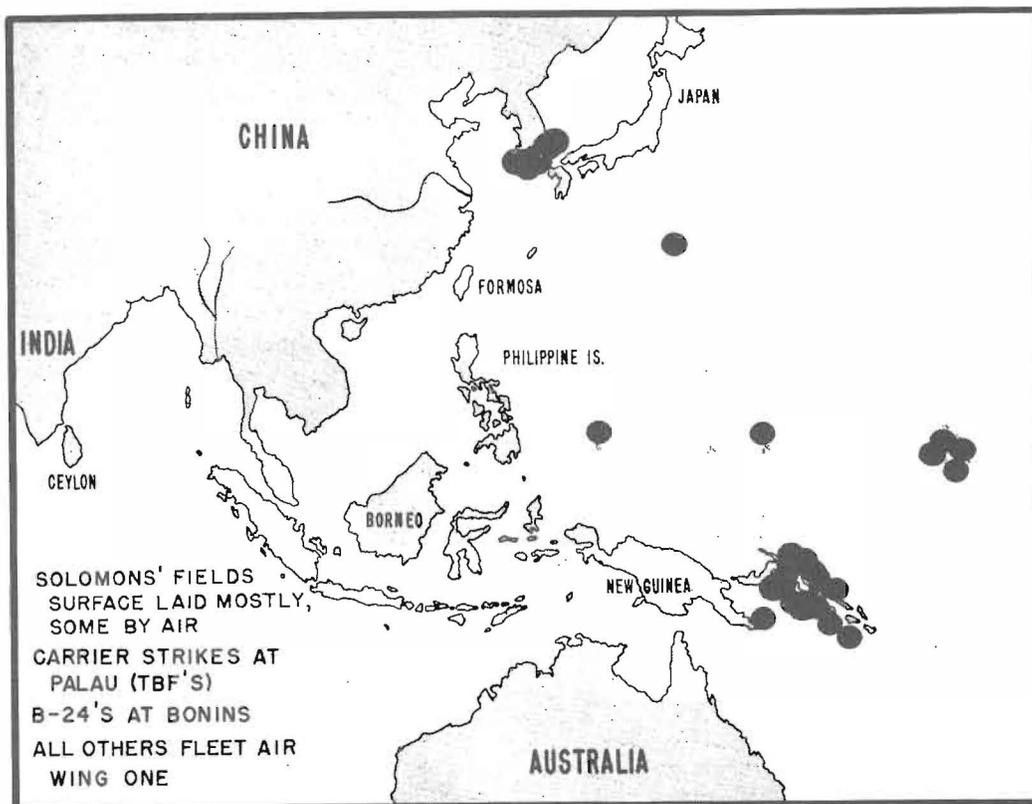


Figure 6-10. Tactical Mining

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Mines in Target

Field	Mine Layer		Number of Mines											
	No.	Type	Mk 6	Mk 10-6	Mk 12-1	Mk 13	Mk 13-5	Mk 25-0	Mk 25-1	Mk 25-2	Mk 25, MM-4	Mk 26-1; 36-0; 36-1	Mk 26, MM2; 36, MM2; 13-6 (A3-2)	Mk 25, M9-1
Surface Craft														
Maramasike, Malaita	1	DM	84											
Guadalcanal	3	DM	255											
Blackett Strait	3	DM	255											
Kula Gulf	3	DM	255											
Munia Island	3	DM	255											
Vella Gulf	3	DM	183											
Cape Moltke	3	DM	255											
Otua Island	2	DM	170											
Otua Island	3	DM	255											
Otua Island	2	DM	170											
West Shortland	4	DM	340											
Taiof Is., Buka	2	DM	170											
East Buka Pass	2	DM	170											
S. W. Bougainville: Puriata River	2	LCI						3						
Hongorai River	2	LCI						3						
Mobiai River	2	LCI						3						
Mibu River	2	LCI						3						
Aircraft														
Buin-Kahili	145	TBF					145							
Buka Pass	51	TBF					37	14						
Buka Pass	9	PV-1					9							
Faisi	30	TBF					30							
Simpson Harbor	16	TBF					16							
Palau	78	TBF		25					53					
Nanpo Shoto	110	B-24							158			58		10
Jaluit	9	PV-1					9							
Jaluit	5	PBY-5					10							
Maloelap	10	PB4Y-1						32						
Maloelap	4	PBY-5					8							
Mille	3	PBY-5					6							
Truk	14	PB4Y-1							39			4		
Truk	4	PB2Y		4								8		
Wotje	7	PB4Y-1					26							
Wotje	13	PBY-5												
S. W. Korea	88	PB4Y-2							85	20	33	19	14	15

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anchorage in southern Bougainville, thus disrupting the enemy's supply and reinforcement of his forces there.

The later mining at Buka Pass by Navy and Marine aircraft was designed to accomplish the same effect in northern Bougainville. In addition, surface-laid mines were planted from DM's, and surface-laid Mk 13 Mod 5 acoustic mines were planted from armored United States landing craft in various rivers along the west coast of Bougainville. The acoustic mines were believed successful in reducing Japanese barge traffic to isolated enemy units. The remaining fields in northern Bougainville had little opportunity to prove effective, for as soon as they were planted the enemy seemed to withdraw all shipping from the area. Records of the Imperial Japanese Navy indicate that several submarines were missing in the Solomons area. (For some time after surface shipping had been withdrawn, supply submarines were used.) Possibly they were casualties due to these or to previously mentioned mine fields.

The last mine laying operation carried out from the Solomons was the mining of Simpson Harbor at Rabaul in February 1944. It was ill conceived since the water was too deep for the available Mk 12 needle mines, and the general topography was unsuitable for mining by TBF's, the only aircraft available. Aircraft losses were high and only one small ship was sunk in this mine field.

The Solomons mine laying was entirely of a tactical nature. Unified planning for surface and aircraft planting of mines was carried out at conferences between the Commander, Service Squadron Six (later Commander, Minecraft, Pacific Fleet) and staff members of the Commander, South Pacific. This mine laying interfered with the enemy movement of naval forces and produced some significant casualties. Four enemy destroyers were sunk by mines planted by obsolescent DM's while the DM's remained undamaged — a most favorable action. Failure to make more extensive use of surface-laid mines during the early Guadalcanal campaign resulted in the loss of a favorable opportunity to hinder enemy naval actions seriously. Although there were no casualties to the DM's carrying out the Solomons mine laying, the aircraft losses were high, a total of 13 aircraft lost in 121 successful sorties. About one-third of these losses were attributable to operational failures of the aircraft. In the Rabaul mine laying, 6 of the 18 participating aircraft were shot down or crashed into nearby mountains after the pilots had been blinded by searchlights.

The second series of operations to be launched from the Central Pacific was the tactical mining of the Marshall Islands in December 1943 and January 1944 to support the imminent invasion of Kwajalein. Mines were planted in the four large atolls of Jaluit, Maloelap, Wotje, and Mille, all of which had underdeveloped harbor facilities but good anchorage areas. These atolls were to be bypassed. To prevent disclosure of the United States' attack plans by any obvious omission, dummy mines were planted at Kwajalein,

the largest atoll in the Marshall group and the focal point of the invading forces. Although there is no direct evidence that the Japanese analyzed the operations in light of the mine laying, there is abundant evidence that the Japanese did not expect Kwajalein to be the invasion point. Dummy mine laying may have been successful camouflage.

The live mine fields were also successful in their purpose. The results of the Marshalls mine laying are difficult to assess because patrol aircraft on antishipping strikes were operating against the areas being mined both during and after the mine laying attacks. Intelligence sources have credited mines with sinking a 4000-ton merchant ship at Mille and with damaging two 2000-ton merchant ships, one at Jaluit and the other at Maloelap. Regardless of cause, the fact is that all shipping disappeared from the Marshalls shortly after the mine attack. Apparently the mining contributed appreciably to this effect.

Previous aerial mine laying in the Solomons area had been carried out with TBF's. Then search aircraft of Fleet Air Wing One undertook the mining assignment, with PB4Y-5 and PB4Y-1 aircraft as minelayers. Much of the mining was done by single aircraft operating at night, following tactics that had been developed in the Southwest Pacific Theater. The PB4Y-1's were employed in low-altitude formation attacks during twilight periods to plant Mk 13 mines and proved well-adapted for mine laying. In general, losses were slight, for the mining targets were not heavily defended and operations were not carried out at excessive range.

The third tactical effort in the Central Pacific was the mining of the Caroline Islands in support of the amphibious operations against Hollandia, New Guinea. Palau was mined by carrier-based aircraft from Task Force 58, and Truk by patrol aircraft. At Palau the mine fields were very effective, producing several merchant ship casualties and ultimately bringing about its abandonment as a Japanese staging point for support of the southern areas. The Truk mine fields contributed to the neutralization of that base, but no ship casualties are known.

During the Marshalls landings, the Fast Carrier Task Forces were engaged in diversionary thrusts against Japanese strongholds in the Caroline Islands. The plans were to mine the Caroline bases from aircraft carriers during these attacks. A strenuous logistic effort was made to assure that larger and more sensitive mines than those previously available would be ready for loading on the carriers. This effort failed by a few days, with the result that the initial carrier attack on Truk was made without the exits having been mined and a substantial amount of enemy shipping escaped from the atoll. The second sortie of the Carrier Task Force, however, which was directed against Palau, did feature the use of mines. It was in this attack that the aerial mine achieved full status as a tactical weapon.

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At the time of the Palau strike, the Marshalls had been secured. The mission of the Task Force was to knock out Palau as a major staging point for supply of the southern areas by the Japanese, and thus prepare the way for the forthcoming invasion of Hollandia, New Guinea, by United States forces. At dawn, on 30 March 1944, the first wave of torpedo planes from the United States aircraft carriers **LEXINGTON**, **HORNET**, and **BUNKER HILL** planted a dense concentration of mines in each of the long, tortuous atoll entrances, trapping some 32 ships in the atoll. Subsequent strikes from all the carriers of the Task Force sank these ships by direct bomb and torpedo attack. The next day additional mines equipped with delayed arming and antisweep features were planted in the harbor and in the anchorage areas of Palau, thus making the naval base useless.

The results of this mining attack exceeded expectations. Several days after the Carrier Task Force had departed, the Japanese attempted to bring a large ship through one of the lesser used channels in the southern part of the atoll. The ship negotiated most of the distance through navigational hazards only to be mined at its destination and subsequently beached. Later, two more ships were mined while attempting to negotiate other channels. The Japanese then made a frantic effort to sweep, with the result that Palau was closed to all shipping for at least 20 days. After this, the base never had an appreciable amount of shipping. It was soon abandoned as a forward operating base for naval ships and aircraft.

After the Palau operation, enough Mk 25 mines were left to mine Truk. An airfield had been completed on newly-acquired Eniwetok, and Truk was mined in April 1944 from this base by PB4Y-1 and PB2Y-3 aircraft of Fleet Air Wing One. The seaplanes mined at low altitude in moonlight, and the PB4Y-1's mainly used formation tactics during twilight periods at low altitude.

At the same time Woleai was being mined by PB5Y-5's from the Southwest Pacific. Since Palau had been knocked out as a staging base, it was thought the Japanese might attempt to use Truk and Woleai from which to launch an attack on United States forces invading Hollandia, New Guinea. Results were similar to those for the Marshalls mining. The Japanese did not use these bases after they had been mined, but evidence is lacking on the part that mines played in this abandonment. There are no records of Japanese ship casualties at either Truk or Woleai from mining, but Truk was closed to all shipping for about a month after the attack. The Japanese had to sweep one of their own defensive mine fields in order to clear a passage into the atoll.

The fourth series of tactical mining operations was directed against the Nanpo Shoto (Bonins) Islands, during the period November 1944 to February 1945, in order to prevent the reinforcement and use of these bases by the

enemy for attack on United States forces operating in the Mariannas. This aircraft mining was similar to that carried out against the Marshall Islands in that it accomplished its objective, but was concurrently assisted by direct air attack on shipping, so that it is impossible to know relative effectiveness. The mining of the Bonins had been planned for the Fast Carrier Task Force operations in July 1944 as part of the Mariannas invasion. The USS **YORKTOWN** was loaded with mines for this purpose but the mining strikes were cancelled because of the sudden appearance of the Japanese Fleet and the impending battle of the Philippine Sea.

Several months later, in November 1944, the Bonins were mined by land-based aircraft operating from the Mariannas before the invasion of Iwo Jima. The islands were attacked in a series of about 40 mining missions. Army B-24's attached to the Seventh Air Force, equipped with precision bombing apparatus and a radar bombsight, were used. Altitudes were increased up to several thousand feet in some missions. Photographic methods, both visual and radar, were used as much as possible to check the locations at which mines had been planted. This was important, because it showed that the Army bombing equipment could be easily adapted to mine laying and it eventually prepared the way for mine laying by B-29's.

The results of the Bonins operations included one destroyer escort damaged by mines, three minesweepers sunk, and a great decrease in shipping to these islands shortly after the mining began. Later, it appeared that the Japanese discovered how to sweep the magnetic mines, and shipping began to increase. By this time, however, intense direct air attacks were being launched against these islands for the Iwo Jima invasions. The enemy never succeeded in reinforcing his Nanpo Shoto bases.

The fifth and final tactical effort launched from the Central Pacific was the mining of the southern coast of Korea by patrol bombers a Fleet Air Wing in June 1945. It was part of a coordinated attack on the shipping attempting to shuttle between Korean and Chinese ports and the Japanese homeland. This was carried out in June 1945, when the B-29's had already begun to blockade a large portion of the Japanese Islands with mines. At the time, the PB4Y-2's based on Okinawa were attempting to attack ships in the Yellow Sea and off the South Korean coast with a new radar weapon, but were having difficulty because the ships were passing through the islands of the archipelago south of Korea where they could not be distinguished as radar targets. Mines were therefore used in order to force shipping out to clear water where the vessels would become vulnerable to attack by the weapon. They not only did this, they sank five ships and damaged six more.

The mines were planted at night through the month of June, with drops made visually from altitudes of 300 to

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800 feet. If visibility was bad, drops were made by radar at an altitude of at least 1000 feet above the surrounding terrain. This usually required dropping from 2000 or 2500 feet. The Korean operations were the first in which PB4Y-2 aircraft were used. They proved successful minelayers.

To summarize: 2817 mines, planted mostly by DM's in the Solomons and 913 aircraft mines in the Central and South Pacific Theaters, resulted in the confirmed sinking of 19 ships, the confirmed damaging of 15 ships, and in the unconfirmed sinking of 1 light cruiser and 4 destroyers. Of the confirmed sinkings, 4 were Japanese destroyers and 2 were Japanese submarines. Of the confirmed damagings, two were Japanese destroyers. Thus, losses to enemy naval vessels were very high. The significant effect, however, was that shipping was denied to every location which was mined. This was the great contribution of mining to the Central Pacific campaign, together with the fact that early difficulties of mine preparation were overcome and that tactics were devised for the planting of mine fields of all types by a variety of minelayers.

CONCLUSIONS

Throughout the Outer Zone Campaign, mining was a very minor form of attack in the march across the Pacific. At no time were the forces committed to it very great, nor was there much planning or emphasis on operations by the high command. Rather were these operations tolerated provided they did not seriously interfere with other, more traditional forms of attack. The Navy's first mine laying was from surface ships and submarines, a form of mine warfare with

which the Navy had become familiar during peacetime by training in Fleet war games and by studies at the War College. On the other hand the Fleet was reluctant to accept the new idea of mines layed by aircraft and was quite willing to have it carried out by other forces. For this reason, although the Navy probably had as many available aircraft suitable for mining operations as did other services, the operations were mainly conducted by the Army Air Forces, the Royal Australian Air Force, and the Royal Air Force.

Since the Navy was not enthusiastic about mine warfare, and since control of the seas by attacks on shipping was not the normal function of the Army Air Forces, the beginnings of mine warfare were slow, uncertain, and somewhat unpopular. In spite of these handicaps, it was clearly demonstrated that mines were handy weapons and could be used by Army as well as Navy aircraft under a variety of tactical conditions. The major tactical lesson of the campaign was that mines must not be layed where they were unsuitable, or, using vulnerable planes, where the enemy defenses were too strong. Thus mining requires a good understanding of the weapon. The major strategic lesson was that a very weak air power is capable of obtaining decisive results against enemy sea power without actually engaging that sea power in surface engagements or even under direct air attack. Mining capitalizes on a weakness of surface sea power, namely, the necessity of using clear harbors, channels, and sea lanes. Very vulnerable aircraft, slow and undefended, laid mines where enemy defenses were very weak, and yet they obtained heavy ship casualties because the enemy was eventually forced to use those very mined channels.

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7.

INNER ZONE OPERATIONS

THE PLAN BREWS

Early in World War II senior officers of the Pacific Fleet showed interest in mining Japan. Such a possibility had been stimulated during 1941 by the activity in countermeasures and by the visits of various Naval Ordnance Laboratory scientists. But in 1942 the possibility of laying mines in Japanese home waters, except by submarines, appeared very remote and, since suitable aircraft and mines were not available, specific plans did not originate in the Fleet until 1944.

Unhindered by the practical problems of actual operations, the seminar group at the Naval Ordnance Laboratory in Washington had developed a theoretical plan for mining Japan from the air which was first written in complete form and discussed on 6 May 1942. The strong desire to carry out the plan devised for mining Japan's Inner Zone was of necessity pushed into the background for several years because of the problems involved in advancing mine developments and mine operations to the point where Japanese shipping could be attacked in the outlying areas. A small amount of work was carried out by the Operational Research Group under Chief of Naval Operations with regard to the geography and development factors required for an attack. The specific plan for such an operation, however, was the responsibility of the area commander, and when the means for such an attack became available, it was Admiral Nimitz who originated the request for mining the Inner Zone of Japan.

The first specific plan for mining the Inner Zone was written by the author, then the Mining Officer of Commander, Service Squadron Six and later Director of Mining, 21st Bomber Command. This plan ran into serious difficulties before acceptance but finally a revised version was adopted by the Committee on Operational Analysis in session to recommend to the Joint Chiefs of Staff the best use of the B-29 forces based on the Mariannas. They recommended it to the Joint Chiefs of Staff and gave it a number one or two priority, depending on the assumptions made regarding the invasion of Japan.

After discussion of this request in Washington, it appeared desirable for the Commander in Chief, Pacific Fleet, to request the assignment of the aircraft direct from

the Army Air Forces. The Commanding General of the Army Air Forces gave a reply with a lukewarm endorsement which promised support and the assignment of B-29's when the weather in the Pacific became unsuitable for high-altitude daylight precision bombing. The operation now had an official status but no actual starting date.

Major General Curtis E. LeMay was convinced of the effectiveness of the operation soon after he assumed command of the 21st Bomber Command. On the basis of the tactical plans submitted by the Director of Mining, LeMay ordered that mining operations be carried out at very low altitudes by single aircraft flights at night, beginning in March 1945. This decision was supported by the request of the Commander in Chief, Pacific Fleet, for the mining in support of the Okinawa Invasion. The number of aircraft available was considerably in excess of those that could be used because of the shortage of mines. Eventually this became the limiting factor in the amount of effort which could be expended against the Inner Zone.

OBJECTIVE

In the fall of 1944 the course of the war indicated the need for an early, sustained mining campaign in great force against Japanese shipping. Only B-29's could carry on such a campaign. The Army had the aircraft, the Navy had the mines. Therefore in November 1944 the Commander in Chief, Pacific Fleet, proposed to the Commanding General, Army Air Forces, that he undertake the imposition of a mining blockade of Japan. The suggestion was accepted, and the Commanding General, 21st Bomber Command, was directed in December to initiate planning for operations scheduled to begin on or about 1 April 1945.

The mission given the 21st Bomber Command was an ambitious one, the blockade of all Japanese sea commerce. But within five months, with the cooperation of other anti-shiping forces, both Army and Navy, the Command was able substantially to accomplish its objective. In the planning, advantage was taken of the lessons learned from the British Mining Campaign against Germany as well as from previous United States Army and Navy mining campaigns in the Pacific. The entire aircraft operation, both planning and execution, was conducted by the 21st Bomber Command,

but all preparations, mine modification, and logistics were provided by the Navy. Only B-29 crews carried out the mine laying missions, but both Army and Navy personnel were utilized in all phases of the planning. The 313th Wing carried out the tactical planning and mine field design, as well as the execution of the mining missions. Mine Assembly Depot No. 4 prepared the mines.

The mining mission was to complete the destruction of the Japanese ship-borne lines of communication. The three principal objectives were: (1) to prevent the importation of raw materials and food into Japan; (2) to prevent the supply and deployment of her military forces; and (3) to disrupt her internal marine transportation within the Inland Sea. It was believed that the mining, if carried out in force, would terminate practically all imports into Japan — first of raw materials, finally of food. As a result enemy industry would come to a halt and the enemy population would starve. Starvation combined with the incendiary raids would reduce the civilian will to wage war. Therefore the operation was called Starvation.

TARGET

When the mining campaign began, the enemy had afloat approximately 2,000,000 gross tons of shipping of vessels displacing 1000 or more gross tons. This shipping passed freely through Shimonoseki Straits into the Sea of Japan and the Yellow Sea, as well as to the southern areas conquered by the Japanese, via the Straits of Formosa. Very little Japanese shipping was able to challenge the mastery of United States submarines in Pacific waters. But on the other hand, enemy mine fields and escorts, as well as air patrols, prevented naval attacks in force on shipping in the Japanese Inner Zone where Japanese shipping and routes were adequate, at the beginning of the year, to supply the enemy's needs.

It is estimated that foods and raw materials were moving into Japan at a rate of 1,000,000 to 1,500,000 tons per month. During 1944, 80 percent of all oil supplies, 88 percent of all iron (iron ore and ingots), 24 percent of all coal (including 90 percent coking coal), and 20 percent of all food required by the Japanese were imported by sea. In food alone the nutrition standards in Japan were such that a variation of 20 to 30 percent determined actual subsistence or starvation for a large part of the population. There were numerous indications that whatever the shipping requirements, Japan's shipping position was approaching a marginal point and any further substantial reductions in either the number or movement of available vessels would strike a severe blow to the Japanese war economy.

Inside the Japanese home waters the Inland Sea formed a natural freight shipping route, well protected and free from the overland obstacles of terrain which prevented the development of extensive railroads and motor transportation facilities. As a result 75 percent of all transportation was waterborne, including transportation of 57 percent of all coal used. Half of the power used in the great industrial region of Kobe-Osaka, Nagoya, and Tokyo was obtained from waterborne coal. The number of Japanese ships available had been greatly reduced by United States submarines but the remaining shipping, for the time being, was invulnerable to submarine attacks because it was operating in the Inner Zone and was protected by extensive mine fields, difficult to penetrate.

The table below gives the Japanese merchant fleet position, on 27 March 1945, for steel ships of 1000 gross tons and over. More than 60 percent of this tonnage was composed of ships of 4000 gross tons or larger. These large ships were the prime targets. One of the mining problems was to sink ships selectively. One mine could sink or seriously damage one 10,000-ton ship at ten times the profit

	Total Gross Tons
Shipping afloat, 7 December 1941, plus all acquisitions and construction to 27 March 1945	9,000,000
Less sinkings, 7 December 1941 — 27 March 1945	<u>7,190,000</u>
Total afloat, 27 March 1945	1,810,000
Less 20 percent factor to cover ships in repair	<u>362,000</u>
Total operable, 27 March 1945	1,448,000

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obtained if the same mine sank or damaged one 1000-ton ship. The mining was to be of a strategic nature and was to supplement the strategic bombing of Japan. The estimates which follow show the importance of waterborne freight to the Japanese.

The shipping necessary to support the faltering enemy war industry each year required approximately 12,000 passages from Chinese and Korean ports via Shimonoseki Straits, approximately 12,000 local voyages between Inland Sea ports, and 15,000 voyages to the Kobe-Osaka region. As the enemy attempted to disperse industries, a move made necessary by the strategic bombing of Japan by the Twentieth Air Force, his transportation requirements increased markedly. Therefore sea transportation increased, for his railroads and motor facilities were already strained to the maximum. Furthermore the destruction of his stockpiles by incendiary and bombing raids required an abnormal transfer of raw materials between different regions. The transfer of his field supplies, which were stored in a few regions, could be greatly disorganized

by strategic mine warfare. Because the flow of oil and aviation gas from his sources in the south had been reduced, such a disorganization would still more seriously affect his war industry.

Figure 7-1 shows the railroad routes and the ports served by railroads which might be used for diversionary ports. Figure 7-2 shows the shipping routes used by the Japanese prior to the inception of the mining campaign, weighted in proportion to traffic. In addition to the merchant shipping, the enemy still possessed a formidable striking force of naval vessels, although this force was meager compared to that which he once possessed. The principal enemy naval units operable were three battleships, two converted battleships, approximately ten aircraft carriers, light carriers, and escort carriers, and seven or eight heavy and light cruisers.

It is believed that the carriers were substantially immobilized because they lacked an adequate aircraft complement. The battleship YAMATO was the backbone of the heavy fleet units. While a naval force could be assembled

Prior to the mining operations the Japanese railroads carried approximately 25% of the freight within the Japanese Homeland. It is estimated that they were operating within 80% of capacity. These facts alone indicate that rail shipping proved a poor substitute for water transportation. This situation was further aggravated by the fact that the main lines all ran from Shimonoseki Straits along the S coast of Honshu to Kobe, Osaka, Nagoya, and Tokyo. If the Shimonoseki Straits could be closed to sea-borne commerce, the strained railroad capacity of Japan would drastically limit the use of NW Honshu ports as diversionary ports for the great industrial centers on the south coast.

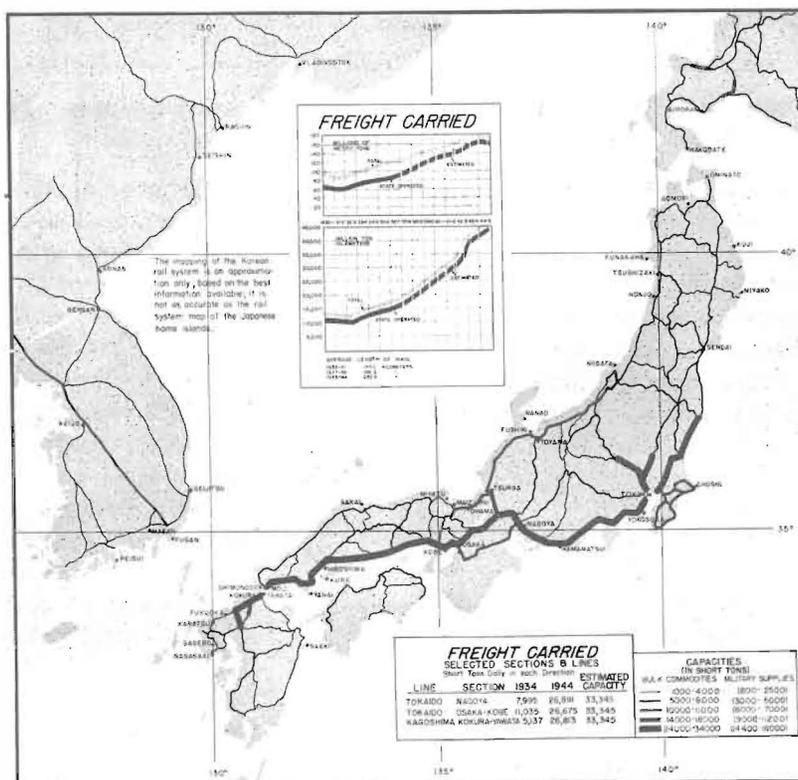
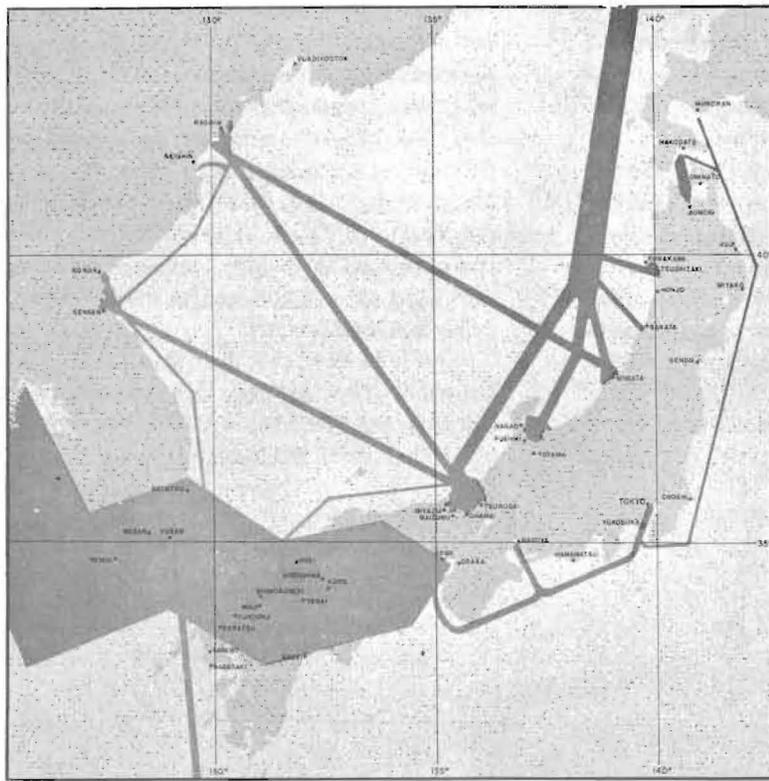


Figure 7-1. Railroad Capacities of Japan

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Approximately 2,000,000 gt of Japanese shipping of 1,000 gt or larger was offload of this time. Most of this shipping passed freely from the Yellow Sea and the Sea of Japan through the Shimonoseki Straits to the Inland Sea 75 percent of all freight transportation within the homeland also moved by water.

About a million and a half tons of food and raw materials were moving into Japan per month at this time. This volume was approaching the marginal point beyond which any substantial reduction in either the number or movement of vessels would strike a severe blow to the Japanese war economy.

Figure 7-2. Estimates of Shipping Situation of the Japanese Empire Prior to Inner Zone mining Operations

for a sortie against Allied naval units, such a sortie was expected only in connection with enemy defensive operations. These men-of-war were based principally at the great Japanese naval base at Kure, although units of the fleet were frequently found in other Inland Sea areas. The United States invasion of Okinawa was imminent at the commencement of the mining operations. To prevent enemy naval interference during the first two critical weeks of the invasion, the Japanese naval forces were also a mining target.

PLANNING PROBLEMS

Mission planning problems were of various kinds. The most important was the altitude for attack. Theoretically, mines were capable of release from any altitude up to and including 35,000 feet. Mines could be dropped either by day or by night. By day, visual methods could be used as in bombing, and radar methods could be used either in the daytime or at night. Mines could be dropped either by single aircraft or by aircraft in formation. But an analysis of these factors clearly showed the advantage of single flights

at night, dropping mines from low altitude by radar.

The reasons were fundamental. First, mining by daylight necessitated defense formation. But mines should be widely dispersed over large areas for effective use. It would have been exceedingly difficult to achieve this using large formations. The mines could be dropped successfully but the mine fields would be too concentrated for efficiency. The second factor militating against daylight missions was the necessity of carrying them out at very high altitudes. Study of the accuracy attained from 30,000 feet with the best possible radar wind measurements or with the best predicted weather showed that at most an average radial error of about two miles could be expected. It was estimated that the accuracy from altitudes of 30,000 feet would be one-fourth of that which could be obtained at 5000 feet.

The third factor against daylight high altitude operations was the limited mine load that could be carried, about one-half or less of that which could be carried at low altitudes by single flights. The fourth factor was that high altitude formation flying resulted in heavy operational

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losses caused by excessive mechanical strain on the aircraft. The mechanical strain on single aircraft flying at night at low altitudes was rather slight, thus reducing operational losses from mechanical failures. The fifth factor was that contact ditching in daylight returns would be possible if ditching were necessary. Air-sea rescue operations would be more effective, since search for longer periods was possible on the day following the night operations. Ditching at night following day operations was dangerous and often meant a night's delay in search for survivors. More effective rescue would result in higher crew morale and better mining.

The sixth factor was that operation of a single aircraft at night would probably result in greater safety against enemy aircraft, especially if full radar operation were used and the target were attacked during overcast periods. A special study of the flak problem for mining was made by Army Air Forces, Pacific Ocean Area (see Annex A). It was concluded that for single aircraft flying at low altitudes at night, an altitude of 5000 feet to 6000 feet gave optimum safety. The seventh factor was that takeoff and landing in daylight would increase the safety of the operations.

The advantages of night operations were evident. More than double the load could be carried. Four times the accuracy could be attained. Efficient mine fields could be designed and laid. Maintenance of aircraft would be greatly improved because of lowered engine strain with a resulting reduction in operational losses. Flak damage and loss would be much lighter. Air-sea rescue facilities would be more effective in reducing loss of crews. No reasonable arguments upheld high-altitude night missions by single aircraft. It was concluded that night operations using single aircraft at low altitudes would be approximately 20 times as effective as daylight operations and approximately ten times as effective as high-altitude night missions, and with lower losses. Accordingly, plans for carrying out night mining missions at low altitudes with single aircraft were presented to the Commanding General on 27 January 1945. He so directed.

Several methods of laying mines at night had been previously used, and several modifications were proposed. The oldest method, to lay mines visually with visual identification of target, was used most extensively by the British, by PBV aircraft in the Southwest Pacific, and by Navy PB4Y1 aircraft in the Central Pacific. It was also used by B-29 aircraft of the 58th Bomb Wing in mine laying operations while based in India. However, it was clear that this method could not be used in the Empire mining where weather conditions permitted the use of visual methods less than 10 percent of the time. The very low altitudes required for visual recognition at night were impossible over Japan because of the mountainous terrain. It was therefore necessary to rely entirely on radar. Radar mine laying had been used by the British and was tried in drills carried out by Commander, Minecraft, Pacific Fleet, at Oahu. B-29's of the 58th Bomb Wing had also made limited use of this

method using APQ-13 Radar. The B-24's of the 42nd Bomb Squadron of the 11th Bomb Group had achieved reasonable accuracy in their extensive use of radar methods in the mining of the Bonins, particularly at Chichi Jima. The methods used by these two groups appeared to be suitable in principle, with some modifications, for a mining Standard Operating Procedure by the 313th Bomb Wing (see Chapter 8).

The Commanding General believed the most effective use could be made of Twentieth Air Force aircraft if the mining was carried out by full wing missions. This was compatible with the most effective use of mines in the initial effort where it was believed desirable to establish strong and heavy mine fields at the principal mining targets in order to force the enemy to sweep and to use specific channels. It was hoped these channels could be determined by reconnaissance and then re-mined. If incomplete mine fields were laid in the principal targets and over a very wide area, it was thought the enemy would be able to avoid the mined areas in wide harbors such as Kobe-Osaka and Shimonoseki. Therefore, in order to leave the enemy no choice, the early mine fields needed to be complete. This effect could be achieved best with full wing efforts. On the basis of this forecast of the enemy reaction, it was hoped that re-mining could be carried out on a continuous group basis at a later time.

The mining objective was to achieve complete blockade of Japanese shipping. It was necessary to undertake this in a logical sequence of steps, each requiring different tactics. Two courses of action were possible. The first was to mine all targets more or less uniformly. This gradual building of the mine field in each area without achieving early blockade at any particular port would serve notice on the enemy that all his ports would be attacked and thus permit him to develop countermeasures at all areas. The advantage of this course of action was that widespread initial attack would swamp his sweeping efforts and probably would achieve very good attrition for a while. The disadvantage was that in many of the principal targets light mine fields would achieve little or no results because the enemy could avoid them.

The second course of action was to lay down the strongest possible mine fields at the enemy's principal shipping bottlenecks, commencing with his Inner Zone in the Inland Sea and the Shimonoseki Straits and working out as rapidly as the mine supply would permit. The advantage of this plan was that the enemy would be faced immediately with a major clearance problem in his most important harbors, their channels, and in the vital Shimonoseki Straits artery. These unavoidable mine fields would result in the immediate maximum disorganization, blockade, and destruction of his shipping. It was hoped that succeeding mining missions could be scheduled rapidly enough so that, as the mining effort spread to the outer parts of the Inner

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Zone, the enemy would be unable to catch up in his countermeasures. Furthermore, the establishment of complete mine fields would force the enemy into sweeping specific channels through them. It was hoped that these channels could be located by reconnaissance and mined by smaller succeeding efforts.

The initial concentrated mining of a few targets in heavy force had the further operational advantage that planning was practical for a full wing effort, whereas planning for 10 to 20 different targets for the initial effort would have been impractical. The principal disadvantage of mining a few targets in great force appeared to be that it offered the enemy an opportunity to concentrate his sweeping or clearance methods in the regions first attacked and thus obtain quicker clearance. It was hoped that the choice of mine types would make this difficult.

There were two important intelligence tasks that were vital to the success of the mining campaign. The first was to ensure a maximum of continued reconnaissance over the mine fields in order to locate swept enemy channels for re-mining and to disclose new types enemy sweeps. Reconnaissance carried out by the Twentieth Air Force required, as an accompaniment, expert photo interpretation of shipping. This combined task was carried out by the Third Photo Reconnaissance Squadron and the Combined Central Interpretation Unit. All other intelligence was provided in two special mine intelligence summaries — one prepared by the Military Intelligence Service and the other by the Joint Intelligence Center, Pacific Ocean Area. These summaries provided some of the most decisive information used in the mining campaign.

The second task was to obtain the best possible records of mine locations in order to determine the accuracy of laying so as to evaluate the effectiveness of particular mine fields and mining missions, and also to provide data for future mine sweeping operations by United States forces. Fortunately radarscope cameras provided an accurate and permanent record of mine drop locations, and more than 50 percent of the drops were recorded in this way. Prior to mining operations a complete reporting system was established by the 21st Bomber Command; it was largely based upon the mining experience of the 42nd Bomb Squadron in the Bonins mining. This system ensured the accurate recording of mine positions from the start of the operation.

THE WEAPON

Five principal types of mines were either on hand or in production for use during the mining campaign. Two used magnetic firing mechanisms, the M-11 and M-9 Mod 1, both of which were believed to be familiar to the enemy. Two others contained acoustic firing mechanisms, the A-3 operating on propeller noise in the acoustic region and the A-5 (in production but not yet available) operating on ship

hull vibration in the subsonic region. The acoustic A-3 was believed to have been recovered by the enemy from previous mining operations. The fifth, the A-6, containing a pressure mechanism, operating on the reduced water pressure under a ship resulting from its motion, was in production but not yet available. It was similar to a mine used on the Normandy beachhead by the Germans with great success. This type was believed to be unsweepable by the enemy, as well as by United States forces. Only the magnetic mines and the A-3 acoustic mine were available for the first month's operations. Both of these types had been compromised.

Reliable intelligence indicated that the enemy had planned to rely principally on his towed catenary magnet sweep which was easily capable of sweeping the United States' unmodified magnetic mines. Intelligence also indicated the enemy's ability to sweep the original acoustic A-3 mine. It was believed his method was explosive, but details were unknown. It was anticipated that the A-6 pressure mechanism (and probably the subsonic A-5 mechanism) would yield better results. Since these mechanisms were not yet available, it was believed early mining would produce a greater overall effect than could be achieved by waiting for several months to initiate operations.

In order to correct the defects and weaknesses of the standard M-11 and M-9 Mod 1 magnetic and A-3 acoustic mechanisms, local modification of these mechanisms was proposed to accomplish two things: first and most important, to defeat the known enemy sweeps; second, to select the largest enemy ships for sinking so as to obtain maximum damage on a tonnage basis. The first of these goals required modification of mine mechanisms to meet specific enemy countermeasures for sweeping. The second required adjustment of the sensitivity of the mechanisms to make them insensitive to small ships.

Unwisely the enemy had chosen a somewhat crude sweep of towed magnets for mass production because it could be used easily with small boats and unskilled personnel. This sweep had been recovered in quantity and had been analyzed. The M-9 Mod 1 mechanism, and less effectively the M-11 mechanism, could be modified by changing their timing to defeat this enemy magnetic sweep almost completely. The change was therefore carried out from the beginning. It was fortunate that the need for ship selection required reduced sensitivity of these mechanisms, which further aided in reducing the effectiveness of the sweep. It was believed that, for a short time at least, the magnetic mines could be made almost unsweepable to the enemy by proper modification prior to laying. This modification was difficult but possible.

Although it was believed the enemy could sweep the original A-3 mechanism by explosive methods, modification of the mechanism made by the Mine Modification Unit on Oahu had altered the characteristics of the mechanism so

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that it could no longer be cleared by simple explosive sweeps. This modification was not considered to be of continued effectiveness in defeating enemy counter-measures, but one or two months' effort on his part would probably be required to defeat it. As a result of these two modifications, it was believed that the two magnetic and the A-3 mechanisms would be very effective for a limited period, possibly for two months.

The second important alteration in the mine mechanisms was the adjustment of their sensitivities. All mines were designed for use in very deep water, and most of the best targets had shallow water. An analysis of the accuracy which could be obtained in the mining operations and of the probable width of enemy channels indicated that the logistic limitations of the mining effort would prevent enough mines from being laid to threaten all ships attempting passage through the mined area. As it later turned out, the ratio of mines to ship passages was small. In order to make each mine of maximum effectiveness, it was necessary to adjust the sensitivity so that the tendency would be to sink the larger ships, and to adjust the target width so that enemy ships would be sunk or seriously damaged rather than slightly damaged, or the mines exploded without

damage to the ships. These mine changes could not be ideally realized because of the complex consideration of sweeping, lack of exact information on the composition of enemy ship traffic, and the characteristics of the mines themselves. The effect of modifying the magnetic mines, however, might be such as to double or triple the amount of tonnage sunk or damaged, and at least some increase in damage would be achieved by modifying the A-3 acoustic mechanism. The Mine Modification Unit and adequate supplies were not yet available in the Mariannas so that it was not possible to put all of these decisions fully into effect for Phase I, but the mines were modified as much as possible for the first two full wing efforts.

The decision to use a full wing increased tremendously the work of planning and execution, since each mine had to be adjusted for the particular target to be hit by a particular aircraft (see Chapter 8). Complex planning was therefore necessary, and in execution each aircraft had to hit the exact target assigned. This considerably reduced the flexibility of operations. The expected gain in tonnage mined was believed worth the additional effort. All mines were provided and prepared for use by the Navy. Figure 7-3 shows the flow of logistic information and supply. Mine

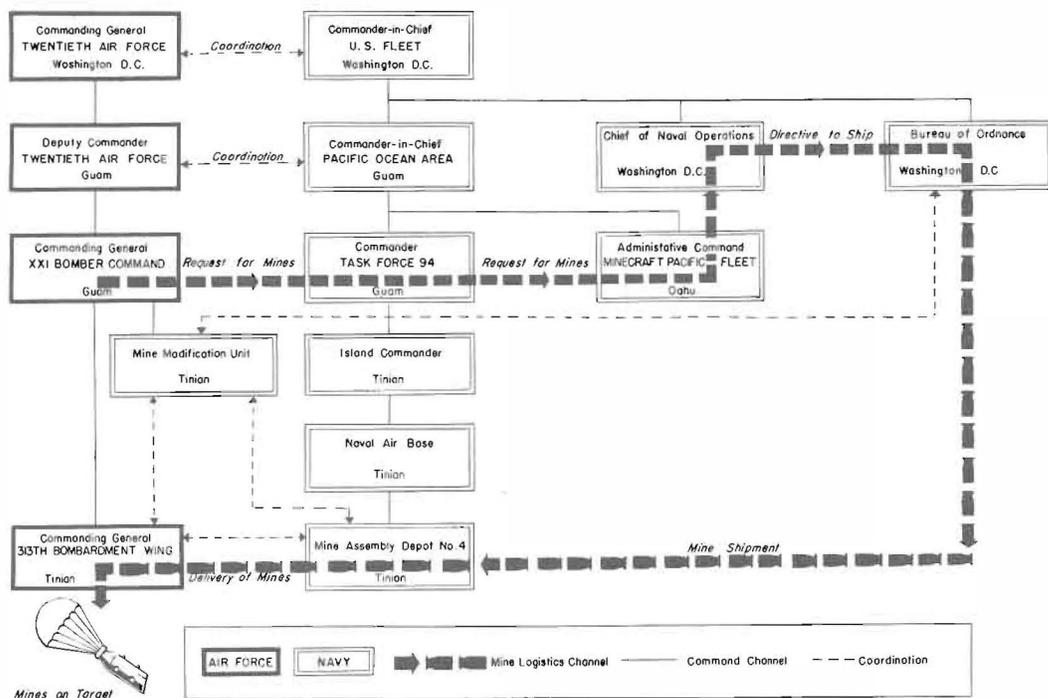


Figure 7-3. Organization of B-29 Mining Operations

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Depot No. 4 was established on Tinian and was ready for operation by 20 February 1945; approximately 1500 mines were available at that date. The shipment of new supplies was slow, however, and therefore the mining campaign was logistically limited.

The mines were handled by the normal ordnance personnel of the 313th Bomb Wing, after special indoctrination in installation of safety and arming devices and parachutes. Particular attention was paid to inspection. Planes were mined up with the same rapidity that they could be bombed up in spite of the fact that each mine was differently prepared and was designated for a particular rack station in each aircraft (see Chapter 8).

SUMMARY OF PRELIMINARY DECISIONS

Single unescorted aircraft were to lay mines at night by radar from low altitudes. All available mines were to be used as early as possible. By successive steps there was to be initiated and maintained the blockade of the main enemy shipping artery, Shimonoseki Straits, the Inland Sea shipping routes which connect Japan's great industrial zones, the northwestern Kyushu and Honshu ports, and of Korean ports if possible. The larger ships of the enemy's merchant fleet were to be selected for sinking. Mine modification was to be used to defeat enemy sweeping, when possible, as new countermeasures occurred.

The command organization for mining was normal except that the logistic and technical aspects were coordinated with the appropriate naval agencies (see Figure 7-3). Continuous and close coordination of the mining effort by all participating organizations was maintained by a weekly mine conference held at the 21st Bomber Command Headquarters and attended by representatives of each of the activities concerned. All tactical planning was carried out by the 313th Bomb Wing to which the entire mining operation was assigned. The general tactical methods employed were directed in accordance with the preceding decisions and with the low-altitude experience gained in previous incendiary attacks in scheduling and choice of radar Initial Points and Approach Points. This made it possible for the 313th Bomb Wing to take full advantage of all previous Wing experience, to modify tactics readily in order to take into account mine-field design and mine ballistics, and to change tactics rapidly as operational experience in mining was gained. The capable execution of the mining missions by the 313th Bomb Wing was a major factor in the successful accomplishment of the mining operation.

OKINAWA SUPPORT: PHASE I OPERATION (27 MARCH TO 2 MAY 1945)

Two planning factors were of importance to the initial operation. First, because of the decision to attack the enemy's shipping lanes by steps or phases, the most logical procedure was to begin by cutting off his shipping in the

Inland Sea area. The most important target was therefore Shimonoseki Straits; Kobe-Osaka came next, followed by the general shipping routes and smaller ports in the Inland Sea. Second, the invasion of Okinawa was scheduled to begin at about the same time as the mining missions. The Commander in Chief, Pacific Fleet, requested the closure of Shimonoseki Straits by mines in support of the Okinawa invasion in order to prevent passage of enemy fleet units through the Straits. The enemy could carry out such a sortie undetected by our submarines or aircraft.

The two requirements were compatible and the decision was therefore made to heavily mine Shimonoseki Straits as the first step in the blockade. At the same time the decision was made to establish strong mine fields in the Kure-Hiroshima region in order to interfere further with any attempted sortie by enemy fleet units during the early weeks of the Okinawa invasion. The mining operation was scheduled for the nights of 27 and 30 March. Action was taken to reinforce gaps (due to aborts in the first mission) in the mine fields at Kure-Hiroshima during April and to harass the fleet units by dropping mines in Kure Harbor and Sasebo. In carrying out Phase I, 246 aircraft were airborne, laying 2030 mines in the target with a loss of 5 aircraft (see Figure 7-4).

The enemy reacted with a most vigorous attempt to clear Shimonoseki Straits by sweeping, partly by using suicide craft. This clearance, carried out on a large scale, was documented by United States reconnaissance aircraft which revealed the location of the swept channels. They were very narrow — about 2000 feet wide — and presented a difficult re-mining problem. The most disturbing aspect of this sweep was the indication that small craft were used as suicides. This, if permitted, would result in many small and unprofitable ship casualties. Early mine modification and desensitization, which had been planned originally to prevent firing on small ships, had been prevented by lack of facilities and experienced personnel. A second enemy reaction was the use of his interceptors to escort the mine laying B-29's so that he might observe and note the location in which mines were dropped. This occurred during the April reinforcing of the Kure-Hiroshima mine fields and was accompanied by plain language broadcasts over the Japanese warning net to all mine watch stations to be on the alert. Thus the enemy early adopted and developed mine location and clearance methods, as distinguished from mine sweeping methods.

It was estimated that the blockade produced by this first operation effectively closed Shimonoseki Straits for ten days or two weeks, which resulted in a reduction of traffic to 25 percent of normal and cut the monthly imports through the Straits about 50 percent. The more complete reaction of the enemy is shown in Figure 7-5 by the new shipping routes caused by diversion. During the period 28 March to 3 May, it is estimated that 35 Japanese

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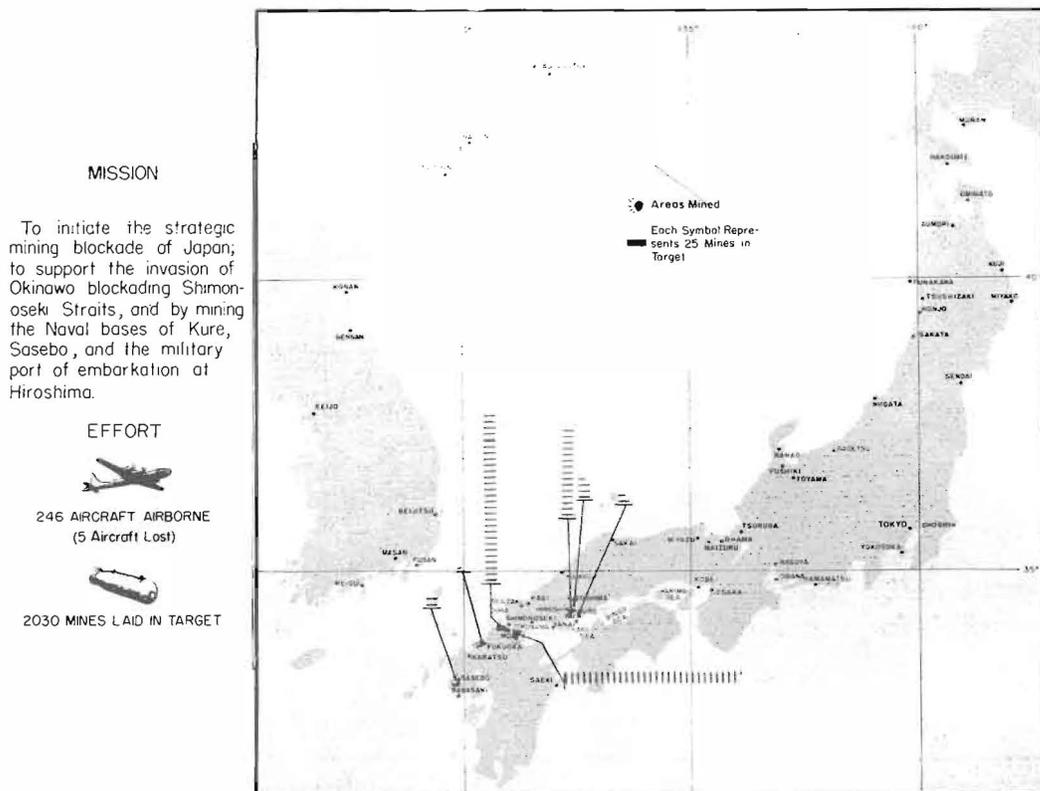


Figure 7-4. Phase I: Okinawa Support, 27 March - 2 May 1945

vessels were sunk or damaged by mines, with a minimum loss of about 100,000 gross tons.

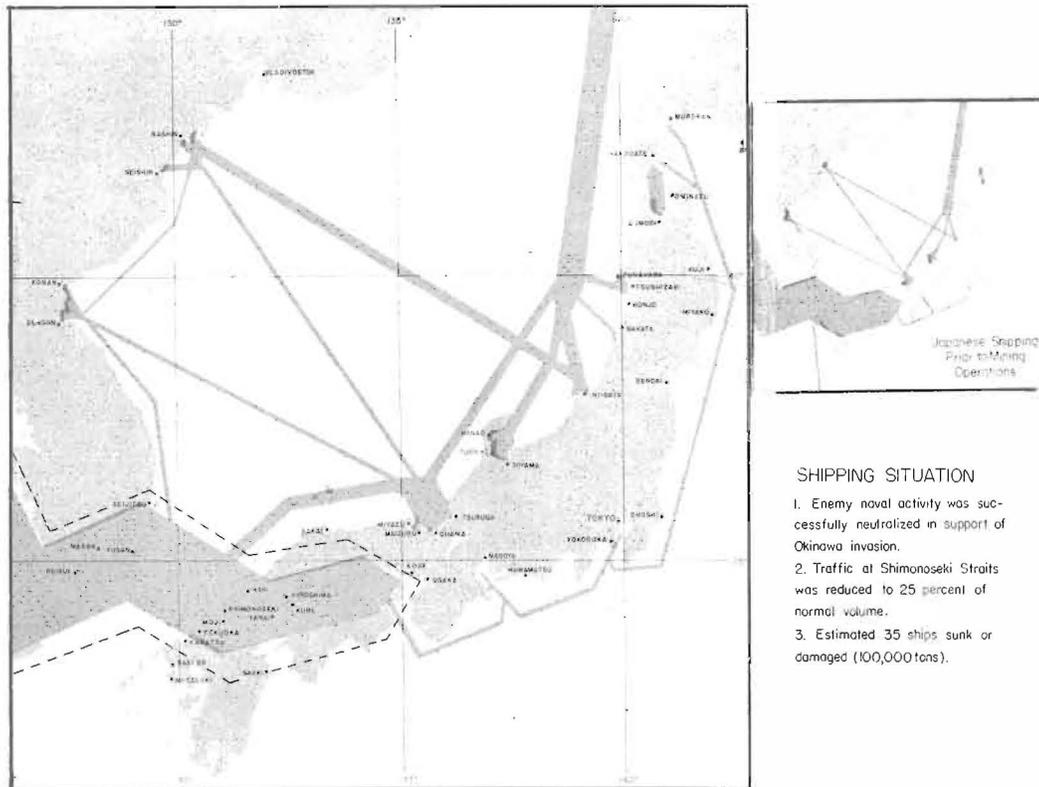
The tactical support of the Okinawa invasion by B-29 mine laying apparently was effective. During the entire Okinawa campaign only one sortie was made by major units of the Japanese Fleet. On 6 April a task force, consisting of Japan's finest remaining battleship (42,000-ton YAMATO), one light cruiser, and seven or eight destroyers, was located by B-29 reconnaissance as it sortied through the Bungo Straits from the Inland Sea and proceeded along the east and south coasts of Kyushu towards Okinawa. On 7 April carrier-borne torpedo planes and bombers of the United States Fifth Fleet sank YAMATO, the cruiser, and three destroyers. The remaining units were damaged. It is considered that mines had the following effect: they delayed this sortie so that when it finally took place, beachheads on Okinawa were firmly established; and they forced the sortie to proceed through Bungo Straits where reconnaissance was

certain, and around the east and south coasts of Kyushu, rather than through the Shimonoseki Straits and the more protected waters west of Kyushu. No naval units sortied from Sasebo to the Okinawa area during the invasion.

INDUSTRIAL CENTER BLOCKADE: PHASE II OPERATIONS (3 MAY TO 12 MAY 1945)

The second phase was planned on the same basis as the first, and a determined attempt was made to effect a complete modification of mine mechanisms and adjustment of sensitivity as was necessary to select large ships and to defeat enemy sweeps. Particularly was the attempt made to defeat effective enemy explosive sweeping of the A-3 acoustic mechanism by adjusting the A-3 sensitivity and time constants. The new unsweepable A-6 pressure mechanism was available. It was expected to present the enemy with an impractical clearance problem, thus appreciably increasing the effect of blockade and the accompanying

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SHIPPING SITUATION

1. Enemy naval activity was successfully neutralized in support of Okinawa invasion.
2. Traffic at Shimonoseki Straits was reduced to 25 percent of normal volume.
3. Estimated 35 ships sunk or damaged (100,000 tons).

Figure 7-5. Diversion of Enemy Shipping After Phase I

attrition. In this phase the blockade was extended to the Inland Sea as originally planned, to Kobe, Osaka, and along the entire network of Inland Sea routes. The Shimonoseki Straits blockade was maintained by re-mining, and attrition mining of Tokyo and Nagoya was undertaken. A total of 195 aircraft were airborne to lay effectively 1422 mines in the targets, as shown in Figure 7-6, with no loss of aircraft.

As a result of this mining the movement of large-type shipping between the Asiatic continent and Inland-Sea ports was almost completely eliminated. The effect of this blockade was increased by bombing and incendiary attacks on the Kobe-Osaka area early in June. It was believed that the amount of ocean-going shipping which moved between the continent and Inland-Sea ports had been very small since Phase II and there was good evidence that most of the vessels which had been operating in that area since the mining were small sailing vessels or other type wooden ships. Figure 7-7 shows the new shipping situation.

Evidence of swept channels continued to accumulate, often from fragmentary information since reconnaissance was frequently incomplete because of weather. The evidence for Shimonoseki Straits channels was very good. The enemy continued to use suicide craft, his Mark 3 catenary sweep, and sound bombs. Reconnaissance in the Shimonoseki Straits region was good enough to show that ship passages had been reduced to two to four per day at the end of May as compared with an estimated 40 per day in March, and that tonnage had been reduced to less than 7000 tons per day as compared with an estimated 70,000 tons per day in March. Japanese ship losses to mines were estimated to have increased greatly during early May. It was believed a high ratio of ship sinkings to damage was achieved with the A-6 pressure mechanism, and the modified M-9 Mod 1 magnetic mechanism was probably just as effective. On the other hand, the A-3 acoustic mechanism was believed to have been easily swept by the enemy and to have been almost ineffective for blockade mining.

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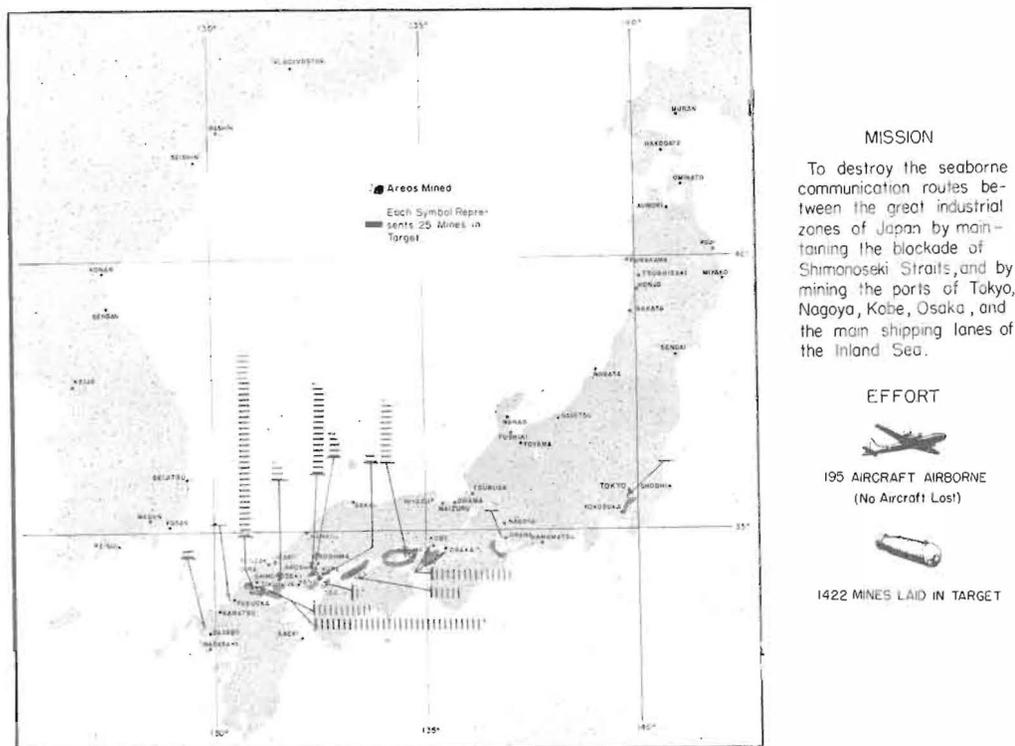


Figure 7-6. Phase II: Industrial Center Blockade, 3 May - 12 May 1945

NORTHWESTERN HONSHU-KYUSHU BLOCKADE: PHASE III OPERATIONS (13 MAY TO 6 JUNE 1945)

Phases I and II established the mine fields at Shimonoseki Straits and the Inland Sea areas. These missions were composed of two efforts by the full Wing plus a number of smaller missions using 20 to 30 aircraft. A study of the results obtained with full wing and with small mining missions indicated that the length of time of closure of a port obtained with larger efforts was not increased in proportion to the effort at any specific port. It was concluded that in order to obtain closure of a particular port or channel, frequent re-mining was much to be preferred over large-scale efforts carried out once or twice a month. Mining every other night using a single group was authorized.

A preliminary estimate of the accuracy of the positions of mine sticks was made, using radarscope photo data. Reconnaissance also permitted an estimate of enemy ship

traffic. It was clear that only a fraction of the mines laid could be placed in the narrow swept channels established by the enemy. It was determined that the number of ship passages per week at Shimonoseki Straits (and probably other targets) exceeded by a factor of four or five the number of mines per week which could threaten these ships. It was therefore concluded that a narrow target width was desirable in order that maximum damage be done to each ship actually mined. A delay of a few days or weeks in the firing of mines in the channel, caused by the smaller threat of firing resulting from narrow target widths, could be tolerated in order to obtain maximum mine effectiveness. The smaller target widths also advantageously decreased the efficiency of enemy sweeps. This conclusion was of primary importance since it was in direct contradiction to the theoretical concept that maximum damage could be obtained if every ship passing was mined even with very small damage. This theoretical concept

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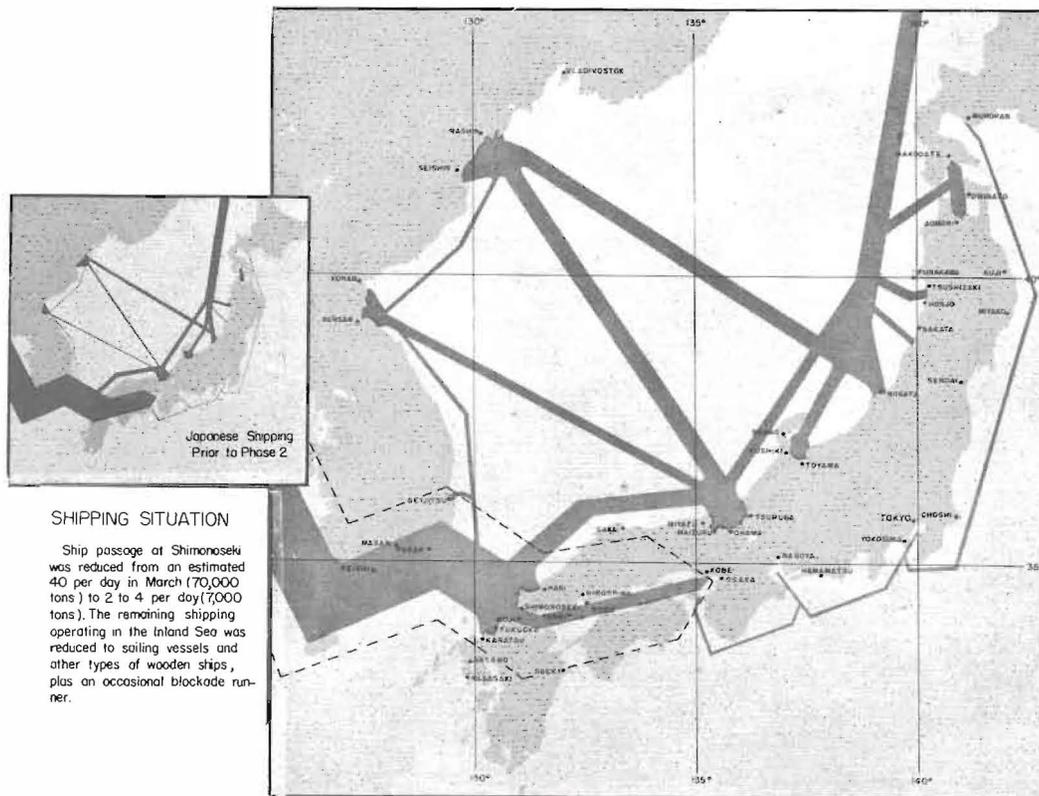


Figure 7-7. Diversion of Enemy Shipping After Phase II

would be true only if the number of mines available to sink ships was considerably in excess of the weekly ship traffic.

In planning Phase III, the narrowing of target widths was combined with the selection of large ships. The ship distribution was determined from reconnaissance. The Mine Modification Unit took on increasing importance, and the complexity of planning was greatly increased. It was evident from the reduction of the Straits traffic that shipping had been diverted to northwestern Honshu ports; accordingly the third phase was directed against these ports in continuation of the original plan. A total of 209 aircraft were airborne to lay 1313 effective mines in the targets, with a loss of three aircraft (see Figure 7-8).

The enemy's reaction to the Phase III mine laying followed the same pattern as before. Ports apparently were closed for a short period and then re-opened after a channel was swept. It did appear, however, that port closure obtained at the northwestern Honshu and Kyushu ports was in general a day or two longer than that obtained in the

Shimonoseki Straits area. It was believed that the basic importance of the latter area had led the Japanese to provide a heavier concentration of sweeping equipment there, enabling them to sweep more rapidly.

Japanese countermeasures observed during May did not show any great progress over those noted earlier. It was believed that the sound bombs were being used successfully against the A-3 acoustic mines. So far as is known, the use of the catenary sweep was continued against magnetic mines — probably with only limited success. A new double catenary appeared at Moji towards the end of May. This sweep was an expected development but was assessed as very clumsy, inefficient, and awkward to use. It definitely indicated that the enemy had recovered and analyzed the modified magnetic mines. It was believed the effectiveness of the magnetic mines would not be appreciably affected by this sweep. It was also believed that no sweep was developed for A-6 pressure mines, but evidence from a German prisoner-of-war revealed that the Japanese were

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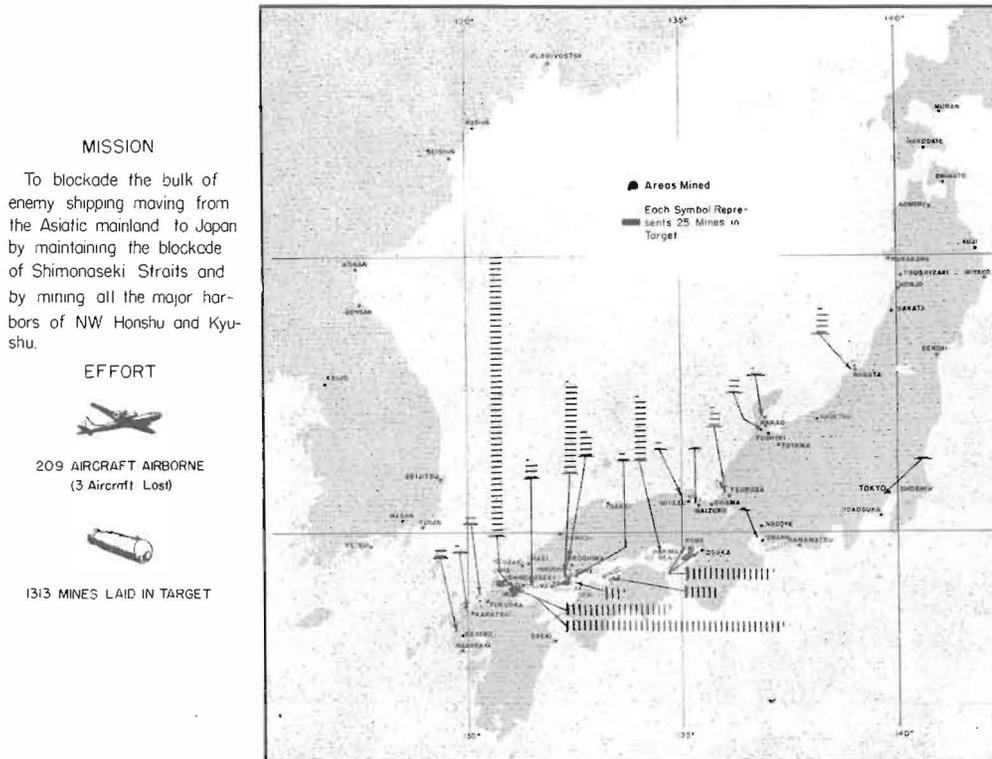


Figure 7-8. Phase III: NW Honshu-Kyushu Blockade, 13 May - 6 June 1945

informed of the pressure principle in mines. No information was available on sweeps which may have been developed against A-5 subsonic mines.

Vessel casualties increased sharply during Phases II and III compared to those of Phase I. During May it was estimated that between 75 and 100 vessels aggregating at least 300,000 gross tons were sunk or damaged by mines. The ship traffic at Shimonoseki continued at a low level as before. For the estimated shipping situation after this phase see Figure 7-9.

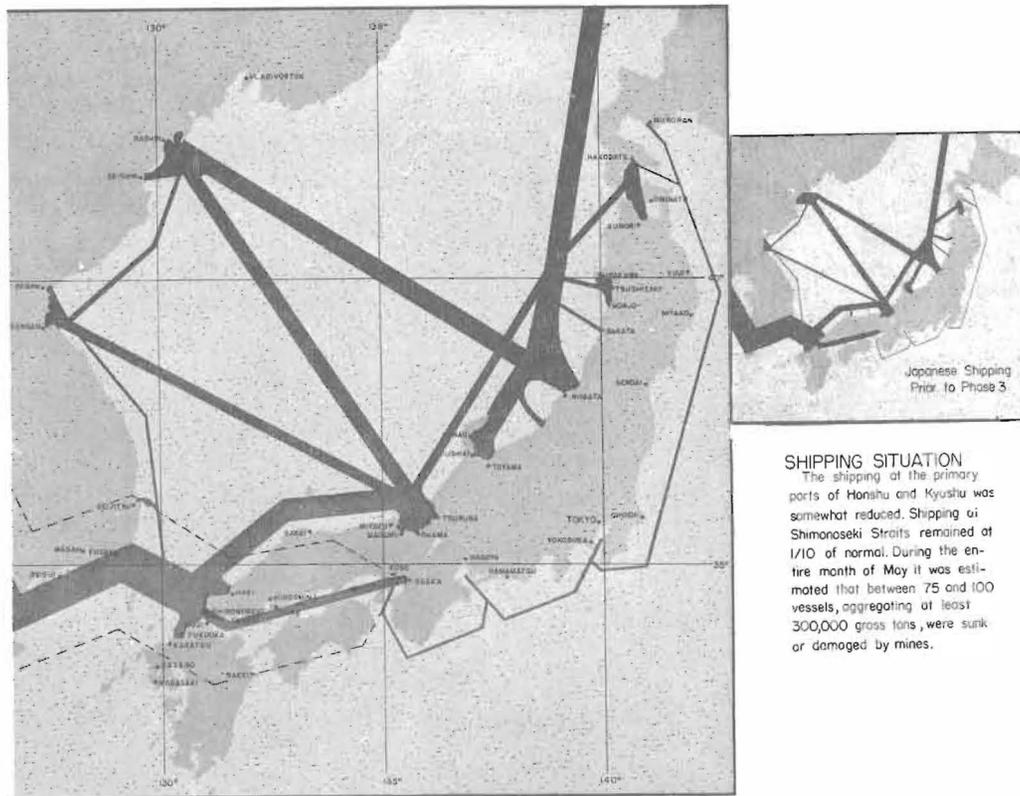
INTENSIFIED NORTHWESTERN HONSHU—KYUSHU BLOCKADE: PHASE IV OPERATIONS (7 JUNE TO 8 JULY 1945)

A study of May operations confirmed the tentative conclusion adopted for the planning of Phase III that maximum effectiveness in operations would be obtained by using many small missions carried out by single groups. It was therefore decided to use a single group of the 313th

Bomb Wing in laying mines during the month, carrying out operations on every other night and hitting a number of targets on each mission. This policy was expected to spread the enemy's sweeping effort over a maximum area, and frequent hitting of the most important targets was calculated to obtain closure for a maximum length of time. Phase III operations indicated that closure was obtained only for two to four days after each mining, even with very large efforts. The experimental mining of certain harbor areas, in particular Moji, Masure, and Hesaki anchorages, showed that these anchorages could be completely denied to the enemy. Because of the extreme importance of the dock facilities at Moji and the convoy arrangements at Moji, Hesaki, and Masure, it was determined to mine these harbors more intensively.

A general study of the enemy shipping indicated that mining of Tokyo, Nagoya, Nagasaki, Sasebo, and the general Inland Sea areas no longer would be profitable with closure of Shimonoseki Straits. Exceptions to this were the

MINES AGAINST JAPAN



SHIPPING SITUATION

The shipping at the primary ports of Honshu and Kyushu was somewhat reduced. Shipping in Shimonoseki Straits remained at 1/10 of normal. During the entire month of May it was estimated that between 75 and 100 vessels, aggregating at least 300,000 gross tons, were sunk or damaged by mines.

Figure 7-9. Diversion of Enemy Shipping After Phase III

harbors of Kobe-Osaka, which still maintained relatively heavy amounts of shipping of large size, probably shipping which had succeeded in crossing the Straits blockade or was engaged in local dispersal of the industrial facilities of Kobe-Osaka. It was concluded that the enemy's probable reaction to submarine and search plane attacks would be to withdraw his shipping from the Yellow Sea to the Sea of Japan and to make increasing use of the northwest Honshu ports.

In order to utilize one group to a maximum extent, it was desirable to plan missions one month ahead. This made it necessary to forecast the enemy's reaction as far ahead as possible. The heavy load on the Mine Assembly Depot, occasioned by the complicated preparation of the mines, also made it necessary to specify the targets as far in advance as possible because the mines had to be prepared ahead of time for each specific target. Shimonoseki Straits was still regarded as the first priority target, especially in view of the predicted transfer of shipping from the Yellow Sea. Its closure was regarded as the primary objective. Most of the remaining effort was to be devoted to other ports of northwestern Honshu. This decision was implemented in the directives given to the 313th Bomb Wing. Modification

of the original directive was necessitated by minor variations in the enemy's reaction from the forecast.

A study of the results obtained from Phase III confirmed the tentative conclusion adopted in planning these missions with respect to the preparation of mines. Reliable information indicated that enemy countermeasures were not yet fully developed and that as a consequence he would probably continue to pass ships through mine fields regardless of losses in order to obtain badly needed supplies. There were strong indications, however, that because of his heavy mining losses the enemy was attempting to develop extensive countermeasures. At the conclusion of the June effort these countermeasures, especially clearance methods, probably would be well organized. Maximum effort during June was especially desirable with the use of the unsweepable A-6 pressure mechanism and with modified magnetic mines which were also believed to be temporarily unsweepable. But the total effort was limited by logistics, and complete blockade was not feasible. It was therefore important to obtain the maximum objective possible with limited means.

The distribution of ship sizes in the enemy traffic was again carefully studied, and it was concluded that maximum

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closure in tonnage and maximum attrition in total tonnage, also a very important factor, should be continued by selection of large ship sizes for sinking. This decision would permit passage of small ships but would make closure to large ships prolonged. Also, it was concluded that the amount of ship traffic would be sufficient to warrant the continued use of narrow target widths in order to get a maximum ratio of sinkings to damage. The general attrition effect would be the sinking and damaging of ships well above the average size.

It was believed that the A-3 acoustic mechanism was completely sweepable, and that its value was low except as a nuisance and antisweep mine. Every indication pointed to the same situation with respect to the A-5 subsonic mechanism. Little or no definite technical information regarding the operational characteristics of the A-5 subsonic mechanism was available. This made difficult a reasonable assessment of its capabilities. Although no final conclusion concerning the A-5 subsonic mechanism could be drawn at this time, to ensure effectiveness it was believed that arming delays and ship counts would be necessary. The A-6 pres-

sure mechanism was still regarded as unsweepable. The magnetic mechanisms were regarded as very nearly so, although there were strong indications that the enemy was developing new types of sweeps, showing definite knowledge of the altered characteristics of the magnetic mines.

It was necessary to make every mine as effective as possible. The most important consideration in the preparation of the mines, therefore, was to mine for the greatest possible number of larger ships, using a narrow target width in order to obtain a maximum number of sinkings and heavy damage and to do this while at the same time confronting the enemy with maximum difficulty in the sweeping of mine fields. A total of 404 aircraft were airborne to lay 3542 effective mines in the target, with the loss of one aircraft. The effort is shown in Figure 7-10.

During Phase IV the normal 2-to-4-day port closure appeared to continue after each mining mission to the major ports. Substantially longer periods of closure, perhaps as much as two weeks, were obtained at the smaller ports undoubtedly as the result of the enemy's unpreparedness for mine sweeping at those ports. During the latter part

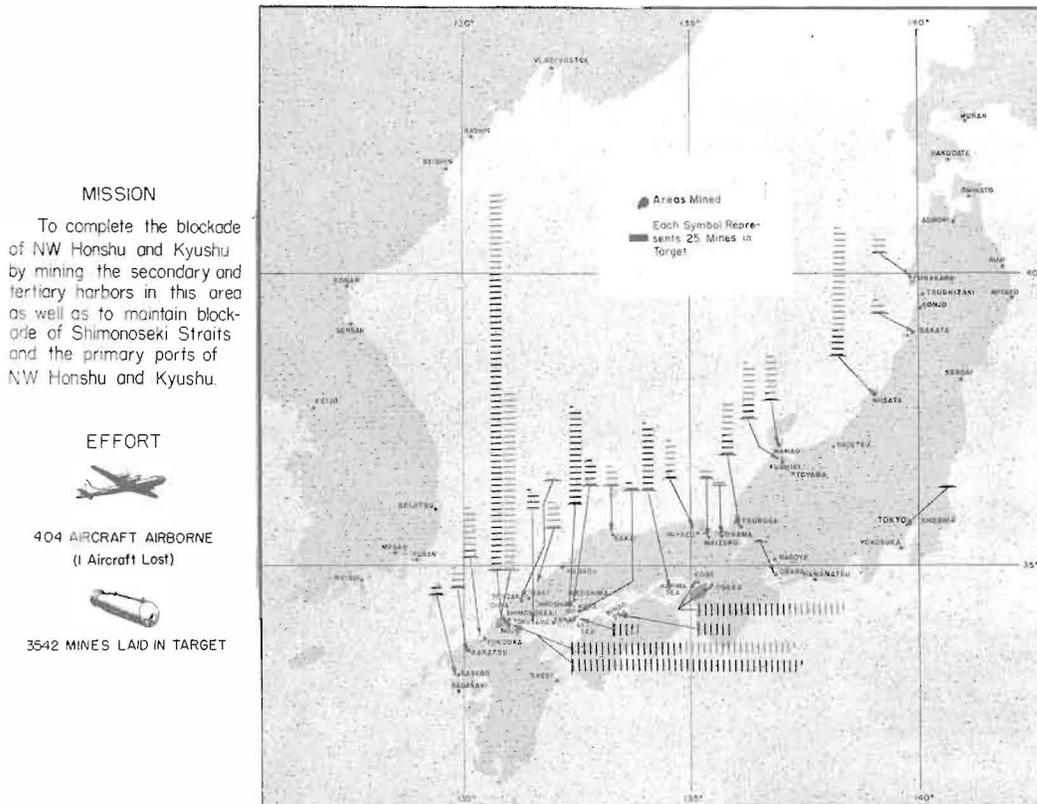


Figure 7-10. Phase IV: Intensified NW Honshu-Kyushu Blockade, 7 June-8 July 1945

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of Phase IV a new type of enemy sweep for magnetic mines was photographed. It appeared to be essentially a floating electric loop energized by a generator carried on a small vessel. It was estimated that this sweep was practical and would be successful against the magnetic mines. By the end of Phase IV the enemy apparently had the capability of sweeping successfully both the A-3 acoustic and the magnetic mines. Little intelligence was available on the development of sweeping methods for the A-5 subsonic mine, but technical tests indicated that the mine was sweepable by explosive methods. Other tests indicated that the mine would fire spontaneously on a variety of ever-present underwater noises. The A-6 pressure mechanism was still considered unsweepable, but the enemy, having learned of the principle of the mine, was assumed to have adopted the known countermeasure of sailing at low speed in order to limit the pressure change to a point below that necessary to detonate the mine. It was believed that enemy countermeasures to mining in the home islands of Japan were reaching the point at which the profit from mining would soon begin to decline — barring some major change in the pattern of the mining operations.

Early in July it became apparent that the Japanese had abandoned the ports of the Yellow Sea as ports of

export to the home islands. This fact meant that substantially all exports from the Asiatic continent to Japan would have to be funneled through a limited number of ports on the southern and eastern coasts of Korea, principally Fusan, Masan, Genzan, Konan, Seishin and Rashin. There was evidence that the enemy was still intent upon using the Shimonoseki Straits port complex, despite the constant re-mining, and that efforts were still being made to keep open the major port areas of northwestern Honshu. The estimated shipping situation is shown in Figure 7-11. An estimated 300,000 gross tons of shipping were believed to have been mined during June.

COMPLETE BLOCKADE: PHASE V OPERATIONS (9 JULY TO 5 AUGUST 1945)

Reliable intelligence concerning the Phase IV mining missions confirmed the conclusions adopted in planning these missions. The shipping attacks by United States submarines and Fleet Air Wing One in the Yellow Sea area and off the southern tip of Korea had definitely forced the enemy to withdraw his shipping from the Yellow Sea into the Sea of Japan. It was believed that this withdrawal was very much hastened by the decrease in the amount of shipping available to him, a large part of this loss being

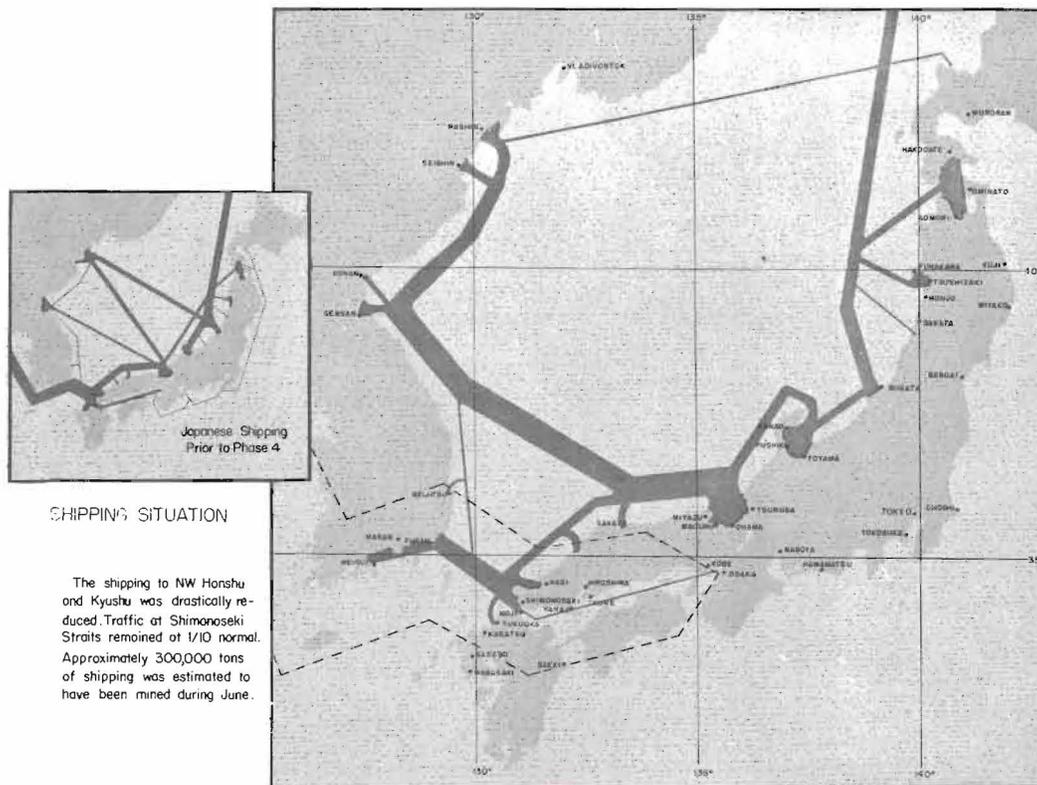


Figure 7-11. Diversion of Enemy Shipping After Phase IV

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occasioned by mining casualties. Fewer and fewer ships were seen by Fleet Air Wing One during the month. Reconnaissance indicated very strongly that, through the Inland Sea areas, the amount of shipping traffic of 1000 tons or over had decreased to a very small figure. The enemy still made use of the Shimonoseki Straits region for unloading, but it appeared that the majority of the ships did not pass through the Straits but unloaded at the various Straits ports. However, the principal port of Moji and the anchorages at Matsure and Hesaki appeared to be completely abandoned. No shipping was seen in these anchorages or ports in the reconnaissance of the area during the month. This was regarded as especially significant in the case of Moji, which contained the principal loading facilities in the area. Shipping continued to use those ports on the outer edges of the Straits narrows which had not yet been very heavily mined, while many ships now anchored in the swift current of the Straits themselves. These ports of the Shimonoseki Straits were not suitable for mining because of swift currents, although mining the edges of the Straits channels appeared to be possible.

During the month of June Navy submarines had made sorties into the Sea of Japan and destroyed approximately 80,000 tons of shipping there. This forced the enemy to adopt convoy tactics and to re-route much of his traffic to night routes, taking refuge during the day in sheltered anchorages. Fleet Air Wing One continued to attack shipping off the southern tip of Korea and made an increasing number of sorties across Tsushima Straits. The enemy shipping situation at the beginning of the month, therefore, presented a picture of concentration of most of his major shipping within the Sea of Japan in the heart of the Inner Zone. This shipping had as one group of termini the ports of eastern Korea stretching between Fusan, Rashin, and Yuki, with ports between Karatsu in Kyushu and Funakawa on northwest Honshu as the other termini. Little or no shipping passed into the Inland Sea. Large imports of coal and fish products still passed into northern Honshu from Hokkaido via railroad ferries.

The forecast of the enemy reaction for the month of July took into account four other agencies which were preparing to attack shipping in the Inner Zone. The first of these were Okinawa-based aircraft, both Army and Navy, which could extend the aerial blockade of shipping across Tsushima Straits, as well as attack land transportation facilities and shipping in the Shimonoseki Straits region. They could also attack shipping at Nagasaki and Sasebo. The second agency was the Third Fleet whose operation plan was available. The Fleet planned attacks on the northern tip of Honshu and on Hokkaido with high priority given to shipping, especially to the railroad ferries between the two islands, and with antishipping sorties planned against northwestern Honshu ports between Sakata and Funakawa. Later

attacks were planned by the Fleet against aircraft facilities between the regions of Kure and Tokyo with a strong possibility that attacks on enemy shipping were to be made by surface craft and fast carrier forces. Further attacks were also planned on shipping at Fusan and Shimonoseki. There was every possibility that the Fleet would continue to attack shipping over the entire region ranging from Shimonoseki Straits to Hokkaido, including such ports as Maizuru. The third force able to contribute appreciably was made up of the air agencies based on Iwo Jima, concentrating on shipping strikes in the general Tokyo region. Fourth, tentative plans also existed for a small-scale renewal, during July, of U.S. submarine attacks against shipping inside the Sea of Japan.

It was expected that as a result of the heavy pressure in the south Korean and Shimonoseki Straits region enemy shipping would probably shift during the month, abandoning the south Korean ports and possibly the Shimonoseki Straits itself, and, provided the Fleet's strikes on Hokkaido were successful, shipping from Hokkaido would be very greatly reduced because of the destruction of port facilities and sinkings in the harbors. The tendency would be to drive shipping to ports lying between Yuya Wan and Funakawa on northwestern Honshu and between Genzan and Rashin in Korea.

There was increasing evidence that the enemy's countermeasures were becoming more successful in the ports which had been mined for a long time. This was attributed to several factors, one of which was the probability that the enemy's mine watch was becoming increasingly efficient. He continued to use searchlights to locate positions in which mines had dropped and to use aircraft to escort United States mine laying aircraft to determine their dropping positions. Special technical tests under the supervision of the Mine Modification Unit were carried out at Oahu on the A-5 subsonic mechanism. These tests provided positive evidence that this mechanism could be swept easily by explosive methods and would probably explode spontaneously due to noises which might often be present in the mine fields. The tests and other reliable evidence indicated that the A-5 subsonic mechanism now could be easily swept by the enemy, so that its effectiveness was greatly reduced. The enemy's new magnetic sweep appeared in numbers. This sweep was the floating loop type, considered a very effective countermeasure against the modified magnetic mines. No definite method of defeating it appeared feasible by further modification of the magnetic mines, and reduction in their effectiveness was expected. The A-6 mechanism was still regarded as unsweepable.

The plan for July was limited by logistic consideration in that only a limited number of magnetic mines and of unsweepable A-6 mechanisms was available. A very considerable proportion of acoustic mines was on hand. It

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was considered, however that the enemy would still find it difficult to meet a large-scale attack, even though a large proportion of acoustic mines was included in the mining — provided that a considerable amount of mining was carried out against the Korean termini and at other diversionary ports where mine warfare countermeasures had not yet been organized. The enemy could be expected to consider his north Korean ports out of range of B-29 operations and would therefore be surprised by the attack on these ports where he undoubtedly lacked appreciable preparation in either antiaircraft defenses or mine warfare defenses. It was essential, however to maintain the blockade of the Shimonoseki Straits area, the ports of Niigata and Fushiki, and other major northwest Honshu ports until attacks by other United States forces could be completely implemented. This would probably not be possible until some time in September.

Shimonoseki Straits were believed to be very nearly closed. The amount of ship traffic there as shown by reconnaissance was about one-tenth of that estimated for the early months of the year. It was necessary to maintain this blockade. Losses and flak damage at the Shimonoseki Straits indicated a heavy reinforcement of enemy defenses there and the use of new high-altitude automatic weapons. During Phase V the 313th Bomb Wing requested permission to use higher altitudes of attack at this target and at Maizuru. It was believed that accuracy would not be too adversely affected by raising the mining altitude because increased experience of mine laying crews had made them much more skilled than in earlier operations. A long lapse in reconnaissance coverage caused by weather had made the positions of possible relocations of the Shimonoseki channels uncertain. This made a small reduction in accuracy less important. It was therefore decided to raise the permissible mining altitude of these two targets during Phase V.

These decisions were implemented in directives to the Wing. Revisions were necessitated during the month because of the successes of the Fleet attacks on Hokkaido and northwest Honshu and of Fleet Air Wing One in destroying rail traffic in Korea. The last was believed to have brought about a great reduction in traffic to Fusan. Reliable evidence also indicated continued improvement in enemy countermeasures, especially in the widespread appearance of the floating loop sweep. The result was a reduction in the length of closure obtained. The enemy appeared to be concentrating this sweeping in limited areas. Because of his withdrawal of shipping to Korean termini between Genzan and Rashin, it was considered essential to prevent any ship movement at Seishin and Rashin by a very heavy mining attack. The same evidence indicated that mining of the ports of Fushiki and Niigata was becoming less and less effective.

At this stage the general conclusion in regard to mine

preparation was that the A-6 mechanism was still unsweepable, that the A-3 and A-5 mechanisms were easily swept, and that the magnetic mechanisms would rapidly become sweepable during the month because of the appearance of the enemy's new floating loop sweep, which was evaluated as effective. The enemy was expected to make increasing and effective use of clearance methods as shown by his extensive use of mine watches. All of this evidence strongly indicated the need for the use of arming delays and ship counts on the magnetic and acoustic mechanisms in order to defeat sweeping methods, except where clearance would be easy because of a good mine watch and a small target area. There was a strong indication that the average size of operable ships was smaller than in previous months. A re-evaluation was made of the effect the changed distribution in enemy ship sizes would have on modifications and sensitivity of adjustments required to obtain the maximum return from mining.

Intercepts of Japanese home radio broadcasts clearly indicated that the Empire's food situation was in very serious straits. It was determined to utilize the emotional importance of hunger to heighten the effect of the mines. Approximately 4,500,000 psychological warfare leaflets (see Chapter 5) were dropped by the 313th Bomb Wing over the major cities of Japan during Phase V. A total of 474 aircraft was airborne to drop 3746 mines effectively in the target areas, with a loss of six aircraft. The effort is shown in Figure 7-12.

Intelligence on the closure effect of the Phase V mining indicated that at the ports of Honshu Japanese countermeasures were improving and that, on the average, closure effect was probably from 25 to 50 percent less than previously. It was believed that substantially no closure at Fushiki was being achieved during this phase. Closure of the ports of Korea was somewhat longer than that at Honshu ports. Evidence on the Korean situation was far from complete, however. It is believed the enemy was unprepared to counter mining operations in Korea, and the longer closure noted was to be expected. It is of interest to note that on 6 August only about 15,000 tons of operational shipping were photographed at Fusan, where over 100,000 tons had been photographed a few months earlier. During the course of Phase V evidence became available that task force operations had sunk or damaged the Hakodate-Aomori rail ferries (except possibly one or two). The volume of shipping at Fusan was decreasing (possibly caused in part by successful air attacks against rail bridges on lines leading into Fusan). As a result of this information, it was deemed advisable to augment the effort against Rashin, which meant decreasing the effort against other targets. Fusan, Niigata, Fushiki, Sakata, and Funakawa were dropped from the schedule of targets because of information that ship traffic was decreasing at these ports or that the enemy was successfully

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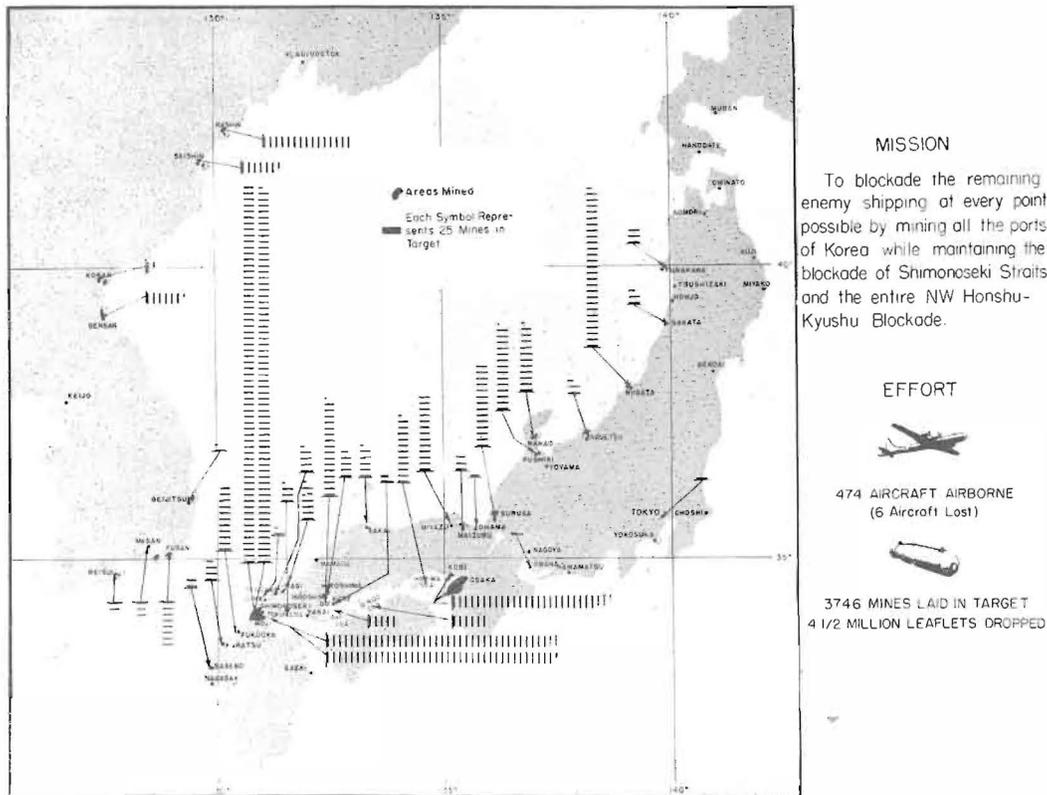


Figure 7-12. Phase V: Total Blockade, 9 July - 15 August 1945

sweeping the mines there. Most of the effort diverted from those five ports was scheduled for Rashin, although some missions were planned against smaller ports on the Japan Sea coast of Honshu where an increase in ship traffic was noted. It is believed that Rashin was closed for most of the period 11 July to the end of the month.

No new mine sweeps or countermeasures were noted during Phase V, although there was an increase in the number of electric loop sweeps. At least six of these sweeps were noted at different ports during this phase. Reconnaissance indicated that the amount of enemy operable shipping had dropped to less than 400,000 tons. Ship losses during the Phase V were estimated to be 300,000 gross tons or more. The enemy ship situation is shown in Figure 7-13. Only a small fraction of the once heavy enemy ship traffic still flowed to the Empire from the Asiatic continent. The shipment of all raw materials had ceased. The shipment of food was only a fraction of that required by the Home Islands. Japan was already blockaded as the Twentieth Air Force laid the last mines on the northwestern coast of Honshu, just as the war ended.

SUMMARY OF ESTIMATED RESULTS

At the end of the campaign the estimated results from Inner Zone reports were as given below. (It is interesting to compare these estimated results with the established results obtained from Japanese records as given in Chapter 3.) The estimates made in this analysis were partly based upon inadequate information, since direct intelligence, such as photos of sunken ships, was rarely available on the complete effect of the mining. The estimates were based upon a synthesis of all known sources of information including all types of aircraft reconnaissance, submarine reconnaissance, captured enemy documents and equipment, prisoner-of-war interrogation, and Japanese plain language broadcasts.

A total of 1528 aircraft was airborne to lay 12,053 mines effectively in the targets, with a total loss of 15 aircraft. Nine aircraft were lost to enemy action, eight on the approach to or at the heavily defended Shimonoseki Straits targets, and one at Niigata. All of the aircraft were lost when 0/10 to 5/10 cloud cover and many searchlights were reported over the targets, with numerous aircraft reported

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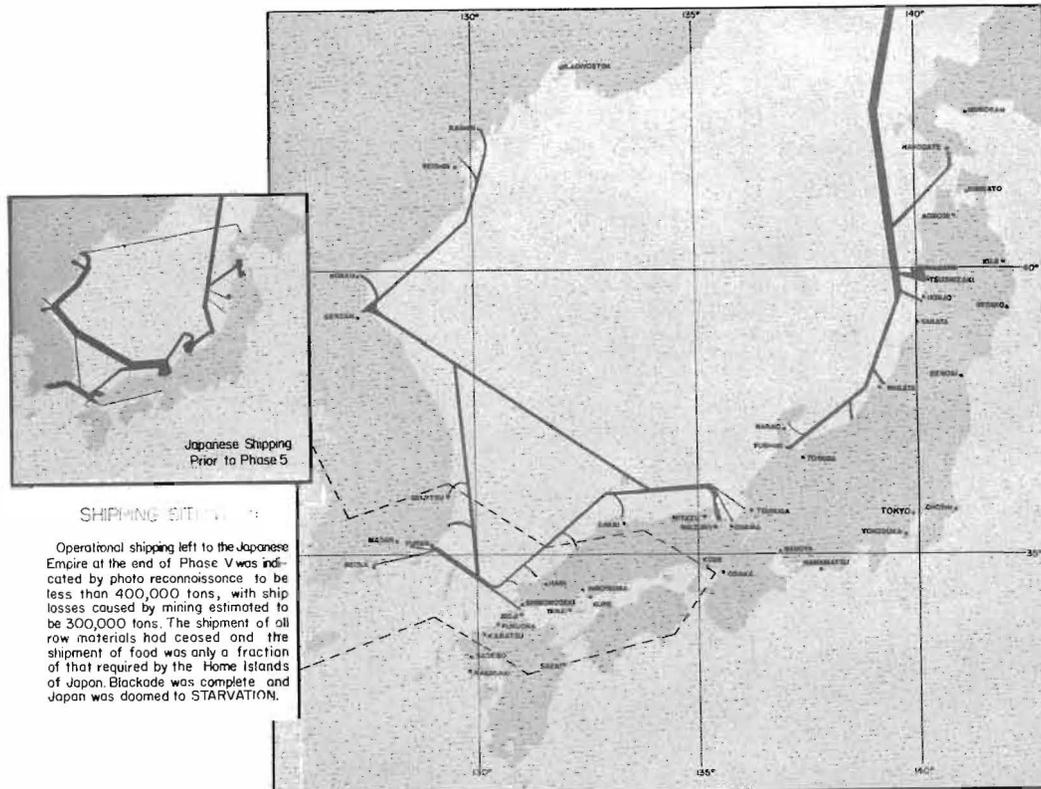


Figure 7-13. Division of Enemy Shipping After Phase V

coned in the searchlights. No aircraft were lost when the targets were heavily overcast.

The requirements for continuous mining were not always compatible with the maximum safety of the aircraft. During later missions every attempt was made to select overcast conditions for the most dangerous missions and to raise the mining altitude. This was partly nullified by increased enemy defenses and weather uncertainty. It is clear that enemy radar fire control was ineffective, probably because of radar countermeasures, and that the mining was carried out with the least losses during overcast conditions at the target. A statistical summary of the entire mining effort is given in Figure 7-14 and Tables 7-1 and 7-2.

Mining established an effective blockade at the end of four and a half months, and enemy shipping which remained operable was reduced to the status of blockade running. After the first month of mining, imports to Japan fell below 50 percent and it is estimated they gradually declined to about 10 percent of the pre-mining figure. Shipping through Shimonoseki Straits and the Inland Sea was reduced to 10 percent of its pre-mining status by June. The great port of Moji was abandoned at the end of May, together with the anchorages of Hesaki and Matsure. By the end of June the port of Niigata was little used; Fusan was abandoned early in July; and Rashin became unusable during the second half of July. The documentation for blockade

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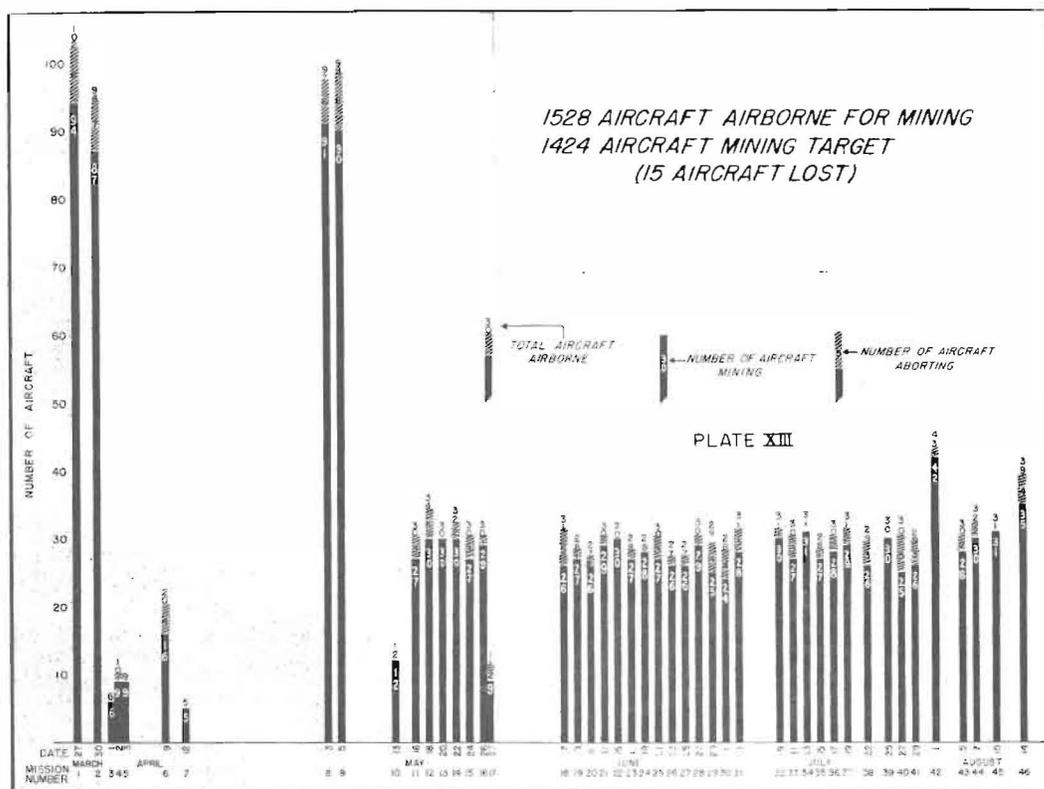


Figure 7-14. Twentieth Air Force Mining Sortie Effort

Table 7-1. STATISTICAL SUMMARY OF TWENTIETH AIR FORCE MINING OPERATIONS, 27 MARCH - 15 AUGUST 1945

MISSIONS		MINES	
Number of missions flown.....	46	Number of mines laid on target.....	12,053
SORTIES		Percentage of 1000-lb. size	49
Number of mining aircraft airborne.....	1,528	Percentage of 2000-lb. size	51
Number of auxiliary aircraft airborne.....	86	Percentages of mine types	
Total number of aircraft airborne	1,614	Magnetic	41
Number of aircraft mining target	1,424	Acoustic	29
Percentage of effective airborne mining aircraft	93.2	Pressure-Magnetic.....	24
Number of mining aircraft scheduled.....	1,560	Low frequency	6
Percentage mining of mining aircraft scheduled..	91.2	Number of mines expended.....	13,102
AIRCRAFT LOSSES		Percentage of mines expended on mining target..	919
Number of aircraft lost of aircraft airborne.....	15	Total mine tonnage laid on target.....	8,989.6
Percentage aircraft lost of aircraft airborne	0.9	LOAD	
Percentage of all other 20th AF combat aircraft lost in some period.....	1.01	Average number of mines carried per aircraft per mission (12X1000-lb mines or 6 to 8X2000-lb. mines).	8.5
Number of aircraft lost to enemy action.....	9	DISTANCE	
Percentage of aircraft lost to enemy action	0.6	Average distance flown, in nautical miles (Shimonoseki straits, with 12X1000-lb. or 7X2000-lb mines)	2,870
Percentage of all other 20th AF combat aircraft lost to enemy action in same period.....	0.4	Longest distance flown, in nautical miles (Funokowa, with 12X1000-lb. mines)	3,110
PERSONNEL CASUALTIES		Longest distance flown by stoging through Iwo Jima (Rashin, with 12X1000-lb mines or 7X2000-lb mines)	3,675
Number of men participating in mining flights.....	17,791	All missions were flown at night. All drops were made by radar. Over 90 percent of the mines were dropped from altitudes of 5000 to 8000 feet	
Number of men killed or missing.....	103		
Percentage killed or missing	0.6		
Total number of casualties	117		
Percentage of casualties	0.7		

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Table 7-2. PHASE BREAKDOWN OF TWENTIETH AIR FORCE MINING OPERATIONS

STATISTICAL SUMMARY

PHASE I. OKINAWA SUPPORT

20th AF Mission Number	Mining Mission Number	Date 1945	Target Name	A/C Scheduled for Mining	A/C Airborne for Mining	A/C Mining Target	Aux. A/C Airborne	Total A/C Airborne	A/C Lost to Enemy Action	A/C Lost to Other Causes	Total A/C Lost	Mines Suspended	Mines In Target	Altitude in Feet	
47	1	27 March	Shimonoseki S., Suo Noda	105	102	94	2	104	3	0	3	924	837	5,000	
49	2	30 March	Shimonoseki S., Kure, Hiroshima, Sasebo	102	94	87	2	96	0	2	2	906	825	5,000	
52	3	1 April	Kure	6	6	6	2	8	0	0	0	48	48	25,700-26,450	
53	4	2 April	Kure, Hiroshima	10	10	9	1	11	0	0	0	84	78	6,000-6,100	
54	5	3 April	Kure, Hiroshima	10	9	9	2	11	0	0	0	84	83	6,000-6,150	
62	6	9 April	Shimonoseki S.	20	20	16	1	21	0	0	0	132	106	5,000-6,300	
66	7	12 April	Shimonoseki S.	5	5	5	1	6	0	0	0	53	33	6,800-7,710	
TOTALS				7 Miss	17 days	258	246	226	11	257	3	2	5	2231	2030

MINE SIZES: 68%, 1000 lb. size; 32%, 2000 lb. size FIRING MECHANISM TYPES: 25% Magnetic; 75% Acoustic

PHASE II. INDUSTRIAL CENTER BLOCKADE

139	8	3 May	Shimonoseki S., Kobe, Osaka, Suo Noda	100	97	91	2	99	0	0	0	740	694	4,800-8,650
150	9	5 May	Inland Sea, Kobe, Osaka, Tokyo, Nagoya	99	96	90	4	102	0	0	0	809	728	6,000-8,400
TOTALS				2 Miss	3 days	199	195	181	6	201	0	0	1549	1422

MINE SIZES: 36%, 1000 lb. size; 64%, 2000 lb. size FIRING MECHANISM TYPES: 23% Magnetic; 27% Acoustic; 50% Pressure Magnetic

PHASE III. NW HONSHU-KYUSHU BLOCKADE

173	10	13 May	Shimonoseki S., Niigata	12	12	12	2	14	0	0	0	140	139	5,800-8,030	
175	11	16 May	Shimonoseki S., Miyazu, Maizuru	30	30	27	1	31	0	0	0	186	165	6,200-11,000	
177	12	18 May	Shimonoseki S., Tsurugo	34	34	30	2	36	0	0	0	216	192	5,800-6,700	
179	13	20 May	Shimonoseki S., Maizuru, Miyazu	32	30	30	1	31	0	1	1	184	184	5,500-6,500	
180	14	22 May	Shimonoseki S.	32	32	30	1	33	1	0	1	192	178	5,300-8,100	
182	15	24 May	Shimonoseki S., Niigata, Nonao, Fushiki	31	30	27	2	32	0	0	0	210	186	5,900-8,200	
184	16	26 May	Shimonoseki S., Fukuoka, Karatsu, Fushiki	30	30	29	2	32	0	0	0	220	206	5,900-8,200	
185	17	27 May	Shimonoseki S., Moji	11	11	9	0	11	1	0	1	77	63	7,450-7,700	
TOTALS				8 Miss	15 Days	212	209	194	11	220	2	1	3	1425	1313

MINE SIZES: 12%, 1000 lb. size; 88%, 2000 lb. size FIRING MECHANISM TYPES: 54% Magnetic; 9% Acoustic; 24% Pressure Magnetic; 13% Low Frequency

PHASE IV. INTENSIFIED NW HONSHU-KYUSHU BLOCKADE

20th AF Mission Number	Mining Mission Number	Date 1945	Target Name	A/C Scheduled for Mining	A/C Airborne for Mining	A/C Mining Target	Aux. A/C Airborne	Total A/C Airborne	A/C Lost to Enemy Action	A/C Lost to other Causes	Total A/C Lost	Mines Suspended	Mines In Target	Altitude in Feet
190	18	7 June	Shimonoseki S., Fukuoka	33	31	26	1	32	0	0	0	337	279	5,700-8,400
194	19	9 June	Shimonoseki S.	29	28	27	1	29	0	0	0	241	234	6,200-8,900
201	20	11 June	Shimonoseki S., Tsurugo	28	27	26	2	29	0	0	0	189	182	7,200-8,200
202	21	13 June	Shimonoseki S., Niigata	30	30	29	2	32	0	0	0	330	311	7,000-7,700
204	22	15 June	Shimonoseki S., Fushiki, Fukuoka, Karatsu	31	30	30	2	32	0	0	0	320	297	7,800-9,000
205	23	17 June	Shimonoseki S., Kobe	28	28	27	2	30	0	0	0	301	277	6,200-8,350
213	24	19 June	Shimonoseki S., Niigata, Miyazu, Maizuru	28	28	28	2	30	0	0	0	256	256	8,000-8,800
214	25	21 June	Ouro, Senzaki, Nonao, Fushiki, Osaka	30	30	27	2	32	0	0	0	320	284	6,500-8,600
221	26	23 June	Karatsu, Fukuoka, Sakai, Niigata	28	27	26	2	29	0	1	1	289	277	4,200-8,700
222	27	25 June	Shimonoseki S., Tsurugo, Otomo	28	27	26	2	29	0	0	0	209	201	6,300-8,700
233	28	27 June	Hagi, Niigata, Kobe, Osaka	30	30	29	2	32	0	0	0	290	275	6,700-8,700
239	29	29 June	Shimonoseki S., Maizuru, Sakato	30	29	25	2	31	0	0	0	263	225	4,200-8,500
244	30	1 July	Shimonoseki S., Nonao, Fushiki	29	28	24	1	29	0	0	0	241	203	7,200-8,700
246	31	3 July	Shimonoseki S., Maizuru, Funakawa	31	31	28	2	33	0	0	0	262	241	7,200-8,900
TOTALS				14 Miss	27 Days	413	404	378	25	429	0	1	3848	3542

MINE SIZES: 63%, 1000 lb. size; 37%, 2000 lb. size FIRING MECHANISM TYPES: 55% Magnetic; 21% Acoustic; 21% Pressure-Magnetic; 3% Low Frequency

PHASE V. TOTAL BLOCKADE

256	32	9 July	Shimonoseki S., Niigata, Fushiki	31	31	30	1	32	1	0	1	292	274	6,900-8,800	
262	33	11 July	Roshin, Fuson, Maizuru, Shimonoseki S.	30	30	27	2	32	0	0	0	221	199	6,900-9,400	
268	34	13 July	Seishin, Masan, Reisu, Shimonoseki S., Fukuoka	31	31	31	3	34	0	0	0	262	254	6,900-12,550	
269	35	15 July	Roshin, Genzan, Konon, Fuson, Noetsu, Niigata	28	28	27	2	30	0	0	0	256	244	6,900-8,400	
275	36	17 July	Shimonoseki S., Seishin, Nonao, Fushiki	30	30	28	3	33	0	0	0	260	238	7,100-8,500	
276	37	19 July	Niigata, Kobe, Osaka, Maizuru, Miyazu, Genzan, Konon	31	31	29	2	33	0	1	1	242	228	7,100-8,400	
282	38	22 July	Shimonoseki S., Roshin, Fuson, Masan	30	29	26	2	31	0	1	1	228	207	7,600-8,300	
292	39	25 July	Seishin, Fuson, Fushiki, Nonao, Otomo, Tsurugo	30	30	30	2	32	0	0	0	245	243	6,900-8,400	
296	40	27 July	Shimonoseki S., Niigata, Miyazu, Maizuru, Senzaki	30	30	25	3	33	0	3	3	235	189	8,000-10,400	
304	41	29 July	Roshin, Fukuoka, Shimonoseki S.	30	29	26	3	32	0	0	0	228	196	7,900-12,900	
305	42	1 Aug.	Roshin, Homado, Seishin, Shimonoseki S.	45	43	42	2	45	0	0	0	376	354	6,900-12,000	
311	43	5 Aug.	Roshin, Geijitsu, Tsurugo, Ouro, Hagi	30	30	28	0	30	0	0	0	275	253	7,000-8,600	
318	44	7 Aug.	Shimonoseki S., Maizuru, Sakai, Roshin	32	32	30	2	34	0	0	0	279	255	7,200-12,000	
324	45	10 Aug.	Hagi, Yujawan, Shimonoseki S., Genzan	32	31	31	3	34	0	0	0	272	269	7,500-12,900	
331	46	14 Aug.	Nonao, Shimonoseki S., Maizuru, Homado	33	33	33	3	42	0	0	0	378	343	8,000-12,800	
TOTALS				15 Miss	37 Days	479	474	445	33	507	1	5	6	4049	3746

MINE SIZES: 44%, 1000 lb. size; 56%, 2000 lb. size FIRING MECHANISM TYPES: 37% Magnetic; 19% Acoustic; 31% Pressure-Magnetic; 13% Low Frequency

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is voluminously covered in over a hundred reports by the Central Interpretation Unit. Typical results taken from these reports are given in Figures 7-15 and 7-16, which show the decline of shipping at Moji, and of ship traffic at Shimonoseki Straits. As a result of the mining blockade of Japan, the end of effective military and civilian production became inevitable and the lack of food imports made starvation of a large part of the population a certainty. This was the situation when Japan surrendered.

During the first tentative application of the general blockade in the Sea of Japan, the enemy shifted his shipping from port to port, temporarily avoiding newly and heavily mined ports but returning later if clearance had been effected. At first he apparently spread his sweeping effort over many harbors. Only after all ports were mined in force was he reduced to a steady defense of a few ports. It was clear that all ports had to be mined by a widespread effort to ensure blockade. As enemy experience in clearance made closure time shorter, it became necessary to mine *all principal harbors continuously* to ensure effective blockade. From the experience gained in enemy reaction at Shimonoseki Straits, an average of ten mines per ship passage appeared necessary to ensure blockade. This is an estimate and may not be very accurate, but it appeared that if fewer mines were dropped, traffic seemed to increase, and although more mines had some effect in increasing closure, this was not in proportion to justify the effort.

It is estimated that a total of 1,000,000 tons or more of Japanese shipping was mined as a by-product of the blockade. In spite of maximum possible enemy shipbuilding, enemy shipping afloat of 1000 tons and over declined from an estimated 1,800,000 tons in March to less than 660,000 in August (as determined by Twentieth Air Force reconnaissance), of which less than 350,000 tons were

operable in the Sea of Japan and effective in the importation of raw material.

By August photographic evidence of casualties showed 131,000 tons of shipping sunk in very shallow water or beached. The ships sunk in deep water could not, of course, be photographed, and although the mining operations began in March 1945, very little photographic documentary evidence was available until early in July. There is good reason to believe that many other ships than those listed in Table 7-3, known from photographic reconnaissance to be inactive, had been mined so heavily they required up to six months for repair. Typical was the 18,000 ton ex *Count Verdi* in Maizuru Harbor, reported inoperative for several months. It had undoubtedly been mined.

The enemy undertook mine countermeasures very intelligently *after* the campaign began. He established a mine watch and clearance methods which increased continually in effectiveness, until port closures were reduced to an estimated one to four days, depending on the target. Reconnaissance at Fushiki showed continuous use of the harbor towards the end of the mining operations. This harbor had been the most concentrated mining target area. Niigata, a more important target, but with a larger mineable channel, was more effectively closed; Shimonoseki Straits, Tsuruga, and similar targets of large mineable area were closed for the longest periods. Thus closure was obtained most effectively for the larger targets, and hardly at all for the smallest target. Towards the end of the mining campaign, the enemy tended to concentrate his shipping (and presumably his sweeping) in fewer harbors. Maizuru, for example, eventually received the shipping once shared between Miyazu, Obama, and Tsuruga after all of these ports had been heavily mined. Prior to heavy and continuous

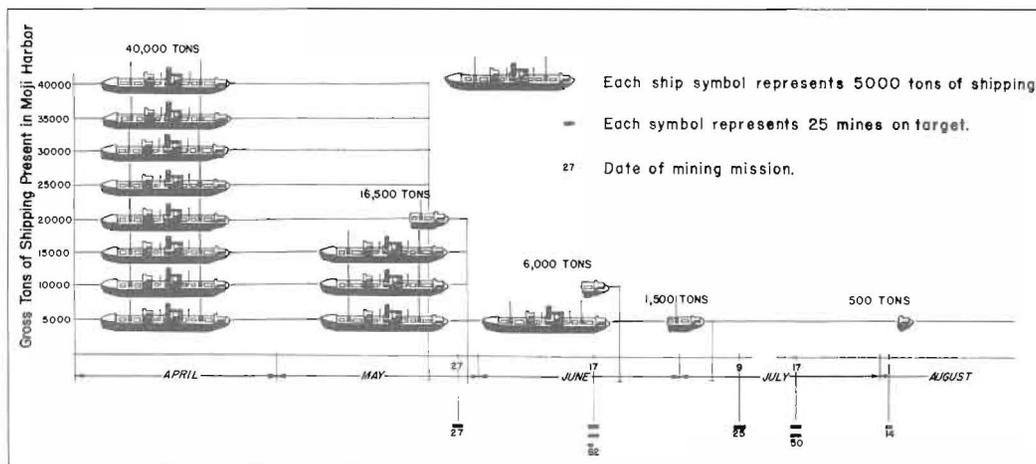


Figure 7-15: Decrease in Number of Ships at Moji Anchorage Caused by Mining

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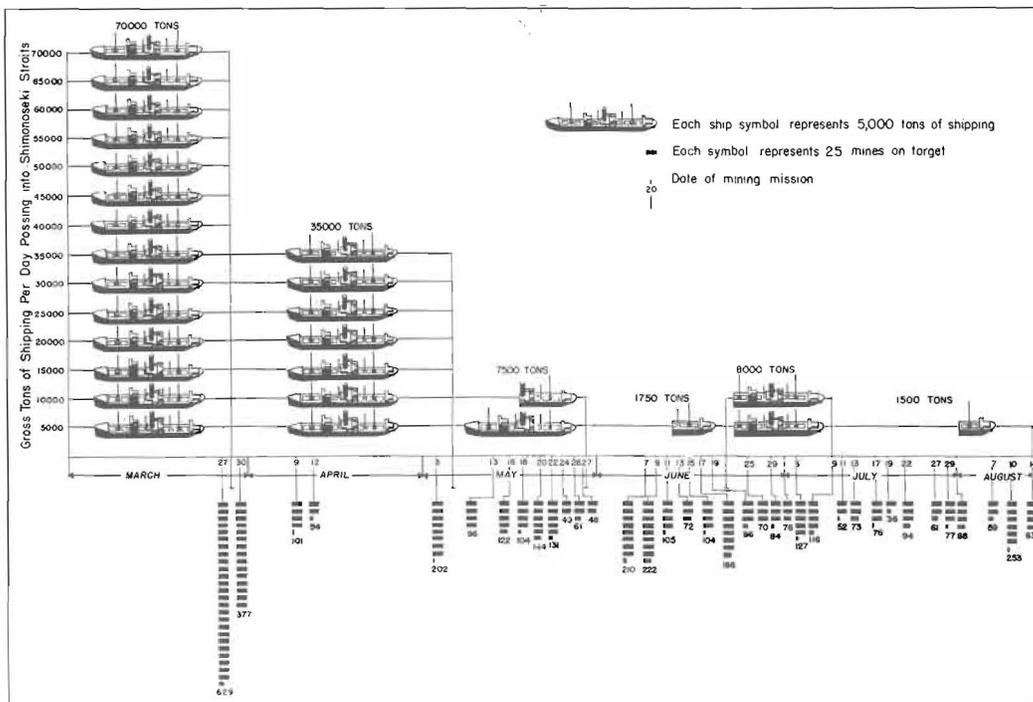


Figure 7-16. Decrease in Ship Passages at Shimonoseki Straits Caused by Mining

Table 7-3. SUNKEN SHIPS PHOTOGRAPHED

SBL (A-Mod)						FTC						SCL					
NO.	PHOTO DATE	MISS-ION #	PRINT NO.	WINDFIELD AREA	SHIP LOFT TONS	NO.	PHOTO DATE	MISS-ION #	PRINT NO.	WINDFIELD AREA	SHIP LOFT TONS	NO.	PHOTO DATE	MISS-ION #	PRINT NO.	WINDFIELD AREA	SHIP LOFT TONS
1	22/5	244	3L:70,71	Shimonoseki S	445 6670	19	6/7	362	3R:67	Maizuru	415 6250	34	7/8	390	2:65,67	Wakamatsu	310 2300
2	21/6	289	2:47,48	Shimonoseki S	445 6670	20	29/7	368	6R:173,174	Niigata	260 1590	35	7/8	390	2:65,67	Wakamatsu	310 2300
3	2/7	312	1R:51,2:59	Shimonoseki S	445 6670	21	29/7	368	6L:173,174	Niigata	270 1925	UNIDENTIFIED					
4	23/7	346	7:36	Tokuyama	445 6670	22	7/8	390	2:65,67	Wakamatsu	260 1590						
5	7/8	390	4R:86,87	Shimonoseki S	445 6670	23	7/8	395	1R:85,87	Shimonoseki S	260 1590	36	29/7	368	1R:114	Niigata	
6	7/8	390	2:65,66	Wakamatsu	445 6670	24	14/8	404	1R:104,105	Tsuruga	300 2245	37	29/7	368	1R:114	Niigata	
7	7/8	391	2:29	Koji	445 6670	TA						38	2/7	332	3L:73,84	Shimonoseki S	
8	21/6	289	2:47,48	Shimonoseki S	210 890							29	6/7	362	2:33	Maizuru	315 10200
9	22/7	345	2:61-65	Kobe	210 900	SBS						39	5/8	374	3R:1,4,12	Fussa	220 1000
10	7/8	390	4R:100	Shimonoseki S	210 900							26	22/7	345	1R:44	Kobe	260 1490
11	7/8	390	2:65,67	Wakamatsu	210 900	27	7/8	390	4R:110,112	Ube	330 3000	40	5/8	374	5:212	Fussa	340 3420
12	7/8	390	2:65,67	Wakamatsu	210 900	SAL						SEA TRUCK					
13	7/8	390	4R:110,111	Ube	210 900												
14	7/8	385	3R:79,80	Wakamatsu	210 900	FTD						MERCHANT					
15	4/7	314	1R:56	Osaka	180 800												
16	7/7	312	3L:300	Shimonoseki S	210 1000	31	7/8	390	4R:100	Shimonoseki S	200 810	CVE (KAIYO)					
17	5/8	374	1R:2	Fussa	230 1150	32	7/8	390	4R:100	Shimonoseki S	200 810						
18	6/8	383	3L:217,218	Oo Harbor	210 1000	33	7/8	390	2:65,67	Wakamatsu	220 1100						

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mining of *all* ports, traffic was shifted from one to the other as occasional mining dictated.

Mining by radar permitted night operations and efficient design of mine fields. Mining could be carried out easily and with safety even under overcast conditions. The accuracy attained, however, was limited by the resolution of the APQ-13 Radar and by the skill of the radar navigators. The results of a study of the accuracy attained show that 59 percent of the sticks fell within one mile of the assigned position, 33 percent between one and three miles, and 8 percent between three and ten miles. Further details are given in Chapter 8, Annex Z.

The position of the enemy-swept channels was sometimes known accurately. This was true of most channels at the Shimonoseki Straits which were usually about 2000 feet wide. Radar accuracy was not sufficient to ensure precise placement, and allowance for combat error in laying was necessary. The mine stick was adjusted in length so as to place a maximum number of mines in the channel. The length depended upon the estimated effect of the target geography, the initial point, and the aiming point. It is estimated that on the average 10 percent or less of the mines fell into the known swept channels.

The effect of mining depends upon a number of complex factors, all of which have been discussed. These include the accuracy of planting in enemy channels, the necessity for widespread and continuous mining (much of which produces blockade without in itself sinking ships), the efficiency of enemy clearance and the organization of his mine warfare countermeasures, and similar factors. However, the intrinsic technical characteristics of the mines are of the greatest importance and are a deciding factor in the final results achieved.

The mines used in this campaign consisted of one new and unsweepable type, the A-6 pressure mechanism, which was of excellent design; the two best standard magnetic types in existence — but whose general characteristics were in principle well known to the enemy and indeed to all belligerents; and two simple and ineffective acoustic types which were capable of being swept explosively. It is doubtful if the mining campaign would have succeeded without the Mine Modification Unit's ability to devise modifications of the magnetic mines. It was possible to capitalize upon a serious enemy mistake, namely his decision to mass-produce the towed catenary magnet sweep which was easily constructed and used. This enemy decision was unimaginative and permitted modification of our magnetic mechanisms so effective that they were essentially unsweepable for three months. When the enemy had corrected his production error the effectiveness of the magnetic mechanisms was reduced to one-third or less.

It is believed that the amount of tonnage sunk was doubled because of adjustment or modification of mines

for ship selection. The A-6 pressure mechanism was the only mechanism which was designed to permit ship selection; the magnetics had to be modified to this purpose. The A-3 acoustic and A-5 subsonic mechanisms were of small value in the campaign. The technical decision to produce these mines as simple acoustic mines rather than as combination magnetic-acoustic mines was unfortunate and did not utilize the experience of the European Theater. As a result the mines were easily swept and allowed no ship selection; although they were undoubtedly a nuisance to the enemy, they did not greatly affect the blockade. It was never possible to overcome, by modification of the A-3 acoustic mechanism or by adjustment of the A-5 subsonic mechanism, the fundamental defects in their design.

The enemy used intelligence, both in the organization of his mine sweeping and in his technical attack on our mines. As a result, he was finally able to counter some of them. The A-6 pressure mechanism remained unsweepable, but its effectiveness was reduced by the absence of combination magnetic-subsonic and magnetic-acoustic mechanisms mixed with it in the mine field, since, when laid alone, it could be defeated by proceeding at very low speeds.

An average of about 2500 mines per month was received on Tinian as compared to the 4000 per month required. The Commander in Chief, Pacific Fleet, authorized and desired a reserve of 4000 mines but this was never available; as a consequence, missions were planned for mines while they were still en route and the composition of the shipment was unknown. This made mission planning, mine field design, and mine preparation difficult. Mines were sometimes laid 36 hours after they arrived at Tinian. The number of mines logistically available was too small to ensure complete blockade from the beginning, or to utilize all the sorties made available by the Twentieth Air Force. At least double the quantity should have been available to ensure blockade. It was only by constant improvisation and by capitalizing upon the enemy's originally unforeseen weaknesses that the mission was accomplished. Its success depended upon the weak position of the enemy's shipping situation and upon the supplementary blockade and attrition obtained by direct air and submarine attacks.

CONCLUSION

Clearly the mining campaign had such high success because the enemy's shipping situation already had so seriously deteriorated at the beginning of the campaign that the effect of any further attrition was grossly magnified. The B-29 mining is estimated to have produced 60 percent of the attrition of enemy shipping between March and August. Alone, this would have been insufficient to produce the collapse of Japanese shipping. The coordinated attack by mining aircraft, antishipping aircraft (both Army and Navy), and submarines fortunately combined to

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achieve the final effect. United States submarines had taken the heavy and early toll of enemy shipping. Mining simply provided the knockout blow.

To summarize the lessons learned: (1) Mining by aircraft in sufficient force can by itself obtain blockade of an enemy's entire merchant or naval fleet. (2) Mining will produce heavy attrition as a by-product of blockade. About 100 tons of shipping can be mined per mine laid effectively in the target, or about 85 tons per mine airborne. (3) Mining must be widespread as well as heavy, so that the enemy cannot avoid the blockade. (4) The force to produce blockade at the vital ports or channels must be great and the operations continuous. Mining of *every* target *every* night, or every other night at a minimum, must be undertaken, and at least one mine must be laid in position actual-

ly to threaten ships in the channel for each ship passage attempted. To lay one mine in a channel, an average of ten mines is required to be dropped in the target area. (5) Effective mining can be obtained by area methods — pinpoint precision is not required or possible for large aircraft engaged in a large scale effort. An average radial error of one mile is adequate. Sufficient intelligence data to warrant pinpoint precision generally is not available. (6) Mines must be unsweepable to be effective over a long period (three months). (7) If the target is small the enemy can and will use effective clearance methods even against unsweepable mines. (8) Clearance methods are difficult if not impractical against targets of large area if the mining is done in force. (9) The best defense against an aerial mining campaign is to prevent the mines from being laid by attacking the enemy's mine laying aircraft.

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ANNEX A

FLAK ANALYSIS

Background

On 7 March 1945, a conference was held to discuss the capabilities of the Japanese antiaircraft in opposing B-29 mining of waters in the vicinity of Shimonoseki, and to arrive at conclusions regarding the most advantageous altitude for aerial mine laying. The following officers participated in the discussion: Flak 0, AAFPOA, Flak 0, XXI Bomber Command, Ass't, Flak 0, XXI Bomber Command, Flak 0, 11th Bomb Group (H), Flak 0, 30th Bomb Group (H), Naval Mining 0, XXI Bomber Command, Army Mining 0, XXI Bomber Command. The 11th and 30th Bomb Groups had recently participated in mining operations in the Bonin Islands. Consequently it was felt that their views on flak, based on recent experience, would provide valuable information for the projected B-29 operation.

The conference was handicapped by a complete lack of photo intelligence showing the defenses of the area in question. However, it was assumed that antiaircraft defenses of all types were likely to be encountered, and the conclusions which were reached were based on this assumption. Another factor influencing the conclusions was that the operations would be conducted during hours of darkness. A third factor which had to be kept in mind was that the altitudes for the projected mining operation were limited to a maximum of approximately 8000 feet.

Enemy Antiaircraft Capabilities

Practically no evidence was available which would indicate any enemy use of flak barges. Therefore consideration of this type of opposition was omitted. Fire from enemy antiaircraft guns could be expected. Heavy antiaircraft fire had not proved effective at night. The enemy had resorted to barrage fire and to predicted concentrations during most of his night firing. This type of fire could be more accurately delivered at altitudes of 10,000-20,000 feet than at altitudes of approximately 5000 feet. B-24 aircraft which had mined the Bonin Islands received meager fire (few bursts) from heavy antiaircraft guns at altitudes in the vicinity of 5000-6000 feet.

Automatic weapons and machine guns had been used quite effectively by the Japanese on aircraft attacking at altitudes of 100 to 3000 feet. The maximum hitting range of the 25 mm guns, the primary automatic weapon of the enemy, was 1500 yards. Hence, at altitudes of 5000 to 6000 feet, fire from these weapons would in most cases prove a deterrent. For defense against B-29 mining operations, the enemy probably would attempt to place an automatic weapon barrage in the path of attacking aircraft. In order to minimize the effect of such fire it was concluded that straight and level flight should be kept at a minimum, that the time interval between attacking aircraft should be staggered and as short as possible, and that different headings should be used for the run over the mine field.

In general, the enemy's operation of searchlights had been fairly ineffective. His searchlights had been less effective at low altitudes (4000-7000 feet) than at high altitudes (10,000-20,000 feet). Furthermore, it was more difficult to track with searchlights at low altitudes than at higher altitudes. It was therefore evident that effective illumination was less probable at 5000 feet than at 10,000 feet.

Barrage balloons had been employed by the Japanese in Formosa, China, Kyushu,

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and Honshu. Two types had been encountered: the conventional barrage balloon with cable, and a free balloon reported at altitudes of 20,000-30,000 feet. The exact purpose of the latter had not yet been determined at the time of the conference, but it was evident that it was not an anti-aircraft weapon. Consideration of the free balloon was therefore omitted. The conventional barrage balloon had been sighted at altitudes varying from 2000-5000 feet, with the majority seen at 4000 feet. It was concluded aircraft flying at 5000 feet should be above barrage balloons, but it was recommended that crews be warned emphatically of the necessity for maintaining a sharp lookout for barrage balloons.

The Japanese also utilized two types of anti-aircraft mortars firing projectiles which on detonation emitted explosive charges suspended from small parachutes. The maximum altitude attainable by this projectile was 3000 feet. The parachute-suspended explosive would not detonate except on contact with the aircraft.

Conclusions

(1) The optimum altitude for safety from anti-aircraft below the limiting altitude of 8000 feet was estimated to be 5000 to 6000 feet. (2) While within range of possible defenses, a tight and level flight should be maintained for as short a time as possible. (3) The conduct of operations over widely scattered areas would add to the difficulty of the enemy's defenses. (4) The enemy would not be able to move anti-aircraft weapons from any given area to the mining area in time to obtain additional concentrations of weapons in that area. Careful routing of aircraft to avoid known anti-aircraft defenses was an obvious consideration. The element of surprise would be a significant factor in reducing anti-aircraft effectiveness, and one which should be fully exploited.

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8.

TACTICS OF INNER ZONE CAMPAIGN

DATA FOR DOCTRINE

Many aspects of strategy in warfare are relatively unchanged by thousands of years of combat. But tactics change with new weapons, countermeasures, means of transportation, technology, and various intangibles such as national psychologies. In the course of another war, there are indications that tactics may undergo even more radical changes than in this one. This is true of mine warfare for which no fixed doctrine can be formulated because it is still evolving rapidly. But the nature of tactical problems is usually similar, good tactics depending on the quality of the planning, training, and organization of a campaign. So mine warfare tactics used in World War II, which are well illustrated by the Inner Zone Campaign, are described for the aid they might give in guiding the development of future tactics.

The 313th Bombardment Wing was the only wing of the Twentieth Air Force carrying out Operation Starvation, as the Inner Zone Campaign was sometimes called. Therefore much of the detailed mission planning that would ordinarily have been carried out on an Air Force level was done by the wing. Further, mine laying by B-29's against Japan was without precedent when the first directives for Operation Starvation were being prepared. To the 313th Wing fell a fourfold assignment: (1) to devise a simple but effective technique for planting mines from B-29's; (2) to train all wing combat crews in this mine laying procedure, and all ground ordnance and armament crews in the preparation, handling, and loading of aerial mines; (3) to set up within the existing operations structure of the wing organization a system of operations to solve the problems of mine warfare; and (4) to carry out mining missions as efficiently as bombing missions.

PLANTING TECHNIQUE

Mining differed from bombing in basic ways. First, the aerial mines used in B-29 operations were equipped with parachutes to retard their rate of fall which caused them to drift with the wind in their descent. Second, a mine is aimed at a point in the water which can only be determined by reference to nearby land-water boundary aiming points. The larger trail, crosstrail, and actual rate of fall of the mine as compared to a bomb prohibited the use of a visual bomb-

sight. From the outset, therefore, it was apparent that radar would offer the best tactical possibilities for mine laying. The original directive on the mining program, dated 26 January 1945, from the 21st Bomber Command to the 313th Bombardment Wing named altitudes between 200 and 30,000 feet for training flights in mine laying. This extreme range complicated the problem of devising a simple technique for arriving at the dropping position because mine drift is a function of altitude and there would be different wind velocities along the path of fall. It was therefore decided to develop a straightforward technique for dropping mines accurately from approximately 5000 feet, and then to adapt this technique to high altitudes.

These tests were the first serious effort to develop specific mine laying tactics for the B-29. Mine laying from low altitudes had been extensively used by the Navy, and considerable testing was done by the Tactical Test Section of the Naval Air Station, Patuxent River, Maryland, to develop a mine laying procedure for very high altitudes employing radar techniques. For these tests PB4Y-1 aircraft were equipped with AN/APS-15 radar equipment specially mounted in the navigator's compartment. Because of differences in crew training and equipment between this test work and the average B-29 crew and gear, it was decided to use the proposed methods wherever possible, but not to restrict experiments to these methods alone. Although the fundamental tactics would be no different for various aircraft types, refinements would be necessary to fit B-29 flight characteristics and adapt navigational instruments and bombsight as well as previous training and skill of the crew to mine laying. The experimental program was to evolve a tactical doctrine based on maximum utilization of B-29 equipment and personnel with an accuracy suitable for contemplated operations.

In February 1945 the average B-29 crew of the 313th Wing included an officer navigator, an officer bombardier, an enlisted radar operator, an enlisted flight engineer, an enlisted radio operator, and gunners. The standard operating procedure for bombing utilized the pilot, navigator, bombardier, and radar operator as a team for making all bombing runs on radar, while permitting changeover to a visual run if visibility was good. In making these runs, the

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navigator and airplane commander usually worked together to eliminate deflection (course) error, while the bombardier and radar operator worked together to eliminate range (rate) error. Variations of this basic routine in using a radar bombing team were slight. All crews had had considerable team training, which made its carryover to mine laying desirable. Furthermore, the average radar operator had little training in scope interpretation. He could usually be depended upon only to operate the equipment and to set up suitable bomb release pips. So methods which placed an additional load upon him were discarded from the start.

After preliminary discussions with the crews assigned to the experimental missions, and with the local radar specialists, the following type problems were investigated: (1) to fly on a course over a radar aiming point, and to drop a mine upon covering a specified distance from the aiming point; (2) to fly on a course towards a radar aiming point, and to drop a mine when at a specified distance from the aiming point; (3) to fly on a course over a radar aiming point, and to drop a mine after a specified time from the aiming point; and (4) to fly on a course towards a radar aiming point, to commence timed runs when a specified distance from radar aiming point, and to drop a mine when the computed time had elapsed. Methods of flying on course, with the radar aiming point a certain distance abeam, were discarded because of scope distortion and the complexity of scope interpretation. Also, methods of dropping on cross bearings were discarded at the outset because they required a highly trained radar operator.

The triangulation range off Tinian, with extensive naval and merchant traffic in the surrounding waters, was not suitable because of the inaccuracy expected in high altitude drops. So all drills were held on bypassed enemy-held islands in the lesser Mariannas, and aerial photography was used to evaluate accuracy. This was not ideal, but it was the best possible arrangement. A land mass large enough to have at least one good radar aiming point was needed together with an offset reference point at least five miles away that could be included in a photograph of the hit for later photographic analysis. An initial point approximately 25 miles from the radar aiming point was also desirable. The only islands that could fulfill even the first requirement were Pagan and Rota; the second requirement was not realizable in the Mariannas.

After considerable coordination with other activities — almost all units in the Mariannas were conducting extensive daily training flights — permission was finally obtained to use both these islands for mine laying experiments (see Annex A for Training-Mission Plan for a mine laying drill at Pagan). Practice mines, requested months before the training program was undertaken, never did arrive until long after actual mining operations were under way. So early familiarization flights were made with general purpose bombs. When the stage was reached where study of wind drift of a mine was essential, a small number of TNT-loaded mine cases was

obtained from the mine assembly depot. The critically limited supply required extreme conservation in experimental mining. This more than any other factor limited experiments in mine laying techniques.

In addition to training area and supply problems, difficulties with cloud cover and various radar and mechanical malfunctions led to the inevitable cancellations and postponements. Notwithstanding, the 313th Bombardment Wing began experimentation the day after it received its first mining directive and had a preliminary standard operating procedure in mine laying techniques completed within three weeks. (See Annex B for a table of the experimental mining missions flown over the mining range on Pagan Island in carrying out this work.)

In all, six experimental missions were flown by one crew of the 504th Bombardment Group to develop tactical method. The standard operating procedure drawn up from these missions was used by four additional crews, one each from the 504th, 5th, 6th, and 9th Bombardment Groups, each crew making two practice missions to test the method's practicability. Results of these indicated that maximum previous crew training had been used and satisfactory accuracy for the majority of the missions contemplated against primary mining targets had been achieved. The photographs obtained on these missions were closely studied. The average accuracies which could be expected for various altitudes of attack were approximately as follows:

Altitude (feet)	Number of Photographed Drops	Average Offset Distance (nautical miles)	Average Radial Error (yards)
2,000	4	0.3	375
6,000	2	0.3	500
10,000	13	4.0	900
25,000	8	6.0	1600

The basic method was the same for all four approaches outlined earlier and there was no significant difference in accuracy. Also, the bomb accuracy on the offset problem was approximately the same as that for mines. All crews were unanimous in the opinion that mine laying could be carried out with high accuracy, once the fundamental techniques of making a good wind run and making a course "good" through a radar aiming point had been mastered. On the basis of the small amount of flight training given most of the experimental crews, one training flight in medium altitude technique was deemed adequate for each combat crew if sufficient ground training preceded the flight.

To summarize the development of mine laying tactics, the low and medium altitude technique adopted after the first tests consisted essentially of making a course "good" from an initial point towards or over a radar aiming point

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(as determined by slant range or timed run), and releasing the remaining mines on a timed run from the first release position. This method was straightforward when used for mine dropping from 5000 feet or below, since the mine drift in the winds normally encountered at this low altitude was of the same order of magnitude as the navigational errors inherent in the radar and could be neglected. In the high altitude method, however, provision had to be made for computing the mine's wind drift which, in many cases, would be of the order of magnitude of several miles. The method of plotting a vector diagram to obtain the mine's trajectory was the same as that developed at the Naval Air Station, Patuxent. A complete exposition of this method and the techniques for both the low and high altitude cases is given in Tactical SOP No. 100-2 (see Annex C).

After actual mine laying operations began, enemy opposition was small, as had been anticipated by Headquarters, 21st Bomber Command. High altitude technique was therefore not necessary. The height of surrounding terrain for the majority of mining targets ruled out very low altitudes of attack. This, together with detailed analyses of the enemy's anti-aircraft capabilities, centered mining altitudes most used between 5000 and 8000 feet. After long experience in this altitude region, Tactical SOP No. 15-14 was written to replace Tactical SOP No. 100-2. SOP No. 15-14 (see Annex D) formed the basis for all except one mission against the enemy by the 313th Wing.

TRAINING

March 1945 was devoted to an intensified ground and air training program in mine warfare by appropriate specialists. The nature of aerial mine warfare, its effect on the enemy, a description of United States mines, and safety in the handling of mines and mine equipment was undertaken by mining specialists attached to the Wing headquarters. Fundamental radar bombing techniques and detailed instruction and flight training in radar mine laying technique was taught by a group of radar-navigator instructors attached to the Wing specifically for this purpose. General background material in mine warfare was given all crews, group by group, by lectures, moving pictures, and literature on the history of mining and related subjects. An instruction period with mines and mine accessories was arranged for ordnance and armament personnel. (See Annex E for the directive from the 313th Wing initiating this ground training, with a brief outline of the material covered and the schedule of presentation.)

Training in mine laying methods followed closely after the background instructions. The first lecture, an hour long, was on general method. This was attended by all members of each combat crew. Navigators reviewed the E6B computer in solving for slant range versus ground range, etc., methods of making an accurate wind run by radar, use of mining tables, and the solution for determining the release point of the mine, and types of mine release. A practice mine laying flight

was then held over the nearby island of Rota. (See Annex F, the directive for this phase of training.) Practice missions were set up with an instructor and two crews in each aircraft to obtain maximum flight time. Each crew was taken through four practice runs: the first was a dry run for familiarization; in the second and third, water bombs or general purpose bombs were dropped; in the fourth, a 1000-pound Mk-26 mine was dropped. During and after each drop photos of the ground were taken from side blisters and camera hatch; so were pictures of the radar scope. Excessive cloud cover during the training period prevented a detailed analysis of the data thus obtained, but in general the results confirmed the accuracy figures given above.

Although flight training lagged initially because of the pressure of current bombing operations, training flights were intensified when the directive for the first mine laying mission was received. On the eve of the first mine laying mission on 27 March 1945, all the required crews had been trained and the four bombardment groups were prepared to undertake the largest mining operation of this type ever attempted.

MINE PREPARATION, HANDLING, AND LOADING

There are differences in the operational characteristics and tactical employment of mines and bombs in addition to those which complicate the preparation and loading of mines in aircraft. There is no way of assessing a mine's operational characteristics from its external appearance. Adjustments governing the sensitivity of magnetic, acoustic, subsonic, and pressure mechanisms are all internal. So are the ship-count selectors on magnetic mines and the arming delays and sterilizers on all types.

The first problem in handling mines was to identify the various mines so that ordnance men, totally unfamiliar with mines, could haul them from ready stowage areas and load them into specified places in aircraft without making an error in mine type. A five-symbol code was finally devised in which the first three symbols specified the type firing mechanism, its sensitivity adjustment, and the number of actuations required to fire it; the fourth symbol gave the delayed arming interval, and the fifth gave the sterilization period (see Annex G). Once this code has been devised, all mine assembly orders issued to the Mine Depot specified numbers of mines of each code type. After each mine was assembled, its code was stenciled in several conspicuous places. Stowage in the ready ammunition areas was arranged in order of code type.

The duties of ordnance and armament personnel included the preparation of mines and loading. Training was given over a three-week period to all four bombardment groups. It was necessarily brief because the wing was then engaged in an all-out incendiary blitz operation against the Japanese homeland. Instruction included correct methods

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of attaching parachutes to mines, correct orientation of parachutes in the bomb bay, protection of microphones in acoustic mines, installation of soluble washers and other safety devices, and methods of securing parachute static cords. Careful handling necessitated by the sensitive nature of the Torpex filler then being used in the mines was stressed particularly.

Handling and loading was more complicated for mines than for bombs. Each separate mine, selected from among 200 different operational combinations, had to be loaded on a specific bomb station in a particular airplane, whereas bombs are loaded in any station in any airplane. Nevertheless, with proper organization it was possible, in the later stages of the mining operation, to mine up a bombardment group just as rapidly as to bomb up the same group. The first few mining missions were full wing efforts. Traffic tie-ups at the ready-ammunition dumps caused by the simultaneous activities of many crews attempting to obtain specific types of mines from a small number of revetments were eased somewhat by dispersing the mines over a large number of revetments and by scheduling crew trips. But the magnitude of the wing operations made it impossible to ease the jam completely. In a single day as many as 360 vehicles were engaged in hauling mines. The different code types were so complex that a sufficient number of revetments never was obtained. After the decision was made to lay mines at group level, the traffic problem was practically eliminated, and loading was greatly facilitated because closer supervision could be devoted to all phases of the activity.

The following procedure was developed and may serve in the future. It was devised for hauling and loading mines for a B-29 bombardment group, for approximately 30 mine laying sorties to be flown every two days. It should be pointed out that careful planning and close liaison between the wing mining section and wing and Group Operations, Ordnance, and Armament, and the Mine Assembly Depot were vital to successful operations. Early in the morning of the day before the scheduled mission, group operations, acting on the basis of a previously-held planning meeting (described below), determined which sorties would be assigned to each of the several squadrons, taking into account equal distribution of loads, rack changes for 1000- or 2000-pound mines, distance to be flown, risk involved, etc. The ordnance section then consolidated the mines to be carried by each squadron, and obtained the number and code types from a master loading plan furnished by the mining section (see Annex S). This consolidated list was also used as a basis for issuing parachutes, release mechanisms, soluble washers, and delayed arming cells.

The consolidated list of mines was then taken to the mine assembly depot, which had already received the directive (described below) ordering the preparation of the mines. The issuing officer determined where each code type was stocked, made revetment assignments, and prepared issue

cards. Each issue card contained the exact type and quantities of mines to be drawn by one ordnance crew (a load for one M-6 BST and two M-5 trailers, or one M-27 BST and one M-5 trailer). Each squadron was assigned a time schedule to report to the mine ready dump to draw mines. At the same time, the squadron ordnance officer was given the issue cards for the mines his crews were to load. He in turn assigned one card (or load) to each of his crew chiefs who went to the assigned revetments and drew the mines. A triple check was kept on each load by requiring the crew chief, the crane operator, and the sentry at the exit gate to certify that the proper code numbers called for on the cards were actually drawn. The mines were then hauled to the squadron area on the flight line.

At a specified time during the day before the mission, each squadron ordnance section drew in bulk all parachutes, release mechanisms, soluble washers, and delayed arming cells required for preparing mines for loading on the following day. With these were furnished special instructions in size of parachute for each type of mine, color of the proper soluble washers to be used in each type, and information on delayed arming cells. Meanwhile, group operations had assigned planes and air crews to each sortie, and armament had made any needed changes in each aircraft's racks to carry the size of the mines specified in the assigned sorties. Therefore at the close of the day before the mission, all mines and accessories were on the line, aircraft were assigned to sorties, and planes were ready for mine loading.

Early on the day of the mission individual mine loading plans prepared by the 313th Wing were given to each ordnance crew (see Annex T). This plan contained the size and code numbers of all mines for a particular sortie. The ordnance crew then obtained the necessary mines from the squadron area on the line and hauled them to the assigned aircraft for loading. The armament crew chief of the aircraft checked the loading plan for dropping sequence, chalking the rack number and location of the bomb station on the mine and entering this information on the mine loading plan. Following this the ordnance crew attached release mechanisms and parachutes, inserted soluble washers or delayed arming cells as necessary, and delivered the mines under the bomb bay. Armament crews hoisted the mines to the correct bomb stations; ordnance crews attached the static lines, and the aircraft was ready to take off. Occasional variations were made in this general procedure in order to suit the size of the operation and timing considerations. For basic methods of installing parachutes on mines, and other data, see Tactical SOP No. 15-8 (Annex H); and supplemental instructions (Annex I).

DIRECTIVES

A brief survey of the directives issued on each level will give a clear picture of the organization and operation of the Air Force, Wing, Group, and Navy mine-preparation

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activities in carrying out missions. Directives on mining from the Air Force (or Bomber Command) to the 313th Wing were usually of three kinds. They concerned mine preparation, target priority, and enemy ship distributions, or cancellations, or changes in specific mining missions. The reasoning underlying the issue of these directives was given in Chapter 7; the directives themselves are described here. The mine-preparation directive was general, giving all operational decisions on mine types that were fixed by planning and intelligence as initiated or received on the Air Force level. It specified principles or rules to be followed in designing mine fields, but did not give details for the mine assembly depot to use in preparing mines. The sample (Annex J) shows that the main function of the directive was to guide the choice of mechanism, type, sensitivity, and ship-count settings, and delay arming and sterilizer times for various targets.

The target-priorities directive was usually specific, providing the basis for all planning on the wing level. The data included areas to be attacked, numbers of mines to be placed in each port, general limitations on dates and altitude of attack, and the order of priority in which mining over a particular period would be carried out (see Annex K). Information in these two types of directive was the starting point for the long-range mine planning carried out by the 313th Wing. The third type of directive, changes in specific mining missions, considerably complicated the work of the wing and lower levels. It largely shaped the final form of the mining organization which handled the detailed aspects of operations (see Annex L).

From these directives, in addition to preparing field orders to the various groups and tactical briefs for interested commands, the 313th Wing prepared two types of directive which dealt solely with the preparation of mines: mine assembly orders to Mine Assembly Depot No. 4, the naval activity supplying mines to the groups, and mine modification orders to the Mine Modification Unit, Tinian, a technical naval unit which prepared and issued operational information on modified mines. Preparation of these directives was called "long-range planning," since it required a detailed specification of the necessary quantities of mine types (or code numbers) that would be needed every other day for a period of several weeks. A rough plan was made for every mission to be flown during the projected period in order to cope with all factors that affected the preparation of each mine.

Four major factors affected this long range planning. One was the total number of mines to be used over the period, the requirements for each target area, and general policies regarding the use of firing mechanisms, delayed arming, ship counts, etc. All of this was specified by Air Force directive. The second was logistics, i.e., the number and types of mines available or en route, together with all necessary parts and subassemblies and their times of arrival at unloading points. This also included such time factors as assembly rates

of various mine types, etc., at the mine depot. The third was detailed hydrographic information and shipping intelligence on each port or channel under attack, together with enemy anti-aircraft positions, area surrounding terrain, and other factors affecting tactics. The last factor was the standard operating procedure determining the number of mines per aircraft which would be carried to each target under consideration.

Such long-range planning was initiated immediately upon receipt of a firm decision from the Air Force with supporting directives. This planning usually took several days of intense work and had to be completed at least four days before the first mining mission. This made certain that the first order of mines could be filled on schedule by the Mine Depot. To indicate only a few aspects of the mechanics of this phase of planning for each port to be mined, the four factors stated above were considered. This resulted in detailed information on percentages of water depths that could be expected. From this, and from Air Force directives employing methods described below, it was possible to set down a comprehensive worksheet showing all mine types required for each individual mission and containing provision for detailed record of actual mines used as operations progressed. This allowed continuous inventory of the status of mines ordered which, together with the records of the mine assembly depots, produced a flexible accounting system. It was successfully used in spite of rapidly changing operational requirements and irregular logistic support. This comprehensive worksheet provided the data from which a mine assembly order was typed (see Annex M).

Long-range planning for mining operations was necessary chiefly because there never were enough mines to build up a reserve stock of ready ammunition during the entire course of Operation Starvation. Since almost 200 different code types were used, however, it is doubtful whether any practical reserve could have supplied the desired quantities of different types for more than two or three group operations; also, considerable lost motion would have resulted from the necessity for assembling mines more than once in order to fully use mine cases, batteries, and perishable components. As it turned out, the long range planning method afforded a sound way of affecting changes of mine preparation dictated by intelligence considerations at two- or three-week intervals. At the same time orders to the mine depot were large enough so that full use could be made of production line methods in mine assembly.

Once mines have been ordered on this basis, the mines specified would be the only ones available for future operations. Any subsequent changes in operations would still have to use available mines. Close liaison was maintained with the mine depot on the progress of each assembly order so that small changes could readily be made, but generally the use of production line methods by the depot militated against change. This limitation was not serious, however, for of the

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14,000 mines assembled by the depot during these operations, only 20 were re-opened and had code types changed after the initial assembly.

Directives issued by the 313th Bombardment Wing to the mine modification unit were generally less complex than those given to the assembly depot. They were of two types — one requested technical information on the effects of modifying standard mine types such as firing characteristics and vulnerability to enemy sweeping techniques, and the second requested mine modification parts so that the mine assembly depot could fill an assembly order. Directives of the first type were generally issued verbally, accompanied by intelligence information on types of enemy shipping or on enemy countermeasures. From a detailed analysis of these data, the mine modification unit furnished the best technical advice on what mine sensitivities or adjustments should be employed under given circumstances. This advice was used by the wing in the detailed design of mine fields. Directives of the second type were issued in an order form (see Annex N).

Field orders and tactical briefs for mining missions are discussed later in this chapter. They formed the basis for operations which the wing directed to its four bombardment groups. These were not prepared until detailed planning for each specific mission was finished.

PLANNING THE MISSION

General. Tactical planning for all mine laying missions was carried out either on wing level, or partly on wing and partly on group level, if only one bombardment group was mining. The first mine laying mission undertaken by the wing was a full four-group effort. At that time the first series of low-level incendiary attacks had been carried out against major Japanese cities in the area east of the Inland Sea of Japan. Not one single low-altitude flight had been flown over the Shimonoseki Straits area, nor had any photo reconnaissance been obtained since the attacks of the 20th Bomber Command against Yawata more than six months before. Planning for the first mining attack, directed against the vital Shimonoseki area, was in itself quite difficult, apart from the fact that mine laying tactics for large forces or aircraft were still very much in the experimental stage. Several days prior to the first mining mission, radarscope missions were flown over the areas to be attacked. The results formed the basis for all decisions on radar aspects of the planning.

Experience from previous low-altitude incendiary attacks gave a rough guide to the scheduling system which would most probably saturate enemy defenses in night operations, but other problems peculiar to mine laying had to be solved. It was necessary to pinpoint each string of mines in a proper water depth with mine types in each string distributed to offer a maximum threat to enemy shipping. It was also necessary to spread the mines over a

large area in order to force the enemy to channelize traffic and to complicate his countermeasure problem. The radar problem and the high degree of accuracy made it necessary for each string to have a prominent radar aiming point along the axis of attack. The most favorable axis of attack would enable the strings of mines to present a maximum threat along the direction of ship movement. At the same time, the aircraft planting the strings should have minimum exposure to antiaircraft defenses and surrounding terrain.

From the outset it was apparent that all aircraft, within a given area at one time, would have to be moving in the same general direction. This narrowed down the basic tactical plan to the following alternatives. The first was to select an initial point approximately 25 to 50 miles from the area to be mined with all aircraft scheduled through this initial point on slightly different axes of attack so that they would fan out over the mine field. The second alternative was to select the most favorable axis of attack for all aircraft, and then compute individual coordinate turning points (or individual initial points) for each aircraft. Both of these methods were tried by different forces in the first mine laying mission. It was found that in planning and execution the second method was far more difficult than the first and offered no advantages. For subsequent missions, therefore, the first method was adopted as a standard operating procedure.

Three or more days before the scheduled takeoff time of each mine laying mission flown by the 313th Bombardment Wing, a planning meeting was held on either wing or group level depending on the size of the force to be used. It was attended by the staff operations officer, navigator, intelligence (AA) officer, radar specialist, and mining specialist. The meeting dealt with the various factors outlined above. The mining specialist would present the mining targets and the forces required according to long-range planning, and then initial points would be selected for each force. Then the staff navigator could proceed to lay out the routes for each force, while the Mining Section made a detailed design of the mine fields.

Specifying aircraft loadings and briefing combat crews differed from the methods normally used in bombing operations. Each mine setting had to be tailored to the area in which the mine was to be planted, which meant that each mine had to be prepared properly by the mine depot, loaded in the proper station in the bomb bay of the aircraft and then released at the precise moment in the mining run to land in the briefed position on the sea bottom,

Mine Field Design. After an initial point was chosen, individual axes of attack were laid out for each target. Using a standard navigator's chart as a worksheet, these axes were drawn from the initial point to suitable radar aiming points (some island or prominent projection or indentation of coastline beyond or behind the area being mined, to give good definition on the radarscope). Along

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each axis of attack the individual strings of mines were plotted.

The spacing between mines in a string depended upon several factors other than the minimum safe countermining distance. In mining long, narrow, swept channels (as in the majority of targets), the mine field had maximum effectiveness if the maximum number of mines from an individual string was placed within the channel limits. The field would be of little use unless at least one mine from the string was laid within the channel. Unfortunately, the axis of attack and mine spacing which gave the largest number of mines in the channel were not generally those which gave the largest probability of at least one mine falling in the channel. It was found that by using 2- to 4-second spacings (in terms of dropping interval at 215 to 230 mph), both of the above conditions were reasonably met when the channel and the course of the aircraft formed an angle of 30 to 90 degrees. In mining anchorage areas, or areas where no known channels existed, mine time spacings were chosen to spread the mines uniformly throughout the area. Generally the spacing varied from 2 to 10 seconds.

The next step in the design of a mine field was to distribute the mines available for the mission to individual strings. As already explained, a certain amount of preliminary mine-field planning was necessary in preparing the mine assembly to insure availability of mine sensitivities appropriate to the depths of water in each field. This planning, like the final distribution of mines to individual sorties, was based on information furnished by the mine modification unit on the sensitivities required to select ships of desired tonnage in accordance with directives from the Twentieth Air Force. Tables were prepared (see Annex O) showing the percentage of mines of given sensitivities planted in various water depths to produce approximately 100-foot target widths against the particular distribution of enemy shipping expected. On the basis of these percentages and the water depths, mines were assigned to the individual strings.

Preparation of Master and Individual Mine-Loading Plans. A master mine-loading plan was included in the wing field order as an annex. The plan gave the sortie or run number, the size of mines in the run, and the dropping sequence desired on each run. In determining dropping sequence, the mines were given a random distribution for sensitivity and type firing mechanism, if the water depth in which the string of mines was to be planted was essentially uniform. If water depth varied appreciably, it was necessary to put the most sensitive mines in the deepest water while retaining a random distribution of types to complicate enemy sweeping as much as possible. From the master loading plan, individual loading plans were made for each sortie. The individual plans were used by the group ordnance and armament personnel so they could get proper mines from

ready storage and then load them in the specified dropping sequence. Each plan listed the required dropping sequence, size, and code designation of each mine in a string.

Navigator's Chart. From the outset a general briefing used in bombing missions was known to be inadequate for the desired accuracy in mining. Individual mining charts were therefore printed for each area and then prepared by the mining section for each navigator of each aircraft. Each chart was an overlay of a particular run plotted on the master worksheet used in designing the field. It showed the exact final position desired for each mine, the radar aiming point, the axis of attack, coordinates of the initial point, size and number of mines, dropping interval, and other data necessary for making the run.

Sample Mine Field. Annexes P through U illustrate the mechanics of mine-field design and include all of the charts, worksheets, loading plans, etc. Annex P is the "tactical brief" worksheet for a hypothetical mission of 30 aircraft divided into three forces mining three separate fields. Only one force is considered in this sample case. The "tactical brief" worksheet, prepared after the planning meeting, lists the number of aircraft required for each force, the number of mines designated for each field, the initial points to be used, and the general location in the field in which the mines are to be planted. Annex Q is the master planning chart on which the mine strings are laid out. All necessary water depths have been indicated on the worksheet. Annex R is a loading schedule used to distribute the mines to the individual strings. On the side of the sheet are the code designation and number of mines available for this particular field in this mission. Across the page are numbered columns, one for each of the individual runs. Annex S is the master loading plan. Annex T is an individual loading plan. Annex U is a navigator's chart for Run No. 7. Annex V is an overlay of the entire mine field.

TACTICAL BRIEFS AND FIELD ORDERS

As soon as the 313th Bombardment Wing began sustained operations, mining every other night or so, the operations were scheduled independently of the Twentieth Air Force bombing missions. To assure proper coordination over the Japanese homeland, the 313th Wing informed the Air Force and other interested commands of mining intentions for each mission planned. This was done by transmitting a tactical brief of the tactical plan for each mine laying mission at least 48 hours before scheduled takeoff time.

Prior to the first mine laying mission a mine field coding system had been established by the 21st Bomber Command (which became the Twentieth Air Force). A code letter was assigned to each area against which mining operations were contemplated. Each area was divided by a numbered grid system. This coding, for which the major mine field code letters are given in Annex W, greatly simplified

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the specification of mining intentions and also formed the basis for directives and changes issued by the bomber command (or Air Force). Only areas in the Japanese home islands were thus coded. The grid system was never extended to the Korean ports and reference to Korean ports was made by name. Prior to the first mission, copies of all coded grids for these areas were transmitted to all commands interested in mining missions. This code system simplified telecon specification of mining intention.

Wing A-3 always issued the tactical brief regardless of the size of the unit going on the mining mission. The tactical brief gave the following information: (1) number of aircraft scheduled; (2) total number of mines scheduled to all fields; (3) approximate time of takeoff; (4) estimated time over target; (5) estimated time of return to base; (6) scheme of attack, like "lone aircraft at night using rope"; (7) altitudes; (8) routes for all aircraft using same route; (9) code areas in which mines would be planted, with total number of mines to each code area; and (10) grids within each code area to be mined. Data for this brief was furnished by the various specialists in operations. Thus the staff navigator (either wing or group) furnished data for the third, fourth, fifth, seventh, and eighth items; the mining officer provided the second, ninth, and tenth items; S-3 and/or A-3 completed the information.

Field orders for mining missions basically resembled orders for bombing missions, following the same War Department authorized form. The particulars in which field orders for mining differed from those for bombing were the methods of specifying targets and individual plane loadings. Since specification had to be made on an individual basis to assure the required accuracy in mine laying, the individual navigator's charts described previously were furnished to the group prior to each mission. In order to have a record of all runs in relation to one another in a particular area, a plot of each mine field was photostated and included as Annex 1 in the field order (see Annex V).

In early mining missions alternate mine fields were designated by latitude and longitude for each of the forces in the event that the aircraft could not reach the primary mine field for any reason. This designation was unwieldy both for the navigator of the aircraft and for inclusion in the field order. After some consideration special charts were printed with all alternate mine fields colored in red (see Annex X). Copies were distributed to all navigators flying on mining missions. Thereafter field orders referred to alternate mine fields as "any area marked in red on individual mine jettisoning chart."

Apart from primary and alternate mine fields, each field order (prior to the last few issued) gave detailed instructions for jettisoning mines and procedures for securing mines from the mine depot in a separate paragraph, "Mining Instructions." Tactical Standard Operating Pro-

cedure No. 15-13 was issued by the 313th Wing summarizing these instructions (see Annex Y). After this standard operating procedure had been issued, no further reference to mining instructions was made in the mining field order.

TACTICAL ANALYSIS BY AREA

Highlights of each mine laying mission carried out by the 313th Wing will be given here, a consolidation of the complete details which can be found in "tactical mission reports" issued by the Twentieth Air Force. The more frequently used approach and retirement routes, initial points, and axes of attack, together with antiaircraft defenses and terrain features that affected their selection are given. Statistical analysis of the mine plots (given below) and the ship casualties (see Chapter 3), for each field, should give an idea of the validity of the mine-field design. An analysis of approach and retirement routes, axes of attack, known defenses, losses, etc., should give an idea of tactical effectiveness.

These analyses can determine how effective the mines were after they were laid, and how effective was the particular method of laying them, and give an appreciation of the interdependence of tactical and technical factors which must be considered in planning a mining attack on a specific target. For example, in the attack on Niigata, only one approach was available. A further severe restriction was that the plant had to be very accurate because the target was so small. It was necessary to weigh the possibility of high losses against the possible effectiveness of the field. Niigata was an important target and it was decided to make the attack in spite of the possible losses. That meant the field *had* to be worthwhile. Actually, losses were less than anticipated (one plane). At least 18 ships were sunk or damaged beyond repair and 13 were damaged in a field of less than 800 mines.

The mining operations have been divided into 16 areas. Figure 8-1 and 8-14 show the geographical locations of each figure reproduced showing approach, attack, and retirement for a specific target. It is keyed to the individual area charts by figure number. Also, large-scale charts for each area mined show all mines planted during the course of Operation Starvation. They are not consecutively numbered but retain the original Twentieth Air Force numberings for purpose of reference. They are preceded by a master chart which keys their general location. Accuracy of detail is limited by the necessity of reproducing from copies, but all initial points, axes of attack, and antiaircraft positions have been reproduced as carefully as possible. The antiaircraft patterns were based on a 6-mile radius of fire from all known heavy antiaircraft positions, which is believed conservative for the altitude at which most of the missions were carried out.

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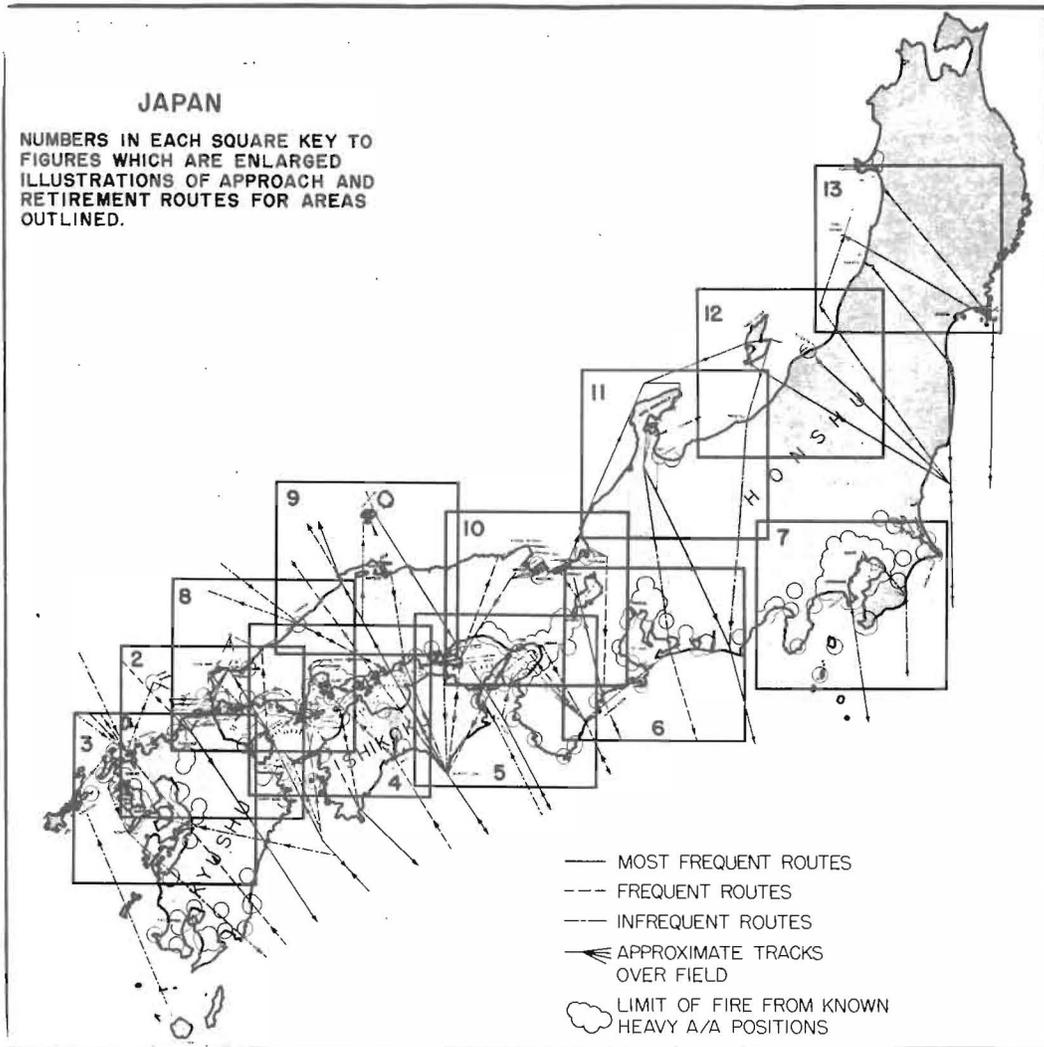
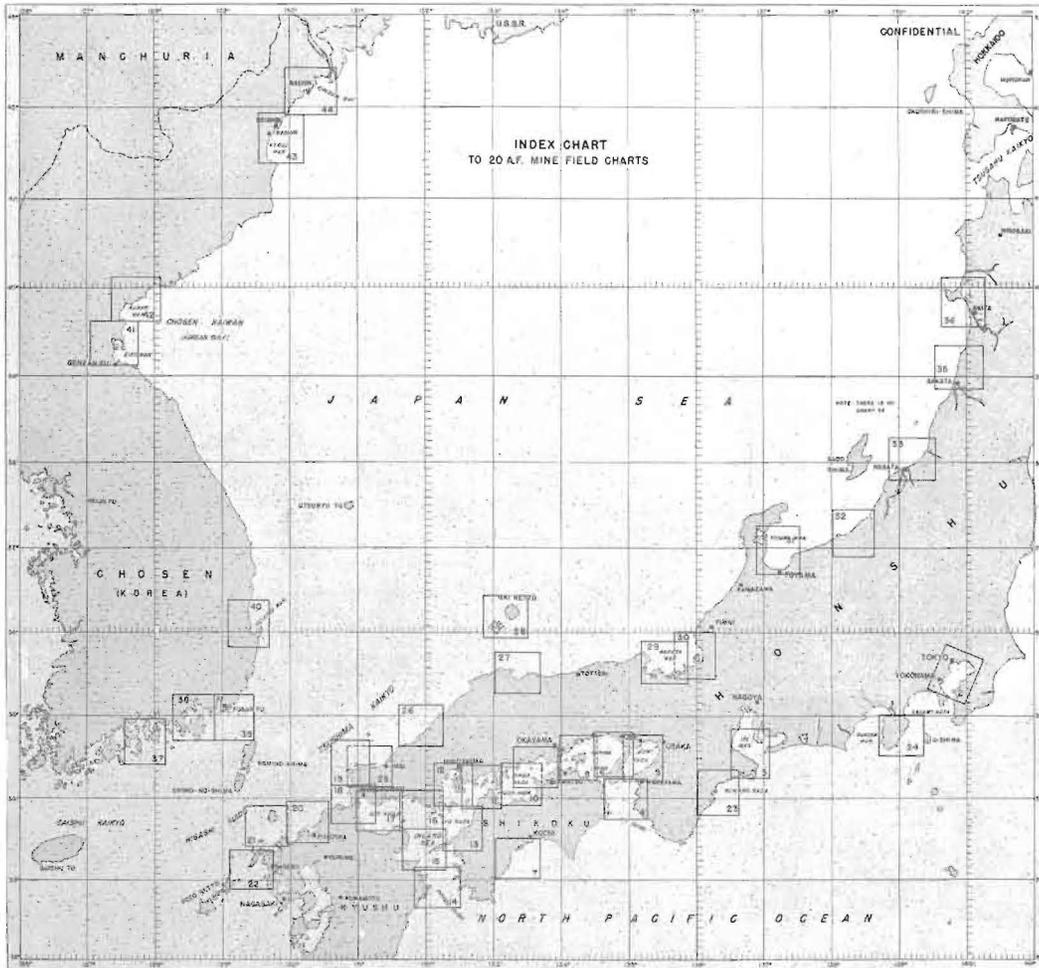


Figure 8-1. Key: Approach and Retirement Routes for Operation Starvation, 27 March – 14 August 1945

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INDEX CHART TO TWENTIETH AIR FORCE MINE FIELD CHARTS



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The charts showing the positions of all mines are, of necessity, printed on a much larger scale than the charts showing mine laying routes. These charts contain all available detailed information on the final positions of all mines planted during Operation Starvation. Except in the very densely mined areas, where a grid system is employed, each chart presents the pinpointed position of each mine dropped in the area, and each position is further coded to show the type mechanism in the mine. Thus a pressure mine is shown by a solid black circle, a subsonic mine by a half-solid, half-open circle, an acoustic mine by an open circle with a vertical line through the center, and a magnetic mine by a plain open circle. The listing applicable to each chart shows the dates of planting and code designation of each mine together with appropriate data on the number of live mines at given dates and a general estimate of the mine clearance problem.

Shimonoseki-Suo Nada Areas. Shimonoseki Straits was the target for the first mining mission and retained highest priority for all subsequent missions. It presented the most difficult tactical problem because heavy defenses surrounded the Straits, and the enemy's shipping channels limited the direction of available axes of attack. The difficulty was accentuated by the frequency with which it was necessary to carry out attacks against this target. The approach to the straits area was generally made through Bungo Suido, crossing the south coast of Honshu between Ube and Tokuyama, and delivering the attack from a suitable initial point on the north coast of Honshu. This was varied quite frequently by cutting across Suo Nada from an initial point in the northwest corner of Beppu Wan and delivering the attack directly at the straits, or by turning at an initial point on the south coast of Honshu (near Ube) and approaching on a due west course north of Shimonoseki to mine the channels in the western approach to the straits. Both these approaches were also used to mine the eastern approach to the straits and the anchorage area off Moji. Once an approach was made from the west by cutting across Kyushu between Sasebo and Fukuoka, using Okina Shima as an initial point. In no instance was an attack delivered from the south because suitable initial points were lacking, and heavy defenses surrounded Yawata and Kokura.

On the first mining mission three aircraft were lost in attacking the western approach to the straits from the northeast. None was lost from the force that flew directly over the straits from the east. The explanation for this could not be given in terms of anti-aircraft positions; the hypothesis was that the coordinate turning point method used by the forces which lost three aircraft had not worked properly and had brought the aircraft over Yawata. This seemed borne out by subsequent missions, since the greatest number of attacks at the Shimonoseki area were

made from the northeast, from a north Honshu initial point (Ima Misaki), and no aircraft were subsequently lost on this axis of attack. Later, four aircraft were lost in attacking from due east, and one was lost on the only mission in which Okina Shima was used as an initial point, attacking from the northwest. The one attack in which the entrance to Wakamatsu was mined was delivered from directly north of Yawata during an undercast, and no aircraft was lost even though the aircraft passed directly over Yawata. Retirement from the Shimonoseki Straits area was made almost without exception through a "groove" across Kyushu, running from a point between Fukuoka and Shimonoseki on the north coast to a navigational check point on the east coast about 30 miles south of Saeki Wan.

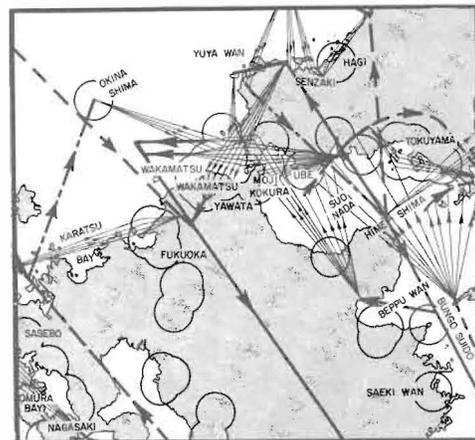


Figure 8-2. Shimonoseki-Suo Nada Areas

The first attacks against Shimonoseki were delivered at an altitude of 5000 feet. After the first few missions, battle damage to aircraft indicated that considerable numbers were being holed by automatic weapons fire, so the altitude was increased to an average of 7000-8000 feet. This was the altitude range for the great majority of missions. Towards the end of the campaign, evidence began to accumulate of the enemy's use of medium size weapons (40 mm), and the last few missions were flown at 12,000 feet to avoid this fire. Increase in altitude as the operation progressed did not adversely affect accuracy, since wind velocities decreased with the approach of summer, and crews became better trained in mine laying.

The mining of Suo Nada was straightforward because enemy defenses were absent. Most of the mining was done from two initial points, either the northwest extremity of Beppu Wan, from which good coverage of the western

portion of Suo Nada was obtained, or from the tip of the peninsula projecting from Shikoku into Bungo Suido, for the remaining area. One or two missions were flown from the previously mentioned initial point near Ube in order to mine a channel through the southern portion of Suo Nada. The axes of attack for these missions are not shown on the chart on this area.

The only other mining in this area was carried out against Tokuyama. This port was heavily defended, but fortunately it was not necessary to re-mine the port after the first field had been planted. Like the other mine fields in Suo Nada, the approach to this area was through Bungo Suido. The initial point selected was on an island (Yashiro Shima) at the southern boundary of Hiroshima Bay, from which the attack was made in a general westerly direction. Retirement from this, and from the western part of Suo Nada, was made by circling north of the Tokuyama Naval Base, crossing the Honshu coast between Tokuyama and Hiroshima, and departing from the Japanese mainland at a navigational checkpoint on the western extremity of Tosa Wan.

For results of mine laying in this general area, see Charts No. 16, 17, 18, and 18B. All navigable water in and around Shimonoseki Straits was thoroughly "polluted" with mines, and the coverage of Suo Nada and the port area at Tokuyama was effective. For an account of the effect, see Chapter 7.

Sasebo-Fukuoka Areas. Mining at Sasebo was carried out only once as a tactical effort in support of the Okinawa landing. The directive to mine Sasebo came as a last minute change, so that planning for this mission was rather hurried. The approach selected was in common with other forces to the entrance to Bungo Suido, then a branch-off directly

across Kyushu to a point just east of the anti-aircraft defenses at Nagasaki, which was used as an initial point. The direction of attack was made on a northeast heading, and the mines were placed across the mouth of Sasebo and Omura Bay. Retirement was then made to Nomo-Saki, southeast of Nagasaki, thence to a departure point on Kyushu, east of Kagoshima.

Several mining missions were carried out against Fukuoka, which was close enough to Shimonoseki to offer a satisfactory diversionary port if not mined to closure. The approach for these attacks was generally around the west coast of Kyushu, using Yaku Shima and Nakadori as navigational checkpoints. The initial points selected were on one of the small islands south of Iki Shima, giving an axis of attack of roughly 075° , which was satisfactory for closing the entrance to Fukuoka Wan. The mining of Karatsu Bay, south of Fukuoka, was also carried out from these initial points. Retirement was then made through the same "groove" used by aircraft returning from Shimonoseki.

Although both Sasebo and Fukuoka were well defended, no aircraft were lost on these missions, probably because of the small size of the forces and the fact that most mining was carried out on the fringe of the defenses. For results of the mine laying in these areas see Charts 20 and 22.

Hiroshima-Kure Areas. Hiroshima and Kure were mined early in Operation Starvation and were persistently attacked during late March and early April while the Japanese Fleet trapped there constituted a threat to our amphibious forces off Okinawa. The basic mine field in Hiroshima Bay was established by two forces. The first force appeared through Bungo Suido with other aircraft proceeding to Shimonoseki, ran along the west coast of

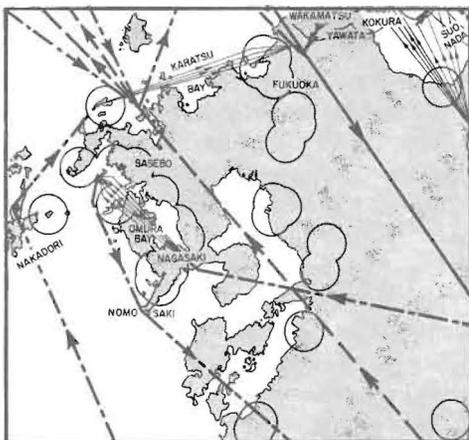


Figure 8-3. Sasebo-Fukuoka Areas

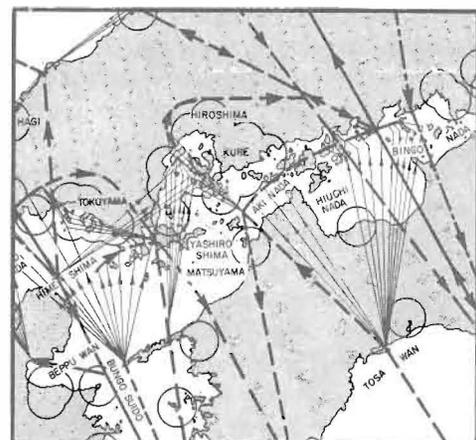
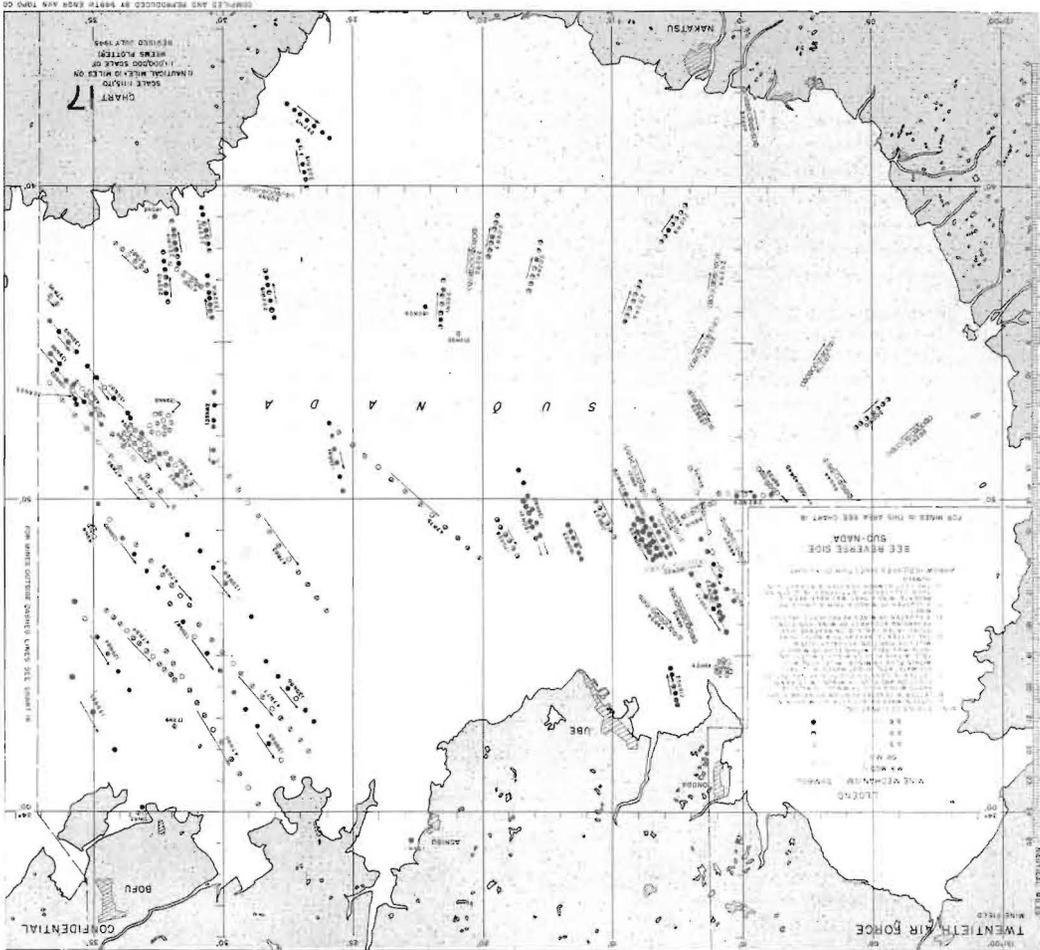


Figure 8-4. Hiroshima-Kure Areas

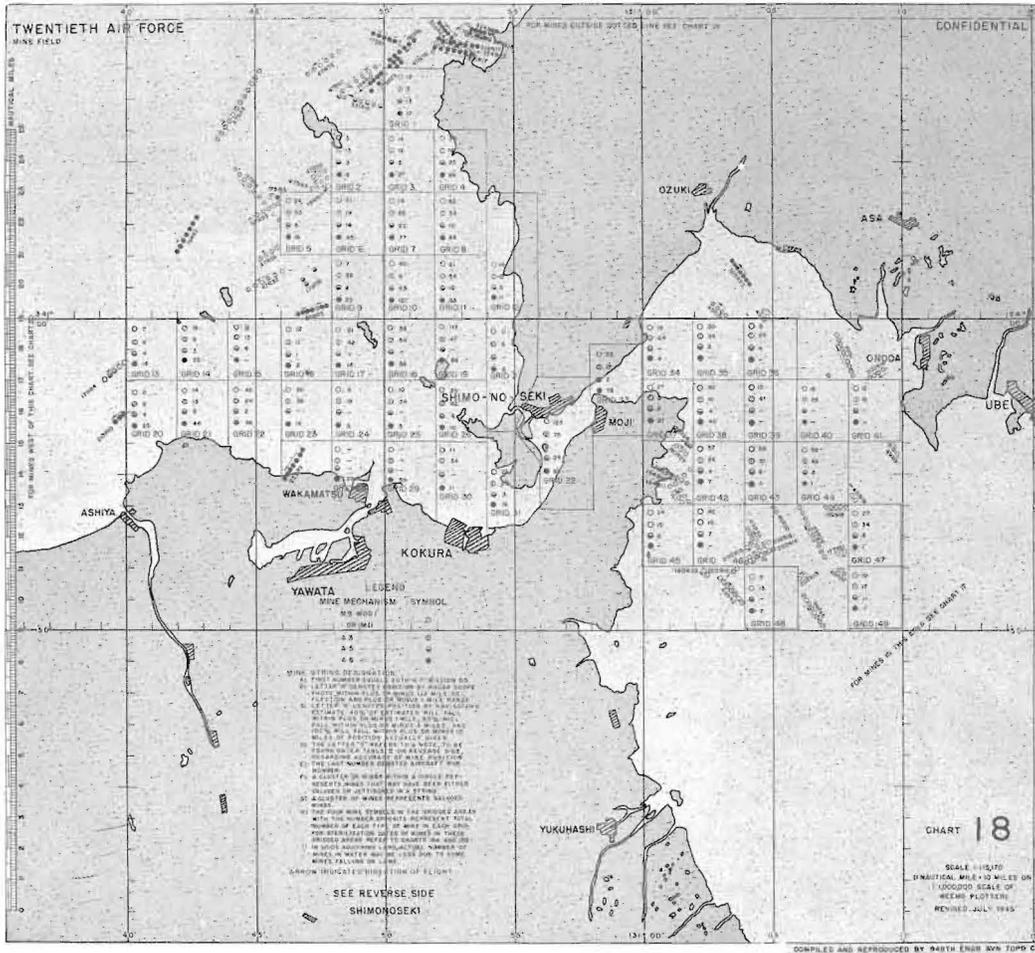


MINES AGAINST JAPAN

Chart 17 Suido Nada

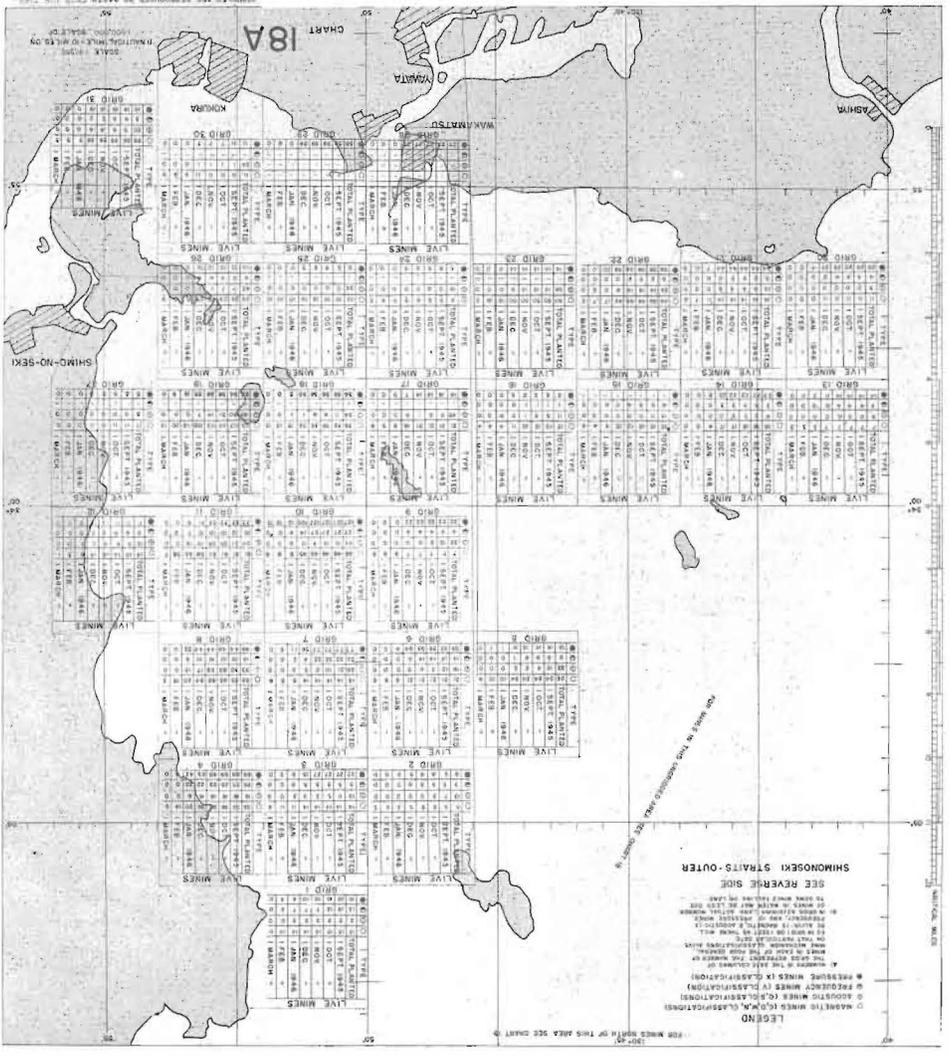
MINES AGAINST JAPAN

Chart 18 Shimonoseki Straits



MINES AGAINST JAPAN

Chart 18A Outer Shimoneseki Straits



MINES AGAINST JAPAN

Chart 18B Listing

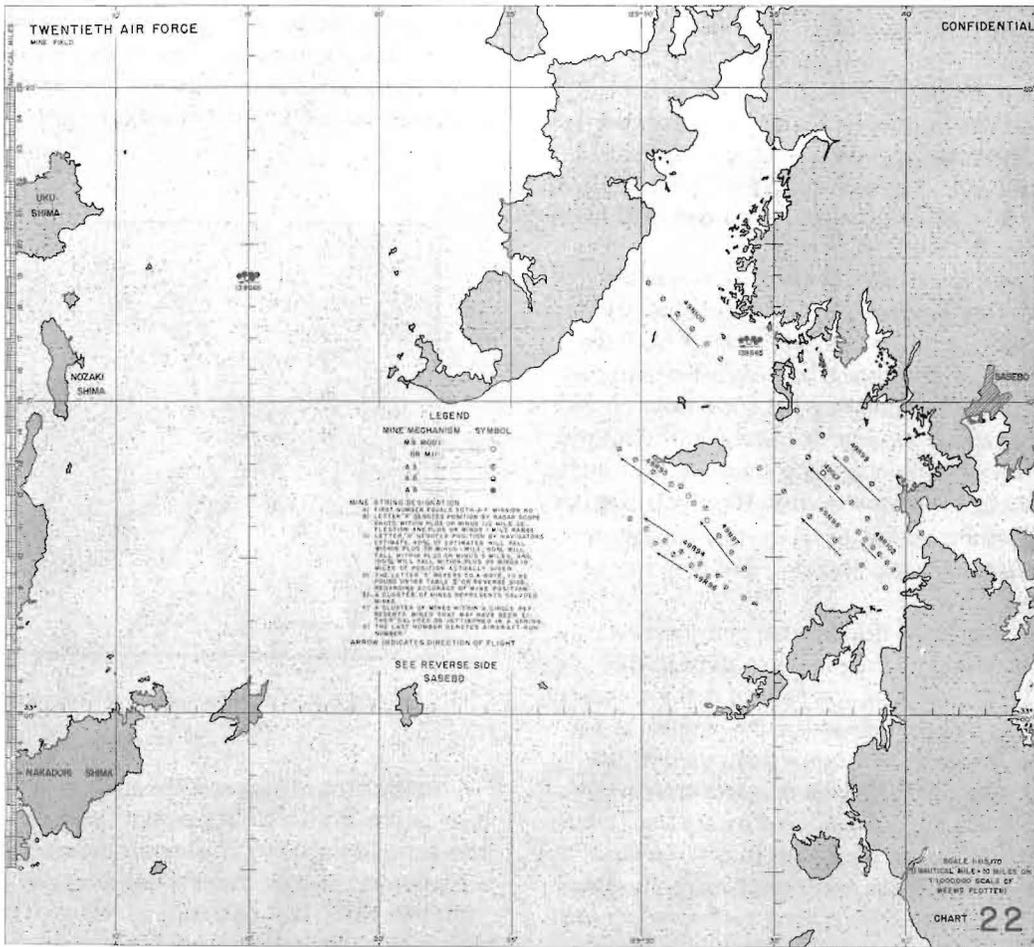
MINES AGAINST JAPAN			Have Mines in Grid 22 to 42		
Starting Date	Mine Size	Mine Type*	Starting Date	Mine Size	Mine Type*
Grid 22	1000 lb	4 211-6, 10 211-6, 1 211-6, 3 211-6, 15 211-6, 12 211-6,	Grid 23	1000 lb	1 211-7, 1 211-7, 3 211-7, 1 211-7, 1 211-7, 1 211-7,
7-19 June	1000 lb	2 211-6, 22 211-6, 12 211-6, 1 211-6,	7-19 April	1000 lb	2 211-7, 4 211-7, 1 211-7,
9-16 July	1000 lb	3 211-6, 1 211-6, 2 211-6, 6 211-6, 3 211-6, 5 211-7,	7-19 May	1000 lb	3 211-7, 1 211-7, 1 211-7,
		2 211-7, 3 211-7, 6 211-7, 4 211-7, 12 211-7, 6 211-8,	7-19 June	1000 lb	1 211-7, 1 211-7, 1 211-7,
		4 211-8,	7-21 August	1000 lb	1 211-7, 1 211-7,
22 Jul-1 Aug	1000 lb	4 211-6, 2 211-6, 3 211-6, 3 211-6, 6 211-6, 4 211-6,	16-27 May	2000 lb	3 211-6, 3 211-6, 3 211-6, 2 211-6, 4 211-6, 6 211-6,
		4 211-6, 1 211-6, 1 211-6,			
16-27 May	2000 lb	2 211-6, 7 211-6, 1 211-6, 3 211-6, 5 211-6, 2 211-6,	Grid 24	1000 lb	1 211-8, 1 211-8, 1 211-8, 3 211-8, 1 211-8, 1 211-8, 1 211-8,
7-19 June	2000 lb	3 211-6, 1 211-6,	7-19 April	1000 lb	2 211-8, 4 211-8, 1 211-8, 1 211-8,
9-16 July	2000 lb	6 211-6, 2 211-6, 3 211-6, 5 211-6, 3 211-7, 3 211-8,	7-19 May	1000 lb	1 211-8, 1 211-8, 1 211-8, 2 211-8, 1 211-8, 1 211-8,
22 Jul-1 Aug	2000 lb	1 211-6, 3 211-6, 10 211-6, 1 211-6, 3 211-7, 4 211-7,	7-19 June	1000 lb	1 211-8, 2 211-8, 1 211-8, 1 211-8, 1 211-8, 1 211-8,
		1 211-8, 1 211-8, 1 211-8, 1 211-8, 1 211-8, 1 211-8,	16-27 May	2000 lb	1 211-8, 1 211-8, 3 211-8, 2 211-8, 2 211-8, 3 211-8,
		1 211-8, 10 211-7, 27 211-7,			3 211-8, 6 211-8, 1 211-8,
Grid 25	1000 lb	3 211-5, 5 211-5, 1 211-5, 2 211-5, 10 211-5, 5 211-5,	Grid 25	1000 lb	2 211-9, 1 211-9, 10 211-9,
16-27 May	1000 lb	3 211-7, 5 211-7, 5 211-7, 3 211-7,	7-19 April	1000 lb	4 211-9, 2 211-9, 1 211-9, 16 211-9, 4 211-9, 6 211-9,
16-27 May	2000 lb	1 211-8, 7 211-8, 2 211-8, 6 211-8, 4 211-8, 1 211-8,	7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9,
7-19 June	2000 lb	2 211-8, 6 211-8, 3 211-8, 4 211-8,	7-19 June	1000 lb	7 211-9, 2 211-9, 7 211-9, 2 211-9, 3 211-9, 2 211-9,
25 June-3 Jul	2000 lb	3 211-8, 10 211-8, 9 211-8, 12 211-8,	16-27 May	2000 lb	2 211-9, 4 211-9, 5 211-9, 7 211-9,
16-27 May	2000 lb	1 211-8, 1 211-8, 2 211-8, 1 211-8,			
22 Jul-1 Aug	2000 lb	3 211-7, 9 211-7,	Grid 26	1000 lb	1 211-9, 2 211-9, 1 211-9,
			7-19 April	1000 lb	7 211-9, 1 211-9, 1 211-9,
			7-19 May	1000 lb	1 211-9, 2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,
			16-27 May	2000 lb	2 211-9, 4 211-9, 5 211-9, 7 211-9,
Grid 26	1000 lb	3 211-9, 9 211-9,	Grid 27	1000 lb	1 211-9, 2 211-9, 1 211-9, 2 211-9, 20 211-9,
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 3 211-9, 1 211-9, 5 211-9,	7-19 April	1000 lb	7 211-9, 1 211-9, 1 211-9,
7-19 May	1000 lb	1 211-9, 1 211-9, 2 211-9, 6 211-9, 3 211-9,	7-19 May	1000 lb	1 211-9, 2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,
7-19 June	1000 lb	1 211-9,	7-19 June	1000 lb	1 211-9, 2 211-9, 1 211-9, 2 211-9,
7-19 July	1000 lb	1 211-9, 2 211-9, 1 211-9,	7-19 August	1000 lb	4 211-9, 2 211-9,
22 Jul-1 Aug	1000 lb	1 211-9, 2 211-9, 1 211-9,			
Grid 27	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,	7-19 April	2000 lb	3 211-9,
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,	16-27 May	2000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,
22 Jul-1 Aug	1000 lb	2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 June	2000 lb	1 211-9, 2 211-9, 1 211-9,	Grid 28	1000 lb	2 211-9, 1 211-9, 1 211-9, 1 211-9, 2 211-9, 1 211-9,
25 June-3 Jul	2000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,	7-19 April	1000 lb	2 211-9, 2 211-9,
16-27 May	2000 lb	1 211-9, 2 211-9, 1 211-9,	7-19 May	2000 lb	1 211-9, 3 211-9, 4 211-9, 1 211-9,
7-19 June	2000 lb	1 211-9, 2 211-9, 1 211-9,	Grid 29	1000 lb	2 211-9, 1 211-9,
25 June-3 Jul	2000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,	7-19 April	1000 lb	1 211-9, 2 211-9,
22 Jul-1 Aug	2000 lb	1 211-9, 2 211-9, 1 211-9,			
Grid 28	1000 lb	2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,	7-19 May	1000 lb	1 211-9, 2 211-9, 1 211-9, 1 211-9, 1 211-9,
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,	7-19 June	1000 lb	1 211-9, 2 211-9, 1 211-9, 1 211-9, 1 211-9,
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,	7-19 August	1000 lb	1 211-9, 2 211-9, 1 211-9, 1 211-9, 1 211-9,
7-19 June	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
25 June-3 Jul	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	2 211-9, 5 211-9,			
7-19 June	2000 lb	6 211-9, 4 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
22 Jul-1 Aug	2000 lb	4 211-9, 9 211-9,			
Grid 29	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 April	1000 lb	1 211-9, 1 211-9,			
7-19 May	1000 lb	1 211-9, 1 211-9, 2 211-9, 2 211-9, 4 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	1 211-9, 1 211-9,			
Grid 30	1000 lb	3 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	1 211-9, 1 211-9,			
Grid 31	1000 lb	2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	1 211-9, 1 211-9,			
Grid 32	1000 lb	3 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	1 211-9, 1 211-9,			
Grid 33	1000 lb	2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	1 211-9, 1 211-9,			
Grid 34	1000 lb	2 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	1 211-9, 1 211-9,			
Grid 35	1000 lb	3 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 April	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 May	1000 lb	1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9, 1 211-9,			
7-19 August	1000 lb	1 211-9, 1 211-9, 1 211-9,			
16-27 May	2000 lb	1 211-9, 1 211-9,			

* Dates are given in the order in which they were listed. All dates are in the month and year.

For all details on the mines see the records of this Committee.

MINES AGAINST JAPAN

Chart 22 Sasebo



SASEBO

Table I Mine Mines

Date	By No. 1	M1	A-1	A-2	A-3	Total
1 Sept 45	---	5	50	---	5	60
10 Sept 45	---	5	04	---	5	14
1 Oct 45	---	5	---	---	5	10
15 Oct 45	---	5	---	---	5	10
1 Nov 45	---	5	---	---	5	10
15 Nov 45	---	5	---	---	5	10
1 Dec 45	---	5	---	---	5	10
15 Dec 45	---	5	---	---	5	10
1 Jan 46	---	5	---	---	5	10
15 Jan 46	---	5	---	---	5	10
1 Feb 46	---	5	---	---	5	10
15 Feb 46	---	5	---	---	5	10
1 Mar 46	---	5	---	---	5	10
15 Mar 46	---	5	---	---	5	10
30 Mar 46	---	5	---	---	5	10
3 May 46	---	04	---	---	5	09

* All mine mines until this date unless swept or cleared.

48998	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
48999	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
48999	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
48999	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
48999	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
* 139065	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
3 May 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89

* These mines were dropped by a plane with cooperative radar. The crew believes they are in line of the two plotted positions. The mines should be considered as being anywhere within the general area. The navigational information for this drop is very unreliable.

TABLE II

Preparation of Mines Laid in Sasebo

48994	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
48995	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
48996	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
48997	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89
30 Mar 45	2000 lb	Q21-89, Q21-89, Q21-89, Q21-89, Q21-89, Q21-89

Details of Mines of Sasebo Minefield, 15 August 1945: Most, if not all, of these mines have probably been swept by the minesweepers for the pressure mine.

Details of Clearance of Sasebo Minefield, 15 August 1945: The magnetic and electric mines can be swept. The location of the pressure mine is so uncertain that very little can be done except to accept a small risk and to use great discipline in staying in the swept channel. The pressure mine are cooperative in 30 fathoms and should stay in 35 fathoms if possible. The enemy swept channel has not been located due to lack of reconnaissance.

MINES AGAINST JAPAN

Shikoku to an initial point on the peninsula projecting from Shikoku into Bungo Suido, and then fanned out over the southern part of Hiroshima Bay, mining both entrances to the bay and the large naval anchorage north of Yashiro Shima. The second force approached directly to a checkpoint on the south central coast of Shikoku, crossed Shikoku to a small island north of Matsuyama which was used for the initial point, and then mined the upper portion of Hiroshima Bay on an axis of attack of approximately 310° . Both forces retired around the city of Hiroshima and back across Hiuchi Nada and the central portion of Shikoku as shown on the chart.

Subsequent missions were flown to reinforce this basic mine field. One used the same direction of attack as the first force, and the others used a branch-off from the Shimonoseki route, with an island in the southeastern portion of Suo Nada (Hime Shima) for the initial point, from which the axis of attack was approximately 060° . This was particularly effective for mining the entrance to Kure and the channel used by the enemy through Hiroshima Bay (see Chart 12). The retirement for the latter route, not shown on the chart, was back across Shikoku, similar to that of the other forces.

The only other mine field planted in this area was an attrition field blocking the shipping lanes through the Inland Sea of Japan. The field was planted in the portion of the Inland Sea southeast of Hiroshima Bay, known as Aki Nada, and in Hiuchi Nada. The initial point used by the aircraft planting this mine field was the same checkpoint on the south central coast of Shikoku used by the force which mined the upper portion of Hiroshima Bay. From this point, the aircraft fanned out over a wide area with axes of attack between 310° and 010° , placing the heaviest concentration of mines in the eastern end of the area known as Bingo Nada. A left turn was made by all aircraft, after which they proceeded to a checkpoint on the southeastern extremity of Shikoku, and thence to Iwo.

All mining in these areas was carried out at 6000-8000 feet, except one mission against the Kure Naval Base, which was flown at 25,000 feet because of the presence of heavy Japanese naval units at Kure. This was the only high altitude mining mission carried out by the 313th Bombardment Wing. For the route of this mission, not shown on the Figure, the initial point was selected on the basis of "metro" winds so that the aircraft would fly directly into the wind, thus permitting the wind drift of the mine to be absorbed in the slant range setting on the radar. The initial point was approximately 30 miles due east of Kure, and approach and retirement routes were direct.

No aircraft was lost in the mine laying carried out in these areas. For positions of all mines planted, see Charts 9, 10, 11, and 12. It is significant that concentrated mine fields were planted in Hiroshima Bay and in the approaches

to Kure, and that a strong attrition field was placed across the main Inland Sea shipping route at Bingo Nada.

Kobe-Osaka-Harima Nada Areas. The Kobe and Osaka areas were mined heavily during the early part of May in conjunction with the mining attacks on the Inland Sea and other south Honshu ports. These fields were then reinforced several times at later dates whenever shipping concentrations seemed to justify further effort.

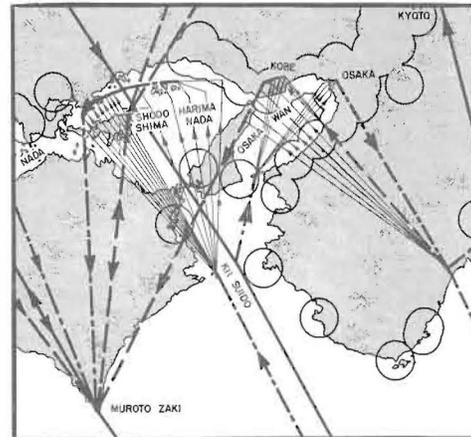


Figure 8-5. Kobe-Osaka-Harima Nada Areas

In the first mining at Kobe and Osaka, an effort was made to put down a blockade mine field and at the same time to avoid the heavy anti-aircraft defenses being brought to bear on the aircraft then making incendiary attacks on both these cities. After a detailed analysis of enemy anti-aircraft capabilities, it was decided to make the attack on an approximate heading of 310° , and to mine the entire upper portion of Osaka Wan, while placing the heaviest concentration of mines off the Kobe port area. The initial point selected for this attack was on the southern coast of Honshu, approximately midway between Kii Suido and Ise Wan. After dropping their mines, the aircraft made a left turn to Muroto Saki (Shikoku), and then returned via Iwo Jima.

One subsequent attack was made using the same initial point, approach, and retirement. After this there was a considerable lapse of time, during which both Kobe and Osaka were effectively knocked out by incendiary attacks. Later reinforcements to the mine fields were therefore made employing new approaches and placing the mines directly in the port areas where they would be of greatest annoyance to the enemy. In general, the approaches for these later attacks were made through Kii Suido, using a small island at the southern end of Osaka Wan for the initial point, and thence directly to the port area of Kobe or

TABLE I
Classification of Mines in East Bingo Noda

MINES WHICH WERE NOT CLASSIFIED

CLASSIFICATION	NO. OF MINES	CLASSIFICATION	NO. OF MINES
1. MINE	42	10. MINE	10
2. MINE	10	11. MINE	10
3. MINE	10	12. MINE	10
4. MINE	10	13. MINE	10
5. MINE	10	14. MINE	10
6. MINE	10	15. MINE	10
7. MINE	10	16. MINE	10
8. MINE	10	17. MINE	10
9. MINE	10	18. MINE	10
TOTAL	100	TOTAL	100

TABLE II
Classification of Mines in East Bingo Noda

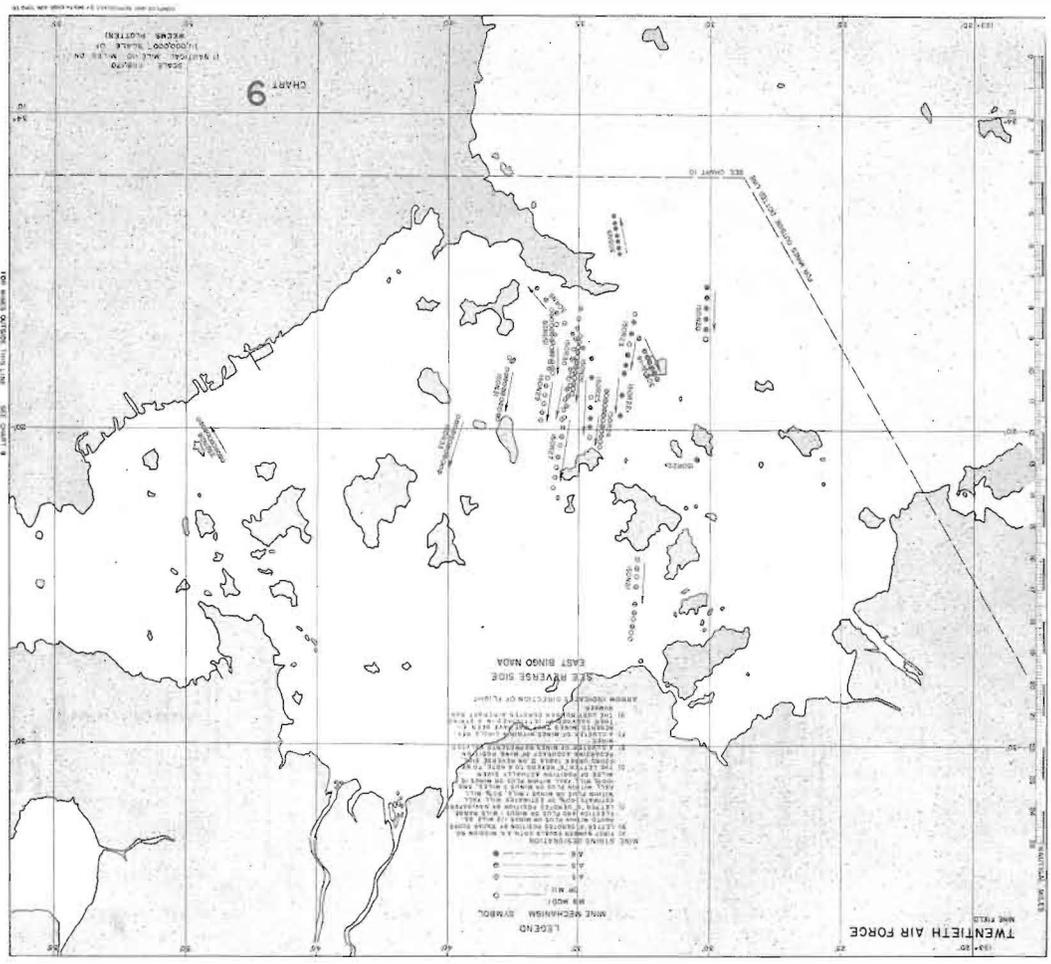
MINES WHICH WERE CLASSIFIED

CLASSIFICATION	NO. OF MINES	CLASSIFICATION	NO. OF MINES
1. MINE	42	10. MINE	10
2. MINE	10	11. MINE	10
3. MINE	10	12. MINE	10
4. MINE	10	13. MINE	10
5. MINE	10	14. MINE	10
6. MINE	10	15. MINE	10
7. MINE	10	16. MINE	10
8. MINE	10	17. MINE	10
9. MINE	10	18. MINE	10
TOTAL	100	TOTAL	100

TABLE III
Classification of Mines in East Bingo Noda

MINES WHICH WERE CLASSIFIED

CLASSIFICATION	NO. OF MINES	CLASSIFICATION	NO. OF MINES
1. MINE	42	10. MINE	10
2. MINE	10	11. MINE	10
3. MINE	10	12. MINE	10
4. MINE	10	13. MINE	10
5. MINE	10	14. MINE	10
6. MINE	10	15. MINE	10
7. MINE	10	16. MINE	10
8. MINE	10	17. MINE	10
9. MINE	10	18. MINE	10
TOTAL	100	TOTAL	100



MINES AGAINST JAPAN
 Chart 9 East Bingo Noda

MINES AGAINST JAPAN

Chart 12 Kure-Hiroshima

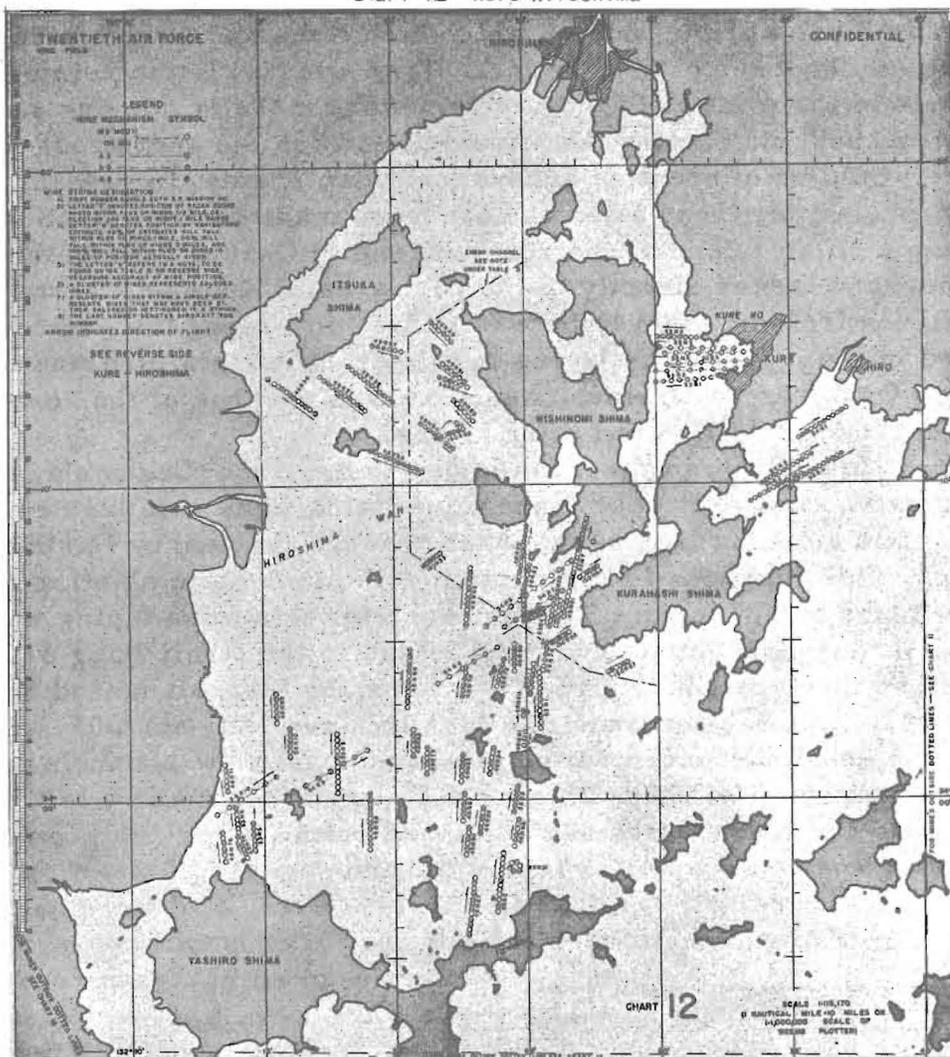


Table I Mine mine

Date	By No. 1	By No. 2	By No. 3	By No. 4	By No. 5	By No. 6	By No. 7	By No. 8	By No. 9	By No. 10
1 Nov 45	121	66	21	11	11	11	11	11	11	11
2 Nov 45	121	66	21	11	11	11	11	11	11	11
3 Nov 45	121	66	21	11	11	11	11	11	11	11
4 Nov 45	121	66	21	11	11	11	11	11	11	11
5 Nov 45	121	66	21	11	11	11	11	11	11	11
6 Nov 45	121	66	21	11	11	11	11	11	11	11
7 Nov 45	121	66	21	11	11	11	11	11	11	11
8 Nov 45	121	66	21	11	11	11	11	11	11	11
9 Nov 45	121	66	21	11	11	11	11	11	11	11
10 Nov 45	121	66	21	11	11	11	11	11	11	11

Table II

Progression of Mine Laid to the Hiroshima

Date	By No. 1	By No. 2	By No. 3	By No. 4	By No. 5	By No. 6	By No. 7	By No. 8	By No. 9	By No. 10
1 Nov 45	121	66	21	11	11	11	11	11	11	11
2 Nov 45	121	66	21	11	11	11	11	11	11	11
3 Nov 45	121	66	21	11	11	11	11	11	11	11
4 Nov 45	121	66	21	11	11	11	11	11	11	11
5 Nov 45	121	66	21	11	11	11	11	11	11	11
6 Nov 45	121	66	21	11	11	11	11	11	11	11
7 Nov 45	121	66	21	11	11	11	11	11	11	11
8 Nov 45	121	66	21	11	11	11	11	11	11	11
9 Nov 45	121	66	21	11	11	11	11	11	11	11
10 Nov 45	121	66	21	11	11	11	11	11	11	11

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Osaka or both. Retirement from Kobe was by left turn along the same route used in the initial mine laying in this area. A right turn was made from Osaka and retirement was along the reverse of the route used as approach in the initial mine laying.

In addition to the mine laying at the Kobe-Osaka shipping terminus, comparatively dense mine fields were also planted in the main shipping lane to this area through the nearby Harima Nada. This was done in conjunction with other mine planting in the Inland Sea of Japan. The approach for this mine laying was also through Kii Suido to a small island in the strait lying off the eastern tip of Shikoku. From this point the aircraft fanned out over Harima Nada on axes of attack between 320° and 005° , placing the heaviest concentration of mines across the channels passing north and south of Shodo Shima. All planes then made a left turn to avoid the Kobe-Osaka defenses, and returned via the prominent cape on the southeastern coast of Shikoku.

No aircraft was lost in these attacks, nor were there any significant deviations from routine. For positions of all mines planted in these areas, see Charts 6, 5, and 8. These charts indicate why the Japanese lost a large number of ships to mines in these areas.

Nagoya Area. Very few mines were placed in Nagoya Bay during Operation Starvation, mainly because the traffic to this port did not justify an extensive mining effort. Several strings of mines were planted across the entrance to Ise Wan, however, to divert enemy minesweepers from the heavily mined waters at Kobe-Osaka and of the Inland Sea. These mines were planted concurrently with those in the latter areas. The force to Nagoya used the same initial point off Kumano Nada as the first mine laying force to Osaka Wan, departed from the initial point on an approximate course of 055° , and planted their mines directly across the entrance to Ise Wan. A right turn was made after dropping

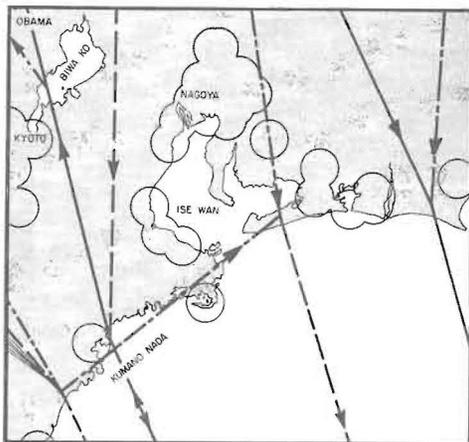


Figure 8-6. Nagoya Area

the mines, and retirement was made directly to Iwo Jima. Chart 3 gives the positions of all mines planted at the entrance to Nagoya Bay.

Tokyo Area. Tokyo's situation was very similar to that of Nagoya, with the exception that the entire Tokyo Bay area was heavily defended and the mouth of the Bay could not be closed by planting mines because the water was too deep. A directive from the 21st Bomber Command ordered a small number of mines to be placed in the harbor areas at Tokyo, Yokohama, and Yokosuka. Four aircraft were therefore assigned to the mission, which was carried out in conjunction with the mining of Nagoya, Kobe-Osaka, and the Inland Sea. Each aircraft was given a separate initial point and axis of attack, and the crews were given the maximum radar countermeasures.

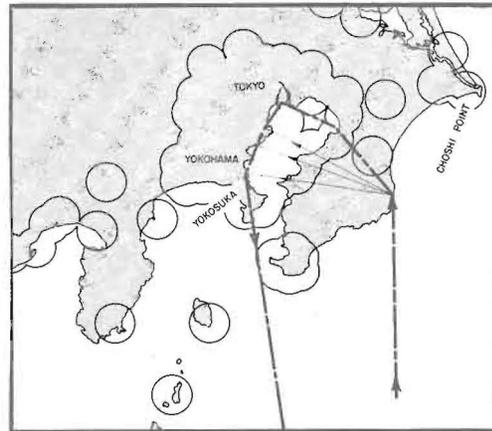


Figure 8-7. Tokyo Area

Approach to the Tokyo areas was made direct from Iwo Jima to a cape on the west coast of Honshu, approximately 40 miles south of Choshi Point. From this location, the aircraft proceeded independently to their individual initial points and axes of attack. After they had dropped their mines, they executed a sharp left turn and returned via Iwo Jima. No aircraft was lost on this mission. For the positions of all mines, see Chart 2.

Hagi-Hamada Areas. These areas are located on the coast of Honshu just north of Shimonoseki Straits, and include Yuya Wan and Senzaki in addition to Hagi and Hamada. After the western approach to Shimonoseki had been mined almost to the point of closure, there was a pronounced diversion of traffic to these small ports north of the straits. They were therefore mined repeatedly in the later stages of Operation Starvation in an attempt to close off all ports through which Korean imports could flow.

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Approach to these areas was made without exception along the same route as that used repeatedly to attack the straits from the northeast, branching off at Hime Shima and thence proceeding almost due north to a checkpoint on the north coast of Honshu, as shown on the chart. The initial point used most frequently for Yuya Wan, Senzaki, and Hagi was a small island (Mi Shima) directly north of Senzaki, at which a procedure turn would be made and the attack delivered in a general southerly direction. This axis of attack was favorable from the mining standpoint, since it was possible to close off all three areas with only a few strings of mines. In one instance Hagi was mined from a slightly different direction, using as an initial point the checkpoint on the north coast of Honshu mentioned above. Hamada was also mined from this initial point, more because it was the only initial point available than that it offered any particular advantages for mining.

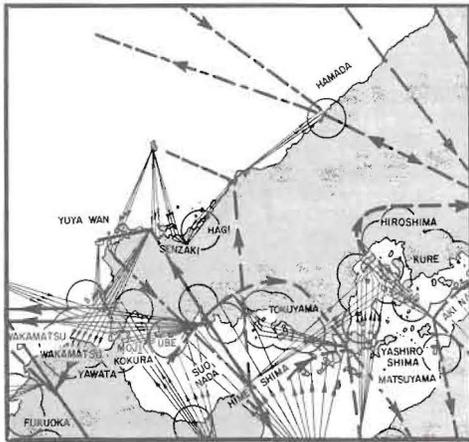


Figure 8-8. Hagi-Hamada Areas

Retirement for mine laying planes against Yuya, Senzaki or Hagi was made along the reverse of the route used to approach Shimonoseki from the north, passing through Bungo Suido and thence to Iwo Jima. The Hamada aircraft retired in a southeasterly direction passing north of Hiroshima and crossing at about the center of Shikoku, thence departing for Iwo Jima from Muroto Saki. No anti-aircraft fire was experienced on these missions, and all aircraft returned safely. For plots showing the results of the mine laying in these areas, see Charts 19, 25, and 26.

Sakai Area. Sakai is a small port near Matsue on the north coast of Honshu, approximately half way between Shimonoseki and the naval port of Maizuru. Its shipping importance increased as Shimonoseki and Maizuru were blockaded. It was mined twice during the later stages of the operation. The approach to Sakai was quite direct since the

route was free of anti-aircraft concentrations. Landfall was usually made on Shikoku at Muroto Saki, from which the aircraft proceeded to the initial point located on a small island on Oki Retto. A procedure turn was made at this initial point, from which the mining attack was delivered on an approximate axis of 155° . Retirement was then made directly via the same checkpoint used for landfall.

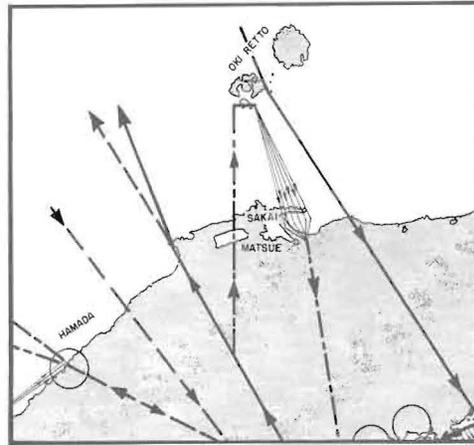


Figure 8-9. Sakai Area

A very narrow channel leads past the port of Sakai and opens into a large bay which was used as an anchorage area. At the suggestion of the bombardment group carrying out the mining during this period, an attempt was made to close this channel by a low altitude visual run in moonlight by single aircraft on a 270° heading at the same time that the main force was mining as described above. This was done, but unfortunately cloud cover obscured the target when the pilot made his run, and it was necessary to drop by radar. These tactics, however, were later used with success in the mining of Sakata.

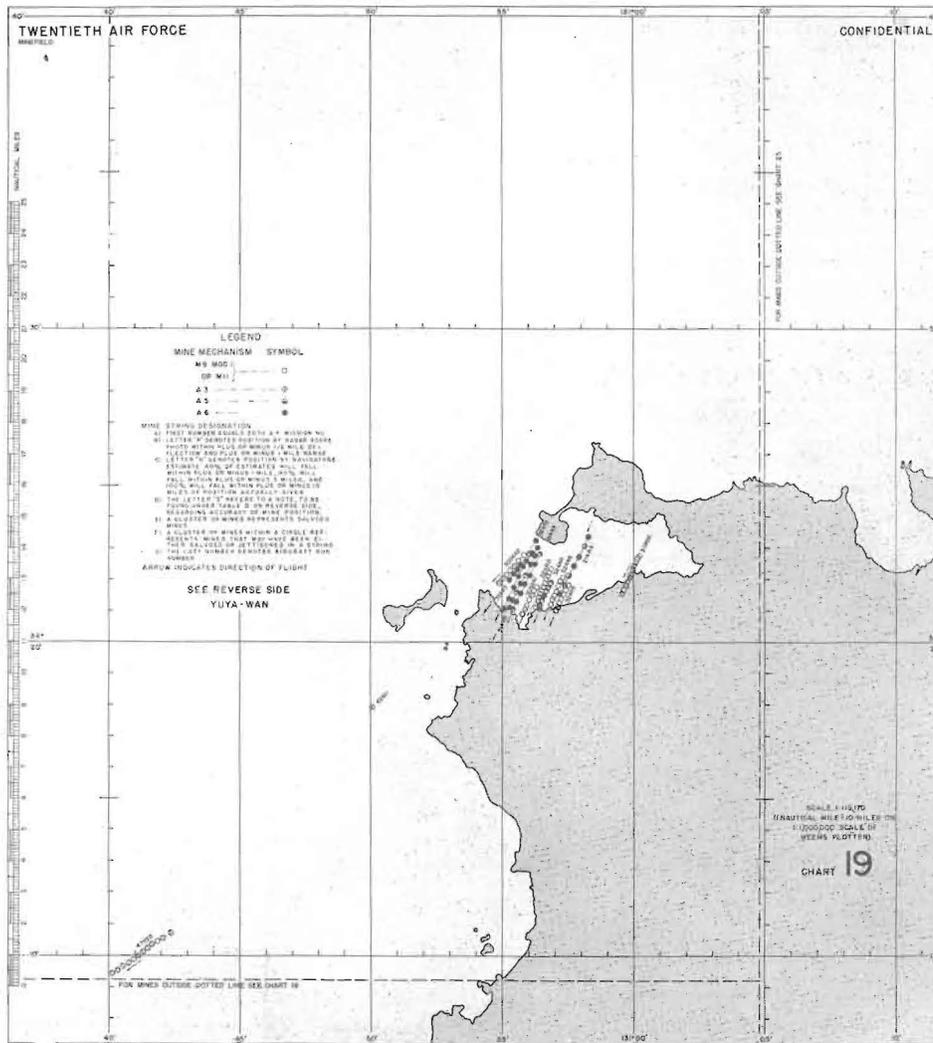
No enemy opposition was encountered at Sakai, and no aircraft was lost at this target. For positions of all mines planted, see Chart 27.

Wakasa Bay Area. Wakasa Bay was a target of primary importance during the greater part of Operation Starvation because of the large naval base and port of Maizuru, and the adjoining ports of Tsuruga, Miyazu, and Obama. Therefore, as soon as the mining attacks were launched against the north coast of Honshu, mine laying was carried out against some portion of Wakasa Bay almost every other night.

Since this bay is situated directly north of the Kobe-Osaka-Kyoto network of defenses, approach to it could not be made directly without passing through zones of fire. All approach and retirement routes therefore skirted these defenses, generally proceeding in a counterclockwise direction

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Chart 19 Yuya-Wan



YUYA-WAN

Table I Live Mines

Date	A1	A2	A3	A4	Total
1 Sept 45	26	8	22	12	68
15 Sept 45	26	8	22	12	68
1 Oct 45	26	8	22	12	68
1 Nov 45	26	8	22	12	68
1 Dec 45	26	8	22	12	68
1 Jan 46	26	8	22	12	68
1 Feb 46	26	8	22	12	68
1 Mar 46	26	8	22	12	68
1 Apr 46	26	8	22	12	68
1 May 46	26	8	22	12	68
1 Jun 46	26	8	22	12	68
1 Jul 46	26	8	22	12	68
1 Aug 46	26	8	22	12	68
1 Sep 46	26	8	22	12	68
1 Oct 46	26	8	22	12	68
1 Nov 46	26	8	22	12	68
1 Dec 46	26	8	22	12	68
1 Jan 47	26	8	22	12	68
1 Feb 47	26	8	22	12	68
1 Mar 47	26	8	22	12	68
1 Apr 47	26	8	22	12	68
1 May 47	26	8	22	12	68
1 Jun 47	26	8	22	12	68
1 Jul 47	26	8	22	12	68
1 Aug 47	26	8	22	12	68
1 Sep 47	26	8	22	12	68
1 Oct 47	26	8	22	12	68
1 Nov 47	26	8	22	12	68
1 Dec 47	26	8	22	12	68
1 Jan 48	26	8	22	12	68
1 Feb 48	26	8	22	12	68
1 Mar 48	26	8	22	12	68
1 Apr 48	26	8	22	12	68
1 May 48	26	8	22	12	68
1 Jun 48	26	8	22	12	68
1 Jul 48	26	8	22	12	68
1 Aug 48	26	8	22	12	68
1 Sep 48	26	8	22	12	68
1 Oct 48	26	8	22	12	68
1 Nov 48	26	8	22	12	68
1 Dec 48	26	8	22	12	68
1 Jan 49	26	8	22	12	68
1 Feb 49	26	8	22	12	68
1 Mar 49	26	8	22	12	68
1 Apr 49	26	8	22	12	68
1 May 49	26	8	22	12	68
1 Jun 49	26	8	22	12	68
1 Jul 49	26	8	22	12	68
1 Aug 49	26	8	22	12	68
1 Sep 49	26	8	22	12	68
1 Oct 49	26	8	22	12	68
1 Nov 49	26	8	22	12	68
1 Dec 49	26	8	22	12	68
1 Jan 50	26	8	22	12	68
1 Feb 50	26	8	22	12	68
1 Mar 50	26	8	22	12	68
1 Apr 50	26	8	22	12	68
1 May 50	26	8	22	12	68
1 Jun 50	26	8	22	12	68
1 Jul 50	26	8	22	12	68
1 Aug 50	26	8	22	12	68
1 Sep 50	26	8	22	12	68
1 Oct 50	26	8	22	12	68
1 Nov 50	26	8	22	12	68
1 Dec 50	26	8	22	12	68
1 Jan 51	26	8	22	12	68
1 Feb 51	26	8	22	12	68
1 Mar 51	26	8	22	12	68
1 Apr 51	26	8	22	12	68
1 May 51	26	8	22	12	68
1 Jun 51	26	8	22	12	68
1 Jul 51	26	8	22	12	68
1 Aug 51	26	8	22	12	68
1 Sep 51	26	8	22	12	68
1 Oct 51	26	8	22	12	68
1 Nov 51	26	8	22	12	68
1 Dec 51	26	8	22	12	68
1 Jan 52	26	8	22	12	68
1 Feb 52	26	8	22	12	68
1 Mar 52	26	8	22	12	68
1 Apr 52	26	8	22	12	68
1 May 52	26	8	22	12	68
1 Jun 52	26	8	22	12	68
1 Jul 52	26	8	22	12	68
1 Aug 52	26	8	22	12	68
1 Sep 52	26	8	22	12	68
1 Oct 52	26	8	22	12	68
1 Nov 52	26	8	22	12	68
1 Dec 52	26	8	22	12	68
1 Jan 53	26	8	22	12	68
1 Feb 53	26	8	22	12	68
1 Mar 53	26	8	22	12	68
1 Apr 53	26	8	22	12	68
1 May 53	26	8	22	12	68
1 Jun 53	26	8	22	12	68
1 Jul 53	26	8	22	12	68
1 Aug 53	26	8	22	12	68
1 Sep 53	26	8	22	12	68
1 Oct 53	26	8	22	12	68
1 Nov 53	26	8	22	12	68
1 Dec 53	26	8	22	12	68
1 Jan 54	26	8	22	12	68
1 Feb 54	26	8	22	12	68
1 Mar 54	26	8	22	12	68
1 Apr 54	26	8	22	12	68
1 May 54	26	8	22	12	68
1 Jun 54	26	8	22	12	68
1 Jul 54	26	8	22	12	68
1 Aug 54	26	8	22	12	68
1 Sep 54	26	8	22	12	68
1 Oct 54	26	8	22	12	68
1 Nov 54	26	8	22	12	68
1 Dec 54	26	8	22	12	68
1 Jan 55	26	8	22	12	68
1 Feb 55	26	8	22	12	68
1 Mar 55	26	8	22	12	68
1 Apr 55	26	8	22	12	68
1 May 55	26	8	22	12	68
1 Jun 55	26	8	22	12	68
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1 Oct 55	26	8	22	12	68
1 Nov 55	26	8	22	12	68
1 Dec 55	26	8	22	12	68
1 Jan 56	26	8	22	12	68
1 Feb 56	26	8	22	12	68
1 Mar 56	26	8	22	12	68
1 Apr 56	26	8	22	12	68
1 May 56	26	8	22	12	68
1 Jun 56	26	8	22	12	68
1 Jul 56	26	8	22	12	68
1 Aug 56	26	8	22	12	68
1 Sep 56	26	8	22	12	68
1 Oct 56	26	8	22	12	68
1 Nov 56	26	8	22	12	68
1 Dec 56	26	8	22	12	68
1 Jan 57	26	8	22	12	68
1 Feb 57	26	8	22	12	68
1 Mar 57	26	8	22	12	68
1 Apr 57	26	8	22	12	68
1 May 57	26	8	22	12	68
1 Jun 57	26	8	22	12	68
1 Jul 57	26	8	22	12	68
1 Aug 57	26	8	22	12	68
1 Sep 57	26	8	22	12	68
1 Oct 57	26	8	22	12	68
1 Nov 57	26	8	22	12	68
1 Dec 57	26	8	22	12	68
1 Jan 58	26	8	22	12	68
1 Feb 58	26	8	22	12	68
1 Mar 58	26	8	22	12	68
1 Apr 58	26	8	22	12	68
1 May 58	26	8	22	12	68
1 Jun 58	26	8	22	12	68
1 Jul 58	26	8	22	12	68
1 Aug 58	26	8	22	12	68
1 Sep 58	26	8	22	12	68
1 Oct 58	26	8	22	12	68
1 Nov 58	26	8	22	12	68
1 Dec 58	26	8	22	12	68
1 Jan 59	26	8	22	12	68
1 Feb 59	26	8	22	12	68
1 Mar 59	26	8	22	12	68
1 Apr 59	26	8	22	12	68
1 May 59	26	8	22	12	68
1 Jun 59	26	8	22	12	68
1 Jul 59	26	8	22	12	68
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1 Oct 59	26	8	22	12	68
1 Nov 59	26	8	22	12	68
1 Dec 59	26	8	22	12	68
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1 Feb 60	26	8	22	12	68
1 Mar 60	26	8	22	12	68
1 Apr 60	26	8	22	12	68
1 May 60	26	8	22	12	68
1 Jun 60	26	8	22	12	68
1 Jul 60	26	8	22	12	68
1 Aug 60	26	8	22	12	68
1 Sep 60	26	8	22	12	68
1 Oct 60	26	8	22	12	68
1 Nov 60	26	8	22	12	68
1 Dec 60	26	8	22	12	68
1 Jan 61	26	8	22	12	68
1 Feb 61	26	8	22	12	68
1 Mar 61	26	8	22	12	68
1 Apr 61	26	8	22	12	68
1 May 61	26	8	22	12	68
1 Jun 61	26	8	22	12	68
1 Jul 61	26	8	22	12	68
1 Aug 61	26	8	22	12	68
1 Sep 61	26	8	22	12	68
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1 Nov 61	26	8	22	12	68
1 Dec 61	26	8	22	12	68
1 Jan 62	26	8	22	12	68
1 Feb 62	26	8	22	12	68
1 Mar 62	26	8	22	12	68
1 Apr 62	26	8	22	12	68
1 May 62	26	8	22	12	68
1 Jun 62	26	8	22	12	68
1 Jul 62	26	8	22	12	68
1 Aug 62	26	8	22	12	68
1 Sep 62	26	8	22	12	68
1 Oct 62	26	8	22	12	68
1 Nov 62	26	8	22	12	68
1 Dec 62	26	8	22		

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when the target was Maizuru or Miyazu, and in a clockwise direction when Tsuruga or Obama were under attack.

The most frequent approach employed when attacking Maizuru was to make landfall on the south Honshu coast roughly midway between Kii Suido and Ise Wan, then to pass between the Osaka and Nagoya defenses to a checkpoint on Biwa Ko, and thence to an initial point on the shore of Wakasa Bay close to Obama. From this initial point the attack could be delivered to either Maizuru or Miyazu on an axis of attack of 255° or 265° , respectively. Retirement was then made in a general southwesterly direction to a checkpoint on Shodo Shima, thence to the much-used departure point of Muroto-Zaki on the southern coast of Shikoku. Only one variation of this route was used during the campaign, and this consisted of using a point on the southern portion of Biwa Ko as the initial point and planting the mines on an axis of attack of approximately 300° . This variation is not shown on the chart.

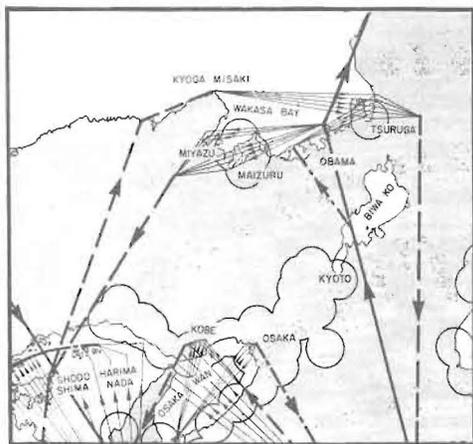


Figure 8-10. Wakasa Bay Area

Two different approaches were used to mine Tsuruga, depending on whether this port alone was to be mined or whether both Tsuruga and Obama were to be hit simultaneously. In the former case, a branch-off from the route to Maizuru was employed, proceeding from the checkpoint on Biwa Ko to an initial point on the shore of Wakasa Bay between Maizuru and Obama, and planting the mines on a heading of roughly 065° . Retirement would then be by right turn to the point of landfall on south Honshu, passing between the defenses at Osaka-Kyoto and Nagoya. When Obama was also a target, however, approach was made from west of Kobe, following the reverse track of the retirement route used to mine Maizuru, to an initial point on the western extremity of Wakasa Bay (Kyoga Misaki). From this initial point, the mining attack could be delivered to Obama

on a heading of about 120° , or to Tsuruga on a heading of 095° , and retirement made as in the first case.

Opposition at all these ports was slight in the early stages of the mine laying, but increased in intensity at Maizuru when the reduction of the Kure and Yokosuka naval bases made the former port the only remaining Japanese naval base. Altitudes of attack were gradually increased from 5000 to 8000 feet, and the last few missions were carried out at 12,000 feet. All aircraft returned safely from missions to these areas in spite of the defenses. For results of the mine laying in these areas, see Charts 30 and 29.

Toyama Bay Area. Ports in the Toyama Bay Area were difficult mining targets because of few suitable initial points, poor radar aiming points, and very small areas of mineable water. Particularly difficult to mine was the port of Fushiki which received much shipping all during the campaign against the north Honshu ports. The same was true of Nanao, though to a lesser extent.

Approach to this area was made without exception along the same route as that used to mine Tsuruga, i.e., from landfall between Kii Suido and Ise Wan to a checkpoint on Wakasa Bay via Biwa Ko; from this point the north coast of Honshu was paralleled to a small island north of Noto Peninsula, at which a turn was made to an initial point on the tip of the peninsula (Rokugo-Saki). From this point, the mining attack could be launched either against Nanao on a general heading of 220° or against Fushiki on a heading of 200° . Retirement was then usually made directly to a departure point on the south coast of Honshu between Ise Wan and Suruga Wan, avoiding the Nagoya defenses, and thence to Iwo Jima. No significant opposition was encountered over this target, nor were any aircraft lost while mine laying. For plots see Chart 31.

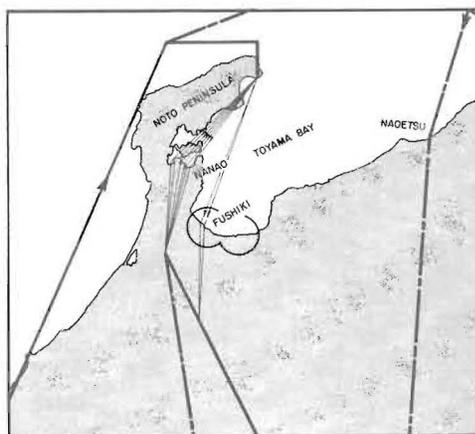


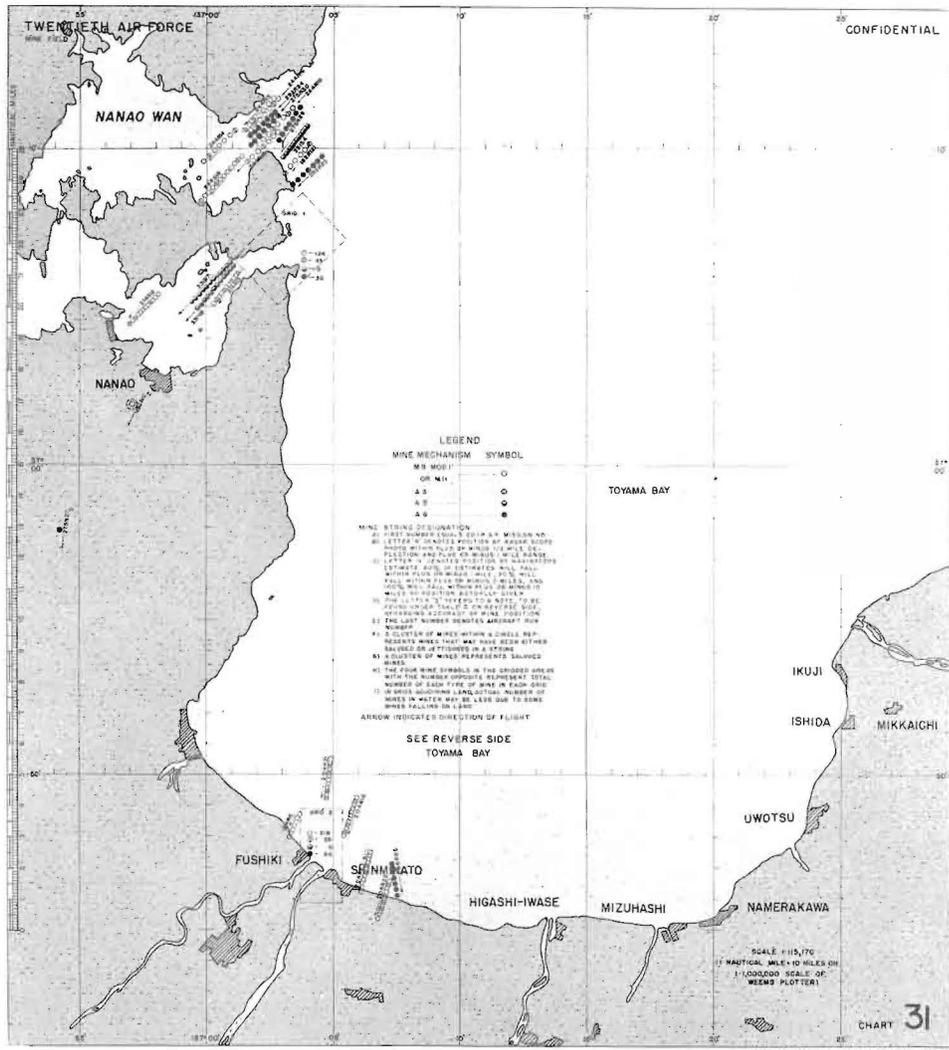
Figure 8-11. Toyama Bay Area

Case No.	Date	Plaintiff	Defendant	Amount	Status
100-100001	1945-01-15	John Doe	Jane Smith	\$100.00	Settled
100-100002	1945-02-20	ABC Corp	XYZ Inc	\$500.00	Pending
100-100003	1945-03-10	John Doe	Jane Smith	\$200.00	Settled
100-100004	1945-04-05	ABC Corp	XYZ Inc	\$750.00	Pending
100-100005	1945-05-15	John Doe	Jane Smith	\$300.00	Settled
100-100006	1945-06-20	ABC Corp	XYZ Inc	\$900.00	Pending
100-100007	1945-07-10	John Doe	Jane Smith	\$400.00	Settled
100-100008	1945-08-05	ABC Corp	XYZ Inc	\$1100.00	Pending
100-100009	1945-09-15	John Doe	Jane Smith	\$500.00	Settled
100-100010	1945-10-20	ABC Corp	XYZ Inc	\$1300.00	Pending
100-100011	1945-11-10	John Doe	Jane Smith	\$600.00	Settled
100-100012	1945-12-05	ABC Corp	XYZ Inc	\$1500.00	Pending
100-100013	1946-01-15	John Doe	Jane Smith	\$700.00	Settled
100-100014	1946-02-20	ABC Corp	XYZ Inc	\$1700.00	Pending
100-100015	1946-03-10	John Doe	Jane Smith	\$800.00	Settled
100-100016	1946-04-05	ABC Corp	XYZ Inc	\$1900.00	Pending
100-100017	1946-05-15	John Doe	Jane Smith	\$900.00	Settled
100-100018	1946-06-20	ABC Corp	XYZ Inc	\$2100.00	Pending
100-100019	1946-07-10	John Doe	Jane Smith	\$1000.00	Settled
100-100020	1946-08-05	ABC Corp	XYZ Inc	\$2300.00	Pending
100-100021	1946-09-15	John Doe	Jane Smith	\$1100.00	Settled
100-100022	1946-10-20	ABC Corp	XYZ Inc	\$2500.00	Pending
100-100023	1946-11-10	John Doe	Jane Smith	\$1200.00	Settled
100-100024	1946-12-05	ABC Corp	XYZ Inc	\$2700.00	Pending
100-100025	1947-01-15	John Doe	Jane Smith	\$1300.00	Settled
100-100026	1947-02-20	ABC Corp	XYZ Inc	\$2900.00	Pending
100-100027	1947-03-10	John Doe	Jane Smith	\$1400.00	Settled
100-100028	1947-04-05	ABC Corp	XYZ Inc	\$3100.00	Pending
100-100029	1947-05-15	John Doe	Jane Smith	\$1500.00	Settled
100-100030	1947-06-20	ABC Corp	XYZ Inc	\$3300.00	Pending
100-100031	1947-07-10	John Doe	Jane Smith	\$1600.00	Settled
100-100032	1947-08-05	ABC Corp	XYZ Inc	\$3500.00	Pending
100-100033	1947-09-15	John Doe	Jane Smith	\$1700.00	Settled
100-100034	1947-10-20	ABC Corp	XYZ Inc	\$3700.00	Pending
100-100035	1947-11-10	John Doe	Jane Smith	\$1800.00	Settled
100-100036	1947-12-05	ABC Corp	XYZ Inc	\$3900.00	Pending
100-100037	1948-01-15	John Doe	Jane Smith	\$1900.00	Settled
100-100038	1948-02-20	ABC Corp	XYZ Inc	\$4100.00	Pending
100-100039	1948-03-10	John Doe	Jane Smith	\$2000.00	Settled
100-100040	1948-04-05	ABC Corp	XYZ Inc	\$4300.00	Pending
100-100041	1948-05-15	John Doe	Jane Smith	\$2100.00	Settled
100-100042	1948-06-20	ABC Corp	XYZ Inc	\$4500.00	Pending
100-100043	1948-07-10	John Doe	Jane Smith	\$2200.00	Settled
100-100044	1948-08-05	ABC Corp	XYZ Inc	\$4700.00	Pending
100-100045	1948-09-15	John Doe	Jane Smith	\$2300.00	Settled
100-100046	1948-10-20	ABC Corp	XYZ Inc	\$4900.00	Pending
100-100047	1948-11-10	John Doe	Jane Smith	\$2400.00	Settled
100-100048	1948-12-05	ABC Corp	XYZ Inc	\$5100.00	Pending
100-100049	1949-01-15	John Doe	Jane Smith	\$2500.00	Settled
100-100050	1949-02-20	ABC Corp	XYZ Inc	\$5300.00	Pending
100-100051	1949-03-10	John Doe	Jane Smith	\$2600.00	Settled
100-100052	1949-04-05	ABC Corp	XYZ Inc	\$5500.00	Pending
100-100053	1949-05-15	John Doe	Jane Smith	\$2700.00	Settled
100-100054	1949-06-20	ABC Corp	XYZ Inc	\$5700.00	Pending
100-100055	1949-07-10	John Doe	Jane Smith	\$2800.00	Settled
100-100056	1949-08-05	ABC Corp	XYZ Inc	\$5900.00	Pending
100-100057	1949-09-15	John Doe	Jane Smith	\$2900.00	Settled
100-100058	1949-10-20	ABC Corp	XYZ Inc	\$6100.00	Pending
100-100059	1949-11-10	John Doe	Jane Smith	\$3000.00	Settled
100-100060	1949-12-05	ABC Corp	XYZ Inc	\$6300.00	Pending
100-100061	1950-01-15	John Doe	Jane Smith	\$3100.00	Settled
100-100062	1950-02-20	ABC Corp	XYZ Inc	\$6500.00	Pending
100-100063	1950-03-10	John Doe	Jane Smith	\$3200.00	Settled
100-100064	1950-04-05	ABC Corp	XYZ Inc	\$6700.00	Pending
100-100065	1950-05-15	John Doe	Jane Smith	\$3300.00	Settled
100-100066	1950-06-20	ABC Corp	XYZ Inc	\$6900.00	Pending
100-100067	1950-07-10	John Doe	Jane Smith	\$3400.00	Settled
100-100068	1950-08-05	ABC Corp	XYZ Inc	\$7100.00	Pending
100-100069	1950-09-15	John Doe	Jane Smith	\$3500.00	Settled
100-100070	1950-10-20	ABC Corp	XYZ Inc	\$7300.00	Pending
100-100071	1950-11-10	John Doe	Jane Smith	\$3600.00	Settled
100-100072	1950-12-05	ABC Corp	XYZ Inc	\$7500.00	Pending
100-100073	1951-01-15	John Doe	Jane Smith	\$3700.00	Settled
100-100074	1951-02-20	ABC Corp	XYZ Inc	\$7700.00	Pending
100-100075	1951-03-10	John Doe	Jane Smith	\$3800.00	Settled
100-100076	1951-04-05	ABC Corp	XYZ Inc	\$7900.00	Pending
100-100077	1951-05-15	John Doe	Jane Smith	\$3900.00	Settled
100-100078	1951-06-20	ABC Corp	XYZ Inc	\$8100.00	Pending
100-100079	1951-07-10	John Doe	Jane Smith	\$4000.00	Settled
100-100080	1951-08-05	ABC Corp	XYZ Inc	\$8300.00	Pending
100-100081	1951-09-15	John Doe	Jane Smith	\$4100.00	Settled
100-100082	1951-10-20	ABC Corp	XYZ Inc	\$8500.00	Pending
100-100083	1951-11-10	John Doe	Jane Smith	\$4200.00	Settled
100-100084	1951-12-05	ABC Corp	XYZ Inc	\$8700.00	Pending
100-100085	1952-01-15	John Doe	Jane Smith	\$4300.00	Settled
100-100086	1952-02-20	ABC Corp	XYZ Inc	\$8900.00	Pending
100-100087	1952-03-10	John Doe	Jane Smith	\$4400.00	Settled
100-100088	1952-04-05	ABC Corp	XYZ Inc	\$9100.00	Pending
100-100089	1952-05-15	John Doe	Jane Smith	\$4500.00	Settled
100-100090	1952-06-20	ABC Corp	XYZ Inc	\$9300.00	Pending
100-100091	1952-07-10	John Doe	Jane Smith	\$4600.00	Settled
100-100092	1952-08-05	ABC Corp	XYZ Inc	\$9500.00	Pending
100-100093	1952-09-15	John Doe	Jane Smith	\$4700.00	Settled
100-100094	1952-10-20	ABC Corp	XYZ Inc	\$9700.00	Pending
100-100095	1952-11-10	John Doe	Jane Smith	\$4800.00	Settled
100-100096	1952-12-05	ABC Corp	XYZ Inc	\$9900.00	Pending
100-100097	1953-01-15	John Doe	Jane Smith	\$4900.00	Settled
100-100098	1953-02-20	ABC Corp	XYZ Inc	\$10100.00	Pending
100-100099	1953-03-10	John Doe	Jane Smith	\$5000.00	Settled
100-100100	1953-04-05	ABC Corp	XYZ Inc	\$10300.00	Pending

Part 31 Listing

MINES AGAINST JAPAN

Chart 31 Toyama Bay



MINES AGAINST JAPAN

Niigata Area. Niigata, one of the first mining targets on the north coast of Honshu, remained high in priority during the entire course of the mining operations. It was inherently difficult to attack because the radar aiming points in the area were very unsatisfactory, but unlike Fushiki, the water depths surrounding the port area were generally mineable. Therefore inaccurate planting was not as serious a limitation as at Fushiki.

Approach to Niigata was generally made directly north from Iwo Jima, passing east of the Tokyo Bay area and not crossing the island of Honshu until approximately 50 miles north of Choshi Point. This approach had the advantage of avoiding the heavy defenses of the Tokyo area and the high mountainous terrain around and north of Fujiyama. The route across Honshu was generally in a straight line to a checkpoint on the southern extremity of Sado Shima, and thence to the initial point on the east coast of the same island. From this initial point mining attacks were delivered at Niigata on a general heading of 105° or against Naoetsu, a small port about 50 miles south of Niigata, on an axis of attack of 200° . Retirement for the Niigata planes was directly across Honshu and along the reverse of the approach route, while for Naoetsu it was directly south to a checkpoint between Ise Wan and Suruga Wan, thence to Iwo Jima.

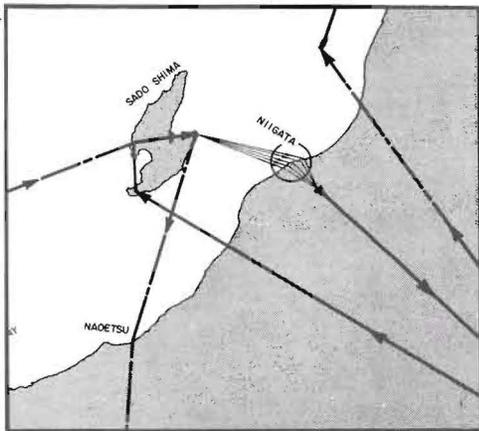


Figure 8-12. Niigata Area

A variation of this attack on Niigata was used several times to confuse the enemy air-raid alerting system, which would track the course of the planes and generally attempt to predict where they would lay their mines. This variation consisted in approaching through the "groove" between Nagoya and Osaka towards Tsuruga, passing west of Tsuruga up along Noto Peninsula as if to mine in Toyama Bay, and then proceeding to the checkpoint on Sado Shima

to mine Niigata. This was a long flight with full mine load, and was not used frequently. Retirement would be the same as for the other approach to this area.

Antiaircraft defenses were never very heavy at Niigata, but one aircraft was lost during the later stages of mine laying. For positions of all mines planted in this area see Charts 33 and 32.

Sakata-Funakawa Areas. Mine laying flights to these areas were made without staging through Iwo Jima and were the longest flights flown by B-29's of the Twentieth Air Force. Only one mission was flown against each port. That against Funakawa was flown first; approach was roughly the same as for previous Niigata missions, except that the Honshu mainland was not crossed until a checkpoint close to Sendai was reached. The same initial point was used for mining both Funakawa and Sakata, a small island (Tobi Shima) off the coast of Honshu about 100 miles north of Sado Shima. After the mine laying run, retirement was made directly across Honshu and thence south to Iwo Jima.

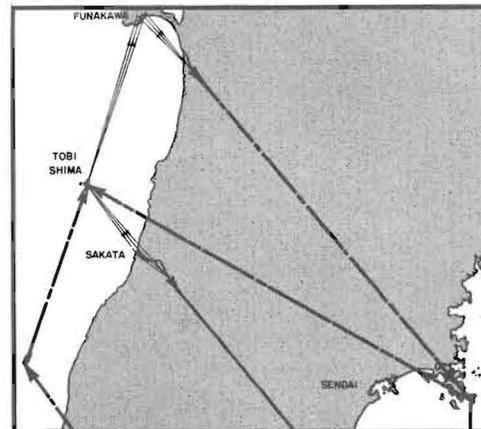


Figure 8-13. Sakata-Funakawa Areas

In mining Sakata, good results were obtained by two aircraft making low-altitude (4000 feet) runs visually by the light of the moon. Flash photographs were made of the drops which showed that mines were planted directly in the port area. No opposition was met on these flights and no aircraft was lost. For results of the mine laying, see Charts 35 and 36.

Fusan-Geijitsu Wan Areas. Lying directly across Tsushima from Shimonoseki, Fusan was one of the most important terminal ports in Korea, and therefore was mined heavily in the last phase of the 313th Wing mining directed against Korea. Geijitsu Wan, which was less important, was mined once in order to discourage diversion from the facilities at Fusan.

MINES AGAINST JAPAN

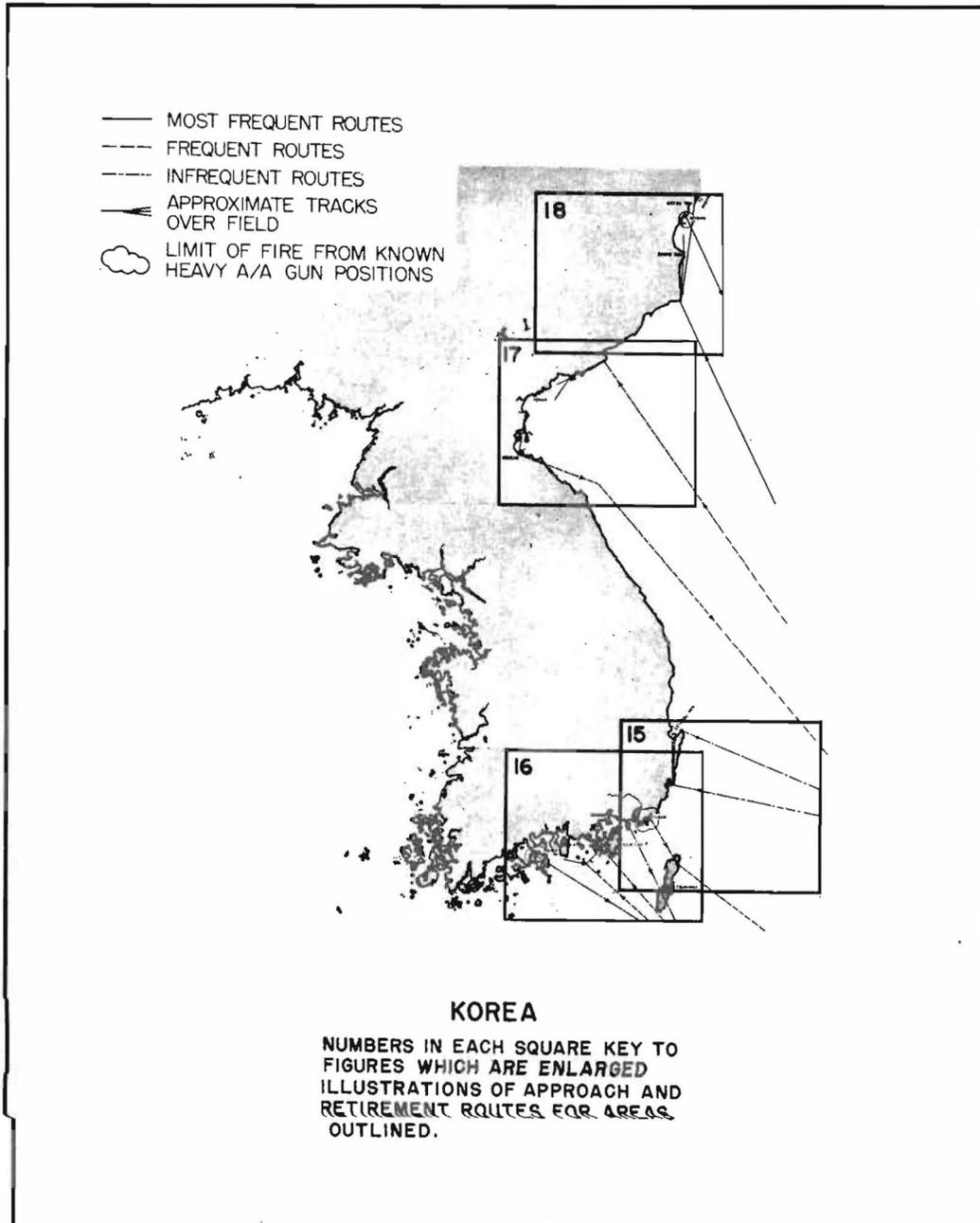


Figure 8-14. Key: Approach and Retirement Routes for Operation Starvation

MINES AGAINST JAPAN

To approach Fusan, landfall was made on the southern coast of Kyushu which was crossed in a straight line to a checkpoint on the north coast between Sasebo and Fukuoka. From this point the route was direct to the initial point on a large island southwest of Fusan (Koje-Do), using the southern tip of Tsushima as a checkpoint. The axis of attack to Fusan was then approximately 045° . After a breakaway to the right, the retirement route passed over the northern end of Tsushima to a checkpoint between Fukuoka and Shimonoseki on northern Kyushu. Return to Iwo Jima was then along the route used by all aircraft mining in the Shimonoseki Straits Area.

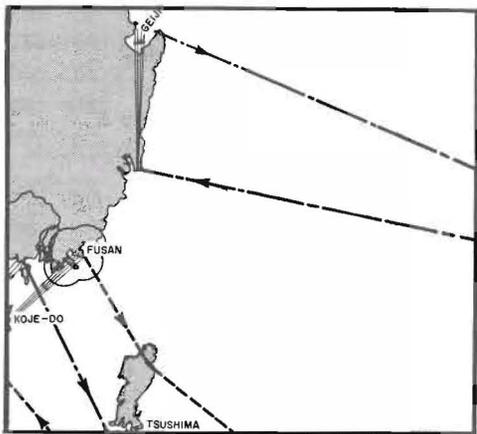


Figure 8-15. Fusan-Geijutsu Wan

The route used for mining Geijutsu Wan was quite different. Landfall was made on Shikoku; the route proceeded to Hamada on the coast of Honshu, from which departure was made to the Korean coast. The initial point was delivered on a north heading. Retirement was along the reverse of the route used for approach. No aircraft was lost during these missions. Positions of all mines planted in these areas are given in Charts 39 and 40.

Masan-Reisui Areas. Both of these ports on the south coast of Korea were mined in conjunction with the mining of Fusan to prevent any large-scale diversion of shipping. The approach route for these attacks was identical to that for mining Fusan, except for the initial point which was slightly west of the Fusan initial point. Attacks were made against Masan in a northeasterly direction, and against Reisui on a westerly heading. Retirement was then made along the reverse of the track used for approach. For results of the mine laying in these areas, see Charts 37 and 38.

Genzan-Konan Areas. Towards the end of the Korean campaign, Genzan was mined three times and Konan only once. Neither had important shipping facilities, but Genzan began to receive traffic when the blockade became effective

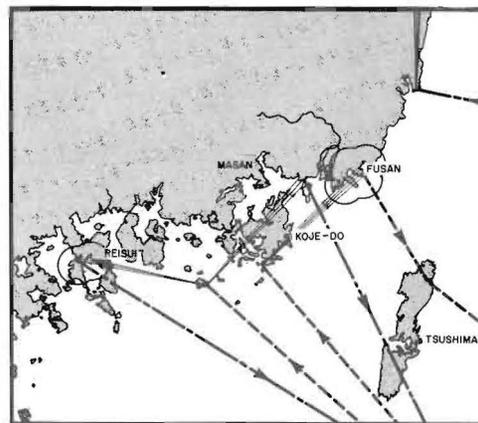


Figure 8-16. Masan-Reisui Areas

at other major Korean ports. On all missions to these two ports, the route cut directly across Shikoku and Honshu from Muroto Saki to Hino Misaki (between Hamada and Sakai), thence from this departure point to a prominent checkpoint on the east coast of Korea (Kutan Tan), close to the initial point. The mining attack was delivered against Konan in a general westerly direction and against Genzan in a southwesterly direction. Retirement was made via another Korean checkpoint off Kosong direct to Muroto Saki and thence to Iwo Jima. All aircraft returned safely from these missions. Positions of mines planted in these two areas are given on Charts 41 and 42.

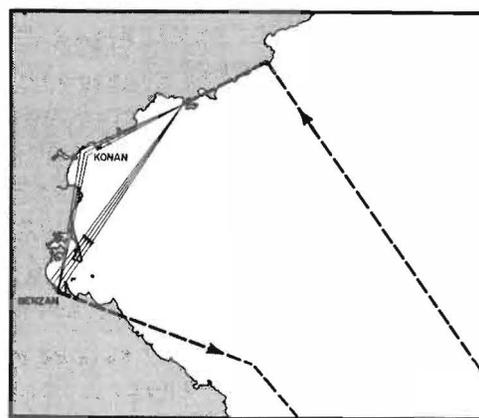
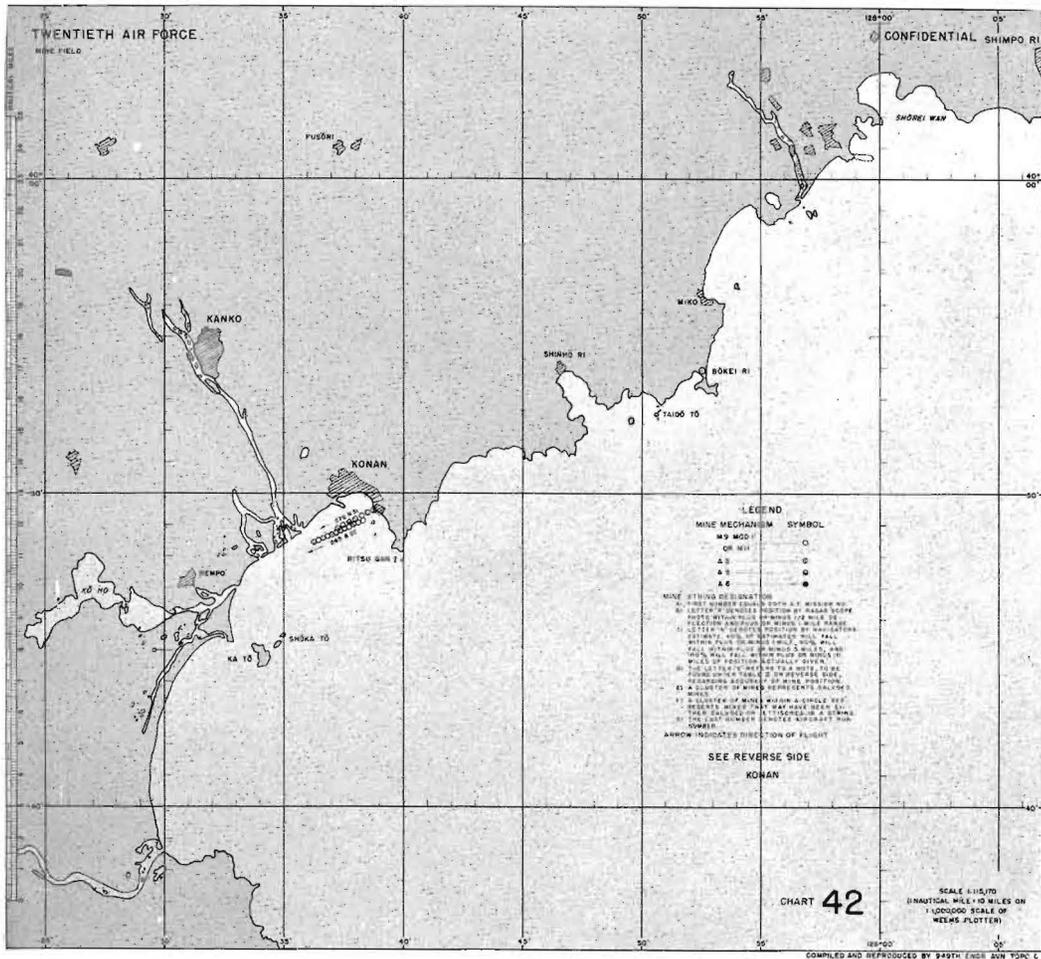


Figure 8-17. Genzan-Konan Areas

Seishin-Rashin Areas. Seishin and Rashin, at the northeastern extremity of the Korean coast only a few

MINES AGAINST JAPAN

Chart 42 Konan



KONAN

Table I Live Mines

Date	M9 Mod 1	M9 Mod 2	A 2	A 4	A 6	Total
1 Sept 45	6	1	11	1	---	19
15 Sept 45	6	1	11	1	---	19
1 Oct 45	6	1	11	1	---	19
15 Oct 45	6	1	11	1	---	19
1 Nov 45	6	1	11	1	---	19
15 Nov 45	6	1	11	1	---	19
1 Dec 45	6	1	11	1	---	19
15 Dec 45	6	1	11	1	---	19
1 Jan 46	6	1	11	1	---	19
15 Jan 46	6	1	11	1	---	19
1 Feb 46	6	1	11	1	---	19
15 Feb 46	6	1	11	1	---	19

* Live and dangerous until this date unless depth or changed.

TABLE II

Preparation of Mines laid in Konan

Date	M9 Mod 1	M9 Mod 2	A 2	A 4	A 6	Total
1 Sept 45	6	1	11	1	---	19
15 Sept 45	6	1	11	1	---	19
1 Oct 45	6	1	11	1	---	19
15 Oct 45	6	1	11	1	---	19
1 Nov 45	6	1	11	1	---	19
1 Dec 45	6	1	11	1	---	19
1 Jan 46	6	1	11	1	---	19
1 Feb 46	6	1	11	1	---	19

* Depth of mines of Konan (M9 Mod 1, M9 Mod 2, A 2, A 4, A 6) is 1000 to 1500 feet unless otherwise stated.

* Depth of mines of Konan (M9 Mod 1, M9 Mod 2, A 2, A 4, A 6) is 1000 to 1500 feet unless otherwise stated.

MINES AGAINST JAPAN

miles south of the Russian border, were the last shipping centers to receive heavy traffic in the closing days of the mining blockade. They were therefore mined during every mission until Russia entered the war, when the mining was terminated. To mine these ports, extremely long range was required. Therefore all aircraft mining these ports staged through Iwo Jima, at first on the return trip, and later on the approach when the Iwo Jima landing strip was readied for take off with full load. Another problem was the proximity of the ports to friendly Russian territory. This was solved by using a route with good navigational checkpoints and by limiting axes of attack to those from readily located initial points although this did not produce the best possible mine fields.

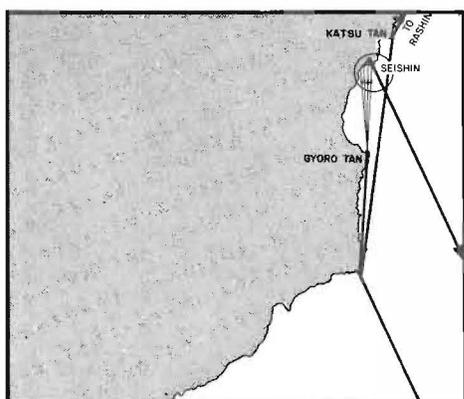


Figure 8-18. Seishin-Rashin Areas

The route to both Seishin and Rashin generally used was in common with that to Genzan and Konan to the north coast of Honshu, i.e., landfall at Muroto Saki (on Shikoku) and thence directly to Hino Misaki. From this point, departure was made across the Sea of Japan to a prominent landmark on the north Korean coast, Musu Dan. There a right turn was made to the respective initial points, a cape known as Gyoro Tan for Seishin and another, Katsu Tan, for Rashin. Attacks on both ports were therefore delivered roughly in a northerly direction. After the mine laying, the aircraft executed a right turn and returned directly across the Sea of Japan to a checkpoint in the Oki Retto islands. From this point they headed for a checkpoint in the center of the entrance to Kii Suido, and then returned to Iwo Jima.

Opposition was slight and no aircraft was lost to enemy action, although anti-aircraft fire was heavy at Rashin on the last two mining missions. For results of the mining see Charts 43 and 44.

REPORTING

The importance of obtaining accurate data on the positions of all mines planted in Operation Starvation was recognized before the first mining mission. An assessment of results could be made only on known locations of individual mine plants. The eventual need to clear or to avoid B-29-laid mine fields was also anticipated, and steps were therefore taken to record them accurately. The experimental missions previously described showed that the release point of a mine could be fixed within about a mile by taking a radarscope photograph at the instant it was released from the aircraft. Since this offered the only objective method of recording release positions in aircraft operating at night, all mining instructions in the field orders specified that radar pictures were to be taken during each mine laying run on the early missions. Eleven aircraft could not be equipped with radarscope cameras, but later the greater portion of all runs were confirmed by radarscope photographs. For the analysis of the accuracy of mine laying thus measured see Annex Z.

Each navigator on a mine laying mission was given an individual chart showing where to plant mines, and he marked his estimate of the actual location. After the mission these charts were collected by the S-2 group and returned to the 313th Wing A-2 section. This section made an overlay showing the estimated positions of all mines dropped. It was sent by courier mail to the bomber command (or air force) together with a plot of all mines jettisoned or planted in alternate areas 20 hours after the landing of the last aircraft (see Annex AA). The 313th Wing sent these plots and a mission summary to the bomber command. The bomber command informed all interested commands in accordance with War Department directives. Because little time was allowed for the preparation of this report, printed and analyzed radar photographs could not be included. Nor was it possible to evaluate all the information on types of mines planted nor distinguish between mines jettisoned and those planted in alternate fields. This data was furnished later on a Mining Specialist Report which formed the basis for the Tactical Mission Report issued by the Twentieth Air Force.

After the navigator's estimates were plotted, the individual navigator's charts were given to the A-2 radar intelligence officer who plotted the positions where the mines were released on the charts. Then the charts were passed to the mining section, where a radar navigator checked each plot, computed wind drift and range of the mine, and established the final impact points for the strings of mines. The charts were then divided into groups covering specific mine field areas. They were recorded by mission number, run number, radar photograph number (if available), with supplemental information on the number and size of mines used on every run plus special remarks to

MINES AGAINST JAPAN

Chart 43 Seishin

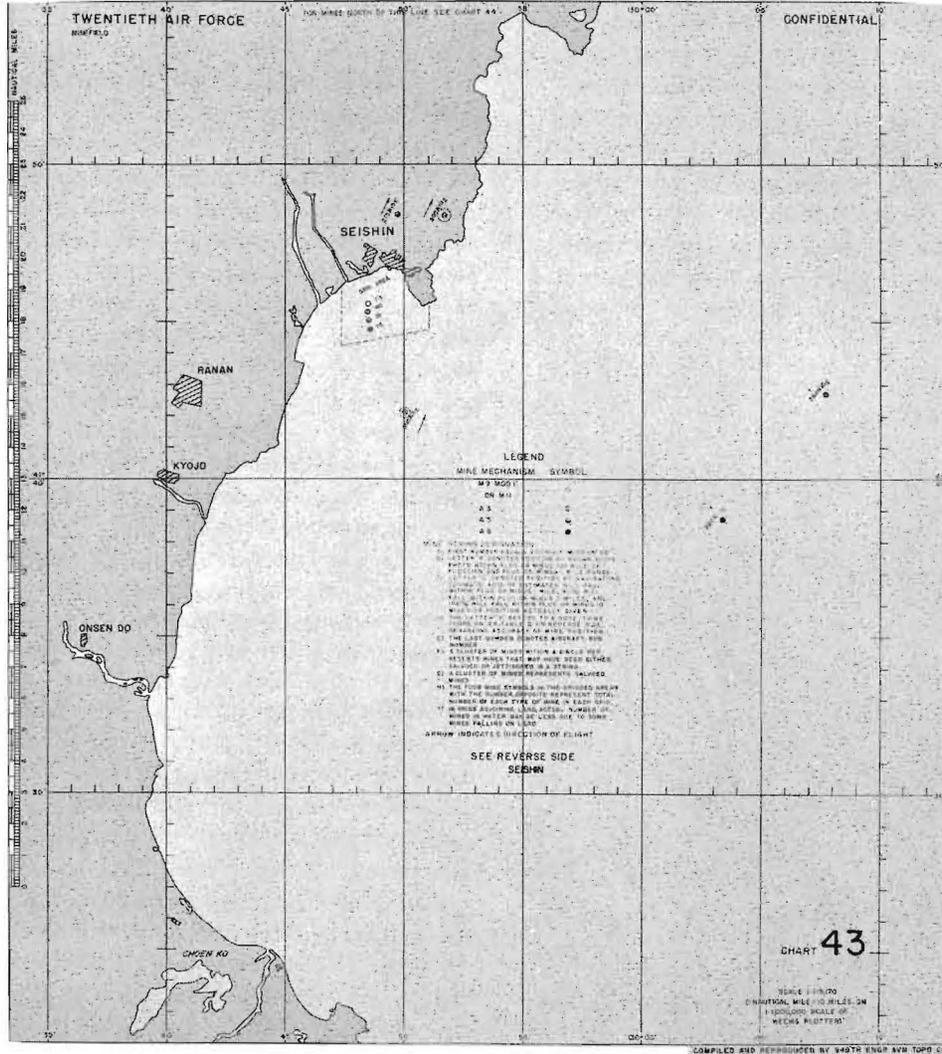


Table I Mine Sites

Date	Area	1	2	3	4	5	6	Total
3 Sept 45	73	---	---	---	---	---	---	73
15 Sept 45	73	---	---	---	---	---	---	73
1 Oct 45	73	---	---	---	---	---	---	73
1 Nov 45	73	---	---	---	---	---	---	73
1 Dec 45	73	---	---	---	---	---	---	73
1 Jan 46	73	---	---	---	---	---	---	73
1 Feb 46	73	---	---	---	---	---	---	73
1 Mar 46	73	---	---	---	---	---	---	73
1 Apr 46	73	---	---	---	---	---	---	73

Table II Preparation of Mine Placed at Seishin

Date	Area	1	2	3	4	5	6	Total
3 Sept 45	73	---	---	---	---	---	---	73
15 Sept 45	73	---	---	---	---	---	---	73
1 Oct 45	73	---	---	---	---	---	---	73
1 Nov 45	73	---	---	---	---	---	---	73
1 Dec 45	73	---	---	---	---	---	---	73
1 Jan 46	73	---	---	---	---	---	---	73
1 Feb 46	73	---	---	---	---	---	---	73
1 Mar 46	73	---	---	---	---	---	---	73
1 Apr 46	73	---	---	---	---	---	---	73

Table III Mines Placed Outside of Grided Area

Date	Area	1	2	3	4	5	6	Total
3 Sept 45	73	---	---	---	---	---	---	73
15 Sept 45	73	---	---	---	---	---	---	73
1 Oct 45	73	---	---	---	---	---	---	73
1 Nov 45	73	---	---	---	---	---	---	73
1 Dec 45	73	---	---	---	---	---	---	73
1 Jan 46	73	---	---	---	---	---	---	73
1 Feb 46	73	---	---	---	---	---	---	73
1 Mar 46	73	---	---	---	---	---	---	73
1 Apr 46	73	---	---	---	---	---	---	73

Table IV Mines Placed in Grided Area

Date	Area	1	2	3	4	5	6	Total
3 Sept 45	73	---	---	---	---	---	---	73
15 Sept 45	73	---	---	---	---	---	---	73
1 Oct 45	73	---	---	---	---	---	---	73
1 Nov 45	73	---	---	---	---	---	---	73
1 Dec 45	73	---	---	---	---	---	---	73
1 Jan 46	73	---	---	---	---	---	---	73
1 Feb 46	73	---	---	---	---	---	---	73
1 Mar 46	73	---	---	---	---	---	---	73
1 Apr 46	73	---	---	---	---	---	---	73

MINES AGAINST JAPAN

clarify the results of each sortie. Where a ground abort, jettison, or alternate mining occurred, complete data on the location and detailed types of mines were included in the remarks for the sortie. This information was then checked against the 20-hour summary and individual group reports. In certain cases it was further supplemented by personal interrogations of the crew.

A worksheet recording the accumulation of this data formed the basic control for the preparation of the Mining Specialist Report. Each sortie was plotted on a chart of the particular area, using the control sheet for a check. These plots showed the location, how the location was established, and the general type of each mine in a string. As many strings as could conveniently be plotted without confusion were recorded on one chart; the series of missions was reported on as many charts as necessary. Two tables were prepared, one showing the types and numbers of all mines planted in each primary mine field, and the other showing the types and numbers of all mines scheduled but *not* planted in the primary mine field. Both tables were compiled from information in the control sheets and corrected loading lists.

When these tables and charts were completed, a final check was made of actual mines planted by comparing actual count of mines on the charts with the tabulations of the two tables. After this check for accuracy, a final critique of mine laying results was obtained by overlaying the final corrected charts on an area chart showing shipping channels, anchorages, water depths, and other pertinent mining information. This overlay gave a quantitative analysis of the effectiveness of each sortie. This information together with special data requested by the Chief of Naval Operations was sent to the Twentieth Air Force. This report was supposed to be filed 15 days after the mine laying mission. This schedule was realized only on the last series of missions when the end of the war eased the pressure of operations.

CONCLUSION

The experience gained in this series of mining operations proved several things. A B-29 bombardment wing can readily be adapted to aerial mine laying by adding a section of specialized mining personnel to indoctrinate operations, ordnance, and flight personnel in mine warfare, and to carry out the detailed work peculiar to mining operations. When properly organized and scheduled, mine laying, in spite of being more complex, can evidently be carried out at a rate comparable to bombing. The 313th Bombardment Wing planted 4000 mines per month in the latter stages of Operation Starvation with a mining section of three naval

officers and one yeoman, assisted in the last month by an army officer (radar navigator). This staff was small for sustained operations. To function at a rate of 4000 mines per month, a mining section should have five mine warfare officers assisted by one yeoman and one quartermaster who is a competent draftsman. In general, the scale on which mine laying is to be carried out should determine the size of the mining section.

The data presented above provides much of the basic information needed to make a critical analysis of the Inner Zone mining operations. More details can be found in the library of the Twentieth Air Force where the tactics of each operation are specifically reported, and in the Report of the United States Strategic Bombing Survey (see Acknowledgment) where interrogations with Japanese on the efficacy of mining are given at some length. A wealth of detail is given in this comprehensive report only because the critical analysis has not yet been made, and it is badly needed to provide a guide in future mining operations. Together with the analysis of results given in Chapter 3, and the staff decisions described in Chapter 7, it should be possible to make a beginning study to determine the conditions necessary for maximum success in mining. Pending such a study one is forced to accept on faith those two conclusions from a review of the campaign which seem most important, namely: a mining officer must know the engineering details of the mines he uses, and mines need not be planted accurately.

In modern mines, with their intricate mechanisms, there is such a close interrelation of the technical and practical features that neither can be independent of the other. In tactical planning the technological features must be introduced as intimately into practical planning as are the gross operational features. This must be done in considerable detail, which means that officers charged with detailed operational planning of such a weapon must have a specific engineering knowledge of it as well as knowledge of its operational features. Secondly, the Inner Zone Mining Campaign has shown that mines can be used with great success even though pinpoint accuracy is unobtainable. It is probable that mines can be used under conditions of very poor accuracy compared with almost every other type of weapon. Thus, mines are devices of great flexibility which can be adapted to almost any type of tactics; in particular, they may be adapted to new types of carriers, such as rockets, which have an inherent inaccuracy by construction. This may be one of the more important lessons to be learned from the tactics of the Inner Zone Campaign. Mines need not be aimed individually; it is sufficient if the required number and kind are statistically distributed over the target.

MINES AGAINST JAPAN

ANNEX A

SAMPLE TRAINING MISSION PLAN

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HEADQUARTERS, 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

12 February 1945

MEMORANDUM:

MISSION PLAN FOR EXERCISE

The flight schedule for the minelaying exercise will consist of TWO MISSIONS for each plane. Each mission will consist of six radar mining runs; two runs at 25,000 feet, two runs at 10,000 feet, and two runs at 2000 feet, altitude. The runs at 25,000 feet and 10,000 feet, altitude, will be made over PAGAN ISLAND, while two runs at 2000 feet will be made over GUGUAN ISLAND. The planes will be loaded with SIX 500 lb. G. P. BOMBS with INSTANTANEOUS FUSING for MISSION No. 1. For MISSION No. 2 the loading will be THREE 500 lb. G. P. BOMBS with INSTANTANEOUS FUSING AND THREE MARK 26 MOD. 1 MINES (1000 lb. SIZE) with an AN/-103 Bomb FUSE in the nose of each mine.

MISSION No. 1

LOADING: SIX 500 lb. G. P. Bombs.
RUN No. 1: (METHOD No. II)
DROP: ONE 500 LB. G. P. BOMB;
LOCATION: PAGAN ISLAND.
ALTITUDE: 25,000 FT.
MINING RUN: OFFSET BOMBING - TIMED RUN-OUT WITH RADAR
AIMING POINT BETWEEN PLANE AND TARGET.
TARGET: COVE ADJACENT TO BANDERA AIRFIELD.
RADAR AIMING POINT: SOUTH POINT.
TIMED RUN-OUT FOR NO-WIND CONDITION: 5.7 MILES ON COURSE
29° T.

RUN No. 2: (METHOD No. III)
DROP: ONE 500 LB. G. P. BOMB.
LOCATION: PAGAN ISLAND.
ALTITUDE: 25,000 FT.
MINING RUN: OFFSET BOMBING - TIMED RUN-OUT WITH TARGET
BETWEEN PLANE AND RADAR AIMING POINT.

MINES AGAINST JAPAN

TARGET: SOUTH POINT.
RADAR AIMING POINT: TOGARI ROCK.
RADAR TIMING POINT: 10 MILES SOUTHWEST OF TOGARI ROCK.
TIMED RUN-OUT FOR NO-WIND CONDITION: 3.9 MILES ON COURSE
55° T.

- RUN No. 3: (METHOD No. II)
REPEAT RUN No. 1 at ALTITUDE OF 10,000 FEET.
- RUN No. 4: (METHOD No. III)
REPEAT RUN No. 2 AT ALTITUDE OF 10,000 FEET.
- RUN No. 5: (METHOD No. I)
DROP: ONE 500 LB. G. P. BOMB.
LOCATION: GUGUAN ISLAND.
ALTITUDE: 2000 FEET.
MINING RUN: DIRECT RADAR BOMBING COURSE 180° TRUE.
TARGET: CENTER OF NORTH SHORE OF GUGUAN ISLAND.
- RUN No. 6: (METHOD No. I)
REPEAT RUN No. 5 AT 2000 FT. ALTITUDE, EXCEPT COURSE 270°
TRUE, TARGET CENTER OF EAST COAST OF GUGUAN ISLAND.

MISSION No. 2

- LOADING: THREE 500 LB. G. P. BOMBS AND THREE MK. 26 MOD. 1 (1000 LB.)
MINES.
- RUN No. 1: REPEAT RUN No. 1 OF MISSION No. 1 - DROP ONE 500 LB. G. P.
BOMB.
- RUN No. 2: REPEAT RUN No. 2 OF MISSION No. 1 - DROP ONE MARK 26 MOD. 1
(1000 LB.) MINE.
- RUN No. 3: REPEAT RUN No. 3 OF MISSION No. 1 - DROP ONE 500 LB. G. P.
BOMB.
- RUN No. 4: REPEAT RUN No. 4 OF MISSION No. 1 - DROP ONE MARK 26 MOD. 1
(1000 LB.) MINE.
- RUN No. 5: REPEAT RUN No. 5 OF MISSION No. 1 - DROP ONE 500 LB. G. P.
BOMB.
- RUN No. 6: REPEAT RUN No. 6 OF MISSION No. 1 - DROP ONE MARK 26 MOD. 1
MINE.

MINES AGAINST JAPAN

ANNEX C

HIGH AND LOW ALTITUDE MINING

C
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HEADQUARTERS, 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

TACTICAL SOP)
:
No. 100-2)

Minelaying Procedure

1. It is directed that the minelaying procedure outlined below be placed into effect immediately.

2. Minelaying by aircraft of the 313th Wing will generally be carried out in weather unsuitable for high level precision bombing. Depending on the particular tactical situation, altitudes of attack may vary from several hundred feet to 30,000. Each run will be made by radar, and generally by single plane flights. If visibility and the method used are such that the bombardier can get visual check points, he will take over the mining run in the same manner as a bombing run, but in most cases radar techniques will be used throughout.

3. Minelaying from aircraft presents the fundamental problem of placing the mine at a designated position in the water, using radar aiming points or visual check points on adjacent coast lines (mainland or islands) to locate that position. This requires that a reference point method be used, since the aiming point will not coincide with the target (which is the designated position in the water). The one outstanding difference between minelaying and reference point bombing is that the mines used are equipped with small parachutes which retard their speed of fall and also cause them to drift downwind after release from the aircraft. At high winds and altitudes of 25,000 to 30,000 feet, a mine may drift downwind as much as five to six miles before hitting the water; at altitudes of 5000 feet and normal winds, the drift will be about one-quarter mile. Therefore, in arriving at the dropping position it is necessary to correct for the wind drift of the mine as well as the course and rate of the aircraft. In other respects, minelaying is similar to reference point radar bombing.

4. Regardless of the method used to arrive at the dropping position when planting mines, it is necessary to compute first this position from the target location and wind data over the target. Strictly speaking, it is not possible to do this until after an accurate wind run has been made in the vicinity of the target. In practice, however, it will be a standing procedure to compute the dropping position from the predicted wind given at the last weather briefing prior to take-off. This calculation will be revised, if necessary, after an accurate wind run has been made during the approach to the target.

MINES AGAINST JAPAN

along a bearing 180° from the heading of the aircraft as determined in Sub-par. (d). The effective trajectory of the mine is now given by the distance PT , with PT' being the component due to the set forward of the mine, and $T'T$ the component due to wind drift during the actual time of fall.

- (f) The course to be made good in the mining run will be given by the direction of the vector RP , while the offset distance (or horizontal range from radar aiming point to release position for the first mine) will be the length of vector RP .
- (g) In the case of low winds that will be encountered at low altitudes (below 5000 ft.), the direction of RP will be approximately the same as RT , and the heading may be assumed to be that of RT' , thus eliminating the necessity for step (d) above. In the case of very high cross winds at high altitudes, however, it may be necessary to make an additional calculation. This will consist of determining the revised heading necessary to make good the course RP ; if this heading is appreciably different from $T'P$, re-plot the position P' on the basis of the new heading and then determine the revised course, RP' , to be used in laying.
- (h) This method of computing the dropping position is illustrated in the vector diagrams and sample calculation on preceding page.

6. Two basic methods will be used for minelaying, the choice being dependent upon the particular tactical situation involved. Method ONE will be specified when it is convenient to fly towards the radar aiming point (RAP) but not over it, and will be particularly suited to low altitude attack, while Method TWO will be specified when it is convenient to fly over a radar aiming point, and will be particularly suited to accurate minelaying close to shore. The two methods are explained in detail below.

7. Method ONE (Target between plane and RAP):

- (a) From the predicted wind data, the navigator will plot a vector diagram (see Figure 8-C1) following the method in Par. 5. He will scale off the horizontal range, RP , in nautical miles. He will then convert this horizontal range to slant range for the altitude to be flown, and give this slant range to the radar operator. The latter will set up a bomb release circle for this slant range on the PPI scope when on the mining run.
- (b) Make an accurate wind run when approaching the target area. If the measured wind is significantly different from the predicted wind, the navigator will replot the vector diagram on the basis of the new wind data, and will furnish the new slant range to the radar operator.
- (c) The IP will be taken about 30 miles from the radar aiming point, along course RP as finally determined on the basis of the wind data being used.
- (d) The turn will be made on course at the IP in the same manner as in a bombing run. The first mine will be released by the bombardier on a "Mark" from the radar operator when the bomb release circle intersects the radar aiming point. True air speed and course must be maintained throughout the mining run.
- (e) The bombardier will preset the angle between the vertical and the radar aiming point at the release position on his bombsights, and drop visually

MINES AGAINST JAPAN

if he can see the radar aiming point. This will require that the bombardier compute this angle from the altitude and horizontal range calculated by the navigator.

- (f) Succeeding mines will usually be dropped on the same course at predetermined time intervals, which will be measured on a stop-watch by the bombardier.
 - (g) The navigator will take a picture of the radar scope at the dropping position for the first mine, while the release circle is still on the scope, and will note the range and time at which the photo was taken.
 - (h) One of the gunners (designated by pilot) will observe the mines dropped to ascertain if the mine parachutes open properly.
8. Method TWO (RAP between plane and target):
- (a) If the altitude of attack is greater than 5000 feet, the procedure outlined through Par. 8(b) to (i) will be followed. For altitudes of 5000 feet or less, alter this method as given in Par. 8(d) and (j).
 - (b) From the predicted wind data, the navigator will plot the vector diagram as shown in Figure 8-C1 following the method in Par. 5. He will scale off the horizontal range, RP, in nautical miles. He will then determine the ground speed that the aircraft will be making in the predicted wind from an E6B computer, and calculate the time of run on dead reckoning to cover distance RP. This calculation will be checked by the bombardier.
 - (c) Make an accurate wind run when approaching the target areas as in Par. 7(b). If a re-plot is necessary, the navigator will recalculate the horizontal range and ground speed for the new wind data, and the time of run to cover RP. This calculation will again be checked by the bombardier.
 - (d) If the altitude of attack is above 5000 feet, the radar operator will be supplied before the flight with slant ranges for synchronizing with the bombardier on the RAP, as in a bombing run. These are given for various altitudes in Table VI. The purpose of synchronizing is to supply the bombardier with a precision point from which to start a timed run on dead reckoning. If the altitude of attack is 5000 feet or below, the radar operator will be given one slant range to set up a bomb release circle for starting the timed run, and no synchronization will be used.
 - (e) The IP will be taken as in Par. 7(c), and the turn will be made on course as in a bombing run. From this point on, the mining run will be made in the same manner as a bombing run (see Tactical SOP Number 15-4)*, with navigator and pilot killing drift, and radar operator and bombardier killing rate. The only difference will be the bombardier's procedure, as described in Par. 8(f) below.
 - (f) The bombardier will set a disc speed into the bombsight for the 500 lb. bomb for the altitude flown. When the navigator gives him the ground speed, he will look up the tangent of the dropping angle for that ground speed and altitude in the bombing tables for the 500 lb. bomb. He will pre-set his rate index on the tangent value thus determined. With the rate motor off he will then engage the telescope clutch, with the tele-

* Not included here.

MINES AGAINST JAPAN

scope index opposite the first synchronizing angle. At the command "Mark" from the radar operator, the bombardier will turn on the rate motor. At the next check angle the radar operator will again call out the new angle and "Mark" when in that position. The bombardier will reset the telescope index to agree with the sighting angle and will make an adjustment with the rate knob, turning it in the same direction as the displacement knob is turned. This adjustment will be repeated at each angle, and the rate will thus be killed on the RAP, the same as in bombing. The bombardier will not have the mine released when his indices meet, however, but will watch the telescope index until it is opposite 0°, and will start his stop watch at this time. At this point, the aircraft should be directly over the RAP. At the end of his timed run, he will toggle off the first mine. Additional mines will be dropped on course at pre-determined time intervals.

- (g) Visual synchronization or course determination will be used whenever visibility permits.
- (h) The navigator will take a picture of the radar scope at the dropping position of the first mine. The radar operator will leave the last range circle used for synchronization on the scope until after this picture is taken; the navigator will note this slant range and the range and time at which the picture was taken.
- (i) A gunner will observe parachute functioning as in Par. 7(h).
- (j) If the altitude of attack is 5000 feet or less, the method outlined in (b) and (c) above should be modified to allow for the fact that the timed run will begin before (rather than over) the RAP, as stated in Par. 8(d). In such cases, the length of run on dead reckoning will be the distance RP added to the horizontal range for the slant range marker set in by the radar operator.

9. The above procedure utilizes the same division of responsibility among the crew as the bombing procedure. In all respects not covered by the above procedure, reference should be made to Tactical SOP Number 15-4 outlining the bombing procedure.

BY COMMAND OF BRIGADIER GENERAL DAVIES:

JAMES T. CONNALLY
Colonel, Air Corps
D C/S Training

OFFICIAL:

BARNETT S. ALLEN
Major, Air Corps, A-3

ANNEX:

Bombing Tables for Minelaying

MINES AGAINST JAPAN

BOMBING TABLE I

TABLE OF BALLISTIC WIND FACTORS

(Navigator)

<u>ALTITUDE (FEET)</u>	<u>BALLISTIC WIND FACTOR</u>
1000	0.96
2000	0.93
3000	0.89
4000	0.85
5000	0.82
6000	0.79
7000	0.75
8000	0.72
9000	0.69
10,000	0.67
11,000	0.64
12,000	0.62
13,000	0.60
14,000	0.59
15,000	0.58
16,000	0.57
17,000	0.57
18,000	0.56
19,000	0.56
20,000	0.55
21,000	0.55
22,000	0.55
23,000	0.54
24,000	0.54
25,000	0.54
26,000	0.53
27,000	0.53
28,000	0.53
29,000	0.52
30,000	0.52

NOTE: Multiply wind measured at the altitude at which plane is flying by ballistic factor given above for that altitude in order to determine ballistic wind for use in tables of Wind Drift of Mine. Assume direction of ballistic wind to be the same as that of wind at altitude.

MINES AGAINST JAPAN

BOMBING TABLE II

1000 LB. MINE, MK 26-1 or MK 36 (Navigator)

NO-WIND RANGE - NAUTICAL MILES

ALT. (FEET)	TRUE AIR SPEED - KNOTS																	
	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320
1000	.24	.25	.26	.28	.29	.30	.31	.32	.33	.35	.36	.37	.38	.39	.40	.41	.42	.43
2000	.28	.29	.31	.32	.33	.35	.36	.37	.38	.39	.41	.42	.43	.44	.45	.46	.47	.48
3000	.30	.31	.32	.34	.35	.37	.38	.39	.40	.42	.43	.44	.45	.46	.47	.48	.49	.51
4000	.31	.32	.34	.35	.36	.38	.39	.40	.42	.43	.44	.45	.47	.48	.49	.50	.51	.52
5000	.31	.33	.34	.36	.37	.39	.40	.41	.43	.44	.45	.47	.48	.49	.50	.51	.52	.53
6000	.32	.34	.35	.37	.38	.40	.41	.42	.44	.45	.46	.48	.49	.50	.51	.52	.53	.54
7000	.33	.34	.36	.37	.39	.40	.42	.43	.45	.46	.47	.49	.50	.51	.52	.53	.54	.55
8000	.33	.35	.37	.38	.40	.41	.43	.44	.45	.47	.48	.49	.51	.52	.53	.54	.55	.56
9000	.34	.36	.37	.39	.40	.42	.43	.45	.46	.48	.49	.50	.52	.53	.54	.55	.57	.58
10,000	.35	.36	.38	.40	.41	.43	.44	.46	.47	.49	.50	.51	.53	.54	.55	.56	.58	.59
11,000	.35	.37	.39	.40	.42	.43	.45	.46	.48	.49	.51	.52	.54	.55	.56	.58	.59	.60
12,000	.36	.38	.39	.41	.43	.44	.46	.47	.49	.50	.52	.53	.55	.56	.57	.59	.60	.61
13,000	.37	.38	.40	.42	.43	.45	.47	.48	.50	.51	.53	.54	.56	.57	.59	.60	.61	.63
14,000	.37	.39	.41	.43	.44	.46	.48	.49	.51	.52	.54	.55	.57	.58	.60	.61	.63	.64
15,000	.38	.40	.42	.43	.45	.47	.48	.50	.52	.53	.55	.56	.58	.59	.61	.62	.64	.65
16,000	.39	.40	.42	.44	.46	.48	.49	.51	.53	.54	.56	.57	.59	.60	.62	.63	.65	.66
17,000	.39	.41	.43	.45	.47	.49	.50	.52	.54	.55	.57	.58	.60	.62	.63	.65	.66	.68
18,000	.40	.42	.44	.46	.48	.49	.51	.53	.55	.56	.58	.60	.61	.63	.64	.66	.67	.69
19,000	.41	.43	.45	.47	.49	.50	.52	.54	.56	.57	.59	.61	.62	.64	.66	.67	.69	.70
20,000	.41	.44	.46	.48	.49	.51	.53	.55	.57	.59	.60	.62	.64	.65	.67	.68	.70	.72
21,000	.42	.44	.47	.48	.50	.52	.54	.56	.58	.60	.61	.63	.65	.67	.68	.70	.71	.73
22,000	.43	.45	.47	.49	.51	.53	.55	.57	.59	.61	.63	.64	.66	.68	.70	.71	.73	.75
23,000	.44	.46	.48	.50	.52	.54	.56	.58	.60	.62	.64	.66	.67	.69	.71	.73	.74	.76
24,000	.45	.47	.49	.51	.53	.55	.57	.59	.61	.63	.65	.67	.69	.70	.72	.74	.76	.78
25,000	.45	.48	.50	.52	.54	.56	.58	.60	.62	.64	.66	.68	.70	.72	.74	.76	.77	.79
26,000	.46	.49	.51	.53	.55	.57	.60	.62	.64	.66	.68	.69	.71	.73	.75	.77	.79	.81
27,000	.47	.49	.52	.54	.56	.59	.61	.63	.65	.67	.69	.71	.73	.75	.77	.79	.81	.82
28,000	.48	.50	.53	.55	.57	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80	.82	.84
29,000	.49	.51	.54	.56	.58	.61	.63	.65	.67	.70	.72	.74	.76	.78	.80	.82	.84	.86
30,000	.50	.52	.55	.57	.60	.62	.64	.66	.69	.71	.73	.75	.77	.79	.81	.83	.85	.88
	TRUE AIR SPEED - MILES PER HOUR																	
	173	184	196	207	219	230	242	253	265	276	288	299	311	322	334	345	357	369

MINES AGAINST JAPAN

BOMBING TABLE III

2000 LB MINE, MK 25

(Navigator)

NO-WIND RANGE - NAUTICAL MILES

ALT. (FEET)	TRUE AIR SPEED - KNOTS																	
	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320
1000	.27	.28	.30	.31	.33	.34	.36	.37	.38	.40	.41	.42	.44	.45	.46	.48	.49	.50
2000	.33	.35	.37	.39	.40	.42	.44	.45	.47	.48	.50	.51	.53	.54	.55	.57	.58	.60
3000	.37	.39	.41	.42	.44	.46	.48	.49	.51	.53	.54	.56	.57	.59	.61	.62	.64	.65
4000	.39	.41	.43	.45	.47	.49	.50	.52	.54	.56	.57	.59	.61	.62	.64	.65	.67	.69
5000	.41	.43	.45	.47	.49	.51	.53	.54	.56	.58	.60	.61	.63	.65	.66	.68	.70	.71
6000	.42	.44	.46	.48	.50	.52	.54	.56	.58	.60	.61	.63	.65	.67	.68	.70	.72	.73
7000	.43	.45	.47	.50	.52	.54	.56	.58	.59	.61	.63	.65	.67	.68	.70	.72	.73	.75
8000	.44	.46	.49	.51	.53	.55	.57	.59	.61	.63	.65	.67	.68	.70	.72	.73	.75	.77
9000	.45	.47	.50	.52	.54	.56	.58	.60	.62	.64	.66	.68	.70	.72	.73	.75	.77	.79
10,000	.46	.48	.51	.53	.55	.57	.60	.62	.64	.66	.68	.69	.71	.73	.75	.77	.78	.80
11,000	.47	.49	.52	.54	.56	.59	.61	.63	.65	.67	.69	.71	.73	.75	.76	.78	.80	.82
12,000	.48	.50	.53	.55	.58	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80	.82	.83
13,000	.49	.51	.54	.56	.59	.61	.63	.65	.68	.70	.72	.74	.76	.78	.80	.81	.83	.85
14,000	.50	.52	.55	.57	.60	.62	.64	.67	.69	.71	.73	.75	.77	.79	.81	.83	.85	.87
15,000	.50	.53	.56	.58	.61	.63	.66	.68	.70	.72	.75	.77	.79	.81	.83	.85	.87	.88
16,000	.51	.54	.57	.59	.62	.64	.67	.69	.72	.74	.76	.78	.80	.82	.84	.86	.88	.90
17,000	.52	.55	.58	.61	.63	.66	.68	.71	.73	.75	.77	.80	.82	.84	.86	.88	.90	.92
18,000	.53	.56	.59	.62	.64	.67	.69	.72	.74	.77	.79	.81	.83	.85	.88	.90	.92	.94
19,000	.54	.57	.60	.63	.65	.68	.71	.73	.76	.78	.80	.83	.85	.87	.89	.91	.94	.96
20,000	.55	.58	.61	.64	.67	.69	.72	.75	.77	.79	.82	.84	.87	.89	.91	.93	.95	.97
21,000	.56	.59	.62	.65	.68	.71	.73	.76	.78	.81	.83	.86	.88	.91	.93	.95	.97	.99
22,000	.57	.60	.63	.66	.69	.72	.75	.77	.80	.82	.85	.87	.90	.92	.95	.97	.99	1.01
23,000	.58	.61	.64	.67	.70	.73	.76	.79	.81	.84	.87	.89	.92	.94	.96	.99	1.01	1.03
24,000	.59	.62	.65	.68	.72	.75	.77	.80	.83	.86	.88	.91	.93	.96	.98	1.01	1.03	1.05
25,000	.60	.63	.67	.70	.73	.76	.79	.82	.84	.87	.90	.93	.95	.98	1.00	1.03	1.05	1.08
26,000	.61	.64	.68	.71	.74	.77	.80	.83	.86	.89	.92	.94	.97	1.00	1.02	1.05	1.07	1.10
27,000	.62	.65	.69	.72	.75	.79	.82	.85	.88	.91	.94	.96	.99	1.02	1.04	1.07	1.09	1.12
28,000	.63	.66	.70	.73	.77	.80	.83	.86	.89	.92	.95	.98	1.01	1.04	1.06	1.09	1.11	1.14
29,000	.64	.68	.71	.75	.78	.82	.85	.88	.91	.94	.97	1.00	1.03	1.05	1.08	1.11	1.13	1.16
30,000	.65	.69	.72	.76	.80	.83	.86	.90	.93	.96	.99	1.02	1.05	1.07	1.10	1.13	1.16	1.18
	TRUE AIR SPEED - MILES PER HOUR																	
	173	184	196	207	219	230	242	253	265	276	288	299	311	322	334	345	357	369

MINES AGAINST JAPAN

BOMBING TABLE IV

1000 LB. MINE, MK 26 or MK 36 (Navigator)

WIND DRIFT OF MINE - NAUTICAL MILES

BALLISTIC WIND - KNOTS

ALT. (FEET)	BALLISTIC WIND - KNOTS																	
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1000	.03	.06	.08	.11	.14	.17	.20	.22	.25	.28	.31	.34	.37	.39	.42	.45	.48	.51
2000	.04	.09	.13	.18	.22	.26	.31	.35	.40	.44	.48	.53	.57	.62	.66	.70	.75	.79
3000	.06	.12	.18	.23	.29	.35	.41	.47	.53	.59	.65	.71	.77	.82	.88	.94	1.00	1.06
4000	.07	.15	.22	.29	.36	.44	.51	.58	.65	.73	.81	.88	.95	1.02	1.10	1.17	1.24	1.32
5000	.09	.17	.26	.35	.43	.52	.61	.69	.78	.87	.96	1.04	1.13	1.22	1.31	1.39	1.48	1.57
6000	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80
7000	.11	.23	.34	.46	.57	.68	.80	.91	1.02	1.14	1.25	1.36	1.48	1.59	1.70	1.82	1.93	2.04
8000	.13	.25	.38	.51	.64	.76	.89	1.02	1.14	1.27	1.40	1.52	1.65	1.78	1.90	2.03	2.16	2.28
9000	.14	.28	.42	.56	.70	.84	.98	1.12	1.26	1.40	1.54	1.68	1.82	1.96	2.09	2.24	2.38	2.52
10,000	.15	.31	.46	.61	.76	.92	1.07	1.22	1.37	1.53	1.68	1.83	1.98	2.14	2.29	2.44	2.60	2.74
11,000	.17	.33	.50	.66	.83	.99	1.16	1.32	1.49	1.65	1.82	1.99	2.15	2.32	2.48	2.65	2.81	2.98
12,000	.18	.35	.53	.71	.89	1.06	1.24	1.42	1.60	1.78	1.96	2.14	2.31	2.49	2.67	2.84	3.02	3.20
13,000	.19	.38	.57	.76	.95	1.14	1.33	1.52	1.71	1.89	2.08	2.28	2.46	2.66	2.84	3.04	3.22	3.41
14,000	.20	.40	.60	.81	1.01	1.21	1.41	1.61	1.81	2.01	2.21	2.42	2.62	2.82	3.02	3.22	3.42	3.62
15,000	.21	.43	.64	.85	1.07	1.28	1.49	1.71	1.92	2.13	2.35	2.56	2.78	2.99	3.20	3.42	3.63	3.84
16,000	.22	.45	.67	.90	1.12	1.35	1.57	1.80	2.02	2.25	2.48	2.70	2.92	3.15	3.38	3.60	3.82	4.05
17,000	.24	.47	.71	.94	1.18	1.42	1.65	1.89	2.12	2.36	2.60	2.84	3.07	3.31	3.54	3.78	4.02	4.25
18,000	.25	.49	.74	.99	1.24	1.48	1.73	1.98	2.23	2.48	2.73	2.98	3.22	3.47	3.72	3.97	4.22	4.46
19,000	.26	.52	.77	1.03	1.29	1.55	1.81	2.07	2.32	2.58	2.84	3.10	3.36	3.62	3.88	4.14	4.40	4.65
20,000	.27	.54	.81	1.08	1.35	1.61	1.88	2.15	2.42	2.69	2.96	3.23	3.50	3.77	4.04	4.30	4.58	4.85
21,000	.28	.56	.84	1.12	1.40	1.68	1.96	2.24	2.52	2.80	3.08	3.36	3.64	3.92	4.20	4.48	4.76	5.04
22,000	.29	.58	.87	1.16	1.45	1.74	2.03	2.32	2.61	2.90	3.19	3.48	3.77	4.06	4.35	4.64	4.93	5.22
23,000	.30	.60	.90	1.20	1.50	1.80	2.10	2.41	2.71	3.00	3.30	3.61	3.91	4.21	4.51	4.81	5.11	5.41
24,000	.31	.62	.93	1.24	1.55	1.86	2.18	2.49	2.80	3.11	3.42	3.73	4.04	4.35	4.67	4.98	5.29	5.60
25,000	.32	.64	.96	1.28	1.60	1.92	2.24	2.57	2.89	3.21	3.53	3.85	4.17	4.50	4.81	5.14	5.45	5.78
26,000	.33	.66	.99	1.32	1.65	1.98	2.31	2.64	2.97	3.30	3.64	3.96	4.30	4.63	4.96	5.29	5.62	5.95
27,000	.34	.68	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	3.74	4.08	4.42	4.76	5.10	5.45	5.78	6.13
28,000	.35	.70	1.05	1.40	1.75	2.09	2.44	2.79	3.14	3.49	3.84	4.19	4.54	4.89	5.24	5.59	5.94	6.29
29,000	.36	.72	1.07	1.43	1.79	2.15	2.51	2.87	3.22	3.58	3.94	4.30	4.65	5.02	5.37	5.73	6.09	6.45
30,000	.37	.73	1.10	1.47	1.84	2.20	2.57	2.94	3.31	3.67	4.04	4.41	4.77	5.14	5.51	5.88	6.25	6.60
	BALLISTIC WIND - MILES PER HOUR																	
	11.5	23.0	34.5	46.1	57.6	69.1	80.6	92.1	103.6	115	127	138	150	162	173	184	196	208

GAINST JAPAN

BOMBING TABLE V

2000 LB. MINE, MK 25

(Navigator)

WIND DRIFT OF MINE - NAUTICAL MILES

ALT. (FEET)	BALLISTIC WIND - KNOTS																	
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1000	.03	.05	.07	.10	.13	.15	.18	.21	.23	.26	.28	.31	.33	.36	.39	.41	.44	.46
2000	.04	.08	.12	.16	.20	.23	.27	.31	.35	.39	.43	.47	.51	.55	.59	.62	.66	.70
3000	.05	.10	.15	.20	.25	.30	.35	.41	.46	.51	.56	.61	.66	.71	.76	.81	.87	.92
4000	.06	.12	.18	.25	.31	.37	.43	.49	.55	.62	.68	.74	.80	.86	.93	.99	1.05	1.11
5000	.07	.14	.22	.29	.36	.43	.50	.58	.65	.72	.79	.87	.94	1.01	1.08	1.15	1.23	1.30
6000	.08	.16	.25	.33	.41	.49	.58	.66	.74	.82	.91	.99	1.07	1.15	1.24	1.32	1.40	1.48
7000	.09	.18	.28	.37	.46	.55	.65	.74	.83	.92	1.02	1.11	1.20	1.29	1.38	1.48	1.57	1.66
8000	.10	.20	.31	.41	.51	.61	.71	.82	.92	1.02	1.12	1.23	1.33	1.43	1.53	1.64	1.74	1.84
9000	.11	.22	.33	.45	.56	.67	.78	.89	1.00	1.11	1.23	1.34	1.45	1.56	1.67	1.79	1.90	2.01
10,000	.12	.24	.36	.48	.60	.73	.85	.97	1.09	1.21	1.33	1.45	1.57	1.69	1.81	1.94	2.06	2.18
11,000	.13	.26	.39	.52	.65	.78	.91	1.04	1.17	1.30	1.43	1.56	1.70	1.83	1.96	2.08	2.22	2.35
12,000	.14	.28	.42	.56	.70	.84	.97	1.11	1.25	1.39	1.53	1.67	1.81	1.95	2.09	2.23	2.37	2.51
13,000	.15	.30	.44	.59	.74	.89	1.04	1.19	1.33	1.48	1.63	1.78	1.93	2.08	2.22	2.37	2.52	2.67
14,000	.16	.31	.47	.63	.78	.94	1.10	1.26	1.41	1.57	1.73	1.88	2.04	2.20	2.36	2.51	2.67	2.83
15,000	.17	.33	.50	.66	.83	.99	1.16	1.33	1.49	1.66	1.83	1.99	2.16	2.32	2.49	2.66	2.82	2.99
16,000	.17	.35	.52	.70	.87	1.05	1.22	1.39	1.57	1.74	1.92	2.09	2.26	2.44	2.62	2.79	2.96	3.14
17,000	.18	.37	.55	.73	.91	1.10	1.28	1.46	1.64	1.83	2.01	2.19	2.38	2.56	2.74	2.92	3.11	3.29
18,000	.19	.38	.57	.76	.95	1.15	1.34	1.53	1.72	1.91	2.10	2.30	2.49	2.68	2.87	3.06	3.25	3.44
19,000	.20	.40	.60	.80	1.00	1.19	1.39	1.59	1.79	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.59
20,000	.21	.41	.62	.83	1.04	1.24	1.45	1.66	1.86	2.07	2.28	2.49	2.70	2.90	3.11	3.32	3.52	3.72
21,000	.21	.43	.64	.86	1.07	1.29	1.50	1.72	1.93	2.15	2.36	2.58	2.79	3.01	3.22	3.44	3.66	3.87
22,000	.22	.44	.67	.89	1.11	1.33	1.56	1.78	2.00	2.22	2.45	2.67	2.89	3.12	3.34	3.56	3.78	4.00
23,000	.23	.46	.69	.92	1.15	1.38	1.61	1.84	2.07	2.30	2.53	2.76	2.99	3.22	3.45	3.68	3.91	4.14
24,000	.24	.47	.71	.95	1.19	1.42	1.66	1.90	2.13	2.38	2.52	2.85	3.08	3.32	3.56	3.80	4.04	4.28
25,000	.24	.49	.73	.98	1.22	1.47	1.71	1.96	2.20	2.45	2.69	2.94	3.18	3.42	3.67	3.92	4.16	4.40
26,000	.25	.50	.75	1.01	1.26	1.51	1.76	2.01	2.26	2.52	2.77	3.02	3.28	3.53	3.78	4.03	4.28	4.53
27,000	.26	.52	.78	1.03	1.29	1.55	1.81	2.07	2.33	2.59	2.85	3.11	3.36	3.62	3.88	4.14	4.40	4.66
28,000	.27	.53	.80	1.06	1.33	1.59	1.86	2.12	2.39	2.66	2.92	3.19	3.46	3.72	3.98	4.25	4.52	4.78
29,000	.27	.55	.82	1.09	1.36	1.64	1.91	2.18	2.45	2.72	3.00	3.27	3.54	3.81	4.08	4.36	4.63	4.90
30,000	.28	.56	.84	1.12	1.40	1.68	1.96	2.23	2.51	2.79	3.08	3.36	3.64	3.91	4.20	4.47	4.75	5.03
	BALLISTIC WIND - MILES PER HOUR																	
	11.5	23.0	34.5	46.1	57.6	69.1	80.6	92.1	103.6	115	127	138	150	162	173	184	196	208

MINES AGAINST JAPAN

BOMBING TABLE VI

(Radar Operator)

SLANT RANGE FOR SYNCHRONIZATION ON DIRECT RADAR AIMING POINT

ALT. (FEET)	SYNCHRONIZING ANGLE - DEGREES								
	70	65	60	55	50	45	40	35	30
6000	2.89	2.34	1.98	1.72	1.54	1.40	1.29	1.21	1.14
7000	3.36	2.72	2.30	2.01	1.79	1.63	1.50	1.41	1.33
8000	3.85	3.12	2.63	2.29	2.05	1.86	1.72	1.61	1.52
9000	4.33	3.50	2.96	2.58	2.30	2.10	1.93	1.81	1.71
10,000	4.81	3.90	3.30	2.87	2.56	2.33	2.15	2.01	1.90
11,000	5.29	4.28	3.62	3.16	2.82	2.56	2.36	2.21	2.09
12,000	5.75	4.66	3.94	3.43	3.06	2.78	2.57	2.41	2.28
13,000	6.24	5.05	4.26	3.72	3.32	3.02	2.78	2.61	2.47
14,000	6.72	5.44	4.60	4.01	3.58	3.26	3.00	2.81	2.66
15,000	7.20	5.82	4.92	4.29	3.84	3.48	3.22	3.01	2.84
16,000	7.68	6.22	5.26	4.58	4.09	3.72	3.43	3.21	3.04
17,000	8.16	6.60	5.58	4.87	4.34	3.94	3.64	3.41	3.22
18,000	8.65	7.00	5.91	5.15	4.60	4.18	3.86	3.61	3.42
19,000	9.11	7.37	6.24	5.43	4.85	4.41	4.07	3.81	3.60
20,000	9.60	7.77	6.58	5.73	5.11	4.65	4.29	4.01	3.80
21,000	10.10	8.17	6.90	6.02	5.37	4.88	4.51	4.42	3.99
22,000	10.58	8.55	7.22	6.30	5.63	5.12	4.72	4.42	4.17
23,000	11.06	8.94	7.55	6.58	5.87	5.34	4.93	4.61	4.36
24,000	11.53	9.34	7.89	6.88	6.14	5.58	5.15	4.82	4.55
25,000	12.00	9.71	8.20	7.15	6.39	5.80	5.35	5.02	4.74
26,000	12.48	10.10	8.53	7.44	6.64	6.04	5.57	5.21	4.93
27,000	13.00	10.50	8.88	7.74	6.91	6.28	5.80	5.42	5.13
28,000	13.45	10.90	9.20	8.03	7.16	6.51	6.01	5.62	5.31
29,000	13.92	11.28	9.53	8.30	7.40	6.74	6.21	5.81	5.50
30,000	14.40	11.66	9.85	8.60	7.66	6.97	6.43	6.02	5.69

NOTE: All slant ranges tabulated in the above table are in nautical miles.

MINES AGAINST JAPAN

ANNEX D

LOW ALTITUDE MINING

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 336, c/o Postmaster
San Francisco, California

TACTICAL SOP)
:
No. 15-14)

14 August 1945

BOMBING

MINELAYING PROCEDURE

1. GENERAL: Aerial mining presents two problems that must be solved by different methods than those of normal bombing. The two problems are outlined herein to present the basis for definite minelaying procedures.
 - (a) The parachute attached to the mine, which protects it from excessive shock on impact with the water, retards its rate of fall and offers a much larger area to air resistance than is presented by a free-falling bomb. This allows wind and resistance to the force placed in the direction of heading of the aircraft on the mine to be much greater than on a bomb. The trail and crosstrail of a mine are therefore so great as to be beyond the limits of the bombsight. This necessitates the plotting of the dropping point by using the reciprocal of the trajectory of the mine from the desired impact point to determine the release point. Tables showing the ballistic wind for the wind at altitude, the wind drift of mine for various wind velocities and altitudes, and the no-wind ranges of mines for various true airspeeds and altitudes have been computed.
 - (b) As mines are planted in water and neither the point of impact nor the point of release can be directly identified, the position of release must be determined with reference to adjacent points of land.
2. SOLUTION OF THE PROBLEM: Basically there are two separate mining situations (see Figure 8-D1), one where the reference point is beyond the point of release and the other where the point of release is beyond the reference point. The same methods for calculating the point of release are used in both situations.
 - (a) General Method.
 - (1) Mark aiming point and point of desired mine impact.
 - (2) Using true altitude enter ballistic wind table and find what percentage

MINES AGAINST JAPAN

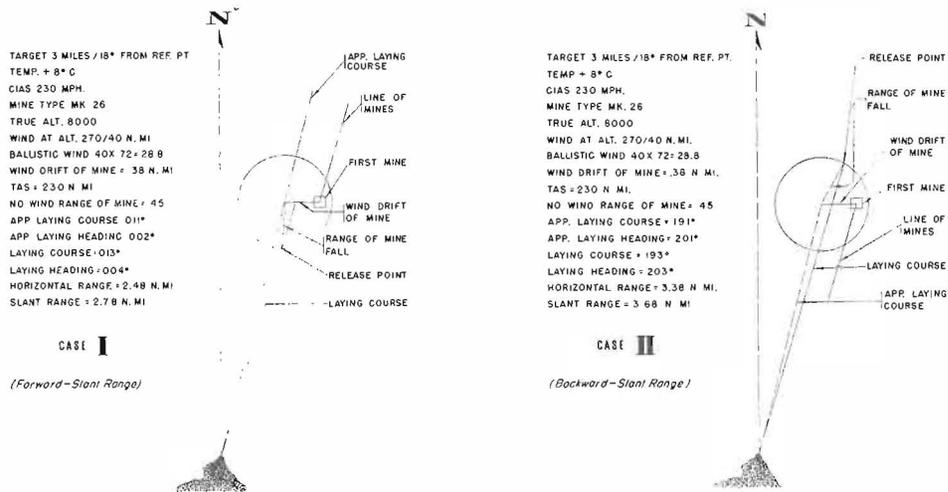


Fig. 8-D1

of the wind at altitude affects the mines during fall. Multiply the measured wind by this percentage.

- (3) Using the wind drift of mine table for the size mines to be dropped, enter the table using altitude and effective wind velocity. This figure gives the distance in nautical miles that the mine will drift. Plot this distance (the wind drift vector) back into the wind from the desired impact point of the first mine.
 - (4) Using the no-wind range table for the size mine to be dropped, enter table with true air speed and true altitude to find the distance in nautical miles the mine will fall along the aircraft's heading. From the point established by the wind drift vector draw the range vector back into that heading which gives the course from this point to the reference point. Use the wind at altitude to establish this heading. (This applies to the case of reference point beyond release. If the release point is beyond the reference point, the heading is determined by the course from the reference point to the point of release and the wind at altitude.) The final point established is the point of release.
 - (5) Measure the distance from the point of release to the reference point. Convert this ground range to slant range. Set this slant range on the computer drum of the radar set.
 - (6) Set the measured true course from release point to reference point on the track line of the radar scope.
 - (7) At the time of intersection of bomb release circle, track line and reference point, release the first mine. Other mines will be released at timed intervals after the first mine release. When using the system with reference point beyond the release point use this intersection when the bomb release circle first reaches the reference point. If release point is beyond the reference point the release will be made at the intersection of the bomb release circle, track line, and reference point on the back azimuth of the track.
- (b) Special Methods: Occasionally conditions exist in which either there is no definite reference point on the prescribed course of the mining run

MINES AGAINST JAPAN

or where the dropping position and reference point are located too near each other to identify the reference point for the release accurately.

- (1) The first of the problems will be solved by use of two bearings from off-course reference points to fix the release position.
- (2) The second will be solved by using a combination of an arbitrary slant range from the reference point to establish a position, and then a timed run from this position to identify the dropping position.

BY COMMAND OF BRIGADIER GENERAL DAVIES:

DELMAR E. WILSON
Colonel, Air Corps,
D C/S Opns and Tng.

OFFICIAL:

s/ Oren J. Poage
Lt. Col., Air Corps
A-3

DISTRIBUTION "C"

MINES AGAINST JAPAN

ANNEX E

TRAINING PROGRAM

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

24 February 1945

SUBJECT: Ground Training in Mine Warfare.

TO: See Distribution.

1. It is directed that the ground training program in mine warfare outlined below begin on 26 February and be completed prior to 15 March.

2. The minelaying missions to be carried out by the 313th Bombardment Wing will be most successful if individual crews have a full appreciation of the nature of aerial mine warfare and its effect on the enemy. The previous experience of the crews of this Wing is such that they have little knowledge of aerial mining. It is therefore proposed to schedule the following lectures in each Group; these lectures will be given by naval officers attached to the Wing who have had extensive experience in mine warfare.

<u>SUBJECT</u>	<u>DURATION</u>	<u>PERSONNEL ATTENDING</u>
1. Mine Warfare	1 hour	All Air, Arm, and Ordnance Ground Crews.
"Aerial Mine Warfare" Movie	20 mins.	All Air, Arm, and Ordnance Ground Crews.
2. Mines: Safety, Handling and Installation	1 hour	Bombardiers and Arm and Ord Ground Crews.
3. Advanced Mine Warfare Movies	1 hour	Officer Crew Members.
4. Mine Warfare Intelligenece	1 hour	Officer Crew Members.
		All Air Crews (in addition to Staff Officers).

3. The following naval mining officers are designated as liaison officers to schedule these lectures in the Groups: Lieut. James M. Martin, USNR - 504th and 505th Groups, Lieut. Norman D. Rice, USNR - 6th and 9th Groups.

4. All Staff personnel of each Group will attend the above lectures.

MINES AGAINST JAPAN

5. Reading material will be supplied by the above officers for study in conjunction with these lectures. It is directed that this material be circulated by the Groups among all pilots and crews when furnished. Because of security requirements, this material must be accounted for and will be returned to the Wing at the conclusion of the training period.

6. Ground and air training in minelaying techniques will be initiated in accordance with a separate directive to be issued later.

Date	Time	504th	505th	6th	9th
26 Feb.	0800	1 (Air) (W)	--	--	1 (Air) and (Gr) (R)
	1000	1 (Gr) (W)	--	--	--
	1500	--	1 (Gr) (G)	--	--
	1600	--	1 (AO) (G) IA	--	--
	1900	IA	--	--	IA
27 Feb.	0800	--	--	--	1 (Air) (Gr) (R)
	0830	--	--	1 (Air) (G)	--
	1000	--	--	--	--
	1030	--	--	1 (Air) (G)	--
	1300	--	--	--	--
	1900	--	--	IA (Except Gunner)	IA
28 Feb.	0800	II (B) (Gr) (M)	--	--	II (B) (Gr) (R)
	1000	--	--	--	--
	1300	--	II (B) (Gr) (M)	--	--
	1900	--	--	--	--
1 Mar.	0800	--	--	--	--
	0830	--	--	II (B) (Gr) (R)	--
	1000	III (AO) (G)	--	--	II (B) (Gr) (R)
	1300	--	--	--	--
	1900	IIIA	--	--	--
2 Mar.	0800	--	--	--	III (AO) (G)
	0900	--	III (AO) (W)	--	--
	1000	--	--	III (AO) (G)	--
	1300	--	--	--	--
	1900	--	IIIA	IIIA	--
3 Mar.	0800	--	IV (Air) (G)	--	--
	1000	IV (Air) (G)	--	--	IV (Air) (W)
	1100	--	IV (Air)	--	--
	1300	--	--	--	--
	1900	--	--	--	IIIA
4 Mar.	0800	--	--	--	IV (Air) (G)
	0830	--	--	IV (Air)	--
	1030	--	--	IV (Air) (G)	--
	1300	--	--	--	--
	1900	--	--	--	--

Legend:

I-Mine Warfare (General)	A.O.-Officer Crew Members	M-Lt. Martin USNR
II-Mines (Handling)	B-Bombardiers	R-Lt. Rice USNR
III-Advance Mine Warfare	IA-A.M.W. Movie	G-Capt. Grossman USA
IV-Mine Warfare Intelligence	IIIA-D and M/S Movie	Gr-Ground Personnel
Air-Air Crews	W-Lt. Wallace USNR	(Arm and Ord)

MINES AGAINST JAPAN

ANNEX F

TRAINING FLIGHTS

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

1 March 1945

660.3

SUBJECT: Training in Minelaying Methods.

TO: See Distribution

1. Instruction in minelaying methods will be given to units of this Wing in accordance with attached schedule. (Incl. No. 1).
2. Training will be conducted by mine training officers attached to this Wing. Program of training will begin 3 March 1945.
3. The Squadrons will be divided into two equal sections, by the Squadron Commanders, for this training.
4. Group training Officers will make available suitable space for the accomplishment of the ground training phase of the program.
5. Morning ground instruction will be from 0800 to 1100; afternoon ground instruction will be from 1300 to 1600.
6. Flying is scheduled for morning periods only as flights will extend into the afternoon. Each aircraft will carry two airplane Commanders, two Navigators, two Bombardiers, two Radar Operators, one Instructor (Wing), one Engineer, and one Blister Gunner.
7. Each A/C will carry 4-500 lb. G. P. Bombs fused no delay nose, 2-1000 lb. Mk 26 mines fused no delay nose, 1-K22 camera, 1-K20 camera, and 1 scope camera.

BY COMMAND OF BRIGADIER GENERAL DAVIES:

DISTRIBUTION:

2 - 504th Group Operations
2 - 515th Group Operations
2 - 6th Group Operations
2 - 9th Group Operations
2 - Each Squadron Operations

s/ Robert T. Iven
1st Lt. AC
Asst. Adjutant

MINES AGAINST JAPAN

DAY	MORNING		AFTERNOON
	GROUND TRAINING	FLYING	GROUND TRAINING
1	Section 1 398th Bomb Squadron	--	Section 2 398th Bomb Squadron
2	Section 1 421st Bomb Squadron	Sections 1 and 2 398th Bomb Sq.	Section 2 421st Bomb Squadron
3	Section 1 482nd Bomb Squadron	Sections 1 and 2 421st Bomb Sq.	Section 2 482nd Bomb Squadron
4	Section 1 483rd Bomb Squadron	Sections 1 and 2 482nd Bomb Sq.	Section 2 483rd Bomb Squadron
5	Section 1 484th Bomb Squadron	Sections 1 and 2 483rd Bomb Sq.	Section 2 484th Bomb Squadron
6	Section 1 24th Bomb Squadron	Sections 1 and 2 484th Bomb Sq.	Section 2 24th Bomb Squadron
7	Section 1 39th Bomb Squadron	Sections 1 and 2 24th Bomb Sq.	Section 2 39th Bomb Squadron
8	Section 1 440th Bomb Squadron	Sections 1 and 2 39th Bomb Sq.	Section 2 440th Bomb Squadron
9	Section 1 1st Bomb Squadron	Sections 1 and 2 440th Bomb Sq.	Section 2 1st Bomb Squadron
10	Section 1 5th Bomb Squadron	Sections 1 and 2 1st Bomb Sq.	Section 2 5th Bomb Squadron
11	Section 1 99th Bomb Squadron	Sections 1 and 2 5th Bomb Sq.	Section 2 99th Bomb Squadron
12	--	Sections 1 and 2 99th Bomb Sq.	--

225/226

DELETED FOR REASONS OF SECURITY

ANNEX G

MINES AGAINST JAPAN

MINES AGAINST JAPAN

ANNEX H

MINE HANDLING AND LOADING

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

1 March 1945

TACTICAL SOP

NUMBER 15-8

MINE HANDLING AND LOADING

1. In order to have mines operate properly, it is absolutely necessary that the procedure outlined below, and on the check-off lists, be followed in handling, preparing, and installing mines in aircraft.

2. The Mine Loading Plans (Annexes S and T) will be prepared by the Wing Ordnance Officer and will accompany the Field Order to Group Operations. There will be a separate Mine Loading Plan for each Airplane Commander.

(a) Group Operations will:

- (1) Place the number of airplane that the Airplane Commander will be assigned on both sheets of the Mine Loading Plan (Annex T).
- (2) Distribute Sheet 1 of the Loading Plan to the Group Ordnance Officer and Sheet 2 to the Group Armament Officer immediately after the plane assignment is made.

(b) The Group Ordnance Officer will distribute Sheet 1 of the Mine Loading Plan to the Ordnance Officers who are to load the particular aircraft concerned.

(c) The Ordnance Officer (and his section) will:

- (1) Draw all the mines specified on the Mine Loading Plans in his possession and the necessary parachutes, release mechanisms, and soluble washers and deliver them to the designated aircraft.
- (2) Give Sheet 1 of the Mine Loading Plan to the Chief Armorer for completion.
- (3) Place the mines on bomb cradles and install the parachutes and soluble washers on the mines.

MINES AGAINST JAPAN

- (4) Attach the static cords to the plane after the mines are loaded.
- (5) Complete the ordnance check-off list and return it to the Wing Ordnance Officer.
- (d) The Group Armament Officer will distribute Sheet 2 of the Mine Loading Plan to the Chief Armorers assigned to the aircraft concerned.
- (e) The Chief Armorer will:
 - (1) Prepare the bomb stations to drop the mines in the sequence directed in the Mine Loading Plan.
 - (2) Mark the desired bomb station on each mine in chalk.
 - (3) Supervise loading the mines.
 - (4) Complete the "bomb station" columns on Sheets 1 and 2 of the Mine Loading Plan after the mines are loaded.
 - (5) Turn Sheet 1 over to the bombardier of the aircraft.
 - (6) Return Sheet 2 to the Wing Ordnance Officer.

3. There are two sizes of mines which will be used. The Mk 25 series of mines weighs about 2000 pounds and is loaded in the same way as 2000 pounds bombs. The Mk 26 and Mk 36 series weigh about 1000 pounds and are loaded in the same way as 1000 pound bombs. There are two major differences between bombs and mines. These are the method of arming and the parachute which replaces the bomb fins.

4. Mines are not armed by air travel as bombs are, but by hydrostatic (water pressure) devices similar to those used on depth bombs. All mines use two of these devices. The extender, which is in the deepest pocket of the mine, arms the explosive train of the mine by placing an electric detonator in the booster charge. The clock starter, which is in the shallow pocket, starts a clock which after 45 minutes connects the electric detonator to the firing mechanism and also arms the firing mechanism. This clock can only run while the clock starter is either manually depressed or when it is under water, so that the clock starter must be operated for a total of 45 minutes before the electrical system can arm. Both the clock starter and extender must be at least 16 feet under water to operate and will retract if pressure is removed.

5. Washers are always placed in the clock starters and extenders to prevent inexperienced personnel or impact from operating them. Wooden washers, which are painted black for identification, are always used until the mines are ready to be loaded, and keep the mine from arming even when under water. Directly before hoisting the mines into the bomb racks the wooden washers are replaced with soluble washers by the ordnance crews. These soluble washers are white or brightly colored for identification and are made of a salt which will dissolve within a few minutes when in water. It is absolutely necessary that the arming devices be dry when the washers are installed. If for any reason mines are removed from a plane after loading, the soluble washers must be replaced by the wooden washers before transporting back to the dump.

6. In order to reduce the impact when they hit water, parachutes 6 feet in diameter are used instead of bomb fins on mines. To prevent this parachute from dragging the mine when it is under water, a release mechanism is used which disconnects the parachute from the mine when it strikes the water. The ordnance crews will as-

MINES AGAINST JAPAN

semble the parachute and release to the mine. This release consists of two semi-circular straps which fit around the mine case and are held together by a bolt on one side and a lead-weighted pin on the other side. The lead weight must always be on the forward side of the release. When the mine strikes the water the lead weight pulls the pin out of the release and the paddles on the two straps wipe the release off the mine. In order for the release to stay on the mine during descent and to come off after water impact it is absolutely necessary that the bands be tightened to the correct tension. The release mechanism can be oriented in any convenient position on the case as long as the paddles are placed directly over the lugs welded on the mine case.

7. The parachute is centered on the mine case by means of a small pin on the center of the tail plate and held on to the release by means of several shackles. On some mines a small well is located in the center of the tail plate. On these mines a circular plate which fits into this well must be screwed into the parachutes before installation. The parachute is opened on dropping by a static line which is attached to a rigid member of the plane. It is very necessary that the parachute be oriented on the mine as instructed, so that this static cord will come out of the top of the pocket of the parachute. For correct operation the parachute must be absolutely dry.

8. After the mines are installed in the plane by the armament crews it is necessary for the ordnance crews to attach the parachute static cords to the plane. It is necessary to follow the method as instructed in attaching static lines to prevent premature opening or failures of the parachutes. Most of the parachute static cords have a small clasp on the end. These can be fastened to any correctly located member. On parachute static cords without clasps it is necessary to tie the end of the cord to a member at least 1/4 inch in diameter or to a clasp of another static line. The length of the line should never be shortened and the end must be attached to a smooth surface free of sharp edges. Mines should never be loaded if the soluble washers or parachutes are damp.

BY COMMAND OF BRIGADIER GENERAL DAVIES:

James T. Connally
Colonel, Air Corps,
D C/S Training.

OFFICIAL

s/ Barnett S. Allen
Major, Air Corps, A-3

DISTRIBUTION:

"B" plus 1 to each Armorer (911)
1 to each Munitions Worker (901)
1 to each Ammunition NCO (505)

MINES AGAINST JAPAN

ANNEX I

MINE HANDLING AND LOADING (SUPPLEMENT)

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

353. ALYDO

10 April 1945

SUBJECT: Supplemental Mine Loading Instructions.
TO: See Distribution.

1. Group Ordnance Officer, upon receipt of Master Mine Loading Plan, will assign Mine Loading Plans to the various Squadron Ordnance Officers in their Group.
2. Squadron Ordnance Officers will prepare an issue slip in duplicate listing mines in their particular plans by code number.
3. Mines will be drawn upon presenting the issue slips (two copies) at the MAD-4 Office which is issuing office for mines. Here assignments to revetments will be made. Mines will be drawn in bulk and distributed to planes on the line.
4. Parachutes and accessories will be issued in bulk with a small number of spares for each squadron.
5. Mines not used for a mission for any reason will be returned to MAD-4, again using issue slip, reporting to MAD-4 office for instructions. Before returning, mines must be examined by naval personnel from MAD-4.
6. If any difficulty is experienced in preparing mines for loading into planes, call Mr. Atkins or his Duty Officer at MAD-4 (Galahad 803) who will send qualified naval personnel to the airstrip to examine mines and make necessary corrections or disposition.
7. After each mission, all plastic caps, wooden washers, release mechanisms, chutes, soluble washers and nuts will be turned in to the warehouse at MAD-4.
8. All openings on mines (clock starter well, extender well, tail plate, and filler hole) must be checked with torque wrench-before loading mines into planes, nuts must be checked to 190 inch-lbs. or 16 foot-lbs. torque tension. Individual squadrons will be responsible for their own mines.
9. Note on Static Lines: Do not wrap static lines around any handle or other object more than twice. Remove slack by taping, not by wrapping extra line around members of the plane.

BY COMMAND OF BRIGADIER GENERAL DAVIES:

DISTRIBUTION: 10 per Bomb Group
2 per MAD-4

s/ Robert T. Iven
1st Lt., AC
Asst. Adjustant

MINES AGAINST JAPAN

ANNEX J

SAMPLE GENERAL DIRECTIVE

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HEADQUARTERS XXI BOMBER COMMAND
APO 234, c/o Postmaster
San Francisco, California

28 May 1945

DIRECTIVE FOR PREPARATION OF MINES

1. Until further direction the following preparation will be used unless otherwise specified in the design of all Starvation minefields. It is based upon a knowledge of enemy countermeasures, ship traffic and characteristics of United States mines.

(a) Use of Arming Delays:

- (1) Arming delays will not be used in water 10 fathoms or less in depth.
- (2) Arming delays will not be used in areas where a mine watch is probable and the water depth less than 15 fathoms in depth.
- (3) Arming delays will be used on the Mk 25 when the M-11 mechanism is used. The delays will be spread over a period of 4 weeks, or until one week prior to the next planned minelaying. A minimum of 30 per cent will have delays of 2 days or less.
- (4) Arming delays may be used with the Mk 36 Mod 1 or Mk 25 with the M-9 Mod 1 or A-3 mechanism but not on more than 30 per cent of the mines, and only in water deeper than 10 fathoms.
- (5) Arming delays will not be used on A-5 or A-6 mechanisms until further direction, and until positive evidence exists that the enemy is able to sweep them.

(b) Ship Counts:

- (1) Ship counts from 1 to 10 may be used on Mk 25 and Mk 36 Mod 1 mines if desired. A minimum of 1/2 or more of the mines will have ship count one and the remainder will have ship counts equally distributed to the maximum selected, unless a specific number is required to meet a known enemy SOP. In general, ship counts will be avoided in the case of minor ports or where enemy minesweeping facilities are suspected to be meager.
- (2) No ship counts will be used on A-3, A-5 or A-6 until further direction

MINES AGAINST JAPAN

and until it is definitely known that they can be swept by the enemy.

(c) Sterilizers:

- (1) All mines will be sterilized at 150-190 days unless shorter sterilizer times are adopted. If long sterilizer times are not available, permission will be requested to lay M-11, M-9 Mod 1, A-3 and A-5 mechanisms without sterilizers.

(d) Dead Periods:

- (1) M-9 Mod 1 mechanisms will be adjusted for dead periods equally divided between 8 and 10.5 seconds.

(e) Sensitivity of Mechanisms:

- (1) Acoustic A-3 mechanisms shall be set as follows for all depths:

60 per cent at normal
30 per cent at medium
10 per cent at coarse

- (2) Sensitivity of magnetic mechanisms M-9 Mod 1 and M-11 shall be set to give a target width not exceeding 100 feet at the planting depth to select merchant vessels as follows:

5 per cent - 200-1000 tons
30 per cent - 1000-2000 tons
35 per cent - 2000-4000 tons
20 per cent - 4000-8000 tons
10 per cent - 8000-over tons

No merchant vessels below 4000 tons are degaussed and 40 per cent above 4000 tons are M coil degaussed.

- (3) Sensitivity of A-5 mechanisms will be set to give a target width of approximately 100 feet at the planting depth as follows:

5 per cent for 200-1000 ton MV
30 per cent for 1000-2000 ton MV
35 per cent for 2000-4000 ton MV
20 per cent for 4000-8000 ton MV
10 per cent for 8000-10,000 ton MV

- (4) Magnetic units of A-6 mechanisms will be set to conform with paragraph e.(2).

(f) Choice of Mine Sizes:

- (1) Mk 25 mine cases will be used at all times in water depths between 15 and 25 fathoms and may be used down to 12 fathoms.
- (2) Mk 36 mine cases will be used at water depths between 3 and 12 fathoms against ordinary targets when proper mechanisms are available, and may be used up to 15 fathoms.
- (3) Mk 25 mine cases will be used at all depths between 6 and 25 fathoms

MINES AGAINST JAPAN

if the targets are BB or CV, and also if proper mechanisms are not available in Mk 36 cases but are available in Mk 25 cases.

(g) Composition of Minefields:

- (1) When possible, minefields will be composed of 20 per cent magnetic, 20 per cent A-3 and 50 per cent A-5 and/or A-6. If this composition is not available for all minefields of a mission the A-5 and A-6 will be used as specified for very high priority targets and magnetic and acoustic types will be used in new and attrition minefields and at minor ports.

(h) Choice of Magnetic Mechanism:

- (1) M-9 Mod 1 mechanisms will be used instead of M-11 mechanisms in Mk 25 mines at depths from 12 to 15 fathoms; 60 per cent M-9 Mod 1 will be used in 15 to 20 fathoms and 20 per cent 20 to 25 fathoms.

(i) Dimensions of Minefields:

- (1) Every effort will be made to present the enemy with the necessity of clearing a channel a minimum of four miles long to his harbor, and as much longer as possible. No firm rule can be laid down since the geography and importance of the target determines the profitable number of mines to be used. Always choose the maximum possible area rather than high mine density if there is a choice.

(j) Density of Minefields:

- (1) A density of 40 mines per square mile shall not be exceeded on any single mission. A density of 20 mines per square mile will be regarded as the normal maximum.
- (2) An accumulated density of 100 live and effective mines per square mile shall not be exceeded in successive missions to the same minefield. Persistent passage of enemy ships through a fixed route shall be regarded as conclusive evidence that the mines already laid in that channel have been 100 per cent cleared, whether delayed arming has been used or not.

2. On the basis of the above it is directed that standard tables of preparation be established by the 313th Wing in order to simplify planning and preparations for missions. A copy of these tables will be provided to this Headquarters.

BY ORDER OF THE COMMANDING GENERAL, CURTIS E. LEMAY:

MINES AGAINST JAPAN

ANNEX K

SAMPLE SPECIFIC DIRECTIVE

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HEADQUARTERS XXI BOMBER COMMAND
APO 234, c/o Postmaster
San Francisco, California

28 May 1945

DIRECTIVE FOR JUNE STARVATION MISSIONS

1. Estimate of the Enemy Shipping Situation:
 - (a) Frequent remining of Shimonoseki Straits area since 13 May is believed to have caused substantial closure of the straits for the past two weeks to ships of 1000 gross tons and over. There is some indication that vessels of less than 1000 gross tons have continued to move through minefields even when navigation has been prohibited for ships of larger size. Photographs of 23 May showed 37 vessels totalling 62,410 gross tons in the Straits area. Of these 37, only 11 were over 1000 gross tons. Northwest Honshu and Kyushu areas mined during May are believed to have been closed to navigation for periods of from three to five days after mining. It is estimated that from 2/3 to 3/4 of principal Japanese imports have in past months entered Japan through the Shimonoseki Straits, Niigata, or Fushiki. An extended blockade of those areas will either keep out, delay, or force to other ports (most of which are less accessible and less easily used) all of those imports carried on vessels of 1000 gross tons or larger.
2. The mission of mining operations during June is to maintain the blockade of Shimonoseki Straits and Northwestern Honshu ports in order to prevent any appreciable importation of food and other raw materials into Japan. This effort is in coordination with shipping strikes directed by CINCPAC by our submarines and Navy search planes.
3. The 313th Wing will make continuous use of one Bomb Group to lay a total of 4050 mines during June in accordance with the following schedules:
 - (a) Mining strikes will be cancelled whenever weather is favorable for daylight precision bombing. The full 313th Wing effort will be directed against daylight precision targets when weather permits, as directed by this Headquarters.
 - (b) Mining of Shimonoseki Straits will be given priority over other targets. Closure of the Straits area including Fukuoka is especially required during the first two weeks of June. Mining of each target will be spread

MINES AGAINST JAPAN

as uniformly as possible over the entire month.

- (c) Mines will be laid in swept channels or in regular channels in accordance with charts held by the Mining Officer of the 313th Wing.
- (d) Field Mike: 1100 mines.
- (e) Field Love: 500 mines.
- (f) Shimonoseki Straits Anchorages at Moji, Shimonoseki, Hesaki No. 1, and Wakamatsu: 100 mines each, total 400 mines.
- (g) Field Uncle (Sakata): 100 mines.
- (h) Field Uncle (Niigata): 600 mines.
- (i) Field Nan (Fushiki): 300 mines.
- (j) Field Nan (Nanao): 100 mines.
- (k) Field Zebra (Tsuruga): 200 mines.
- (l) Field Zebra (Maizuru and Miyazu): 100 mines.
- (m) Field Charlie (Fukuoka and Karatsu): 300 mines.
- (n) Field Able (Kobe-Osaka): 200 mines.
- (o) Field Able (Harbors of Kobe-Osaka): 75 mines each - total 150 mines.

4. Mines will be prepared and laid in accordance with previous directives except that all mines will be adjusted to sink ships in accordance with the following weighting factors:

500-1000 tons	10 per cent
1000-2000 tons	45 per cent
2000-4000 tons	25 per cent
4000-8000 tons	20 per cent
8000-over	--

Extensive use of delayed arming will be made in magnetic and acoustic types. The A-6 mechanism will be assumed to be compromised.

5. Dropping altitude will be determined by the 313th Wing.

6. Scope photos will be taken of every ship sighting and every attempt will be made to record any ships sighted either by radar or visually.

7. When possible approaches and retirement courses will be consistent with Air-Sea Rescue facilities.

8. Electronic Jamming is authorized.

BY ORDER OF THE COMMANDING GENERAL: CURTIS E. LEMAY.

MINES AGAINST JAPAN

ANNEX L

**SAMPLE DIRECTIVES ORDERING
MISSION CHANGES**

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INCOMING DIRECTIVES FROM XXI BOMBER COMMAND
ORDERING CHANGES IN SPECIFIC MINING MISSIONS

T-26-10:

SUBJECT: STARVATION 17.
SCHEDULE MINING FOR MOJI AND NUMBER 1 LOVE ANCHORAGES IN PLACE OF
MIKE IN ACCORDANCE WITH PREVIOUS DIRECTIVE T-25-22 DATED 250730Z.

AIMCR 5713:

SUBJECT: DIRECTIVE FOR MINING MISSIONS 25, 26, and 28.
1. EFFECTIVENESS OF 313TH BOMBING MINING AT SHIMONOSEKI
STRAITS HAS DRIVEN MANY LARGER SHIPS TO SECONDARY DIVERSIONARY PORTS.
2. CANCEL MINING OF SHIMONOSEKI STRAITS MINEFIELDS LOVE AND
MIKE FOR MISSIONS 25, 26, and 28.
3. USE CANCELLED MINES IN MINEFIELD GRIDS XRAY 1, 3, 5, 7, 8, 11,
AND YOKE 6, 7, AND 24.

AIMCR 6147:

SUBJECT: DIRECTIVE FOR MINING MISSION NUMBER 31.
REFER YOUR APNCR 5072 DATED 041007Z JUNE. CANCEL SORTIES PLANNED FOR
FIELD CHARLIE IN MINING MISSION NUMBER 31 AND DIVERT TO FUNAKAWA AREA.
USE OF COMPLETE A-5 FIELD RECOMMENDED IN THIS AREA.

AIMCR 6000:

SUBJECT: MINING MISSION NO. 38.
1. SCHEDULE MINING MISSION NO. 38 for 22 JULY EXCEPT FOR SORTIES
TO MINEFIELD ZEBRA.
2. SCHEDULE ZEBRA SORTIES TO MOST SUITABLE OF FOLLOWING
TARGETS: GENZAN, FUSAN, MASAN, REISUI, SHIMONOSEKI, SENZAKI GRIDS XRAY
3 AND 4.

AIMCR 5283:

SUBJECT: MINING MISSION 45.
CANCEL MINING OF TSURUGA FOR MINING MISSION NO. 45 AND USE CANCELLED
MINES AT GENZAN.

MINES AGAINST JAPAN

ANNEX M

SAMPLE MINE ASSEMBLY ORDER

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

5 August 1945

SUBJECT: Mine Assembly Order No. 82.

TO: Officer-in-Charge, Mine Assembly Depot No. 4.

1. Prepare the following 622 mines at maximum assembly rate. The minimum schedule as arranged verbally, will be to have sub-order "X" completed by the morning of 6 August, sub-order "A" by the morning of 10 August, and sub-order "B" by the morning of 12 August. Every effort must be made to exceed this minimum schedule:

<u>Sub-Order</u>	<u>Code</u>	<u>Size</u>	<u>Quantity</u>	
X	D31-B8	1000 lb.	4	
	D21-B8	"	3	
	D33-B8	"	4	
	D25-B8	"	3	
	D31-J8	"	6	
	D21-H8	"	4	
	N21-B8	2000 lb.	3	
	N31-H8	"	2	
	D11-B8	"	7	
	D11-H8	"	9	
	A	D11-B8	1000 lb.	10
		D31-B8	"	9
		D21-B8	"	4
D15-B8		"	5	
D33-B8		"	4	
D25-B8		"	1	
D11-H8		"	5	
D31-J8		"	4	
D21-H8		"	2	
V11-B8		"	13	
V11-E8		"	14	
V11-F8		"	14	
V11-G8		"	14	
V11-I8	"	13		
	Et cetera			

MINES AGAINST JAPAN

ANNEX N

SAMPLE MINE MODIFICATION ORDER

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

20 July 1945

SUBJECT: Mine Modification Order No. 5.

TO: Mine Modification Unit, Navy No. 3247.

1. Prepare the following modified arming cells to be used by Mine Assembly Depot FOUR in preparing Mine Assembly Order No. 81:

<u>Quantity</u>	<u>Code</u>	<u>Description</u>
100	E	Mk 2 Arming Cell adjusted to approx. 1 day operation.
100	F	Mk 2 Arming Cell adjusted to approx. 2 days operation.

2. Devise a method of installing a CD-14 delayed arming clock in the Mark 36 MM2 and Mark 25 MM4 mines. Prepare sub-assemblies and modification parts for assembling the following quantities of such mines:

<u>Quantity</u>	<u>Description</u>
5	Mark 36 MM2, with CD-14 delayed arming.
23	Mark 25 MM4, with CD-14 delayed arming.

These sub-assemblies and modification parts should be furnished to Mine Assembly Depot FOUR in sufficient time to assure delivery of completed mine assemblies by 26 July 1945 or as otherwise specified by Mine Assembly Depot. A schedule of delivery should be worked out between Mine Modification Unit and Mine Assembly Depot FOUR in order to assure meeting the delivery schedule of Mine Assembly Order No. 81.

FOR THE COMMANDING GENERAL:

Robert T. Iven
Capt., AC
Asst. Adjustant

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MINES AGAINST JAPAN

ANNEX O

TABLE OF MINE SENSITIVITIES

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TO PRODUCE APPROXIMATELY 100-FOOT TARGET WIDTHS

Mine Type And Sensitivity (First 2 Sym- bols of Code Designation)	% of Each Sensitivity to be Planted							
	(Meters) (Fathoms)	7-11 4- 6	11-15 6- 8	15-19 8-10	19-24 10-13	24-29 13-16	29-37 16-20	37-46 20-25
				<u>1000 lb. mines</u>				
D1		--	5	45	85	90	--	--
D3		60	70	50	15	10	--	--
D2		40	25	5	--	--	--	--
S2		95	40	60	70	85	--	--
S3		5	60	40	30	15	--	--
				<u>2000 lb. mines</u>				
D1		--	--	--	5	65	95	100
D3		--	--	50	70	30	5	--
D2		--	--	50	25	5	--	--
N1		--	--	--	--	--	10	35
N2		--	--	--	10	50	75	65
N3		--	--	45	75	50	15	--
N4		--	--	55	15	--	--	--
S2		--	--	--	70	85	100	100
S3		--	--	--	30	15	--	--
V1		30	40	40	40	40	40	--
V2		70	50	50	50	50	50	--
V3		--	10	10	10	10	10	--
X1		--	--	--	--	5	50	90
X3		--	--	5	30	70	50	10
X5		20	35	65	60	25	--	--
X7		80	65	30	10	--	--	--

MINES AGAINST JAPAN

ANNEX P

C O P Y SAMPLE TACTICAL BRIEF WORK SHEET C O P Y

MINING MISSION NO. 48

DATE 1 April 1946

TOTAL A/C 30
TOTAL MINES 240

FORCE I

Target Minefield Mike (Shimonoseki Straits Area)
No. of A/C 12 1000 lb. Mines 4x12 - 48 2000 lb. Mines 8x7 - 56
Total Mines 104
I.P. (Ima Misaki): 34-25-OON 131-08-OOE

Axis of Attack Between 207° T and 220° T
Location of Mines Western approach to Shimonoseki

Grids M9, M10, M11, M12,

FORCE II

Target Minefield Zebra (Maizuru)
No. of A/C 8 1000 lb. Mines -- 2000 lb. Mines 8x7 - 56
Total Mines 56
I.P. (Ogami Shima): 35-37-3ON 135-48-30E

Axis of Attack Between 250° T and 260° T
Location of mines In entrance to Maizuru Wan

Grids Z7

FORCE III

Target Minefield Rashin
No. of A/C 10 1000 lb. Mines 2x12 - 24 2000 lb. Mines 8x7 - 56
Total Mines 80
I.P. (Katsu Tan) 41-53-3ON 129-57-OOE

Axis of Attack Between 037° T and 040° T
Location of Mines In Rashin Wan

Grids Minefield Not Gridded

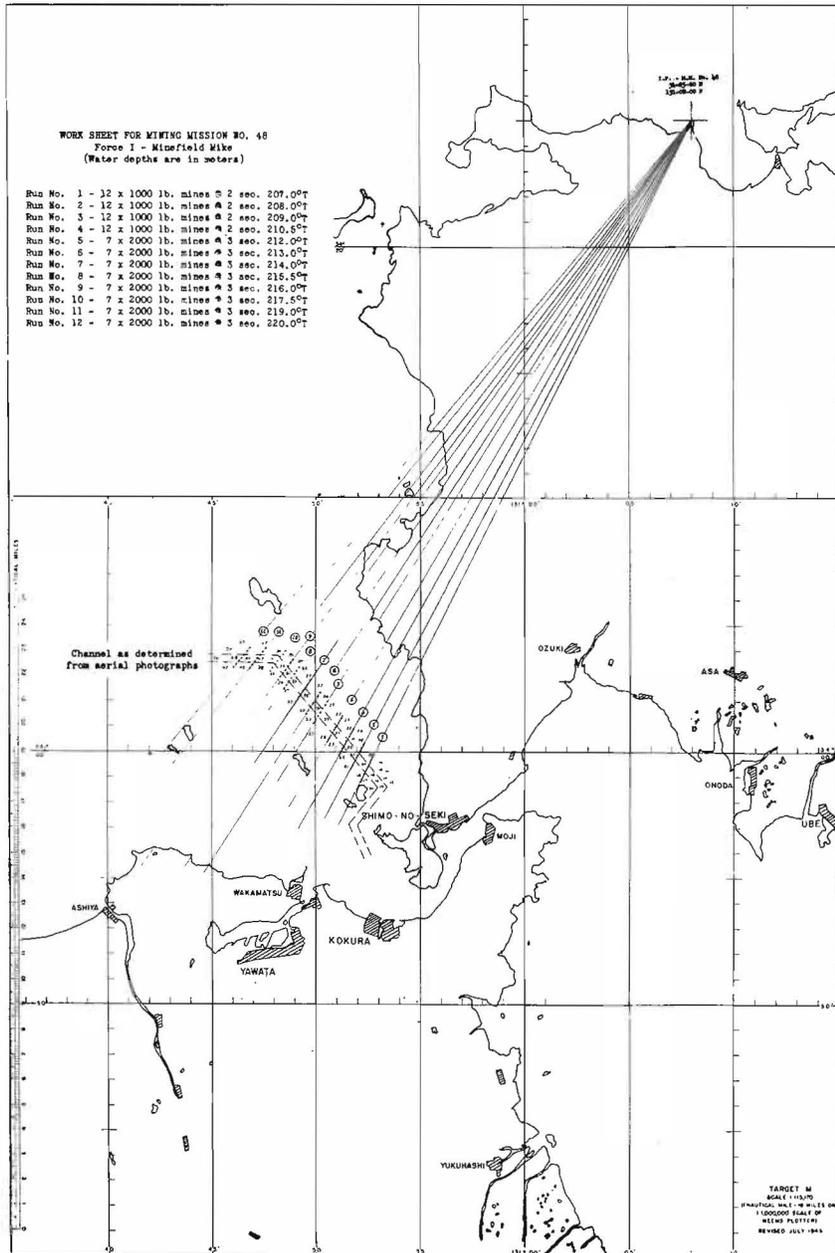
MINES AGAINST JAPAN

ANNEX Q

SAMPLE MASTER PLANNING CHART

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MINES AGAINST JAPAN

ANNEX R

SAMPLE LOADING SCHEDULE

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Mining Mission No. <u>48</u>		1000 lb. <u>48</u>		2000 lb. <u>56</u>		TOTAL <u>104</u>							
Force I - Field Mike - Shimonoseki Straits Area													
1000 lb.	Avl	1	2	3	4	5	6	7	8	9	10	11	12
D11-B8	13	2	3	4	4								
D31-B8	5	2	1	1	1								
D21-B8	1	1											
D15-B8	8	1	2	2	3								
D33-B8	3	1	1	1									
D25-B8													
D11-H8	6	1	2	2	1								
D31- J8	1	1											
D21-H8													
S21-A8	1				1								
S21-E8	2	1		1									
S21-F8	2		1		1								
S21-G8	2			1	1								
S21-H8	2	1	1										
S31-A8													
S31-E8	1	1											
S31-F8	1		1										
S31-G8													
S31- I8													
Total	48	12	12	12	12								
2000 lb.	Avl	1	2	3	4	5	6	7	8	9	10	11	12
X11-B8	21						1	1	2	2	3	6	6
X31-B8	18					4	3	2	2	3	2	1	1
X51-B8	3					1	1	1					
X71-B8													
V11-B8													
V11-E8	1						1						
V11-F8	1							1					
V11-G8	1								1				
V11- I8	1									1			
V21-D8	1							1					
V21-E8	1								1				
V21-F8	1									1			
V21-G8	2						1				1		
V21-H8	1					1							
V31-B8													
V31-E8													
V31-F8													
V31-G8													

SUMMARY	
Mag. Mech.	36 35 per cent
A-3 Mech.	16 15 per cent
A-5 Mech.	10 10 per cent
A-6 Mech.	42 40 per cent
Total	104 100 per cent

MINES AGAINST JAPAN

	Avl	1	2	3	4	5	6	7	8	9	10	11	12
N21-B8													
N31-H8													
D11-B8													
D11-H8													
D31-B8													
D21- I8													
QS21-A8													
QS21-E8	1						1						
QS21-F8	1								1				
QS21-G8	1									1			
QS21- I8	1											1	
QS31-H8													
Total	56					6	8	6	7	8	6	8	7

Totals 104

MINES AGAINST JAPAN

ANNEX S

SAMPLE MASTER LOADING PLAN

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247

MINING MISSION NO. 48 - MINE LOADING PLAN

<u>Run</u>	<u>Size</u>	<u>Mines loaded in sequence to be dropped (read across)</u>						
Force I								
1	1000 lb.	D11-B8 D21-B8	S21-E8 D11-B8	D31-B8 D31-B8	D15-B8 S21-H8	S31-E8 D33-B8	D31- J8 D11-H8	
2	"	D33-B8 D11-B8	D11-B8 D31-B8	S31-F8 D15-B8	D15-B8 S21-F8	S21-H8 D11-H8	D11-H8 D11-B8	
3	"	D11-B8 D15-B8	D15-B8 D11-B8	S21-G8 S21-E8	D11-B8 D11-H8	D11-H8 D11-B8	S31- I8 D33-B8	
4	"	S31-A8 D11-B8	D11-B8 D15-B8	D15-B8 D31-B8	D11-B8 D11-B8	S21-F8 D15-B8	D11-H8 S21-G8	
5	2000 lb.	X31-B8	V21-H8	X31-B8	X51-B8	X31-B8	S21-E8	X31-B8
6	"	X51-B8	X31-B8	X11-B8	V11-E8	X31-B8	X31-B8	V21-G8
7	"	X11-B8	V11-G8	X31-B8	S21-G8	X31-B8	V21-E8	X11-B8
8	"	X11-B8	V11-G8	X31-B8	S21-G8	X31-B8	V21-E8	X11-B8
9	"	X31-B8	V21-F8	X11-B8	X31-B8	X11-B8	X31-B8	V11- I8
10	"	X11-B8	X31-B8	V21-G8	X11-B8	S21- I8	X11-B8	X31-B8
11	"	X11-B8	X11-B8	X31-B8	X11-B8	X11-B8	X11-B8	X11-B8
12	"	X11-B8	X11-B8	X11-B8	X11-B8	X31-B8	X11-B8	X11-B8

MINES AGAINST JAPAN

ANNEX T

SAMPLE INDIVIDUAL LOADING PLAN

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MINE LOADING PLAN
SHEET NO. 1

RUN NO. 7

MINING MISSION NO. 48

AIRPLANE COMMANDER

PLANE NO.

DATE OF MISSION

1 April 1946

GROUP

DATE LOADED

SQUADRON

TIME LOADED

Required
Dropping
Sequence

Mk-Mine

Code Letter

Bomb Station

(For Bombardier)
Sequence Dropped

1	25	X31-B8	
2	"	S21-F8	
3	"	X51-B8	
4	"	V21-B8	
5	"	X11-B8	
6	"	V11-F8	
7	"	X31-B8	
8			
9			
10			
11			
12			

Checked after mines were loaded by

(Chief Armorer)

Mark 25 Mine 2000 lb. size; Marks 26 and 36 Mines 1000 lb. size.

- Routing:
1. Group Operations for plane number.
 2. Group Ordnance Officer for distribution to Ordnance Officer concerned.
 3. Ordnance Officer for drawing required mines from mine ready dump.
 4. Chief Armorer for recording bomb stations.
 5. Plane Bombardier for recording sequence dropped.
 6. Interrogator for information and forwarding to Wing Ord. Officer.

NST JAPAN

MINE LOADING PLAN SHEET NO. 2

RUN NO. 7

MINING MISSION NO. 48

AIRPLANE COMMANDER

PLANE NO.

DATE OF MISSION

GROUP

DATE LOADED

SQUADRON

TIME LOADED

Required
Dropping
Sequence

Mk-Mine

Code Letter

Bomb Station

1	25	X31-B8	
2	"	S21-F8	
3	"	X51-B8	
4	"	V21-B8	
5	"	X11-B8	
6	"	V11-F8	
7	"	X31-B8	
8			
9			
10			
11			
12			

CHIEF ARMORER'S CHECK LIST:

Initials

1. Bomb Stations assigned and recorded.
2. Bomb Stations prepared for loading designated mines.
3. Proper bomb station and side of plane placed on each mine with chalk.
4. Mines loaded.
5. Parachutes are dry.
6. Static cords are connected to rigid members of the plane, above and aft of the parachute, capable of supporting 250 lbs.
7. Mines are loaded in proper stations.
8. Sheet No. 1 given to plane bombardier.
9. After Plane returns, tag static lines with plane number and date and return to Wing Ordnance Officer.

(Mark 25 mine 2000 lb. size; Marks 26 and 36 mines 1000 lb. size)

ROUTING:

1. Group Operations for plane number.
2. Group Armament Officer for distribution to Chief Armorer concerned.
3. Chief Armorer for completion and forwarding to Wing Ord. Ofcr.

MINES AGAINST JAPAN

ORDNANCE CHECK-OFF LIST FOR MINE LOADING

AIRPLANE COMMANDER
PLANE NO.
GROUP
SQUADRON

DATE

(Fill out this part of list when mine is on cradle and
before parachute is installed)

1. Dry soluble washers (2) installed in each mine.
2. Securing nuts tight over each washer.
3. Lucite covers (2) removed from each mine.
4. Parachute release mechanism oriented correctly on mine case so that inertia release is free of lugs on mine case.
5. Orientation lugs placed on case with cotter key if one is not welded to case.
6. Lead end of inertia release on forward end of release mechanism.
7. Shear wire installed through washer and release pin and ends bent at right angles.
8. Release mechanism conforms to curvature of mine case. (No large air gaps between mine case and release mechanism).
9. Release mechanism has proper tension. (Inertia weight should just slide with force and should feel sloppy when moved from side to side.)
10. Lock nit tight.

(Fill out this part of list after parachute is installed
and before loading mine)

11. Centering plate placed on parachute if necessary.
12. Parachute correctly oriented on mine case for loading on proper side of plane.
13. Parachute shroud line shackle pins tight.
14. Small wire fed through eyes of parachute shroud line shackle pins.
15. Soluble Washers and parachute are dry.

(Fill out this part of list after mines are loaded in plane)

16. Static cords are connected to rigid members of the plane, above and aft of the parachute, capable of supporting 250 pounds.
17. Parachutes are correctly oriented.
18. Tie cords in pockets of parachute are intact.
19. All slack is removed from static lines and taped with Scotch or friction tape.
20. Static lines are free of tie straps.
21. Static lines are clear of each other so that release of one mine will not open other parachutes.
22. Return wooden washers and Lucite covers to Wing Ordnance Officer.

Loaded under supervision of
(Crew Chief)

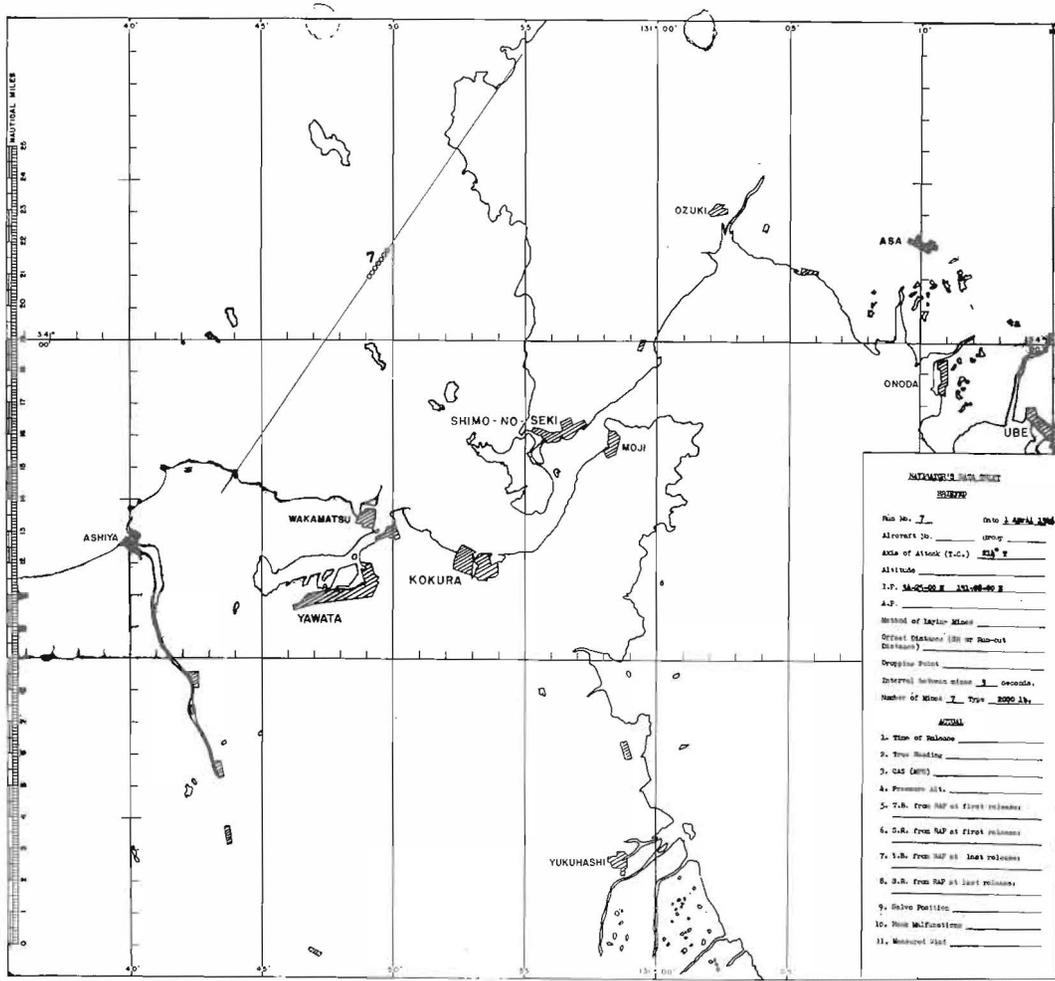
Checked by
(Ordnance Officer)

Return this check-off list to Wing Ordnance Officer

MINES AGAINST JAPAN

ANNEX U

NAVIGATOR'S CHART FOR RUN NO. 7

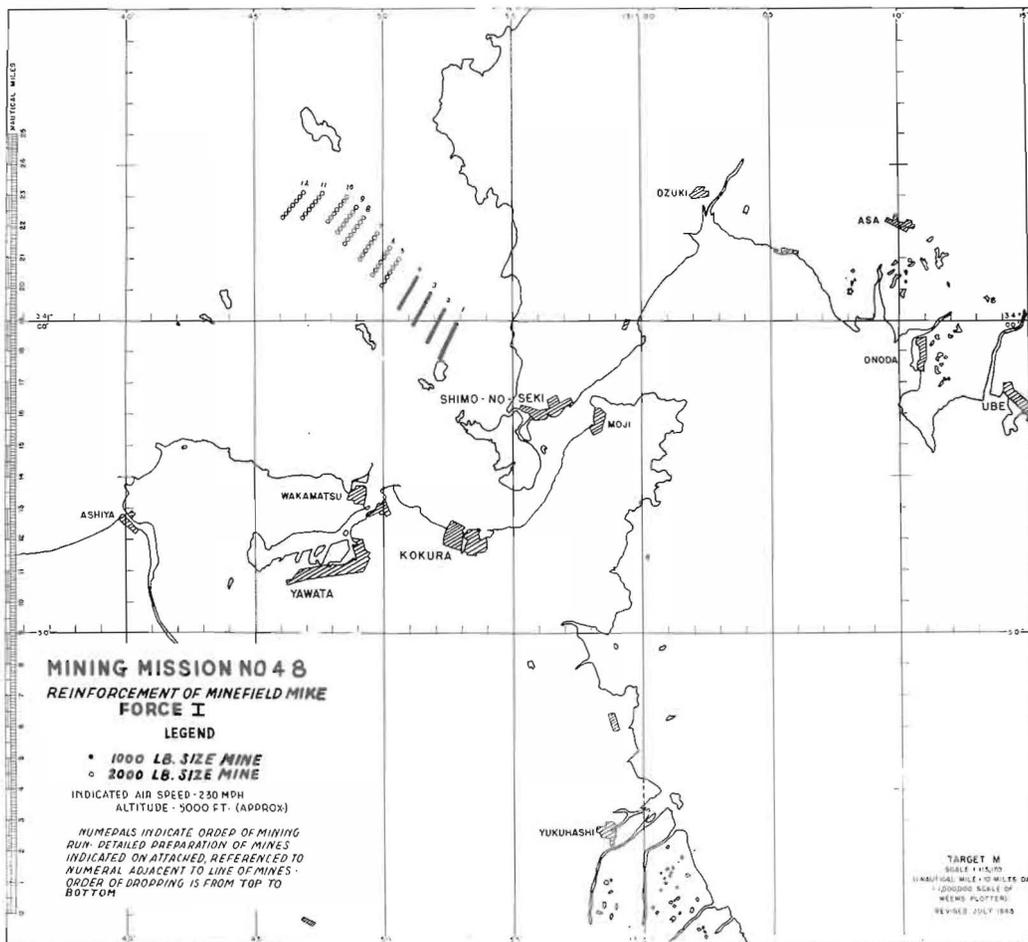


COMPILED AND REPRODUCED BY BARTH ENGR AND TOPO CO

MINES AGAINST JAPAN

ANNEX V

OVERLAY OF MINE FIELD COMPILED FROM NAVIGATORS' PLOTS



MINES AGAINST JAPAN

ANNEX W

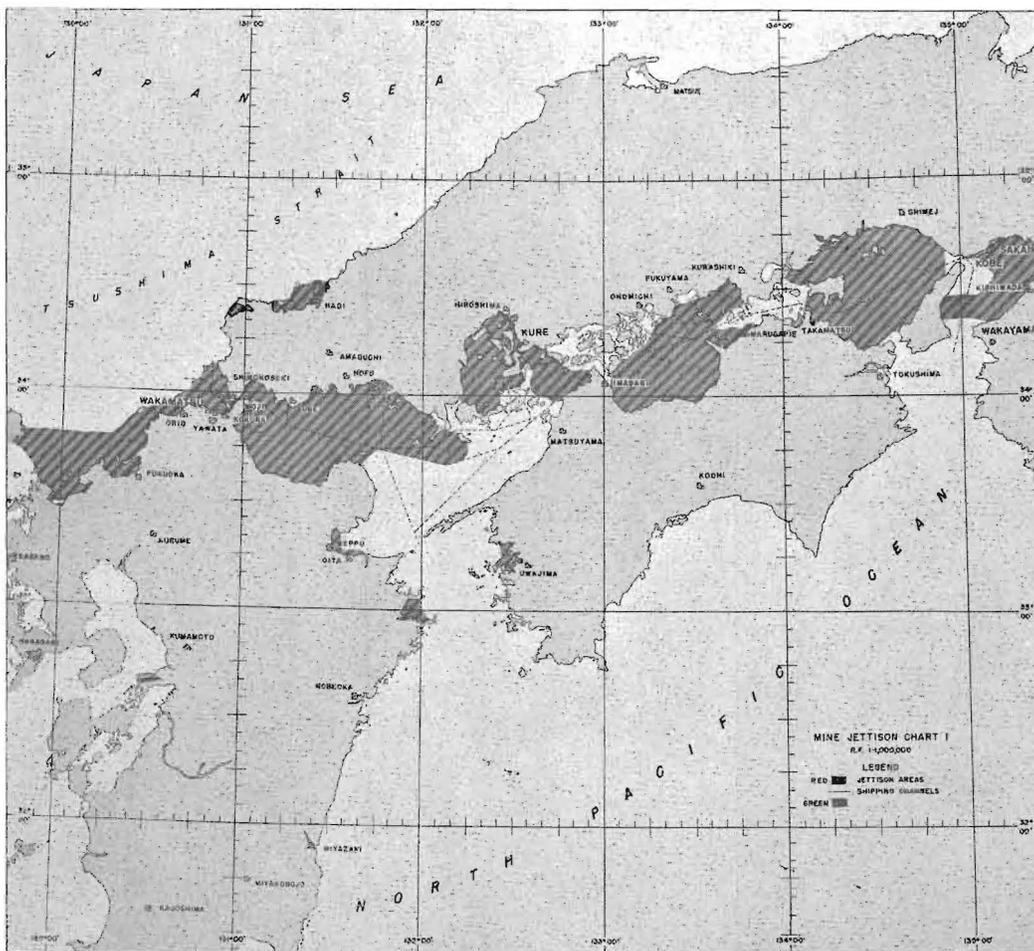
MINE FIELD CODE

<u>Code Letter</u>	<u>Mine Field</u>	<u>Code Letter</u>	<u>Mine Field</u>
ABLE	Kobe, Osaka	MIKE	Shimonoseki (West)
BAKER	Aki Nada	NAN	Toyama Bay Area
CHARLIE	Fukuoka, Karatsu	OBOE	Tokyo Bay
DOG	Harima Nada	QUEEN	Nagasaki
EASY	Shodo Shima (north)	ROGER	Sasebo
FOX	Bingo Nada	SUGAR	Shimizu, Shimoda
GEORGE	Hamada	TARE	Nagoya Bay
HOW	Kure	UNCLE	Niigata, Sakata
ITEM	Hiroshima (south)	WILLIAM	Funakawa
JIG	Hiroshima (north)	X-RAY	Yuya, Hagi, Senzeki
KING	Tokuyama	YOKE	Sakai
LOVE	Shimonoseki (east) and Suo Nada	ZEBRA	Wakasa Bay Area

MINES AGAINST JAPAN

ANNEX X

MINE JETTISON CHART



MINES AGAINST JAPAN

ANNEX Y

MINING INSTRUCTIONS

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HEADQUARTERS 313TH BOMBARDMENT WING
APO 247, c/o Postmaster
San Francisco, California

15-13
Page 1

TACTICAL SOP)

15 July 1945

NO. 15-13)

OPERATIONS MINING INSTRUCTIONS

1. GENERAL: Instructions as authorized herein will be followed in the preparation and execution of all mining missions.
2. PROCUREMENT: 1000 lb. mines (MK 26 and MK 36) and 2000 lb. mines (Mk 25) and accessories will be obtained from MAD 4 upon presentation of issue slips in duplicate.
3. PREPARATION OF MINES:
 - (a) Naval personnel will be present to direct loading crews to proper reventments and to direct loading of trailers. Ordnance personnel will be stationed at entrance of both storage areas to check trucks and trailers for proper loading.
 - (b) Microphones of all acoustic mines "Q" and "S" series, must be protected from sunlight during trip from storage areas to the planes and while on the hardstands awaiting loading.
 - (c) Hemispherical plastic covers of clock starters and extenders must be removed from mines and turned into the Wing Mine Ordnance Officer. Flat plastic covers of MK 14 extenders must be replaced on extenders after soluble washers have been installed.
 - (d) Nine-foot chutes will be used on all 2000 lb. mines except "M" and "N" series, which will use six-foot chutes. All 1000 lb. mines will use six-foot chutes.
4. JETTISONING PROCEDURES:
 - (a) In the event it becomes necessary to jettison mines shortly after take-off, release will be made as far off shore as practicable. A distance of 30 miles or more off shore of Saipan or Tinian is considered a safe distance for dropping mines.

MINES AGAINST JAPAN

- (b) Jettisoned mines must be dropped in deep water (over 600 ft.) and position accurately fixed. It should be remembered that jettisoned mines will be alive and dangerous unless dropped in deep water. Mines should be dropped above 1200 feet if possible.
 - (c) In jettisoning aerial mines it must be emphasized that the mines can be a serious hazard to friendly ships and lead to loss of friendly lives if necessary precautions are not followed.
 - (d) It is considered preferable to jettison mines on land over Honshu or Korea rather than jettison mines in the Sea of Japan between Honshu and Korea.
 - (e) If it becomes necessary to jettison mines in the Sea of Japan (between Honshu and Korea), this will be done at maximum speed in order to induce parachute failure. This measure is necessary in order to reduce danger to our submarines. Mines jettisoned in the Sea of Japan will be reported with special care.
5. METHODS OF RADAR DROPPING: Mines will be dropped by one of four methods depending upon position of mine run for each sortie.
- (a) Forward slant range to radar aiming point.
 - (b) Time run-out from radar aiming point.
 - (c) Back slant range to radar aiming point.
 - (d) Slant range - bearing from two offset radar aiming points.
6. RADAR SCOPE PHOTOGRAPHY: Each aircraft will be equipped with one radar scope camera to the extent of availability of radar scope cameras. Aircraft making a forward slant range release will take a minimum of three scope photos; one 15 miles prior to radar aiming point, one 10 miles prior to radar aiming point, and one at point of mine release. Aircraft making a time release run will take a minimum of three scope photos; one photo at a point 10 miles previous to radar aiming point, one at a point 5 miles previous to radar aiming point, and one at a point of first mine release.
7. MINING AIRSPEED: 230 MPH GAS will not be exceeded while the mines are being dropped because of possibility of mine parachute failure.
8. SPECIAL INSTRUCTIONS: Crews will be briefed to avoid any possibility of mining friendly ports in Russian territory when mining ports in North Korea.

BY COMMAND OF BRIGADIER GENERAL DAVIES:

Delmar E. Wilson
Colonel, Air Corps,
D C/S Opns and Tng.

OFFICIAL:

Oren J. Poage
Lt. Col., Air Corps,
A-3

DISTRIBUTION: "C"

MINES AGAINST JAPAN

ANNEX Z

RADAR MINE LAYING ACCURACY

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Introduction

This is a study of the accuracy with which the XXI Bomber Command B-29's laid mines in Japanese waters. All mines were laid at night with the use of APQ-13 radar. The actual position at which each mine hit the water was not known, since it could not be observed. This position was calculated from the known location and course of the aircraft at the time of dropping, as determined by radar scope photos and known mine ballistics, including the effect of wind drift.

Radar scope photos of adequate quality for plotting were obtained for 50 per cent of the sorties flown. This study covers more than 600 sorties flown in the last 39 missions (Missions 8-46 inclusive) of the Inner Zone Campaign. There were 40 separate targets, and all of the targets mined during these missions are included in the study.

All mine positions were plotted through the use of radar scope photo. The negative was projected onto a 1/115,000 scale map of the area. By adjusting the size of the projected image to coincide with the map, the aircraft position in the air, which is represented by the center of the photo, was plotted on the map. By reference to the lubber line on the photo for course, to the navigation data on the radar navigator's log sheet for altitudes, speed, wind, and release time, and to ballistic tables for the mines used, it was possible to compute the position to which the mines would fall from the known position in the air. This computed position was then compared with the planned position for that particular stick of mines to give the error in laying.

Conclusions

The following accuracy in nautical miles was attained:

Median circular error (radial error)	0.94 nm
62.5 per cent of the drops were between	0 and 1 nm
34 per cent of the drops were between	1 and 5 nm
3.5 per cent of the drops were between	5 and 10 nm
Median range error	0.49 nm
Median deflection error.....	0.58 nm
Median error of navigator's estimate	1.2 nm
40 per cent of the estimates were between	0 and 1 nm
52 per cent of the estimates were between	1 and 5 nm
8 per cent of the estimates were between	5 and 10 nm

In the Figure 8-Z1 the distribution of circular error of a total of 649 cases is represented. The median error is 0.94 nautical mile. In Figure 8-Z2 the distribution in range error is shown, divided by the ordinate in an over set and in a short set. The median error is 0.49 nautical mile. Of the drops, 69.5 per cent are over and 30.5 per cent are short. In Figure 8-Z3 the distribution in deflection error

MINES AGAINST JAPAN

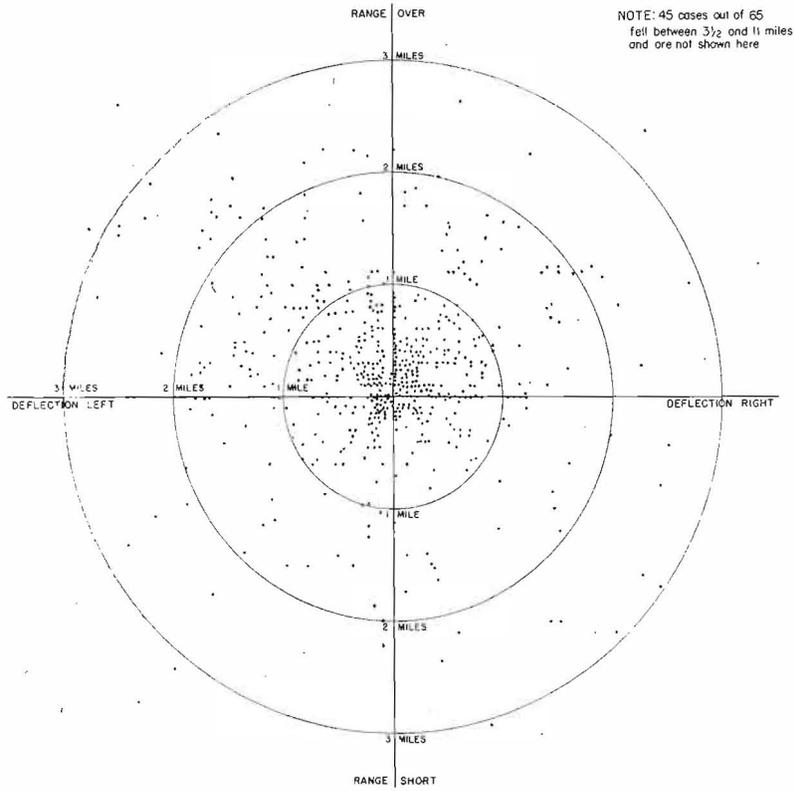


Fig. 8-Z1 Distribution of Circular Error in Radar Mine Laying

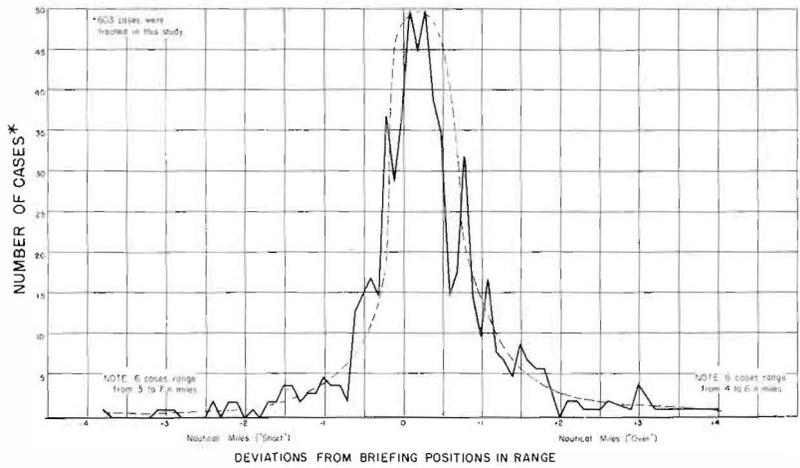


Fig. 8-Z2 Distribution of Errors in Range in Radar Mine Laying

MINES AGAINST JAPAN

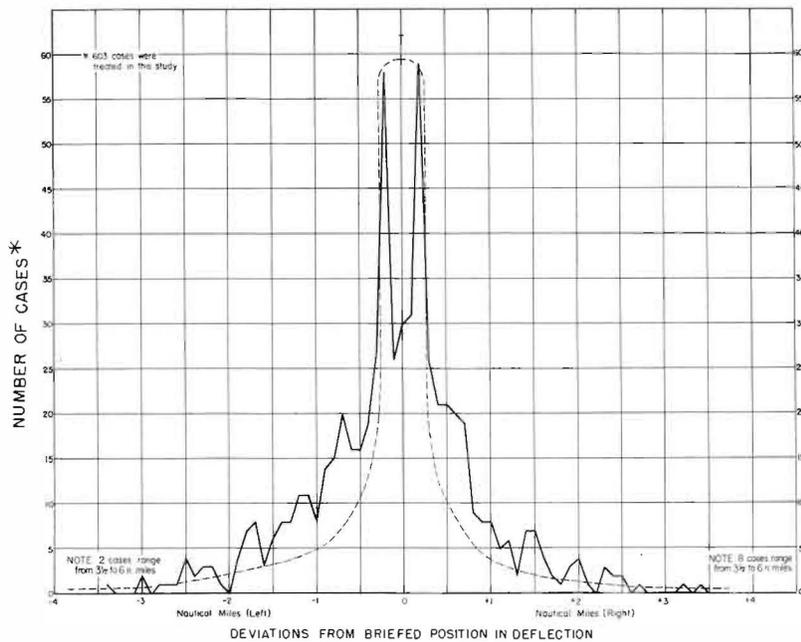


Fig. 8-Z3 Distribution of Errors in Deflection in Radar Mine Laying

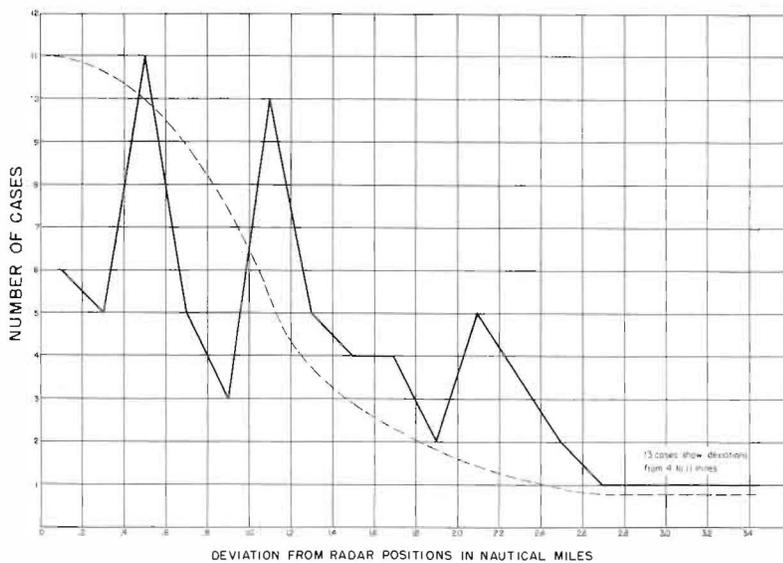


Fig. 8-Z4 Distribution of Errors of Navigators' Estimates in Radar Mine Laying

MINES AGAINST JAPAN

is shown divided by the ordinate to a 'right' set and a 'left' set. The median error is 0.58 nautical mile. The errors were approximately equally divided between right and left. Figure 8-Z4 shows the distribution of error made by navigators in estimating the position of their drops. The median error is 1.2 nautical miles.

Discussion of Errors

In determining the accuracy with which mines have been laid, three general categories of error must be considered. The first set of errors are navigational, which involve wind, heading, altitude, and aircraft stability. Secondly, in the radar instrument are possible sources of error such as the pulse width and screen dispersion. Finally, the actual plotting of mine drop position involves some error.

Navigational Errors: An error of 0.02 nautical mile will result from a 10 nautical mile error in True Air Speed. The maximum error in determining True Air Speed will in general be less than 10 nautical miles. Therefore, the maximum error from this source will be 0.02 nautical mile. Using the normal wind velocity of 30 nautical miles per hour at 8000 feet, a 10 knot error in wind velocity will cause an error of 0.10 nautical mile in the drop position. A variation in wind direction of 10° will give an 0.07 nautical mile error. It has been possible to make a reliable check on wind direction and velocity by using several independent sets of wind measurements from aircraft going over the same target area. In comparing this individual wind data with that of predicted wind direction and velocity, it was determined that in most cases the error in the wind direction was less than 10° , and in velocity about 10 knots. Therefore, an error of 0.17 nautical mile (0.10 plus 0.07 nm) is the maximum to be expected from errors in wind direction and velocity.

The pilot can fly so close to the briefed altitude that any error caused by variation in altitude is negligible and not worth considering. For every degree an airplane varies around its horizontal or longitudinal axis the radar beam will intersect the surface of the earth 0.023 nautical mile from the point indicated on the scope. An assumption of a 3° variation is very liberal for mining conditions at night. The relatively low altitudes (6000 to 12,000 feet) at which mines were laid resulted in particular stability of the aircraft. With a 3° variation, the maximum error will be 0.07 nautical mile.

Radar Errors: While not strictly a radar instrument error, the 3-second sweep time of the sweep beam does produce an apparent error in the radar scope photo. At the moment of 'Mines Away,' photographing of the radar scope is begun to give a record of the aircraft's position in the air at the time of drop. This procedure, except for psychological errors, starts at the moment of the mine release and requires 3 seconds. One additional second is allowed for personnel lag in operating the camera. The total of four seconds elapsed time should give an average time lag of 2 seconds. The aircraft traveling at 230 knots would go a distance of approximately 0.15 nautical mile. In plotting the position of the aircraft using the center of the scope photo, the aircraft's position will constantly be plotted as being 0.15 nautical mile 'over.' This is clearly shown in Figure 8-Z2. The range curve is displaced approximately 0.2 nautical mile on the over side.

The pulse width error is caused by the fact that a transmitted radar pulse makes pin points appear to be 0.027 nautical mile in diameter. The 3° width of the beam on the radar scope causes a pin point to cover 3° in azimuth. The maximum error caused by beam width would be 1.5° in azimuth. Using a distance of 5 miles slant range as the average distance to targets, the error would be 0.13 nautical mile.

There is an error due to screen dispersion. The coating on the inner

MINES AGAINST JAPAN

face of the radar scope causes a beam of electrons to create with perfect focus a light mark of 0.02 of an inch. On the 10 mile range scale this represents 0.08 nautical mile. Since the pin point is actually spread 0.01 inch in all directions to make the 0.02 diameter dot, the actual maximum error will be 0.01 inch or 0.16 nautical mile.

Plotting Errors: A series of identical radar photos were given to two individuals to plot separately. The positions of the plots were compared and it was found that there was an average error of 0.12 nautical mile between the two sets, and that the greatest disparity between plots was 0.14 nautical mile. The errors were random in direction.

Effect of Errors: In summarizing the mine errors, all except those resulting from photographic timing are assumed to be random errors. The root mean square value for all errors, except timing, is 0.08 nautical mile. Of greatest significance is the photographic timing error, because of the fact that it always shows the aircraft to be 0.15 nautical mile past the actual point of release. The displacement of the curve for range error, which in Figure 8-Z2 is 0.20 nautical mile on the over side, correlates very closely with the calculated value of 0.15 nautical mile. The median error of 0.94 nautical mile is not appreciably affected by errors in plotting or computation, and represents closely enough the accuracy actually obtained in minelaying.

Error in Navigator's Estimate: About 50 per cent of the drop positions reported in all missions are based solely upon the estimated position of the drop as made by the radar navigator. For purposes of mine planning it was assumed that the accuracy of the drops was the same as those verified by radar scope photos. For the purpose of mine sweeping, however, it was essential to obtain an independent measure of the error in the navigator's estimate.

The estimate of this error was obtained from a random sample of 78 cases in which the radar navigator reported an estimated position of dropping, and for which good radar scope photos were later available for an independent check. The results are given in Figure 8-Z4. In 88.5 per cent of the cases, the navigators give the drop closer to the briefed position than was actually so. In 5.1 per cent, the estimated positions were less accurate than was actually the case, and in 5.4 per cent of the estimates the locations were precise. However, the quantitative deviation of the distribution reported by navigators' estimates is actually only slightly different than that given by radar scope photos.

MINES AGAINST JAPAN

ANNEX AA

REPORT FORM FOR MINING MISSION SUMMARY

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SUBJECT: Mission Summary for Mission No. (B.C. No.). Target area _____
Flown (date)

1. Wing designation:
2. Time Take-Off (First and Last):
3. No. A/C Airborne:
4. Mines Airborne: (by types, i.e., 400 Mk 25 - 100 Mk 26-36)
5. Disposition of Mines Airborne:
 - (a) Primary fields:
 - (b) Alternate fields:
 - (c) Jettisoned:
 - (d) Returned:
 - (e) Unaccounted for:

NOTE: Disposition of mines must be by No., types and codes. In the case of jettisoned mines, exact coordinates must be given for the protection of friendly shipping.

Consolidated Loading Lists and individual loading sheets for A/C will no longer be required at this Headquarters. These sheets may be utilized at the Wing to arrive at the breakdown by codes. An example of the type information needed would be:

(1) Primary Fields: M/F Mike 14 A/C; M/F Love 12 A/C

Mk 25:	X11-B8	21	10
	X21-B8	16	3
Mk 26-36	Q21-A9	--	12
	etc.		

(2) Alternate Fields: none

(3) Jettisoned: 1 A/C jettisoned 6 X11-B8 at 32-30N 130-33E.

6. No. A/C failing to mine and reasons:
 - (a) Mechanical:
 - (b) Personnel:

MINES AGAINST JAPAN

- (c) Weather:
- (d) Other:
- 7. Time of attack:
- 8. Altitude over Field:
- 9. True Air Speed at Mine Release:
- 10. Length of Mine Run:
- 11. Wind Reported over Field:
- 12. Clouds and Visibility:
- 13. Time of Return
- 14. No. A/C Lost:
 - (a) To enemy A/C:
 - (b) To enemy A/A:
 - (c) To accident:
 - (d) To ditching (specify cause if known):
 - (e) To operational causes (excluding ditchings):
 - (f) To other causes or unknown:
- 15. Personnel casualties:
 - (a) Killed:
 - (b) Wounded:
 - (c) Missing:
- 16. Enemy Air Opposition:
- 17. Enemy Anti-aircraft:
- 18. Enemy RCM noted and effect:
- 19. Radar Scope Photographs Obtained:
- 20. Observations:
- 21. Remarks:

Due: To be filed with the Twentieth Air Force 20 hours after the landing of the last expected A/C that mines the primary field and returns direct to base or 20 hours after the estimated 'gas expiration' time, which ever is earlier.

MINES AGAINST JAPAN

9.

REQUIREMENTS FOR NEW MINES

WEAKNESSES OF EXISTING MINE TYPES

In the light of the Pacific war, two general criticisms of United States mine development stand clear. First, it was ultracautious as a result of high naval policy. Although the research and development on new mines was completed at an early date, the United States did not introduce a single new firing principle, but followed in the wake of British and German combat use. After theoretical guidance by the Operational Research Group at the Chief of Naval Operations was established, completion of unsweepable types such as the pressure and low frequency mines was deliberately delayed for several years, although they had been developed to a practical state by the Naval Ordnance Laboratory by 1943. This delay proved not the slightest hindrance to the enemy and harmed United States mine warfare.

The second general criticism of United States mine development policy is that it was not guided by the Fleet, and so the laboratory developed many unneeded mines and failed to develop other essential mines. These factors, though no fault of the Naval Ordnance Laboratory, tended to make its development program inefficient. Of the many mines developed, the Bureau of Ordnance lists 65 which were given Mark and Mod designation. Approximately 34 were released to service but only 7 were actually used in combat to any appreciable extent. Indeed, the biggest production was of a mine never actually used in combat because it was unsuitable. The Naval Ordnance Laboratory was approximately twice as efficient as the average development agency in producing useful devices (see Chapter 11). Even so, the record is not one which can be viewed with satisfaction.

The combat use of mines in the Pacific campaigns revealed the weaknesses of existing types. The most severe specific criticism is that they were insufficiently tested for service use and therefore inadequate information was available on operational limitations and actuation characteristics. In particular, insufficient information was available on dropping speeds, wind drift, and underwater endurance, especially with different types of bottom, water currents, and waves. Information on countermining distance was good but information on sweepability of mines was almost entirely lacking. The lack of reliable information on susceptibility to explosive sweeping was fatal in the case of the A-3 and A-5 mech-

anisms, which were operational failures because they could be swept explosively. Many were laid uselessly at the cost of heavy Army casualties.

The second important deficiency was the failure to provide concise actuation data in a practical form for several mines used in operations. The data desired was the target width as a function of the target, water depth, and target speed. For magnetic mines this data was available and in usable form, but a great deal of processing of data in the field was necessary which should have been done by the Bureau of Ordnance. For the A-3 and A-5 the information was almost entirely missing even though the A-3 was in service over a year. Lack of this made it necessary for the Chief of Naval Operations to refuse to discuss their operational characteristics with the Twentieth Air Force when the data available to its staff proved inadequate for combat mine field design. The information provided for the A-6 made it possible to work out a reasonable rule of thumb but was not considered operationally adequate.

A third weakness was that the United States mines, with the exception of the M-9 Mod 1 mechanism and the A-6, lacked flexibility. This was probably due to administrative decisions fixing operational characteristics and actuation needs on the basis of theoretical assumptions made by civilians (or Reserve Officers lacking field experience) in the Bureau of Ordnance, the Naval Ordnance Laboratory, or the Chief of Naval Operations. For this reason, for example, the inflexibility in adjustment of the very sensitive M-11 proved to be disadvantageous compared to the M-9 Mod 1 which was flexible in use because its timing characteristics could easily be changed. Both mechanisms were designed with *a priori* but different assumptions of desired operational characteristics which were not upheld by the facts in the case of the M-11. It is necessary for mechanisms to have a reasonable degree of flexibility. At the minimum it is necessary to provide adjustments for selection of different target sizes or for different types of targets. The A-6 was the first mine which, in its basic design, provided good target selection.

A fourth weakness of the United States mines was their unadjustable overwide target widths. Target widths are of very great operational importance and must be

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adjustable to suit a particular operation because very narrow target widths are necessary in some operations, but in others very wide target widths can not only be tolerated but are actually desirable.

A fifth weakness of the United States mine development was the failure to profit by the broad experience of both the Germans and the British. For this reason the A-3 and A-5 mechanisms both failed to meet the test of operations because they were too easy to sweep. This could easily have been overcome by using combination acoustic-magnetic mines. There was a tendency to underestimate Japanese countermeasures, and enemy countermeasures in general, on the basis that they would be unable to devise better countermeasures than those of the United States. This is a fundamental defect in planning because it tends to lead to simply-designed mines which Navy forces may be unable to sweep at that time, but which a hard-pressed enemy may be able to sweep by simple modification of basic sweeping methods. For example, any acoustic mine can be swept by some form of explosive sweep. This is a conclusion derived from basic physical concepts. The certainty that the enemy will sweep explosively completely destroys the effectiveness of uncompounded acoustic mines. All acoustic mines should therefore be combined with some other mechanism to prevent explosive sweeping. As a matter of fact, the generalization can be made that no mine is of any value if it can be swept explosively, since explosives provide the readiest form of energy available in large amounts in time of war.

A sixth weakness of United States mines is that their preparation is too complicated and requires too much expert knowledge. There is no reason that mines cannot be made ready ammunition.

In general, United States mines are too easy to sweep. This is probably true even of the A-6 mechanism. The reason appears to have been the policy assumption made by the Chief of Naval Operations that sweepability is essential for Navy operations. This assumption is open to question, but if valid, it would be better to abandon mines as a major weapon because a mine must be unsweepable to be successfully used in the future. All our potential enemies will develop unsweepable mines and will utilize mine clearance instead of sweeping as a basic defense. The Japanese learned this lesson and developed extensive if unsuccessful experience in mine clearance as shown by their concentrated use of searchlights against mine laying aircraft.

BRIEF EVALUATION OF SERVICE MINES AND MECHANISMS

Mk 6 and Mk 16 Mod 1: These mines use antennae and horns which must contact the target to fire. For defensive use, a simpler mine than the Mk 6 would be better and more reliable. However, the Mk 6 and Mk 16 Mod 1 are reasonably good mines which could be improved by modification to make them more easily prepared. For offensive

use this type should be abandoned and a new moored contact mine should be developed.

Mk 10 Mod 1: A submarine-laid contact mine, it is a useful mine for attrition fields.

M-3 and M-5: Operational restrictions are so severe in these copies of the German magnetic needle mechanisms that they are almost useless. Target widths against most targets are too small and too critical with depth, and the M-5, used in a moored mine, is too susceptible to pre-maturing due to currents and waves.

M-4: This magnetic mechanism was too insensitive for use except against targets in very shallow water. It is easily swept. Used in the bomb-type Mk 13 mine, it has severe restrictions on release speed and altitude. This mine was obsolete before it was released to service.

M-9 Mod 1: This magnetic mechanism is excellent. Though now obsolete, it probably accounted for more enemy casualties than any other type produced by the Bureau of Ordnance because the enemy mass-produced countermeasures against early operational characteristics which were quickly and successfully modified in later lays. It possesses excellent flexibility in time and has good sensitivity, although not quite as much as is desirable in the Mk 25 and Mk 26 Mod 2 (MMU). Unfortunately no provision was made for target selection, but this was easily remedied by field modification because of the simple nature of the mechanism. Mine preparation was not too difficult. In general, this design was good. Eventually this mine was readily swept by the enemy.

M-11: This highly sensitive magnetic mechanism should have its excellent sensitivity retained. But it is too inflexible in timing and does not permit target selection except by a field modification which is difficult due to an uncertainty in actuation characteristics. It was easily swept by the enemy towards the end of the Inner Zone Campaign with or without modification, and was obsolete by the end of World War II.

A-3: This acoustic mechanism is easily swept by explosive sweeps and therefore is essentially unusable. With the A-3 Mod 2 mechanism, some provision for target selection is made. Its target width is far too wide, which makes it unsuitable for most blockade types of mining. It is obsolete.

A-5: This low-frequency acoustic mechanism is too inflexible. No provision was made for target selection by altering any of its operational characteristics. However, it has excellent firing characteristics for certain types of mining because firing is well localized under the ship. But this mechanism is now obsolete because it can also be swept explosively.

A-6: The pressure-magnetic mechanism is excellent and undoubtedly the best developed by any belligerent. No serious weaknesses have yet appeared. Firing is well localized; target selection is possible. The only weakness,

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which has not seriously affected its performance, is that it can be temporarily avoided by a ship's going very slowly. Its timing is such that it can be swept by an aggressive sweeping policy with a large ship and a simple magnetic sweep. This last difficulty can be easily remedied. Mines using this mechanism are very easily prepared and are the nearest to ready ammunition of any yet produced by the Bureau of Ordnance.

In spite of the deficiencies noted above, two United States mines were very effective in the short and intensive mining campaign carried out against the Japanese Inner Zone. These were the mines containing M-9 Mod 1 and A-6 mechanisms. These mechanisms probably accounted for most enemy mining casualties. An insufficient number of United States mines was available for achieving actual blockade of Japan; the lack of the A-6 in a 1000-pound case was serious, and new mechanism types were not available for a prolonged campaign. It was necessary to attempt a more limited objective. A large number of small mines would have made it possible to attack the enemy's smaller ships. This would be essential to achieve a complete blockade by the use of mines.

GENERAL OPERATIONAL REQUIREMENTS

Several United States mines were excellent in design. The United States pressure mine was probably the best produced by any belligerent. But in view of the general weaknesses of most United States mines the needs of future mine development should be critically examined. A new mine should meet the following general requirements for suitability in operations: (1) It must be substantially unsweepable except by a ship or a ship-like structure. (2) It must be flexible in providing easy field adjustment of its constants to meet enemy countermeasures and to select various sizes and types of targets. (3) It must be substantially ready ammunition, and mine mechanisms must be interchangeable in mine cases. (4) Complete operational information must be available in the simplest possible form so that the operating possibilities and the limitations of the mine are clear to nontechnical personnel. (5) The mines developed must be such that effective mine fields can be laid to blockade inland waterways, ports and harbors, trade routes or very wide straits in the open sea, and also ships lightering to shore along widely separated strips of coastline.

Specific operational characteristics are described below. They may change with developments in ships, mine sweeping methods, and minelayers. It is improbable, however, that any will change with sufficient rapidity to alter the basic factors which are discussed. A maximum of 25 parameters is considered for mines, categorized according to method of laying and whether they are ground or moored, influence or contact. The reasons for particular requirements are given in detail in the text which follows immediately, but for convenience the requirements are summarized for each type of mine in Table 9-1 (page 287).

AIRCRAFT-LAID INFLUENCE GROUND MINES

Size, Operating Depth, and Target Size: These three factors are directly connected. Only small mines are needed to destroy small boats, ships used on inland waterways, or minesweepers. Small mines are more economical and effective than larger mines against small boats, since the gradient of pressure against the boat, as well as the total force, determines its destruction. At the other extreme, very large mines are required to damage seriously or to sink very large ships. For particular types of men-of-war built with special strength, like submarines, very large mines are also required. It is also clear that the greater the depth, the larger the mine required for a particular size of surface ship. To achieve economy in mine laying, the most vital factor in operations where maximum damage to the enemy is required with every single sortie, a variety of mine sizes must be provided. Experience in World War II indicates that if the entire range of targets including inland waterways is considered, ground influence mines must cover ships ranging from 50 tons to 100 thousand tons in size, operating in water ranging from 2 to 30 fathoms deep, depending on the ship size. This requires mine sizes bearing explosives ranging from 100 to 8000 pounds in weight.

Target Width: The target width (or sensitivity) required for any particular operation cannot be specified *a priori* since it depends on particular operating conditions. These vary, for example, with the strength of the mining attack and the ratio of the number of mines planted to ship traffic. It is always desired to maximize the damage due to a single sortie. If traffic passing through a channel is so heavy that some ship is certain to fire every mine placed in the channel within a relatively short time, then the mines should have a target width narrow enough to sink any ship firing it, though some might get by. On the other hand, if the traffic is light, it may be desirable to increase the target width of the mines so that every ship is certain to strike at least one mine though it might not be sunk. Between these two limits, intermediate target widths may be required. On other occasions, different target widths may be desired for ships of different sizes, for example, in order to mine only the larger and more profitable targets. To meet changing operating conditions a choice of target widths and sensitivities should be possible by making a simple and easy adjustment. The experience of World War II indicates that three target widths, 50, 100, and 200 feet, provide sufficient flexibility for different operational conditions.

Ship-Speed Dependence: Most of the influence fields of ships depend to a considerable extent upon their speed. This is especially true of acoustic fields in which the propeller noises depend upon the velocity of the propeller blades in the water or upon the amount of vibration and noise in the hull due to the engines. These increase tremendously with the speed of the ship. This is also true

of the hydrodynamic fields and even of magnetic fields. Although the magnitude of the magnetic field is not altered by a ship's speed, its duration is — something which will be true of any influence field explored in future research. In practice, ships passing over an influence mine field will take advantage of any insensitivity at a particular speed. They will proceed at maximum or minimum speed in passing through mine fields if that exploits the weakness in a firing mechanism. Limitations in a mine firing mechanism at particular speeds are therefore undesirable. For merchant ships, 10 knots cover the entire practical range of present construction, most ships having a top speed from a little below 10 to 12 knots. The ordinary cruising speed in present men-of-war is up to 20 knots; maximum speed is about 40 knots. Therefore mines should be designed to actuate independently of speeds between 2 and 15 knots for merchant ships and between 4 and 40 knots for naval vessels. The upper limit is based on the assumption that mines will be laid in open waterways. The lower limit is based on the assumption that under ordinary circumstances it is difficult to maintain safe steerageway at speeds less than two knots in most channels where the effect of tide and wind is appreciable. This is true even when auxiliary power, such as tugs, is used.

Release Speed: The intrinsically delicate nature of mine-firing devices has influenced designers to impose restrictions on operating speeds of both surface and aircraft minelayers. This limitation has very serious effects on mining operations. Time over a target is a measure of danger to the minelayer. The psychological urge of any crew in action over a target is to go as fast as is permitted. If flak is heavy or if there are errors in the aircraft instruments, the tendency will be to exceed the specified maximum speeds, with an appreciable number of aircraft exceeding this limit inadvertently. From the operating forces' point of view, any limitation in their tactics, and particularly in the speed of the minelayer, is very detrimental and may require special modifications of ordinary tactics which will disturb all the techniques learned during training. For all of these reasons the effectiveness of mine laying will be reduced. In extreme cases mine laying will be refused if the speed limitations for a particular mine are too severe. Therefore the aim of the designers should be to set so high a speed limitation that it exceeds the available operating speed of any minelayer which may be used.

Release Altitude: All the preceding discussion on release speed applies with equal force to release altitude. Any limitations in release altitude, either high or low, affect adversely the tactics of the aircraft minelayer and its safety. In designing mines for future operations the potential enemy countermeasures are unknown. No prediction can be made as to whether extremely high altitudes or extremely low altitudes will be the best tactics. Thus the aim of the designer should be to avoid any restrictions on the altitude at

which mines may be released. In fact, the altitude should be limited only by the capabilities of the aircraft itself.

Arming Delays: These were extensively used in the mines laid in the Inner Zone and proved important. The advantage of a delay in arming a mine is that an unarmed mine cannot be swept, but is immediately a threat as soon as the arming period is completed, regardless of enemy sweeping capabilities. It is therefore possible to mine a target "constantly" with either a single effort or at sporadic intervals. This is important both in tactical and in strategic operations and is of maximum importance when the mines can be swept by the enemy. It is of limited use if unsweepable mines are available. Under these circumstances the delayed arming is desirable only if the enemy employs a ship-like structure to sweep. Since this is one of the possibilities in future mine sweep development, even mines unsweepable by artificially produced influence fields should be provided with arming delays. The effectiveness of arming delays in the Inner Zone is shown by the complaint of the Japanese that mines continued to appear in swept channels after these were presumably cleared. The mine plants included relatively easily swept magnetic mines in which arming delays were extensively used. The effect of the arming delays was to allow increased flexibility in operations. There is no doubt that continuous mining on a daily basis is desirable in attacking a heavily used port, yet operations seldom permit this and arming delays give the same effect.

Sterilizing Time: In the offensive use of mines, future operations in the mined areas by United States forces must always be anticipated. Since United States forces may be unable to sweep their own mines, it is essential that provisions be made to clear mines in enemy waters. The only practical means of doing this with future mines is to provide appropriate sterilizers which will disarm the mines at a controlled length of time after laying in accordance with planned operations. Sterilization periods must cover a very wide range since it may be desirable to disarm mines within a few days after laying or only after a mine's useful life has been spent. For an unsweepable mine this may be a very long time, depending upon both United States and enemy action. Particularly in minor ports which the enemy may use for handling diverted shipping, it may be profitable to mine the diversionary area only rarely and yet to lay a field which will prevent its use by the enemy for an extended period during the mining campaign. Exact intelligence on diversionary areas will often be lacking; therefore in a heavy attack many such areas must be mined as a precaution, and it will be desirable to maintain the effectiveness of the secondary or tertiary mine fields for periods up to six months, perhaps longer. Thus the desired maximum sterilizing time after arming is 180 days.

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Trajectory: Mine trajectory is subject to considerations similar to those for release speed and release altitude. Mine laying operations ought not to require special training for crews since this will often be impossible. In the event that mining appears desirable on an emergency basis or for a limited period by aircraft commands not specially trained, mine laying can be carried out only if the normal training of the command is adequate for the operations. This means, in effect, that the trajectory, including meteorological factors, should be essentially similar if not identical to those of the other projectiles or bombs normally used by the command. For this reason mine cases should be designed with characteristics resembling those of bombs as closely as possible. Then the normal bomb aim devices can be used and the standard operating practices employed. Both the accuracy and flexibility of mining operations would be greatly increased.

Impact Fuze: Among the principal targets in mining operations during World War II were harbors and other highly built-up areas. These will probably continue to be principal targets. Where it is necessary to lay mines directly inside anchorages or small ports, many will fall on land, among harbor installations or in adjacent cities, because obtainable accuracy in practical operations is relatively low. In extreme cases 50 percent or more of the total lay will fall uselessly on land. This is unavoidable. This wastage of mines has another disadvantage because a new mine can be recovered by the enemy directly after its first use in operation. Analysis gives an enemy information which assists his own mine development and countermeasures. So an impact fuze is needed to explode the mine if it falls on land or in very shallow water, at the same time permitting the mine to be armed in water of a specified minimum depth. This fuze will make the mines formerly wasted serve as bombs to destroy harbor or nearby city installations and at the same time defer disclosure of mine design to a later date, depending on the percentage of failures in the impact fuze device.

Safety Devices: Safety standards for mines used during World War II were relatively high and satisfactory. Very few accidents or none at all could be ascribed directly to the faulty design of safety devices. Most accidents were due to the excessive sensitivity of the torpex used in the mines. This high standard should be continued and improved, if possible, because such safety is highly important in many respects, including crew morale.

Life: Considerations regarding maximum time for sterilizers apply with equal strength to mine life. In all mine fields, especially the main ones, the field is gradually built up to the point where mines block the entire area except for channels cleared by the enemy. The number of mines required to block off unchanneled areas may be exceedingly high. Since an enemy can eventually determine both the probable life of the mine and the area in which mines are laid, he can find new channels automatically made available

by dying mines unless mine life is long. Later mines would normally be aimed specifically at cleared channels. Short mine life therefore involves high wastage in operations, because it requires the expenditure of an excessive number of mines merely to assure the continued blocking of unchanneled areas. A minimum life of 180 days is sufficient to prevent this. Potential life should be extended as far as is practical within design limitations.

Temperature: During World War II almost all ammunition was stored in the open and often under the most adverse conditions. In offensive action storage begins almost immediately after new bases are established. Under these circumstances ammunition is merely dropped, with no special provision for protection against the elements, although minimum protection such as shade with canvas can be provided under specially favorable circumstances. During World War II, mines were stored in places which ranged from the tropics to the Arctic. In places like Eniwetok in the Mariannas, mine cases reached temperatures as high as 140°F., and in the Arctic they were snow covered at temperatures as low as -50°F. In future operations mines may reach even lower temperatures while airborne in stratospheric regions. Mines are also required to operate over a considerable range of water temperatures, from 32°F. to about 85°F. Future designs of mines therefore should anticipate extreme ranges of temperatures for storage in both the tropics and the Arctic, for flight in the stratosphere, and for operations in any of the waters of the oceans or inland waterways.

Sweepability: The necessary fundamental characteristic of a mine is that it be, in effect, unsweepable by any potential type of enemy mine sweep device. In particular, the mine must not be sweepable by any type or combination of explosive sweep, especially since explosives may be used from aircraft with particular ease to clear great lengths of channel in a very short time. Explosives may also be used both from small boats and from land in simple combinations of explosives, either fast- or slow-burning. This fact indubitably accounted for the extensive premature failures of the A-3 in the Inner Zone Campaign, and probably of the A-5. The mine must not be sweepable by any single magnetic, acoustic, or other influence sweep, or by any simple combination, as for example, a magnetic plus an explosive sweep. The highest aim of the designer should be to provide a variety of mine types, each of which he believes to be unsweepable. If this is impossible in the immediate future, it should be possible to design mine fields containing not more than two or three types, in which the mine field as a whole is unsweepable, regardless of the order or method the enemy may use in attempting to sweep it. The designer should keep two things in mind at this stage; first, that sweepability and endurance requirements may be met by increasing the number of mechanism components to as many as five; and second, that firing, where

multi-component mechanisms are used, may meet the requirements by depending upon permutation in firing and also upon the establishment in the mechanism of gate values for magnitude and time dependence.

Endurance: Only rarely is complete intelligence information available on the hydrodynamic and geographic conditions of each target area. This is especially likely to be true in future mining when diversionary areas may become major targets. For this reason, rock, sand, or mud bottoms cannot be determined in all cases, nor will the values of existing currents, tides, or wave conditions be known. Mines must therefore be designed with a high resistance to accidental actuation by environmental noises, magnetic or other influence fields, or by motion prior to settling in a permanent position. Currents as swift as 11 knots occur in some possible targets, but these are extremely rare and alternative targets are generally possible. Five knots in surface currents is a satisfactory limit for endurance requirements. Wave limitations will be more important in future design than in the past because ships will be diverted to exposed areas. For this reason, mines after settling for one tidal cycle should be able to endure waves of 30 feet or less in depths of 10 or more fathoms without accidental firing or damage. Further, the mine should be able to endure any combination of the factors discussed above. The specifications for endurance are probably among the most severe which the mine designer will have to meet. The principal reason for hewing to these severe restrictions is that the men designing the combat mine fields may be in actual ignorance of the oceanography of certain targets which may be vital, especially in tactical operations. Any factor which restricts the scope of the design is highly undesirable.

Antirecovery Devices: These were used by the Germans to prevent mine disclosure. They are dangerous to handlers and never prevent eventual recovery by the enemy. Though the impact fuze is a type of antirecovery device, it serves another and very essential purpose. The increased hazard of a device designed solely to prevent recovery does not offer sufficient advantage for its use.

Ship-Count Devices: These are unnecessary in unsweepable mines since they are intended to prevent easy enemy sweeping. Newly developed "unsweepable" mines may be swept by ship-like structures, so it is still desirable to provide ship-count mechanisms temporarily. Eventually, the need for such devices should be eliminated since they reduce the threat of mines and their function of complicating the enemy's sweeping problem will be assumed by the unsweepability of the mines themselves.

Sensitivity to Mud: Harbors and inland waterways contain mud into which a mine may penetrate several feet. This must be given serious consideration in design so that a mine can be actuated at the depths at which it may come to rest. Mines may also be covered with sand by currents or wave action after planting; they should still fire when not

buried unreasonably deep. In Niigata, where mines fell into a channel which normally required continuous dredging, the mines were buried. It is always desirable that the mine fire during dredging operations since continuous dredging is normally required in many of the principal harbors of the world.

Mechanism Size: Both logistics and mine preparation make it undesirable to have a large variety of mine mechanism sizes where separate storage is required. A minimum number of sizes should be provided, preferably not more than two, and the various firing devices should fit interchangeably into a standard size cavity. Simplicity in preparation is exceedingly important in actual field operations. Anything that complicates ammunition storage is a serious matter, and primary consideration must be given this in design.

Storage: Long-time storage and neglect occur in peacetime and in inactive theaters during war. Storage under severe climatic conditions and for extended periods up to several years should be anticipated. For example, during World War II, mines were often partly immersed in brackish or salt water unavoidably. At Tinian the atmosphere itself was especially corrosive because of acids in the volcanic dust. This rapidly deteriorated some parts of the mine mechanisms used in the Inner Zone Campaign. A thorough study should be made of the mines' resistance to environmental conditions.

Loading Characteristics: Slight modifications in the dimensions of the Mk 26 mines would have permitted more than a 50 percent increase in the mine load carried by a B-29. For obvious operational reasons mines should be the same size as bombs and interchangeable with them in the bomb stations of aircraft. No revision of the loading system in the aircraft should be required under any circumstances. In actual operations modifications of the loading system of the aircraft are usually impractical especially where tactical or short-term mining operations are concerned.

Preparation: Mine design should be such that mines are ready ammunition. During World War II, special mine details were required for preparing and testing mine mechanisms. This made it exceedingly difficult to provide personnel for hurried operations, a most undesirable situation. Future mines should be designed so that only normally trained enlisted ordnance personnel are required for preparation. The mine and its mechanism should be, in effect, ready ammunition which requires only such a simple operation as inserting the mechanism in the mine cavity or arming the mine with the detonator and booster. This requirement for simplicity may appear difficult to the mine designer, but it is of basic importance and has been achieved for other ammunition of equal complexity.

Countermine Distance: In a target area which is heavily used, dense mine fields are desired and it is operationally impossible to obtain a geometrically perfect mine laying

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pattern. Mines must be laid statistically. The density should not be limited to any appreciable extent by the permissible countermining distance. An enemy will probably try to clear his channels with explosives. The mines should therefore be proof against nearby explosions of large charges, for then the amount of explosive required to clear a long channel would be prohibitive. In short, mines should be capable of withstanding the explosion of 600-pound depth charges at a distance of about 50 feet. The criterion is that the countermining distance should be small enough to make clearance impractical.

AIRCRAFT-LAID MOORED MINES

There will be numerous targets in which the water is too deep for ground mines. For such targets it is essential to have a moored mine which can be dropped from aircraft. Such a mine was not available during World War II and, as the Japanese interrogations testify, this made sweeping considerably easier. At times it is desirable to use moored mines in shallow water plants along with ground mines to complicate the enemy's sweeping problem. Many of the factors governing the influence ground mines apply to the moored type (see Table 9-1). Those which are different are considered below.

Size, Operating Depth, and Targets: Only one size of mine, 2000 pounds, is required for a moored mine because it is aimed primarily at large ships. This mine should be designed for use in water up to 300 fathoms. There is no particular advantage in using a moored mine except in very deep water, so smaller sizes are unnecessary.

Target Width: Provision should be made for contact firing and for influence firing at several target widths. If the mine could be made to ride reliably at a shallow depth for contact firing, an influence mechanism would be unnecessary. However, an influence mechanism is advantageous as a standby when heavy seas, or variable or heavy currents dip the case. Furthermore, the case could ride at greater depths than permissible for contact firing and the mine could be planted in waters far too deep for ground mines. It would also prevent short mine life in an exposed position where contact firing would predicate a shallow lay.

Depth Taking and Dip: It is important that the depth at which a moored mine case rides be accurately adjustable, and especially that efforts be made to counteract hydrodynamic influences on the cable and the mine case. They would otherwise dip greatly when the current is heavy. An antidip mechanism can make all the difference between a successful and an unsuccessful moored mine in a large percentage of mining targets.

Sweepability: This factor is the same as for the influence ground type, but in addition it would be desirable to provide specific devices to increase the difficulty of attempted enemy sweeping. These devices might be grap-

nels, sprockets, cable cutting devices, or devices which permit the enemy sweep to pass through the mooring cable.

The remaining factors are similar to those of the influence ground mine except that an additional mechanism must be provided for contact firing (see Table 9-1).

AIRCRAFT-LAID MOORED HOMING-TORPEDO MINES

An enemy action to be anticipated is diversion of shipping to unloading areas along the coast with cargo being lightered ashore. This was done by the Japanese as a result of the Inner Zone Mining Campaign. Similar unloading methods were, of course, developed by the United States Navy as part of its amphibious assault. It appears that such diversion may be forced when ports are blockaded and definite provisions must be made to meet this countermeasure. The ordinary mine will not suffice, because it has such a relatively narrow target width and such wide areas have to be covered. An excessive number of mines would be required. Furthermore, it is very often true that the water will be too deep for ordinary ground influence mines. Moored mines themselves would not be sufficiently effective without very heavy replacements which would be operationally impractical. For these reasons enemy ship diversion can only be met by a mine having a very large target width of 3000 feet or more. Such a mine could be used to blockade trade routes, or the open seas, or very wide straits. In the Asiatic Theater, for example, it would have been highly desirable to mine the Straits of Formosa during one phase of World War II. Ability to mine open sea lanes would create a catastrophic sweeping problem to any enemy, and many narrow straits or narrow seas could then not be used at all. The Mediterranean, the Black Sea, and the Red Sea would fall in this category. *Development of this mine should be given the highest priority.*

Size, Operating Depth, and Target Size: The mine should probably be built in two sizes, one of 2000 pounds and one of 4000 pounds. A maximum operating depth of about 300 fathoms would cover almost all the targets that were considered in World War II and those that might be attacked in future wars. It would be uneconomical to use such a mine against small targets. It should be designed for targets ranging from small merchant ships on upward.

Target Width: This should be from 10 to 20 times that of the usual influence mines, that is, 3000 feet or more. The remaining characteristics of this mine would be similar to those of the aircraft-laid moored mine. One suggestion regarding the mechanism is that an acoustic mechanism should be used to arm the homing device. The homing device would release and home the torpedo only if a homing object exists. Otherwise the mine should revert to a waiting state.

OTHER MINES

Surface-Laid and Submarine-Laid Influence Ground Mines. These mines should have essentially the same characteristics as aircraft-laid influence mines except for such modifications as may be required for laying. These modifications could be simple. It is not necessary to provide a special mine for defensive use. An offensive mine can be used for this purpose without any modification.

Rocket Mines: Long-range guided rockets will be well suited for mining, since great accuracy is not generally so essential for mining as for many other types of bombardment. The mine types to be used should be the same as those discussed above, except for modifications necessary for the method of laying.

Drill Mines: These should be supplied for training in the preparation of mines and their tactical use under operating conditions in war games. Their use could provide experience in countermeasures and data for evaluating the effectiveness of new mine types as they are produced. An audible and visible (night and day) signal when the mine is actuated must be provided for drill mines. The accuracy of location is not very important; 500 feet would be adequate. It is vital that all normal planting characteristics be retained, that no modification of the basic elements of the mine be made which would bring about abnormal behavior. Only the charge should be reduced. The mine itself should be regarded as expendable and its recovery should not be required.

Table 9-1. SUMMARY OF OPERATIONAL REQUIREMENTS FOR NEW MINES

Mine Layer	Type	Operating Depth (minimum, maximum) in Fathoms	Mine Size in (Pounds)	Target Widths for Ship Size (in Tons)						Mechanism	Ship Count Device	Loading Characteristics
				Wooden	Wood and Steel	Steel-Cruisers-Submarines-Capital Ships						
				10 to 50	200 to 500	2000 to 4000	4000 to 8000	16,000 to 35,000	35,000 to 70,000			
Aircraft	Influence Ground Mine	2-4	100	x ¹	x ¹					Entire mechanism to be contained in a single compartment, to fit interchangeably in standard size cavity for 1,000, 2,000, 4,000, and 8,000 pound sizes, and a separate set to fit 100, 250, and 500 pound sizes. Three-component mechanisms are desired with a total number of five components working on five or more separate types of influence fields. Firing to be dependent on permutations as well as combinations.	0-10	Capable of loading interchangeably in bomb stations with bombs of same size.
		4-6	250	x ¹	x ¹							
		6-8	500		x ¹							
		8-15	1000			x	x	x				
		15-30	4000				x	x	x			
				X = Target width adjustable to 50, 100, or 200 feet and to remain automatically constant with depth. X ¹ = 50-foot target width only. Wooden ships. X ² = 50 to 100-foot target width only. Wood and steel ships.								
	Influence Moored Mine	20-300	2000	Adjustable to 50 or 100 feet for ships of 500 to 65,000 tons.						Contact and one or more influence types	None	Capable of loading interchangeably with 2,000-lb bomb.
	Moored Hoisting Torpedo Mine	15-300 15-300	2000 4000	3000 feet for ships of 1000 to 65,000 tons.						Influence mechanism to arm hoisting device, hoisting device to release and home torpedo if hoisting field or object exists.	0-10	
Surface	Influence Ground Mine	3-25	2000	Adjustable to 50, 100, or 200 feet for ships of 100 to 10,000 tons.						Entire mechanism to be contained in a single compartment, to fit interchangeably in standard size cavity for 1,000, 2,000, 4,000, and 8,000 pound sizes. Three component mechanisms are desired with a total number of five components working on five or more separate types of influence fields. Firing to be dependent on permutations as well as combinations.	0-10	To fit tracks of LW mine layers
	Influence Moored Mine	20-300	2000	Adjustable to 50 or 100 feet for ships of 100 to 10,000 tons.						Contact and one or more influence types	None	
Submarine	Influence Ground Mine	10-20 15-30	2000 4000	1000 to 2000	2000 to 4000	4000 to 8000	8000 to 16,000	16,000 to 35,000	35,000 to 70,000	Entire mechanism to be contained in a single compartment, to fit interchangeably in standard size cavity for 1,000, 2,000, and 4,000 pound sizes, and a separate set to fit 100, 250, and 500 pound sizes. Three-component mechanisms are desired with a total number of five components working on five or more separate types of influence fields. Firing to be dependent on permutations as well as combinations.	None	To fit all submarine tubes
	Influence Moored Mine	20-300	2000	Adjustable to 50 or 100 feet for ships of 100 to 10,000 tons.						Contact and one or more influence types	None	
Rocket	Influence Ground, Moored, & Hoisting	Same as for aircraft laid mines with necessary modifications for launching.										
	E-till: All types											
	Expendable, charge only reduced, all other characteristics normal plus actuation signal.											

Characteristic	All Mines Laid By Aircraft	All Ground Mines	All Moored Mines And Homing Torpede
Release Altitude	Unrestricted		
Trajectory and Wind Drift	Similar to bombs of same size, so that normal bomb aiming device can be used.		
Depth Taking and Dip			Depth-taking by hydrostat and anti-dip mechanism.
Sensitivity to Mud		Must operate under depth of mud normally reached on planting	
Arming Delay		0-90 days	0-90 days delayed rising from anchor, or from a depth of 50 fathoms, whichever is less.
Endurance		After settling for one tidal cycle, must not premature in currents of 3 knots or less on sand or mud bottoms, nor on account of waves of 30 feet or less in depths of 10 fathoms or more.	Must not premature or walk on account of surface measured currents of 3 knots or less nor on account of waves of any wave length of 30 feet or less.
Fuse	Explode on land or in very shallow water, arm as mine in water of specified minimum depth.		
Countermining Distance	150 feet to charge of like size.	150 feet to charge of like size, 50 feet to 600-pound depth charge for mine sizes of 1000 pounds and heavier.	
Sweepability		UnswEEPable by any type or combination of explosive sweep, or by any single magnetic, acoustic or other influence sweep, or by any simple combination.	UnswEEPable by any type or combination of explosive sweep, or by any single magnetic, acoustic or other influence sweep, or by any simple combination. Add sweep obstractors such as grapnels, sprockets, mechanical or explosive cutters, and cutouts.

Characteristic	All Mines
Preparation	Simple enough to be prepared by any ordnance enlisted personnel in ammunition dump and to be used as ready ammunition.
Safety Devices	Double set of independent safety devices.
Temperature	To operate satisfactorily after exposure to stratosphere temperature and to storage on hardstand in tropics. After planting to operate at all water temperatures.
Release Speed	Maximum operating speeds anticipated within next twenty years of Army and Navy aircraft, surface, and submarine mine layers.
Life	180 days or longer after arming.
Anti-recovery Device	None
Starilization Time	0-180 days after arming.
Ship-Speed Dependence	Substantially independent of ship speed between 2-15 knots (merchant) and 4-40 knots (warship)
Storage	Mines and components to be capable of several years' storage under all climatic conditions in open ammunition dumps, subject to weather, to immersion in water, and to corrosive atmospheres.

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10.

THE PROBLEM OF COUNTERMEASURES

THE GRAVE THREAT OF MINES

Not all of the mines sketched in the previous chapter will be developed and some will be developed which were not mentioned. But the prospect of huge unsweepable mines of terrific explosive power and capable of building an effective sea-blockade is a threat to a great maritime nation and naval power like the United States.

At the end of World War II, the United States was the world's first sea power, possessing more than 51 percent of the world's shipping. Britain, the only other important sea power, and the United States together possess nearly all of the world's shipping. The great land powers of the earth, on the other hand, have no appreciable naval establishments or experience. Their part of world shipping is negligible. Russia, for example, possessed only 3 percent at the end of World War II.

In order to establish sea power, huge expenditures are required, and great skill in seamanship must also be developed. This cannot be done in any short period because the art of naval construction, strategy at sea, and the use of naval weapons require the support of experience in all those fields and particularly the support of a great industrial nation. Some of these factors will make it almost impossible for the dominant land powers with their present boundaries to develop positive control of the seas. These same factors, however, will make mine warfare attractive to the land powers because it will permit them to develop negative control of the seas without finding it necessary to develop special new technologies or skills. They will already require the necessary aircraft or guided missiles for other kinds of air operations. They can acquire the skill and knowledge of mine development with far less difficulty than they can establish a major naval fleet. Further inducements are the economy of mining and the well known fact that defense against mining is difficult, if not impossible, once mines are laid.

Thus the development of the aircraft influence mine had altered the importance of mine countermeasures from a minor to the major defensive consideration of the Navy. The difficulty of mine countermeasures is so great that rapid progress in this defense can be obtained only by a most ambitious program of research, development, and

operational training, and by the strongest possible directives to the materiel bureaus and to the Fleet. By the end of World War II, these policies were so weak that very little important progress had been made.

INHERENT DIFFICULTIES IN COUNTERING INFLUENCE MINES

The reasons for the technological and practical difficulties in mine countermeasures are largely fundamental. The first influence mines used the magnetic field of a ship for firing. This was the best-known influence field surrounding a ship and had been studied for over two decades. It was also the most easily countered field of a ship, since magnetic fields are readily produced artificially by an electric current flowing in a cable or in seawater. The magnetic field of a ship itself can be readily reduced, and may, where desirable, be reduced to a very small value. The second type of influence field developed by all belligerents almost simultaneously was the acoustic field. It cannot be practically reduced by artificial means since it is intimately connected with ship propulsion and there is no basic way of reducing noise without lowering propulsion efficiency, although it may be diminished by going very slowly. The acoustic fields in the sonic-frequency region do propagate readily. It is in general possible to activate sonic mine mechanisms with artificially produced acoustic fields, especially by explosive methods which are economical and are operationally simple.

The second step taken by the Germans and British was to combine the acoustic and magnetic elements into one unit which required the simultaneous existence of the two influence fields and a certain timing relation between them. It was harder to sweep this mine than either of its simple prototypes, but it could be swept by increasing the complexity of sweeping methods. Even at this stage, sweeping became seriously cumbersome. The next step taken, again by all belligerents, was to develop firing mechanisms operating in the extremely low frequency vibration field of a ship, and in its hydrodynamical fields, particularly the Bernoulli effect, which produces a decrease in pressure under a ship as it passes over the bottom. The use of these influences introduced basic difficulties. In very shallow

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water it is impossible to propagate the low-frequency vibration waves for any appreciable distance and it is completely impossible to propagate changes in hydrostatic pressure of very long duration. This makes it far harder to use artificial sweeping fields for these influences. Since the fields cannot be propagated, they exist only in the immediate neighborhood of the sweep gear. Equally difficult is the fact that vibration or pressure fields of appreciable and practical intensity can only be achieved by using very large mechanical structures, which, with the perfection of the subsonic and pressure devices, must be approximately the same size and dimensions as a ship.

No easy basic solutions for the sweeping of pressure mines was apparent even two years after V-J Day, for no practical means had been found to sweep mines of this type under war conditions. The sweeping of Japanese harbors, for example, with the aid of the best United States sweeps, required about four months after mining had completely ceased and when full naval sweeping effort could be safely applied to this problem alone. Even so, the clearance of United States combination pressure-magnetic mines was achieved entirely because they were self-sterilized, no positively known sweeping of a live pressure mine having taken place.

During World War II the United States did not explore or develop numerous influence fields, deeming their exploitation impractical for technological reasons. These fields are mostly second-order effects, such as the gravitational field accompanying the change in mass distribution as a ship moves over the water, or the change in the cosmic ray field as it is affected by the change in distribution and composition of mass accompanying the passage of a ship, or other influence phenomena. Most of these have in common the fact that there are no known ways of easily propagating or reproducing these effects except by the actual use of a ship or a ship-like structure. It was the Germans who took the last steps in developing mines, though these never reached combat. One unit combined *three* firing elements: pressure, magnetic, and acoustic. The Germans also produced an experimental cosmic ray unit, and a gravity unit was designed and under construction. It will be exceedingly difficult to sweep the mines of the future!

Technologically, the future development of new mine-firing mechanisms operated by these new influences is possible in not only simple mechanisms but in combinations and permutations including elements already developed. Only moderate progress has been made in countering even the simpler mechanisms with artificially-produced influence fields. A more accurate analysis of the influence fields of ships, including the various time-derivatives as seen by the mine, as well as the maximum and minimum fields and their duration, will make it possible to place gate values on amplitudes, rates of change, duration, and on the time and amplitude relations of several influences of the mine

mechanisms. This will make it more and more difficult to deceive the mechanisms themselves. Further it offers the possibility of several hundred new mine types, all basically unsweepable.

Thus technological promise in the development of mine mechanisms makes it almost certain that it will be impossible to sweep mines except with structures which are substantially the equivalent of a ship. Such structures will be extremely expensive, short lived, and will have such narrow sweep paths that sweeping will be a major naval expense, perhaps a prohibitive one. The direction in which mine sweeping tends to develop is thus necessarily a brute force method, and this was the experience in World War II.

PRACTICAL DIFFICULTIES IN COUNTERING INFLUENCE MINES

The "egg crate" and "cube steak" sweeps for pressure mines were the size of small ships, built from pontoon sections and towed by several small tugs. They each required approximately 15,000 man-hours for assembly and the extended facilities of a dockyard for a period of several months near the operation areas. One mine apiece was fired by several "egg crates" in actual service sweeps in the European theater. It was possible that a number of mines could be fired before the sweep required dry-docking and repair. But the narrow sweep path, the difficulties in assembly and in towing to the area in which sweeping was to be carried out, and the great cost were severe handicaps in the use of this sweep. The "cube steak" was very similar to the "egg crate." "Guinea pigs" were ordinary ships used to test whether channels were actually clear. Only one of them fired a mine (with temporary damage to the ship in actual service). The German Sperrbrecher was a special ship sweep in which mines at times fired very close to the ship. Sperrbrechers were capable of surviving a number of mine explosions. Again, however, these were expensive, specially-constructed ships whose use was dangerous to operating crews and which required frequent repair.

A second type of mine countermeasure is to clear the mines by destroying them after locating each one by observation, scanning equipment, or dredging or scouring the bottom with special nets or grapnels. These approaches have in common the fact that their application is independent of the mechanism inside the mine. They depend only upon the ability to locate each mine or to dispose of it by mechanical means, and do not involve fundamental considerations concerning influence fields. They are primarily concerned with the practical operational methods involved in mine location. Such methods were widely employed during World War II and in a few instances with reasonable success. For example, during the mining of the Suez Canal by the Germans, the British employed native mine watchers, each having a long stick and a bag of sand. Since the Canal is narrow, several watchers could see each mine as

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it splashed into the Canal. Each watcher then laid his stick on the ground, pointing in the direction of the mine. He placed the bag of sand on the stick to hold it in place. A Countermeasure Officer later investigated each reported mine and determined as closely as was practical its location. It was then disposed of, usually mechanically. Under those highly specialized conditions, a narrow canal permitting excellent observation of the entire channel, this simple method worked very well. It is impractical where the mines fall far from shore, during the night, or where bottoms are soft so the mines bury themselves deep in the mud or sand, or in other circumstances where visual observations or simple mechanical methods of dealing with the mines are not feasible. The Japanese also used mine watchers, illuminating with searchlights those areas where it was important to maintain clear channels.

Other methods of mine location were attempted by various belligerents during World War II. Radar tracking of individual aircraft can provide some information on the possible localities in which mines were dropped. Such tracking in detail is difficult and can be partially counteracted by deceptive action. Investigations were also made with sonic detectors in an attempt to locate the position of mine drops in channels. Tremendous progress was made with sonic devices to determine the instantaneous positions of torpedoes during proof runs. There is an excellent possibility that a row of microphones along predetermined channels can locate with reasonable accuracy the position of mines dropped in those channels.

The United States Navy carried out extensive investigations on the location of mines by mine detectors towed under water. Successful use was also made of sonic scanning for moored mines. In all of the mine-detection methods, towing was a major difficulty. So was the fact that in long-used channels, which are mined, a great deal of metallic debris normally accumulates so that new mines cannot be located. Operational attempts were made during the war to recover live mines from under water. These attempts were always unsuccessful, killing the recovery personnel. With much less difficulty, explosive methods were used to destroy mines which had been located. Insufficient data is available on the practical success of these explosive methods in actual operations, but experimental data indicate they can be successful.

Where the sea-bottom is sufficiently hard to prevent ground mines from penetrating, mechanical methods of clearance may be used with great profit. In this case mines need not be located individually, and delayed-arming, ship counts, and similar means previously used to defeat sweeping have no effect. The channel is cleared purely by mechanical means. But the method is very clumsy and difficult and of limited applicability. Like mine-location or detection ships, the mine-sweeping ships themselves are in great danger from mines specifically designed for that purpose.

Other minor forms of protection against mines are all of a highly technical nature. For example, the magnetic fields of ships can be reduced by degaussing, or the noise of ships can be reduced as was done with submarines. This reduces the target areas of ships for mines of particular sensitivity, reducing the danger. But it is hopeless and uneconomical to attempt reduction of various influence fields in order to cross safely the mine fields of the future.

Countermeasures against mines at the end of World War II show that a well-organized operational test is needed and a more complete investigation of the possibility of combining *all* of the various mine-location and mine-disposal methods into one coordinated operational mine defense plan. This will not be easy, but it may be more practical and more economical than the use of ship-like sweeps for mine clearance. It will probably depend mainly upon enormously improved instruments. The only certain mine defense is the obvious one of preventing the mines from being laid by attacking the minelayers. An absolute defense of this kind is difficult to evaluate since mine channels may extend many miles to sea, far from the urban areas or industrial targets which are also primarily to be protected. Provision to attack enemy aircraft without special consideration of mining is thus needed and lifts the problem to the development of general strategic defense.

CONCLUSION

By 1945, mine development had proceeded to the point where mine fields were unsweepable. No easy or obvious means of defense has as yet been suggested, in spite of extensive operational experiments during World War II. Well-designed mine fields in the future will be sweepable only by a ship or a ship-like structure which will be prohibitively expensive. Mine clearance and mine destruction methods, though extremely difficult both operationally and technically, offer some hope of an ultimate method of defense. Mechanical methods of clearance and specialized protections such as degaussing have some minor value but offer no general solution. Mine defense seems to be almost impossible if minelayers themselves cannot be destroyed prior to the laying of mines, and if mines are laid in force.

Mine defense is one of the gravest problems the Navy now faces. Mine countermeasures remain perhaps the weakest link in the United States' naval security. Neglect of this aspect of warfare may prove the Achilles' heel of the nation's defenses. For the United States to control the seas in the future, it is absolutely vital for mine countermeasures to have a development parallel to the potential development of mines. This is part of the general problem of weapons development analyzed in Chapter 11.

The following recommendations are made. (1) A special naval board should be convened to consider the means necessary to provide for mine defense. (2) A special task force should be designated to work out the operational

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procedures necessary for mine location and mine destruction. (3) Provisions for dispersion of ship loading and unloading facilities should be investigated. Such dispersal would make ship loading and unloading inefficient and would require revision of existing railways or roads. It would also be necessary to dispense with the normal protections of harbors, thus increasing the perils from the sea.

The mining of an entire coast, however, would be a much more difficult problem than that of mining harbors with their associated narrow channels. (4) An extensive research program should be initiated, together with the establishment of a major research laboratory, if necessary, in order to supplement existing technical aids to mine sweeping and mine clearance.

11.

PROBLEMS IN THE DEVELOPMENT OF NEW WEAPONS

THE CRUCIAL PERIOD

The minute and often painful historical details of mine warfare in World War II have been recounted. Though mining completed the maritime blockade against Japan, which had been largely accomplished but could not be completed by United States submarines, mining could have made an earlier more significant contribution to the war effort. After filtering through the haphazard complex of research and development, it does seem wonderful that so much could have been accomplished, but there has been too much self-congratulation with victory. More could and should have been done — and sooner.

The effort of the civilians in the Naval Ordnance Laboratory, whose enthusiasm made United States mine development possible, was largely vitiated during the early part of the program by lack of guidance on the Fleet's practical needs. This guidance, in turn, was absent because there was no strategic plan for mining. This was discussed at length in Chapter 4, "Mine Policy." But lack of strategic planning is not the whole story. When the great success of the Luftwaffe's early mining campaigns forced mine development on the United States, an unconscionably long time was required to develop the mines; they were not available for large scale use until almost five years after development had begun.

This lag was caused only in part by the deficiencies of peacetime planning and the lack of contact between the laboratory and Fleet. There are so many difficulties in research, development, production, training, and in forming suitable tactics for operations, that it is impractical to expect to make widespread use of any new weapon much sooner than 3 to 5 years after it is proposed. The reasons for this are all cogent. It is difficult to pluck from the welter of alternatives the exact weapon which should be developed to meet the needs of the Fleet, and even if it is a sound choice, a combat trial is required before it can be generally adopted. This takes a great deal of time, in spite of urgent need. So, in World War II, it was almost impossible to speed overall decisions to the points where full scale logistics and use of a war-developed weapon was practical much before the end of the war.

Many of the most useful weapons had been developed

before war began. For example, practically all ships of the Fleet, including many of the amphibious landing craft, had been designed and were in pilot production during peacetime. Amphibious tactics were worked out by Marines in continental bases before actual operations in the Pacific, and it was at this time that amphibious vehicles were tried out. Early radar was developed by the Naval Research Laboratory and commercial companies (such as the Bell Telephone Laboratories) before the war, and it was this radar that was used in the early and important naval and air battles. (Microwave radar, a greatly improved type, was not available in appreciable quantities until the last year of the war.)

The aircraft used by United States carrier forces were almost entirely of prewar design, so were the bombers of the Army Air Forces. The B-29 was on the drawing boards before the war began and was tested by September 1942. Most of the bombs and other weapons and missiles used by both the Fleet and the Army were of prewar design — the Garand Rifle for example. In the Atlantic, the majority of all of the submarine kills were made by land-based aircraft or by surface ships using prewar design depth charges and depth bombs. The new and more intricate antisubmarine weapons accounted for only a very small percentage. It was not until Okinawa and the Kamikazes that the VT influence fuze was fortunately available in sufficient quantities to permit its large scale use by the Fleet.

If new weapons, such as the atom bomb, microwave radar, new antisubmarine weapons, mines, new torpedoes, influence antiaircraft shells, and rockets had been available in 1942 and 1943, their effect would have been decisive in ending the war early and at a much lower cost to the United States. The lesson, then, is clear. A process as complicated as development is bound to be slow; delay should be expected and planned for. Developments begun and completed during wartime are late developments and do not in general decide the actual outcome of a war except under special circumstances when the war is prolonged. Therefore the crucial development of weapons occurs during peacetime. The military security of the United States is assured more fundamentally by developing the best possible weapons during peacetime than by mass training in the use

of present weapons which will be obsolete in the event of another war.

Another fact is important during World War II: American weapon development lagged behind that of the European belligerents. The United States initiated many developments because particular weapons used by the Germans or the British were successful. This was true of radar, rockets, anti-aircraft guns, tanks, torpedoes, mines, VT fuzes, guided missiles, and a host of others. It was in the development of only a few specialized weapons that Americans excelled: craft for amphibious operations, the Air Corps' heavy bomber, and the scoring success of American scientists, the atom bomb. So it is not enough to recognize simply that weapon development is most crucial in peacetime. It is a peacetime job that requires an efficient type of developmental organization geared to solve the problems posed by naval strategy — not, as has often been the case, geared to offer a grab-bag full of tricks, some of which may prove needed.

If reliance is placed upon the haphazard methods of weapon development previously employed, the case history of mines and of other devices outside the scope of this volume will be repeated again and again. For this reason there is suggested in this chapter an approach, organization, and procedure for devising new weapons which should result in the greater efficiency of development and the more certain usefulness of the product. But first, difficulties and mistakes of the past must be analyzed specifically. They fall into two groupings. Sectionalism, the first, is the wasteful isolation, one from the other, of agencies, individuals, and ideas. The second is properly an intangible facet of the first grouping, but is dealt with more easily if various aspects are separated. It is the environment or aggregate of conditions surrounding the utilization of individuals in the development of new weapons.

SECTIONALISM IN WEAPON DEVELOPMENT

In the main, for the Navy, the problem of weapon development is one of a more effective partnership between the Fleet, scientists, and industry. Weapon development by any one of the three working alone is most likely to fail. The suitability of a particular weapon for use is as important as the feasibility of its construction, and it means that the ultimate users of a weapon, operations, must be in close contact with technical development personnel, and that the development engineers must know the skills and capacity of industry. No high-level coordination alone could be in sufficient detail. If coordinating agencies, which remove duplication of effort and thereby somewhat increase the

¹ It should be noted, however, that the Naval Ordnance Laboratory was about twice as efficient (on the basis of use) as other laboratories working on weapon developments, and its products compared very favorably in results with those of other nations. The Germans dropped 65 mines per Allied ship loss in 1940 and 112 mines per Allied ship loss in 1941. The British, by 1943, had laid 52 mines for each enemy ship casualty. In the mining campaign against Japan, the United States laid an average of 23 mines for each ship sunk or damaged, but against a technologically inferior enemy. In another instance, the Naval Ordnance Laboratory developed a magnetic detector at one-tenth the cost of a similar development by another laboratory.

technical efficiency of the country as a whole, intercede between the engineer who develops a weapon and the man who uses it, the weapon may be efficiently produced only to be found unusable. The man behind the man behind the gun never pulls the trigger and he cannot always predict how it should be done. An interpreter would not necessarily help.

The development of the influence mine by the Naval Ordnance Laboratory is a case in point. It demonstrates the weaknesses of isolation from operational requirements for weapons and of haphazard planning, and it points up the necessity for cooperation between operations and development, between military and civilian personnel. The influence mine was basically a new weapon when used offensively in World War II. It required the development of influence-firing devices, and it required a mine case suitable for planting from aircraft. The strategy, the tactics, and the technology were all new.

The staff of the Naval Ordnance Laboratory, which had been established in 1918 to develop mines and which grew with extreme rapidity in 1940, showed great initiative in imaginative, creative, and exceptionally productive work. But much of Naval Ordnance Laboratory's productiveness in mine design was wasted in developments which were not required by the Fleet. In effect, Naval Ordnance Laboratory scientists were simply turned loose to develop mines. This proved inadequate to meet, in proper time, the practical mine problem — a variety of mine types actually useful in combat. Individuals and groups had produced a multitude of designs which they hoped might fit actual needs — no other recourse was open to them. The Bureau of Ordnance and the Naval Ordnance Laboratory assigned Mark and Mod numbers to 65 of these mine designs, and at one time or another released 39 to service use. Yet out of this total, only seven, or about ten percent, were used to any appreciable extent in combat. Indeed, the biggest production of any single mine was the Mk 16, never released to service, later converted to the Mk 16 Mod 1, which was also never used.

This unsuitability was not confirmed until production had been completed and it was too late. The unused and unusable stock of the Mk 16 and similar obsolete or obsolescent mines produced during World War II totals over 26,000. They equal in number the mines used in all offensive mining operations of World War II. Thus, not only was mine development only 10 percent efficient, but 50 percent of mine production was wasted in the manufacture of unsuitable types. The laboratory¹ had been in a position of having to decide what was needed as well as to carry out

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research and development on the mines and mechanisms. It was natural that under these circumstances much confusion would result.

The waste resulted from lack of a sensible developmental methods to guide, test, and approve the development, production, and use of new weapons. It was especially unfortunate that all initiative shown by individuals at the Naval Ordnance Laboratory in the problems of the military feasibility and suitability of particular weapons was condemned and prevented by the policy of the Bureau of Ordnance and higher echelons. This policy, expressed first in July 1942 in a letter from Bureau of Ordnance to the Naval Ordnance Laboratory, stated that the Bureau wished the Naval Ordnance Laboratory to neither release nor obtain operational data. It also terminated the Naval Ordnance Laboratory operational seminars in which individuals were trained in an understanding of military problems. To prevent what seemed busybody activity, but which actually prevented direct coordination of military and development thinking, the Naval Ordnance Laboratory's Operational Research Group was ordered to the Office of the Chief of Naval Operations where later the Bureau of Ordnance was able to enforce its isolation from the Naval Ordnance Laboratory (see Chapter 4). Its position in the Office of Chief of Naval Operations, manned by ex-civilians without field experience, also isolated it from the Fleet. Thus removed unwillingly from the physical realities of both development and combat, it became academic, conservative, and political in its efforts.

One must conclude that mine development fell very short of its possibilities, and that this failure fully to realize a maximum economy in development resulted from failure to employ rational methods of planning. Though the men in the laboratory were able to produce a number of very good mines which proved to be exceptionally effective against the technologically-backward Japanese Navy, all except one of their mines were inferior to German and British models. Earlier and greater progress would have been possible if naval mine development had been carried out from the beginning by an organization which could function to provide for the actual mine needs of the Fleet.

There are other types of enforced isolation of the development agency from the using and producing agencies which cause waste and confusion. In peacetime, the crucial period for weapon development, the compartmentalization becomes even stronger and can have serious results. An especially distressing example is that of torpedo development prior to World War II. This was carried out entirely under the supervision of submarine officers of the Fleet who were assigned to each of the departments and subsections of development and production at the Newport Torpedo Station. This Fleet guidance should have been perfect. The station was responsible for the design and the production, the Fleet trials and tests, in fact the entire performance.

In 1941 the torpedo was supposedly developed to meet the needs of the United States Fleet. Yet, at that time, the research officer at Newport was not thoroughly familiar with the theory for the locations of the vents for depth control; neither were any of the research personnel with whom this was discussed at Newport. Vent locations were chosen by trial and error. The influence exploder used a large unwieldy search coil without signal amplification at a time when electronic amplifiers were routine in solving such problems. It operated only on one polarity of a ship's signature. It is doubtful that the exploder would have ever worked below the magnetic equator. The generator had a commutator ripple ten times that of commercial generators to the detriment of successful operation and, further, used two windings for filament and plate voltage rather than the superior method of winding for 110-volt AC and furnishing needed potentials through a power transformer.

The production officer was not allowed knowledge of or access to those parts of the influence exploder production which were considered top secret. No adequate Fleet trials had ever been held and the performance of the torpedo in respect to depth-keeping, to countermining, and to firing on actual or simulated targets and other operational characteristics were actually unknown. Modern industrial practices were not used in the design or manufacture. There had been no adequate measurement of the depth at which the torpedoes would fire under targets and no accurate measurement of ships' magnetic fields. No torpedoes had ever been fired under simulated combat conditions. Neither had personnel been trained in the use and preparation of the influence mechanism of the torpedo because the secret nature of the mechanism might be disclosed. This later proved illusory since both the British and the Germans used magnetic torpedoes earlier than the United States.

Excessive secrecy about torpedoes was a liability. In combat too many torpedoes using the magnetic influence exploder prematured dangerously. There were also too many misses believed due to failure of the mechanism to actuate. When these factors became apparent and use of the influence magnetic exploder was discontinued, defects of the mechanical part of the exploder immediately appeared, resulting in a very high dud rate. The large percentage of failures had had a tremendous effect on the morale of the submarine fleet. One submariner had successfully fired one torpedo into a Japanese tanker and then surfaced and fired 12 duds. Another submariner sent back a dispatch saying "To hell with the torpedoes, I'll catch 'em and club 'em." Tests carried out at Pearl Harbor revealed the relatively trivial nature of the reason for failure after a few days' trial. The firing pin did not reach the detonator before the mechanism was damaged when the head was crushed! The firing pin was speeded up by lightening it, and the number of duds dropped to a few percent. The failure to develop

efficient torpedoes over a 20-year program span occurred because no adequate operational specifications for torpedo performance were written, competent organizers and engineers were not employed in its development, no adequate operational tests were carried out, no indoctrination or operational trials were made by the Fleet to reveal weaknesses, and there was no education of industry nor opportunity to develop a design based on sound industrial engineering practice. The failure to take all of these considerations into account resulted in a defective design.

It should be noted that torpedo development represented one of the worst rather than a typical Navy prewar development.

The sectionalism, in this case supposedly justified by the secret nature of the weapon under development, had backfired dangerously. It is generally true that developments cannot be kept secret for more than a year or two. Physics is an open book to the technicians of every country, and technical developments are being carried out by every potential belligerent. No secrets except those of actual manufacture and the operational characteristics of particular weapons can be kept. The usual excuse for excessive secrecy is that it prevents easy and premature disclosure to the enemy. This is an illusion based on two fallacious assumptions: first, that the enemy lacks the resources and intelligence to create similar new weapons independently, and secondly, that a static and conservative policy of perfecting old weapons will assure weapon superiority. Both assumptions are erroneous.

World War II provides convincing data to substantiate the futility of excessive secrecy. For example, the Germans, the British, and the United States each developed pressure, magnetic, and acoustic mines independently. Each belligerent naively thought that it alone possessed new developments such as radar, rockets, guided missiles, homing torpedoes, and influence fuzes. Even the Japanese had a magnetic airborne detector of their own. They had developed many of the new types of weapons, but were too poor in technological personnel and resources to compete with the United Nations (Allied Nations). The most dangerous of our potential enemies will eventually possess technical and military competence at least equal to that of the United States. Too conservative an approach will therefore result in inferior weapons. A sounder policy would be to recognize the fact that all "secrets" have short lives because they will be discovered independently, since fundamental physical principles are common property and lead logically to similar weapon development. The aim of weapon development should be to keep always *ahead* of any potential enemy in ideas and technology and assume that he is working on similar developments.

The obstacles to making the necessary combination of technical skill, strategic insight, and practical operational knowledge in the development of new weapons — whether due to organizational structure or secrecy restrictions — were not unique in the United States. Interrogators who questioned German scientists and technicians after V-E day concluded that ". . . the Luftwaffe, the most technical of the services, with its flying personnel, flak, signals, and other specialists, was commanded by men who only imperfectly grasped the essentially technical and scientific character of their force."²

"If there had existed a close cooperation on the highest level in the (German) General Staff," the report goes on to say, "between the best technical brains from industry and from the three services, it is likely that many operations (for example, Stalingrad and Tunis) would have taken a very different course." The muddle over the creation of an adequate nightfighter system is a classic case in point. It had been observed how, in 1940-41, England had suffered just because of the lack of proper nightfighter defense. It was also seen how, by degrees, the Royal Air Force developed one; but, instead of drawing the obvious conclusions, no further notice was taken of this fact until the enemy went over to the offensive and Germany was placed in exactly the same predicament that England had experienced almost two years previously.

"The initiative in research and specialized development," the report states later on, "was nearly always taken by isolated personalities without any previous orders or directions from a higher level. But as these persons could have no insight into the overall conduct of the war, nor were guided by any policy regarding higher strategy as conceived by the leaders of the state, it was only by accident, as it were, that successful modifications and improvements made their appearance."

The British were probably the most successful nation in effecting cooperation between their military and scientific personnel. In their mine warfare organization, for example, the Fleet, planning, and development agencies were coordinated throughout the entire process of development. A United States naval officer who reported on the British organization for mine development³ emphasized two steps in their procedure. The first was that the opinion was sought of a group in the operational divisions of the Admiralty who were familiar with the strategic and tactical requirements of mining as well as with technical characteristics of the weapon. Emphasis was placed on a mine's usefulness. The second step was the function of HMS VERNON (Mining) a shore establishment concerned with schooling, mine recovery and investigation, and mine sea trials. It was their job to determine whether or not the mine

² *Air Military Weekly Intelligence Summary No. 317, 1 October 1945, "Eine Minute Nach Zwölf — Too Late, the Theme in GAF Research."*

³ *Intelligence Report, Serial 347, dated 9 February 1942, from Naval Attaché, London.*

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was practical from a seagoing point of view. Besides testing to see whether it would work, they tested to see if it was simple enough to be used at sea by men with short training and without the ministrations of highly skilled technicians.

To illustrate further the cooperation of British scientists and the military, J. H. Hildebrand makes a pertinent comparison between chemical warfare development in Britain and in the United States.⁴ "The Chemical Board furnished a particularly instructive example of joint action. Its chairman was J. Davidson Pratt, a prominent and able civilian industrial chemist, director of Chemical Defense Division; its vice chairman was a major general; and its members included such men as the president of the Physical Society, the major general from the War Office responsible for chemical warfare, several distinguished organic chemists, one of Britain's most eminent meteorologists, an RAF adviser, a military intelligence officer especially assigned to chemical warfare intelligence, the commandant and section chiefs of Porton Field, the experimental and proving ground for chemical warfare. It is particularly noteworthy that the commandant of Porton, at one time an air commodore of the RAF, later an army colonel, operated under the authority of the civilian director.

"This board would discuss, for example, a possible new weapon or device; progress would be reported at subsequent meetings always in the presence of the officers ultimately responsible for its adoption. When the job was done, if successful, no salesmanship was required to secure prompt acceptance. We had no such coordination of military and scientific authority. Our Chemical Warfare Service is not a using but only a procuring service and such partnership as existed with the appropriate divisions of National Defense Research Committee depended upon the tact and skill of the chiefs of these divisions."

Hildebrand cites a number of examples where the lack of collaboration between development and using agencies resulted in an initial unsuitability that could otherwise have been avoided. The M-47 bombs, gasoline jelly incendiaries, were just a few inches too long to permit them to fit end to end in the bomb bays. This, he states, resulted from the gap between the developing organization, a National Defense Research Committee division concerned with chemical warfare problems, and the Air Corps. He also says that the Eighth Air Force used the United States 4-pound magnesium incendiaries very little at first because the clusters opened immediately upon release from the bomb bay, and in the stepped formation used by the bombers, they endangered the planes that followed. Later this was corrected by a delayed release and the clusters were used.

Thus sectionalism in weapons development can be roughly divided into two kinds: the separation between the

man who develops a weapon and all others for exaggerated reasons of security; and the separation between the man who needs a weapon, the man who develops it, the man who produces it, and the man who uses it, all for reasons of organizational clumsiness. The separation between civilians and the military, in terms of mutual acceptance, for reasons of training, tradition, prerogative, and lack of mutual understanding is a human rather than an organizational or procedural isolation and will be discussed in a later section.

EXISTING DEVELOPMENT AGENCIES

Since the end of the war several organizations have been set up within the naval establishment in an attempt to correct the organizational problems in weapon development. The Office of Naval Research is one. It administers the research policy of the Navy. However, it is directed by regular Navy officers who are not primarily qualified or trained in research (more on this later). Special task forces have also been established such as Task Force Number One, for the atom bomb tests. They are indeed excellent, but should, however, be integrated and established for the systematic trial of all new weapons, rather than for a single extraordinary weapon.

A Mine Warfare Section still exists within the Office of the Chief of Naval Operations, but with a reduced status, which is true of most of the Naval establishment. For this reason it is unable to carry the full workload of delineating completely the operational requirements of the fleet in future mine development. So, whereas research effort has not yet been proportionately reduced from its war peak, the *guidance* for research has been reduced, which is almost as bad. The Bureau of Ordnance is still the controlling agency for the development of new weapons, but in the main this continues to be done on the old basis used prior to World War II. Changes have occurred, naturally, but they are changes which do not touch the basic need of guided weapon development adequately and systematically organized to fulfill Fleet needs. Successful weapon development cannot depend upon the initiative of individuals. Only if a systematic organization is established can this country be assured that weapons can be satisfactorily developed between this war and another.

At the end of World War II the Navy Department was favorably inclined towards the intensive and effective employment of research and development to attain pre-eminence in naval technology. Since this was also true at the end of World War I, but only for a short time, the question is whether this inclination will persist without external stimulus, and whether it will be followed. The practical implementation of such a research policy depends upon the Navy using each available research agency wisely.

⁴ "The Scientist and the War" by J.H. Hildebrand, *American Chemical Society*, 23, 25 December 1945. pp 2317-2321

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The basic needs of the Navy should form the basis for reviewing the capabilities of these research agencies and facing squarely the fundamental question of whether or not research can be adequately administered by navy officers, who, however noted and competent in their own profession, must deal with the unfamiliar psychology of one of the most complex and difficult professions of our civilization — science.

Nothing is new in the general principle of the answers that follow; all of the remedies have already been proposed by others. However, these well known remedies are summarized from the viewpoint of one who has been both a practical navy officer and a research physicist, with an equal respect for the personnel of both professions. A primary assumption is that another war, like the last, will be won principally with weapons developed and tested before it begins. The three principal types of developmental agencies available for this peacetime mission are Navy laboratories, university and research foundations, and industrial laboratories. Their relative advantages and disadvantages for weapon development are considered below.

The Navy laboratories were responsible for a majority of the down-to-earth naval developments used during the war, and these were often developed at a very low cost compared to costs of similar weapons developed by other agencies. The naval laboratories' primary undivided interest and full-time job is weapon development, with the closest guidance in needs and practicability given by naval officers. Tests of developed weapons are most easily carried out in naval laboratories, and they will probably retain priority over other laboratories in Navy financial support during periods of economy. Naval laboratories have retained some of the high quality personnel they collected during wartime, but the disadvantages of naval laboratories are that present personnel policy hinders employment of competent scientists and engineers and tends to enervate those who remain in government service. During peacetime this alone outweighs advantages. Another important disadvantage is that present policy does not adequately support the basic research needed to keep development laboratories virile. Development and research are often subordinated to the other functions of the service.

During World War II, universities and research foundations developed the majority of the radically new and outstanding devices requiring initiative and imagination. To their advantage, the most competent personnel will continue to work in these organizations. They are also the source of new ideas and information. One marked disadvantage of university research laboratories and foundations is that academic personnel have an excessive dislike of any attempt to control their interests or research. This will make any Fleet guidance very difficult. Also, because their primary interest and major competence is in research, development is likely to be low in efficiency and skill,

imperfect in production practicability and high in cost. Their interest in Navy development will tend to be the selfish interest of obtaining funds; their actual interest in military devices will be low, and basic research will be done anyway if other funds are available. Besides the lack of close Fleet guidance, a final disadvantage is that test will be very difficult.

The performance of industrial laboratories during the war varied, but when given the opportunity, they did top-notch jobs at both improvements and new developments. They usually have the advantage of possessing high-quality development personnel and, of all the laboratories, are the most efficient in design because their personnel is familiar with materials, practical techniques, and production problems. Profit motive is their primary interest — which leads to greater economy. One disadvantage is that usually only the largest commercial companies support research as well as development staffs. The general disadvantage of industrial laboratories is that military devices tend to have low priority during peacetime since the civilian commercial market is the major source of profit, and during peacetime it is unprofitable to design military weapons. This may apply particularly during the decades 1946-66 because of the shortage of technical personnel. The military guidance of industrial laboratories is moderately difficult, and test is also somewhat difficult.

The conclusion is that the service laboratories will have every advantage over other agencies in the development of new weapons during peacetime *except competent personnel* — a fatal defect. If (and it is a big if) this defect can be corrected, there will be required fundamental and aggressive support of research by the use of a very few experienced, high-caliber, professional research personnel in the higher echelons of the services, and there will be required the education of military officers toward a sympathetic understanding of the psychology of research personnel. Widespread mutual respect between officers and scientists is necessary to assure pre-eminence in military technology by service laboratories.

SCIENTISTS AND THE MILITARY

It is true that the dramatic impact of the atom bomb and the many technical weapons which saw service in World War II have dramatized the military usefulness of scientists. But this fundamental acceptance by both civilians and military personnel was so sudden that the attitude is not consistently applied in the many important details that go to make up their day-to-day efforts in weapon development. Certainly the relationship was not smooth during the war, though now, through the haze of the past, the comradeship looks warmer. The stock of evidence to prove that such a lack of understanding exists between civilian and military personnel in weapon development is great and detailed. It involves intangibles such as resentment over prerogative,

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pay differences, authority without concomitant knowledge, the presence or lack of discipline, and so forth. It involves the basic indoctrination necessary to each profession. The scientists' too-ready acceptance of the new because of its possibilities, though often unproved, is diametrically opposed to the too-slow acceptance of the new by the military because it *is* unproved, though in the final stages combat trial is the only way of establishing its worth.

Specific procedures in a weapon development organization geared to tap the best men in each field and draw them closer together is not enough. Nor is it enough to state the need for widespread mutual respect between the scientists and service personnel, or even to grant high-level civilian authority and responsibility in weapon development (discussed in detail in a later section), and expect the interchange of ideas to react in a far-reaching manner in developing mutual understanding. A practical procedure for educating civilians and the military in each other's attitudes and worth must be followed for all echelons. Now, the weapon engineer is too often satisfied if his device works, no matter what professional skill is required to make it operate, nor what hot-house conditions must prevail. And too often the officers and men afloat will dismiss his efforts contemptuously because their needs and training appear to have been disregarded.

Thus the administration of development and research in weapons is especially difficult because it involves the cooperative efforts of two such groups of people whose thinking is fundamentally very different. Scientists and the military cannot be expected to think in each other's terms; it would devitalize each in his own field. They must, however, learn to understand each other's thinking. Ordinarily, when attempting a research or development project, the physicist or engineer first tries to understand the nature of his problem and then seeks maximum information on all pertinent background. The engineer must not only be skilled in the technical aspects of the problem, he must also understand the needs of the user and the way in which his completed project will be used. To work effectively, the military development engineer or research physicist must understand some of the practical operating conditions under which his weapon will be used. Therefore laboratory personnel should spend a minimum of one year in the Fleet during the early part of their careers. This should be supplemented by about three months, say, every three years.

The best way of providing this experience in operational conditions is to assign development personnel to the Fleet in connection with the initial use of equipment developed by the service laboratory. This policy should also be applied as widely as possible to outside agencies which contribute to the development of weapons. All men in military research and development should receive training in military principles equivalent to that given to Navy officers at the War Colleges. This is especially important because

without such training the research engineer will not be able to appreciate thoroughly the military factors included in the developmental mission directive. This supplemental training is just as important for junior as for senior laboratory personnel and should be made obligatory.

To supplement their service in the field and education in military principles, a considerable number of officers should be assigned to each service laboratory as advisors, and as research and development apprentices. They will be able to point out the detailed practical aspects of military operations which are so important in the use of weapons, aspects which are, at best, imperfectly understood by the research and development engineer. Officers so assigned should have neither direct responsibility nor authority within the laboratory itself. They should have a status similar to that of the laboratory personnel while with the Fleet. This will be successful if members of both professions adopt a cooperative attitude, neither believing himself superior to the other professionally.

CIVILIAN AUTHORITY IN WEAPONS DEVELOPMENT

This mutual recognition of professional worth implies that there should be no encroachment by the military or scientists in each other's field. There was quite a tussle on this score during World War II, the military retaining technical as well as administrative control of the service laboratories and civilians (though under a decided disadvantage) occasionally raiding some normally military fields. One such effort was Operational Research, which did emphasize the applicability of numerical aspects of the analytical method to military operations. These civilian operational research groups did not fully realize that the method is familiar to the Army and Navy and is commonly used to some extent in the Estimate of the Situation (though it is unfortunate that only a limited number use it fully). The studies of the groups usually required adequate statistical data on different, but existing combat procedures. On the basis of these studies they were able to point out the best procedures or to indicate corrective modifications. They rarely were able to develop new tactics. This requires creative military skill and is more a psychological than an analytical problem.

In the majority of cases, however, the civilian scientist and engineer are given too little authority and responsibility in the service laboratory which should be their domain. Provided some way can be found to employ scientists and engineers of high professional caliber in the service laboratories, the continuity of administration is assured only by such authority. Then, also, academic and industrial developmental agencies can be included in weapon development as partners through supervision of contracts by the appropriate service laboratories and with such arrangements continued on a professional plane.

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Neither continuity nor professionally efficient contacts would be assured if administered by military officers untrained in development and with short tours of development duty.

This is very important. A regular officer ought not to resent the judgment that it is inadvisable for him to administer development and research. In industrial laboratories a business man is not usually chosen to administer research and development. An administrator is chosen who has risen to his command by showing his ability in all the development or research echelons from apprentice to master engineer or physicist. The *a priori* evaluation of scientific competence or of some expensive research proposal requires, above all, professional experience to separate the good from the bad. It would be no more unwise to place an inexperienced naval reserve officer, like some of the scientists who served in uniform during World War II, in command of a battleship, than it is to place a regular navy officer inexperienced in research and engineering in charge of the administration of research and development.

It is true that a few regular officers have been eminently successful in dealing with scientists. They have done this by teaming up with skilled scientists and making wise use of their advice. A deliberate partnership is therefore possible, but this is subject to a special weakness, the short term of duty of regular officers in each tour in a developmental billet. Research projects are long-term projects. Only rarely, under great stress, will the results of research be implemented in much less than five years. Thus, with three-year tours of duty, one regular officer can see through but few projects. Continuity is lost just when each incumbent begins to learn research ropes. Because of this, many projects are prematurely abandoned; for example, the United States-designed influence mines of 1917-1918. The regular officer who administers research and development should have a term of at least 10 years in order to be effective. If short tours are continued and civilian advice relied upon, the actual responsibility and authority should be carried by civilians. If not, each tour is reduced in effectiveness because too long a proportion of time is lost through initial lack of experience.

In brief, the entire administration of research and development by Service laboratories should be the responsibility of civilians chosen on the basis of their successful record in like work. In addition, noted scientific administrators should have high-echelon responsibility for the administration of research and development in the services themselves. In the Navy they could be part of the present Bureau system, responsible to the Chiefs of the Bureaus, just like naval officers. Under this system, for example, the billet of Research and Development in the Bureau of Ordnance would be held by a civilian rather than by a naval officer. In order to insure

appreciation of the seagoing point of view, an initial full year of sea duty should be required of such an administrator, followed by at least three months of sea duty every three years. Similar though lesser responsibility should be placed on advisory civilian personnel in the appropriate part of the Office of the Chief of Naval Operations. Civilian advisors should be attached to the chief's staff in the Fleet itself. This policy would insure the Navy the same competence in research that its seagoing officers now have in naval affairs. This presupposes that civilians and the military have an equal duty to insure the security of the nation by full development of the weapons and methods of naval warfare.

The regular Navy need have no fear that such an arrangement would in any way reduce its authority over naval affairs and construction. Civilians would be as responsible as Navy officers to the chiefs of the bureaus or to the Chief of Naval Operations. Their careers would be completely dependent upon their performance and subject to the judgment of the Chiefs of the Bureaus and of the Chief of Naval Operations. Since the Navy bureaus want distinguished performance on the part of their service laboratories, the bureaus must trust the civilian engineers and scientists who staff these laboratories and must delegate authority to them. Then the success or failure of weapon development by the service laboratory can be fixed on the individual technical director. The director can be credited with the successes of his laboratory or blamed for its failure, and he can be replaced if necessary. The fact of the matter is that naval warfare, like all warfare, has become so complex that the full guidance of detailed aspects relating to civilian professions can no longer be carried out effectively by Navy officers alone.

To sum up: Experience in World War II has indicated strongly that the direction of research and development and its administration are civilian functions requiring military guidance. Military direction and administration of weapons development groups fails to produce the best results on the average, but so too, on the average, does weapons development guided only by civilians or only indirectly by the military. The lesson for the future is to develop new weapons in times of peace in an organization which ensures a continuing civilian-military partnership as an integral part of each branch of the Armed Services. The security of the nation requires a Navy which is both civilian and military, each profession charged with responsibility and authority for its own functions, but in which the user has the ultimate responsibility and authority for approval and adoption of the weapon he is to use. Within the naval establishment itself, definite responsibility and authority must be delegated to civilians who should occupy the controlling positions in the administration of research and development, subject, however, to the control by the chiefs of the bureaus and the Chief of Naval Operations.

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THE SCIENTIST AND THE SERVICE LABORATORY

Before enlarging on the organization and procedure for weapon development which will ensure the active cooperation of the man who makes a device and the man who uses it, there must be discussed what is probably the crux of the problem — the need for highly competent scientists and engineers in military research and development. It was said earlier that the only ground on which the potentialities for weapon development of service laboratories compared unfavorably with university and industrial laboratories was in personnel. Educating scientific and military personnel in each other's needs, and giving civilians high-level responsibility will come to naught unless the service laboratories are staffed with competent people. The mediocrity of their staffs during peacetime is notorious. All the money, buildings, facilities, officers, and streamlined procedures will not be able to force creative achievement out of incompetence.

Granting that the greatest problem of the service laboratory is to get and to keep scientific and technical personnel of high quality, it is still true that the best among them are actually repelled by such service because of restrictions on their personal freedom in working and restrictions on the manner in which they may go about achieving the goals set for them. It is the general opinion that almost all of the work done within Government laboratories is second- or third-rate (the Department of Agriculture is a notable exception). Before World War II, the cream of the graduating research students were employed by the universities and the best of the remainder were employed by the bigger industrial companies. The next best went to the smaller or poorer companies. The residue was composed of students who could not find jobs in any commercial organization. The standard procedure of the professors charged with helping them find work was to send them to take Civil Service examinations. They were usually able to pass these examinations, and it was usually these fourth-rate individuals who manned Government laboratories. No wonder then that performance was poor! The employee in the service laboratory had no real pride in belonging to this laboratory. Usually he dropped his outside professional contacts, for he felt he was not respected by his peers.

The professional level of an organization is self-perpetuating until a major change is forced on it by some significant event. World War II did just that to the service laboratory. Patriotism brought in highly competent people. Now that many, if not most, have left, the laboratories are likely to sink again to their prewar level of meek inferiority. Not enough of the top scientists are likely to remain long unless service laboratories are organized on a basis which takes account of the successful operating principles of other laboratories rather than as a Government project differing

only in kind, say, from a census activity.

It is recognized that Civil Service was developed around the praiseworthy purposes of preventing political influence from bearing on the choice of a majority of public servants and of protecting an employee from the possibilities of unjust dismissal. But the price has been unnecessarily heavy. All the effort has been funnelled into the negative activity of preventing abuse, rather than channelled into the positive procedure of attracting competent men and developing increasingly high standards by reward for merit.

It would be inappropriate in this chapter to suggest specific corrective measures. The problem is a large one, in itself, and the main intent of this chapter is to stimulate thinking on all the problems in weapon development and to suggest organizational and procedural correctives. Civil Service is but one part of this, though fundamental, governing as it does the type and quality of civilian who would work under these procedures. It is appropriate, therefore, to indicate the type of environment in which scientists and engineers are most productive, and the manner in which the present Civil Service system fails to provide it. Necessary modifications will have to be worked out and put into effect if men and their ideas are to be used efficiently in maintaining the security of the United States.

The four important basic differences between Civil Service treatment of technical employees and that accorded by universities and industrial laboratories are: Trust is replaced by rules. Individual accomplishment and merit is replaced by the negative avoidance of doing wrong. Scientific accomplishment is rewarded not by greater scientific responsibility, but by detailed supervisory chores. And fourth, the intelligent hiring and firing of individuals is replaced by a hocus-pocus neutrality that will furnish the wrong fish if only he has the right number of scales.

To treat them in the order listed: Rules ensure only that each Civil Servant remain on his job for a specified number of hours, and also that he appear to be busy during that time. They embarrass incentive to accomplish a working objective by specifying many of the mechanical details, and in their enforcement they often involve embarrassingly undignified procedures which cause far more irritation and harm than an original infraction. Myriad rules are bad enough with the average individual, but they are even worse when applied to the somewhat maverick nature of a good scientist or engineer. For example, in one service laboratory, tardiness was punished by a pay deduction equivalent to about twice the time involved. Result: clock-watching. In another case, where a misplaced sense of military discipline was coupled with the peacetime Civil Service regard for the inviolability of the end of the working day, employees staying late were required to register. The last man was responsible for the state of the windows and the laboratory janitors were to inspect and report on

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failure to comply. This was so resented by the technicians, many of whom were PhD's and university professors, that they reacted by leaving the laboratory exactly at closing time, in spite of the urgency of their work.

The drive for accomplishment which characterizes competence is always discouraged by such recourse to petty discipline, and unfortunately such incidents are not as uncommon as they are silly. Surrounding a man with rules psychologically forces the work objective into a secondary position of importance. This will not be brooked by a man who takes his work to heart. A leading scientist, who was asked his main reason for leaving a Government laboratory about a year after the war was over, shrugged his shoulders and answered, "I felt as if I were in prison." Service laboratories are now in competition for able personnel with both universities and industrial laboratories which have recognized the ineffectiveness of petty rules and discarded them. Instead of being governed by a mass of rules, their employees are judged by their performance. For example, at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, the research staff has no official hours or days, or even weeks, in which they are required to report to work. Attendance *per se* is not the criterion of performance or competence. The individual is judged by his research accomplishment. This freedom is not without restriction in the sense that the responsibility for achievement rests on the individual who has been given the authority to pursue an objective. But it is this freedom which brings about an attitude of mind which makes the individual want to work and to create. In a large organization, it is poor economy to reduce the efficiency of an entire staff to catch a few laggards.

There is another serious effect of Civil Service rules. They were devised to emphasize the qualities considered best suited to distinguish between good and the bad among one million employees, mostly nonprofessional, so criteria are necessarily watered down to such personal characteristics as neatness, accuracy, dependability, industry, or supervisory ability. These are disturbingly inadequate in evaluating scientific and developmental performance; they only measure the general ability of an individual to work in any Government office. Because supervisors are required to fill out several dozen rating forms within two or three days, they often become cynical or callous. The individual who does nothing makes no mistakes and profits, since the evaluation lays more emphasis on whether or not he does anything wrong rather than on what is accomplished, the effect is to discourage the aggressive, efficient employee (who might make a mistake) and put a premium on the timid souls who pad gently through the years.

Should, perchance, a good scientist be recognized, the nature of his promotion is such as to impair his scientific usefulness by rewarding his scientific achievement with administrative responsibility! While this is true to some

extent in other research institutions, the amount of paper work involved in government service is such that a government scientist is promoted *out* of science into the paper and politics of administration. This is a double-edged fault. Firstly, it cuts down on the time a scientist can devote to research. Secondly, since higher pay (therefore higher rating) is the reward for any achievement, technical or not, there are high-ranking administrators who may not be competent scientists but are falsely judged to have scientific competence by others. This often reduces the prestige of a laboratory. This system of promotion bleeds both the laboratory and the scientist of his professional skill because, to get a high rating, an individual almost universally must take administrative responsibility. Therefore the scientist's value to the nation is reduced.

The fourth and last difficulty with Civil Service to be discussed here is the hiring and firing of scientists and engineers. During World War II, Civil Service failed lamentably in furnishing to the laboratories men with needed skills. The Naval Ordnance Laboratory (among others) solved the problem in the emergency by resorting to a system of contracts whereby it paid an individual so much per day for his services. In this way the laboratory was able to assemble a notable staff of scientists and engineers in short order. Justification as a wartime expedient is no longer valid, and the contract system can no longer be applied except under the most special circumstances.

There has been some recognition of the special qualifications of scientists in the forming of special panels to redraft job requisites and to hire and fire for an entire group of Government laboratories on the basis of farmed-out authority from the Civil Service Commission. The panel may represent a step in the right direction, but in working within the limits of the authority it was delegated, it adheres to the standardized requirements of Civil Service which are so inapplicable to a group of specialists. Although it may be able to modify the requirements to some extent, there is still no adequate provision for hiring an individual who is exactly the right man for a given job even if he is available. The "rare bird" procedure which does permit hiring a particular man for a particular job is subject to the difficulty that once the particular job is gone, the justification for retaining the individual has also disappeared. More fundamentally inadequate is the fact that the "rare bird" procedure does not apply to the mass of technical employees who make up the bulk of a laboratory and sets a limit to its ultimate proficiency.

The system of a set of stated qualifications to be applied uniformly to all personnel considered in all positions of the same type and level often achieves just the opposite of its intent; by specific rigid formal qualifications for a *type* of job, it often prevents the hiring of an individual ideally suited for a specific job. To give a minor example; a technical editor is chosen on the basis of technical

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experience, his experience in journalism, English, etc., going unrecognized. This rigidity probably excludes the men most qualified for technical reporting from that occupation in Government laboratories. There are extraneous qualifications which have nothing to do with specific fitness, such as legal residence or veterans' preference. The latter may be regarded as a source of trouble, but it is unfair to use it as a scapegoat. The same type of difficulty applies to all standardized requirements because they do not bear on individual fitness. The inapplicability may be more obvious here, but the effect is just the same in other cases. For example, a University degree does not guarantee a man's suitability for a particular job, but the lack of it might be used to eliminate one eminently suited.

Then, in Civil Service, after the appointment of the somewhat wrong man, he is afforded maximum protection against the possible misapplication of power by his supervisor, which means that all but the grossly incompetent are secure in their positions (within a given budget). Since there is no dollar and cents evaluation of an individual's effort, as there is in private industry, and no accepted method for rating scientific performance achievements, supervisors are bound to attempt the maximum rate of promotion for all their subordinates. Otherwise morale, and therefore output, would suffer. The reaction is the disgruntlement of the superior individual who is held to the common pace. He soon begins to produce at the common rate of effort. With the removal of both professional and individual competition, the quality of output is bound to go down.

It is true that a scientist does not choose a place to work simply because the atmosphere is pleasant, or because it is easy to get equipment, or because he is treated with respect. A major reason for his choice is whether or not he likes the work he would be doing and whether it would enhance his professional standing. Professional prestige is vital to scientists. It stands clear that if Civil Service rules for scientific employees can be changed to provide a permanent attraction for superior employees, service laboratories have a good chance of obtaining recognition within the scientific and engineering professions, and this will ensure a high quality of research and development for the Navy.

There are several other ways in which the position of the scientist and engineer in the service laboratory can be given some of the advantages of non-Government laboratories with consequent good effect on their work. The first is to enlist the individual's concern and creative activity in the general developmental mission. Provided Fleet apprenticeships for the scientists and laboratory apprenticeships for Fleet personnel can be worked out, considerable detailed information should be furnished when the developmental mission is given to the service laboratory. The laboratory should not only be given specific data necessary to a particular development but should also be given considerable

information on the general nature of the War Plan or Estimate of the Situation, even though this is highly classified. Only thus can the entire nature of the problem and the desired characteristics of a weapon be understood in relation to other weapons. Besides, it is highly probable that given this broader base of information, men engaged in the original and assigned development will invent or develop new and perhaps better weapons to achieve the desired objective.

To restrict the planning information to only a few top administrators, especially the information on practical operational characteristics, has a tremendous negative effect. The ill effects have been shown in torpedo development. Such secrecy actually prevents the technical personnel from carrying out the development intelligently. Instead of secrecy and compartmentalization of information, it is highly important to have a large amount of group thinking on each weapon development problem. The research procedure commonly used at universities consists of seminars or group study, at which the entire department staff discusses critically the research carried out and reported by one individual or team. This group thinking, in which individuals who represent diverse points of view bring their ideas to bear on one problem, is far more effective than the same number of people working separately on the same problem, because in a group the scope of overall knowledge is tremendously increased and fresh points of view stimulate each thinker. It also happens usually that the most fruitful and penetrating ideas contributed during a seminar are those of the working research personnel, not the administrators. The enforcement carried out in secrecy tends to be slow and far less effective.

The service laboratories should arrange sabbatical exchange of their personnel with industrial organizations and also with the universities and research institutions. This exchange procedure is common among universities and would broaden the knowledge of men in the service laboratories. It would also stimulate their efforts and give men in outside research and development agencies detailed knowledge of the service laboratories' problems.

At least 20 percent of each service laboratory's total resources should be applied to basic research. Though much of it would have no bearing on military development problems, publication of high quality research would bring public and professional recognition to the service laboratory, and promising young men would be attracted to the laboratory, reversing the trend between World Wars I and II. It would also have the important purpose of spurring development personnel. This policy is used by organizations like the Bell Telephone Laboratories and the General Electric Company. Their personnel includes Nobel Prize winners who have done important fundamental research not directly connected with the needs of their companies. At the Bell Laboratories, for example, Williams

was the synthesizer of Vitamin B-1, which is certainly not connected with the telephone industry. The performance and fine reputation of the Bell Laboratories is partly due to its attitude towards the basic research carried out by a small portion of its staff.

In view of the necessary subordination of research in the service laboratory to the important developmental engineering groups which, after all, they *support*, present policy in the Navy has unfortunately tended to make research secondary in *all* respects, even to the point of keeping it inferior or eliminating it entirely on the policy basis that basic research is unnecessary in a development laboratory. But since it stimulates development personnel, and attracts new, high-quality men to the laboratory who will be proud of their association with it, it becomes important that basic research be maintained on a priority basis.

It is important to remark in passing that every service laboratory should be provided with superior professional, technical, and shop facilities. Of particular importance is that laboratory personnel must have easy access, at a moment's notice, to good libraries of their own which cover technical subjects as completely as the library of a large university. Also, to be effective, each man needs sufficient space and privacy to carry out his work efficiently. This has not characterized service laboratories. The most creative research of the United States is done at the universities, and the most successful development is done by companies which apply university methods to their development groups. The service laboratories should modify for their own needs the research atmosphere of the universities because it is good sense to adapt the methods used by successful organizations.

WEAPON SUITABILITY AND FEASIBILITY

Before suggesting an organization for weapon development which would overcome the difficulties already described, it is necessary to define the criteria by which a weapon's probable success can be judged during development. The first lesson gained from experience in mine development is that the broad general purpose of the development must be known at the beginning. This sounds simple and obvious, but unfortunately it is often overlooked or is not communicated. Development is growth which must be controlled not by blind attention to detail but with full consciousness of the entire sweep of the process. The developmental mission can be derived only from the basic mission of the Navy (dependent, in turn, on the strategy of warfare to be adopted). First of all, it must be known in a general way. Is antisubmarine warfare to be one of the basic missions of the fleet? Are amphibious landings against shore defenses and sea mines to be one of the primary missions? Is the Fleet to be protected against guided missiles, Kamikazes, or atom bombs? Are atom bombs to be launched in guided missiles from submarines?

Once the specific developmental mission has been determined, two general cases in weapon-development arise. In the first, the Fleet proposes a specific weapon, or the need for a weapon to solve a particular kind of problem. In the second case, the weapon is proposed by an individual of a technical organization who thinks it may meet one of the needs of the Fleet. In the first case, specifications, or other characteristics of the weapon problem, must be submitted to technical personnel who determine whether or not the specifications or need can actually be realized with the then given state of technology. In the second case, the proposed weapon, considered technically feasible, must be submitted to the Fleet, which determines whether the weapon would actually meet any practical needs and whether it would be necessary. It boils down to this: If the Fleet proposes a suitable weapon — is it feasible? If the laboratory proposes a feasible weapon — is it usable or suitable? (See Figure 11-1).

No matter where an idea originates, the problem of feasibility is primarily determined by technical personnel, but suitability, while largely determined by the Fleet, is a joint problem. There will, in general, be a choice between various plans, and there will be the choice of continuing old weapons which may not be entirely satisfactory. In any event, the entire problem must be considered as a whole and a decision arrived at only after consideration of both the feasibility and suitability of the various proposals.

Suitability depends upon the Fleet mission, upon the Estimate of the Situation, upon production (particularly those aspects relating to new weapon development), and upon the specific operational problems. The relationship of these four factors is not simple, because the Estimate itself may be changed by the development of new weapons proposed by a laboratory. This may reveal a new course of action which, in turn, may require development of completely new types of weapons. Thus the question of suitability never remains static, but is subject to a continual process of re-examination.

Strategical decisions will greatly affect a weapon's suitability. In World War II, when a Fleet mission was to take and to hold islands, harbors, and channels formerly held by the enemy, the early policy decision was made not to release mines which could not be swept by United States forces. Sterilization was not considered sufficient. The decision not to produce a non-sweepable mine prevented the early development of the pressure and vibration mines and held to a minimum what might have been an earlier, more significant contribution to the war against Japan. In place of the difficult development of superior mines, the deliberate and easier development of inferior mines in great quantity, particularly the A-3, was pushed. In the end, the A-3 proved unsuitable because the Japanese countermined it so easily and because the majority predated within a few

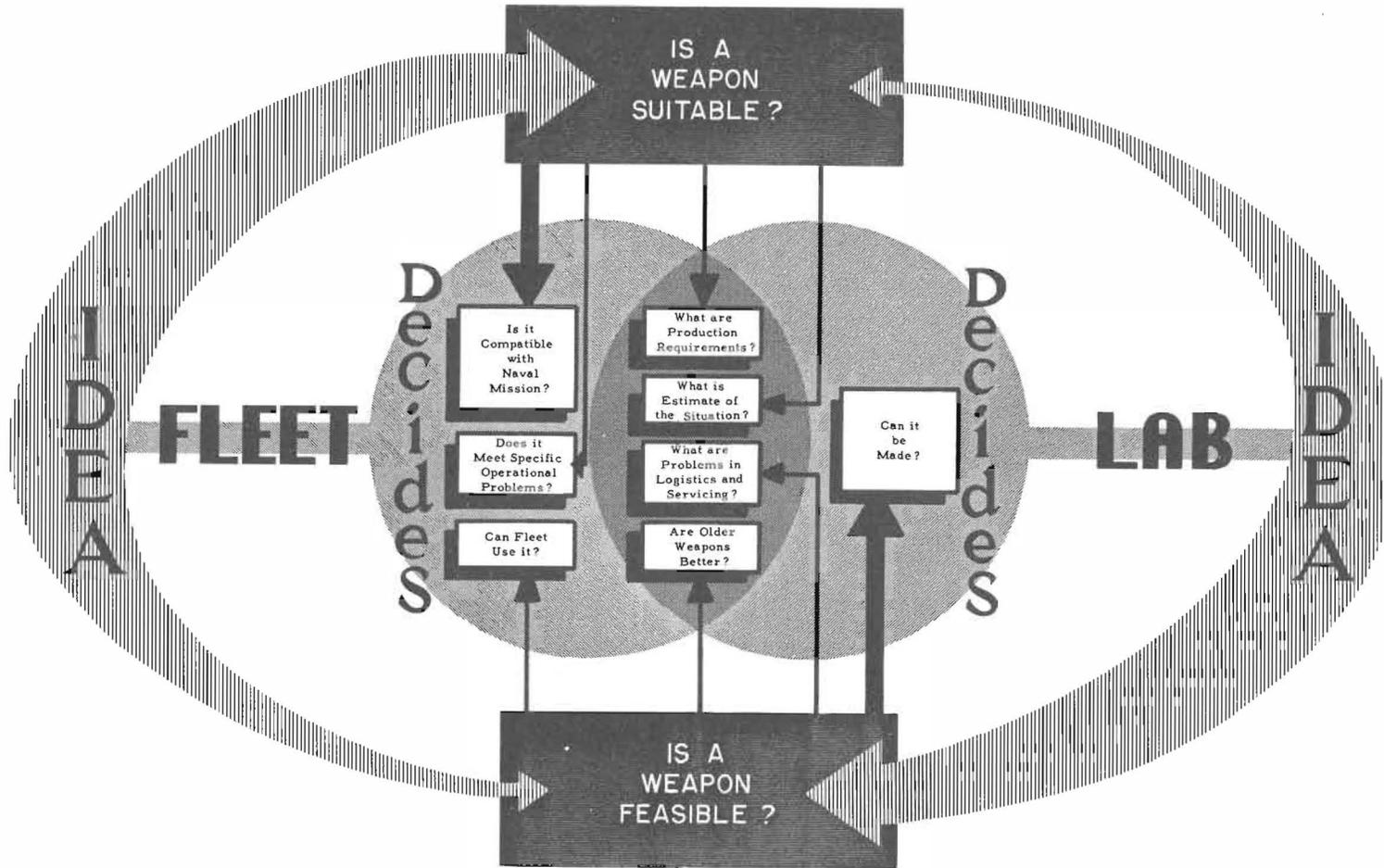


Figure 11 - 1. Weapon Suitability and Feasibility

weeks. Similarly, the general policy in developing mines which called for great sensitivity without flexibility made mines less suitable because of Japanese countermeasures, even though this problem was surmounted by emergency last minute changes by the Mine Modification Unit. If the military users and the civilian technical development engineers had discussed the entire situation frankly, mine development might not have been committed to a false start and the development of the more suitable type of mine pushed to conclusion. Open-mindedness is a requisite in reaching a final decision on suitability which will be a result of the necessary compromises between conflicting operational and technical problems. The Fleet finally determines suitability, though it should make this decision only after all of the technical limitations of the proposed weapons have been exhaustively explained.

If a particular Estimate of the Situation is used as a basis for requiring a particular weapon development, each new weapon must be analyzed to decide on its potential superiority to existing weapons. It must be markedly superior, for though a new weapon might provide, say, a 20 percent gain in accuracy, this gain might be so outweighed by an increase in the complexity of training and logistics that there would be no worthwhile advantage.

In production, both cost and facilities for manufacture must be considered. Comparative costs should be established and evaluated; requirements for special machinery or other specialized facilities must be weighed. The latter might be exceptionally important in the event of competition between particular weapons for a particular part of the nation's productive facilities. And finally, production of a new weapon would have to be viewed in light of the nation's entire productive facilities and stocks of strategic materials. The new weapon might be best in all other respects and yet incapable of actual efficient production because it might force the rescaling of the Nation's entire production facilities of other weapons.

The way in which a weapon meets specific operational problems is the final test to which an otherwise suitable device must be put. A new weapon may answer the basic needs of the Fleet, it may be markedly superior to existing weapons, and it may fit easily into the existing production scheme of the Nation. If, however, it is not screened for suitability in the breakdown of the Fleet mission into specific missions and specific operations, it may still be invalid for use. For example, a superior offensive moored mine might be developed which is needed and practical for production but which cannot be planted in actual operations by existing mine layers because any surface movement in the target area requires more speed than the surface layer possesses, or because the required altitude for aircraft operations may be so high that the plant will be too inaccurate, or because it may require more stowage space than a submarine can afford and still make the operation feasible.

Often the feasibility of a proposed type of operation (not of the weapon) determines the suitability of a weapon. The feasibility of enemy alternative courses of action, countermeasures, or defense, i.e., enemy operations, will affect suitability in a similar way. Thus a weapon which may be adequate in all other respects may still be unsuitable because of operational factors associated with the overall feasibility of the specific operations themselves. For example, psychological attitudes of the operations personnel will radically affect suitability. A weapon may be suitable in all other respects, but if operating personnel dislikes or fears it sufficiently, this alone may make it unusable from the viewpoint of relative effectiveness. Specific operational problems are very significant criteria in finally assessing the suitability of a new weapon, and these criteria are apt to be misjudged if the complete responsibility for new weapon development is given wholly to either a laboratory or to the Fleet or to only one or two individuals of either profession. Each projected weapon must be checked against all known and conceivable operational factors and types of operation in which it might be used before final suitability is established.

Feasibility is related to the technical problem in a very broad sense since technical considerations determine whether or not a proposed weapon can be produced practically. By and large, the problem of feasibility is more important to the development groups than it is to the Fleet, although there are a number of elements in every weapon whose feasibility can only be determined with the help of the Fleet. For example, logistic problems involved in servicing must be considered very carefully. If batteries are required, will they have sufficient shelf life? Will they endure in the tropics? Will they endure in the arctic regions? Among the many practical problems met during World War II, all of which must be used to set the standards a weapon must meet to be feasible, are those of long storage, methods of handling and transportation, exposure to the corroding atmosphere of volcanic islands, corrosion in temporary ammunition dumps, etc.

Technical personnel may be able to produce a weapon, and the weapon may be eminently suitable in operating characteristics, but only the Fleet can determine its feasibility for actual use. Even though feasibility of development is largely determined by technical personnel, there are important limitations imposed by those who operate the weapon. If it requires too advanced a technical training (and knowledge), or if a specialist is required who would be relatively useless for general duties, the weapon may be impractical for widespread use and therefore ultimately infeasible. The Fleet must consider the logistics required by a new weapon as compared with its alternative. For example, one weapon may be capable of providing great accuracy with a relatively small logistic supply, but must be operated by highly skilled technical personnel.

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Another weapon, of relatively low accuracy, may require a much greater logistic supply, but can be serviced and used easily by very inexperienced personnel. The balance is delicate, and predetermined rules cannot be successfully applied.

In the final choice, all of the considerations in determining suitability and feasibility mentioned above must be taken into account, as well as the factors which restrict the older weapons already in use. These considerations should then lead to a firm decision and to the choice of a definite course for the development of a particular weapon or a set of weapons.

STAGES IN WEAPON DEVELOPMENT

The development of a weapon should always coincide with the corresponding development of its countermeasure. Two developmental agencies, or two sets of agencies, should be chosen to conduct the research and development of both the weapon and its countermeasure because the two must interact to produce the perfection of both. Neglecting this aspect may vitiate a weapon because of a trivial weakness. In mines, for example, the A-3 was relatively useless because it was exceptionally vulnerable to explosive sweeping. This was not revealed because of the very inadequate countermeasure development by the Bureau of Ships. Similarly, a bottle filled with gasoline was able to penetrate the apparently invulnerable armor of some of the earlier tanks, taking advantage of a trivial weakness to incapacitate the whole tank. This was later corrected, but it is clear that parallel, coordinated, and equally forceful investigation of countermeasures would reduce such occurrences.

The first step in the development program is to obtain all of the necessary research data that bear on the problem (see Figure 11-2). Research personnel should be fully informed of the nature of the operational requirements and desired performance of the new weapon, and of the reason for the data which they are to obtain. Little or no military guidance is needed in this stage of development. Primarily a matter of obtaining fundamental data, it is best left entirely to the research personnel. However, if the research personnel are not fully acquainted with the purpose of the new weapon there is a danger that the data obtained will not cover a sufficient range and the full possibilities will not be explored. The research group should be charged with the responsibility for obtaining all the necessary data and supplying it to the development group.

The second step in the creation of the new weapon is to assign its development to one engineering group, and simultaneously, the development of its countermeasures to another. The two groups should proceed independently, but should interact by a complete exchange of information on the progress. Furthermore, the earliest models should be countered in actual trial by the countermeasure group, and

the development group should attempt to circumvent these countermeasures. In each case the creative imagination of either group should not be limited by the particular approach used by the other. Possible countermeasures and weapons which the enemy might develop should be taken into consideration by each group. This joint and competitive program will sharpen both developments and drive them rapidly in the direction of the best possible weapon and the best possible countermeasures.

The actual development should begin before the research stage is finally completed. The preliminary development can use the main features revealed by research data. Usually both development programs will reveal the necessity for further research, and this should be obtained as rapidly as possible before the research groups close out their programs. Exchange of research information to the development and countermeasure group is often best done by transferring appropriate research personnel on a temporary assignment until the development and countermeasures reach the stage where the detailed knowledge originally possessed by the research group is no longer needed. At some time during the development program it may be desirable for the development and countermeasure group to carry out small pertinent programs of research rather than to throw trivial problems back to a research group which may have terminated its main program.

When weapon or countermeasure development has reached the point where a laboratory model has been tested and has appealing operational characteristics, the development status should be reviewed by both the Fleet and War Plans to decide whether or not the particular weapon is suitable, feasible, and still desired (see Figure 11-3). The end of the laboratory phase of the development is the appropriate time to review the new circumstances, for the laboratory model will usually not be ready for final testing until several years have passed after the original decision. When a practical device appears, it is necessary to confirm the original developmental decision. This is no time for sentiment. Far less waste occurs if a weapon, no longer needed or bettered by a simultaneous development, is abandoned at this stage rather than continued as a project because work has already been invested.

If continued development is decided upon, the third step in the creation of a new weapon takes place. The laboratory models should be assigned to an industrial company for production engineering and pilot production. This will require the solution of the industrial engineering problems pertaining to mass production, the choice of materials and the elimination of the special skills which are required in the manufacture of the laboratory model and are unavailable for mass production.

The fourth step is the test of the pilot model. During development, extensive tests will have been carried out. These would be part of the development program and

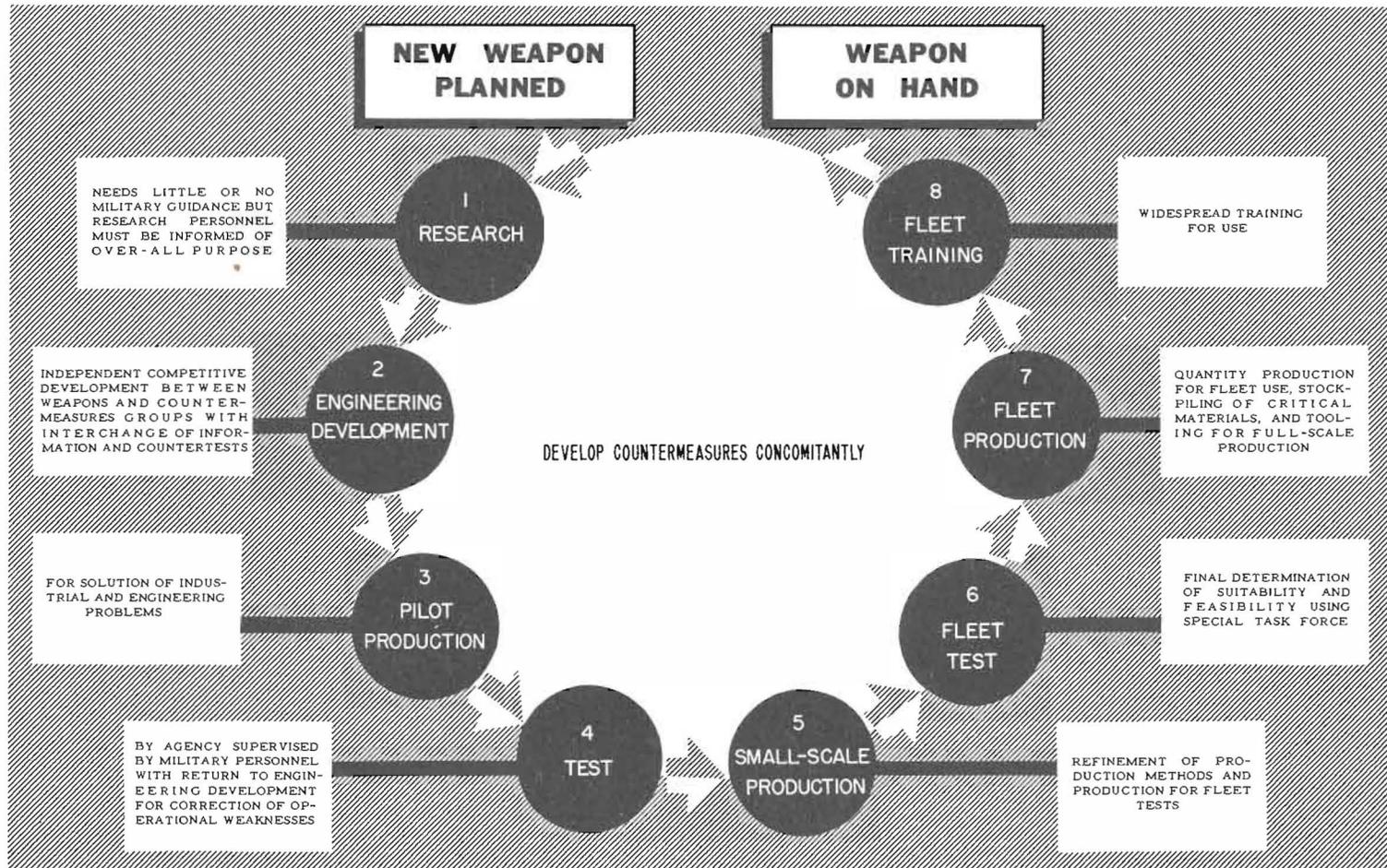


Figure 11 - 2. Stages in Weapon Development

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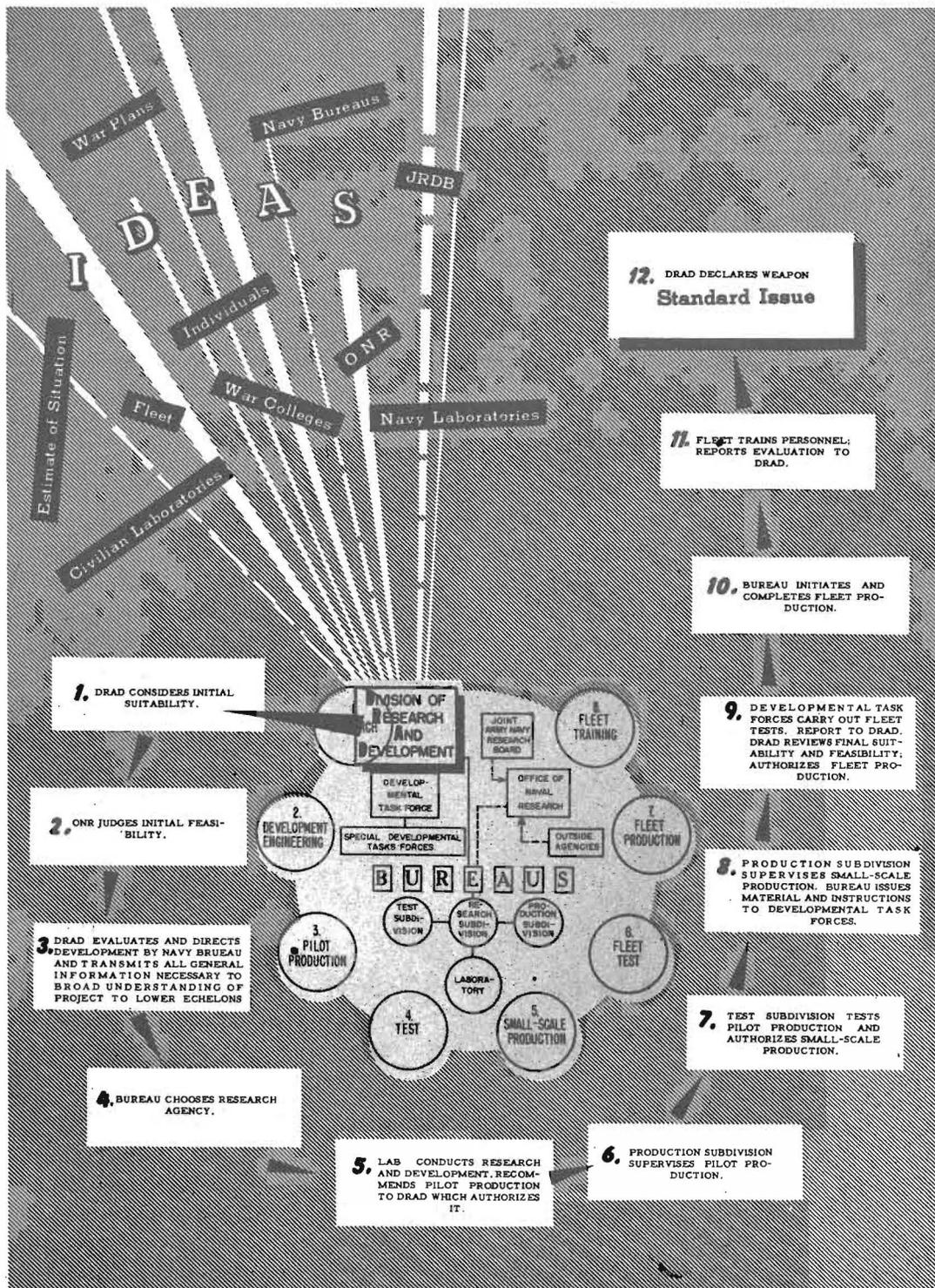


Figure 11 - 3. Procedure for Weapon Development

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would be carried out entirely by development personnel. The test of the pilot model should be much more rigorous and should be carried out by a special test agency supervised by military personnel and not under the supervision of development personnel. Representatives of the development agency however should participate and be free to make suggestions and criticisms. The primary purpose of these tests would be to determine whether or not the weapon is suitable from the military point of view, especially in its operational characteristics, ruggedness, ease of preparation, and, in general, practicability for Fleet use. The test agency, which supervises this phase of development, should be responsible for the final report on the capability and status of the weapon.

The test should be so complete that all important Fleet aspects of the weapon would be revealed, including susceptibility to enemy countermeasures, the logistic problems, the manufacturing problems, and all phases of use or operational planning. If undesirable characteristics or weaknesses are proven, the weapon should be returned to the development agency for correction. Only when satisfactory pilot production has been achieved is the weapon ready for the fifth step.

The fifth step is small scale production by industry in a weapon's final form with corrections made of all the weaknesses shown in the test of pilot production. The purpose of small scale production is twofold, it permits refinement of industrial engineering procedures, and provides a sufficient number of weapons for a Fleet test.

The Fleet test is the sixth step in the creation of a new weapon and should be undertaken by a special task force which makes a final trial of suitability and feasibility of the new weapon for actual use by the Fleet. This is the final decision on the weapon's acceptability, or its temporary rejection for further development if profitable. If the new weapon successfully passes all of the criteria, it is ready for the seventh step.

The seventh step in the creation of a new weapon is Fleet Production. The purpose of this production is to provide a sufficient number of weapons to allow its widespread preparation and use by Fleet personnel as part of their training in Fleet problems. A further object of Fleet Production is this: in the process all the necessary tooling would be carried out by industry, if tooling takes an appreciable proportion of the time required for production, and if industry is prepared by experience to produce the new weapon in the necessary quantities in case hostilities are imminent. This would save stockpiling completed weapons. But on the basis of this production all of the necessary stockpiling of critical materials or critical parts could be planned or carried out, and the production problems weighed in relation to the overall industrial mobilization of the country. This consideration may be vital, because, if the weapon is a very important one, its wide scale production

in time of war might lead to serious bottlenecks. For example, 90 percent of the country's planned production of electronic parts might be needed, or a large amount of scarce material, or a particular kind of craftsmanship not ordinarily available.

The eighth and final step is carried out when Fleet production is available. The Fleet training would acquaint the entire Fleet with the weapon's capabilities and would reveal many new weaknesses and defects not found in the preceding tests and trials. Eventually revisions, usually minor, may be required in the production. It would often be desirable to have both development and industrial representatives attend some of the trials and assist in overcoming defects in training and use. These representatives may be able to help correct field procedures and would at the same time be educated in some of the practicable problems of the Fleet.

The eight steps required in the logical creation of a new weapon are similar to the pattern followed in the development of civilian goods. This pattern has been exceptionally successful in the United States in manufacturing high-quality products which meet the needs of the user. The pattern has been shaped by continuous competition between industrial organizations. The same continuous competition does not exist between military organizations, and consequently the quality of weapons production has suffered severely. It is put to test only at rare intervals, in time of war, when the quality of the weapon is crucial to the security of the country. The step-by-step program outlined above, together with the organizational structure suggested below, would help to supply the severe standards usually provided by commercial competition or by the crucial test of war.

ORGANIZATION FOR WEAPON DEVELOPMENT

One of the strongest reasons for sensible planning is economy. The unorganized development of naval torpedoes at Newport required hundreds of men and consumed millions of dollars over two decades, yet an inferior product was produced which could have been and was quickly bettered. In the cases where development was intelligently planned and guided, they were completed more economically. For example, the Navy developed the magnetic airborne detector at a cost about one-tenth as much as the Office of Scientific Research and Development model. The Naval Ordnance Laboratory model is the one which is being used for postwar geophysical surveys because of its greater versatility and superior performance. Similarly, certain comparable torpedo developments were completed by the Naval Ordnance Laboratory earlier, and performed better, than the devices produced by Office of Scientific Research and Development groups. Yet in both cases the Office of Scientific Research and Development probably averaged an

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appreciably higher quality in personnel, but lacked or actually resisted military guidance.

Throughout this report, the guidance misapplied or absent at the Naval Ordnance Laboratory during World War II has been severely criticized. In an absolute sense this criticism is justified, but on a yardstick furnished by more completely unguided and purely civilian groups, the productivity of the partly-guided developments of the Naval Ordnance Laboratory was outstanding. Its developments were tremendously varied, relatively economical, and were for the most part completed at a very early date. In one fuze design alone, about three hundred million dollars was saved in production costs with the additional advantage of improved performance. Altogether, nearly two billion dollars worth of production resulted from its designs.

It is concluded that unorganized, unplanned, or unguided weapon development will be costly, inefficient, or both. The Navy faces drastic reduction in its operating funds in the postwar period. One can predict, on the basis of public statements, that if funds are curtailed, Navy policy will favor Fleet operations, and perhaps other of its activities, at the expense of weapon development, which will inevitably slip gradually back to its prewar and secondary status in the Naval establishment. This has not yet occurred, but if there must be a choice, it is to be expected that the current value of a striking force will be favored over the potential value of weapon research. This need not be fatal provided each development dollar is economically spent. Required economy can be achieved by careful organization of the development structure.

For insuring the development of new weapons, the following organization is proposed (see Fig. 11-4): (1) a Division of Research and Development (DRAD) should be formed in the office of the Chief of Naval Operations, and under this division, a Developmental Task Force (DTF) as a permanent command with such temporary developmental task forces in addition as may be necessary; (2) the existing Office of Naval Research and Development; and (3) the existing Navy bureaus.

The function of the Research and Development Division of the Chief of Naval Operations will be to direct and authorize research and development in each new weapon or field. This division should be kept fully informed on the operational aspects of future war plans by the War Plan Division of the Chief of Naval Operations and by the War College. It should be directed by Regular Navy Officers of the Fleet during their regular tours of duty ashore. This division, upon its own initiative, should propose and authorize new developments and should authorize the development or research proposed by any other Navy (or outside) agency, or by individuals. On this division should rest complete responsibility for the research and development of the Navy. The developmental task force operating under its authority will grant final approval on the work-

bility of any new weapons.

The Research and Development Division would reserve the right to make the final decision regarding the adoption of a new weapon for production and training the Fleet in its use. The existence of this division and its control by regular Navy officers of the Fleet would make certain that the weapon was both suitable and feasible in meeting the expected Fleet operations in wartime. It would have the responsibility of coordinating each new development project.

The second agency, the Office of Naval Research and Development, would evaluate the technical possibility of new weapons proposed by any agency or individual. This office should pass upon the technical feasibility of a new weapon before development is initiated by the Research and Development Division. Furthermore, the Office of Naval Research and Development would suggest the specific development agency to which would be given the research task. The development agency chosen would usually but not necessarily be one of the Navy bureaus. In making its technical studies this agency should use the joint Army and Navy Research and Development Board and outside research agencies as well as the Navy bureaus. It should be kept informed of the progress of all research and development projects initiated by authority of the Research and Development Division and should advise the division of each development's progress or change in technical feasibility. This office, under the Secretary of the Navy, should be manned completely by civilians, each a competent administrator and skilled in making research and development studies so that the technical evaluations will be of high quality.

The third agency would be the Navy bureaus. Under each bureau there would be three subdivisions for weapon development: the research subdivision, the test subdivision, and the production subdivision. As at present, the function of the Navy bureaus would be to administer and supervise the actual research and development of the new weapon, to make initial tests, and to authorize pilot production for use by the Development Task Force in making Fleet tests.

The bureau research subdivision should be directed by a civilian administrator distinguished in research and development. He may have both officers and civilians as his assistants in work which is essentially that of planning, directing, and coordinating. Besides the service laboratory under bureau cognizance, the head of the research subdivision would also make use of outside research agencies and individuals. The heads of the service laboratories (which are the working establishments) should invariably be civilians with notable research experience.

The test subdivision of the Navy bureaus should be headed by a regular Navy officer who must have both civilians and officers as his assistants. The test subdivisions will test the pilot production which will be used for tests by

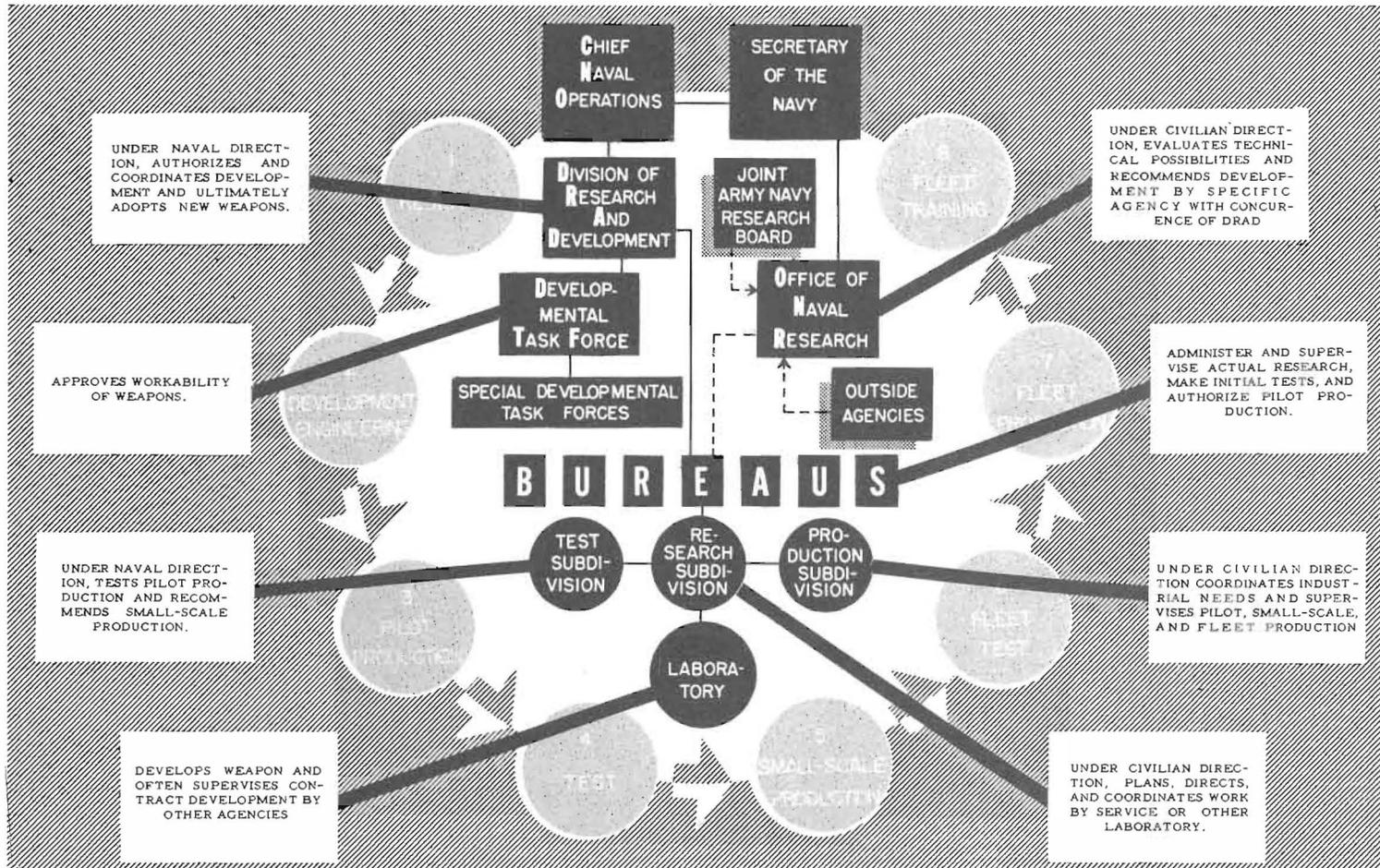


Figure 11 - 4. Organization for Weapon Development

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the development task force. If the new weapon is adopted, the production subdivision of the Navy bureaus would coordinate the needs of industry in the development of the new weapon when pilot production is undertaken. It would administer and supervise the pilot production, small scale production, and final production of the new weapon. This subdivision should be headed by a civilian production engineer familiar with the problems of industry. He may have as his assistants both civilians and officers.

PROCEDURE IN DEVELOPING NEW WEAPONS

The Research and Development Division of the Chief of Naval Operations should keep continuously informed of the Nation's military mission from which the Fleet mission is derived, obtaining it from the War Plans Division of the Chief of Naval Operations and from the War Colleges (see Fig. 11-3). It will also keep informed of needs of the Fleet and of the potentialities of new weapon development as judged by the Office of Naval Research, the Navy bureaus and their development subdivisions, the Joint Research and Development Board, and other outside research agencies and individuals. On the basis of the Fleet missions, the Division of Research and Development will derive appropriate developmental missions or consider possible developmental missions which may be proposed by any military or civilian agency or individual. The Division will transmit all of the appropriate *general* information necessary to a *broad* understanding of the problem to the lower echelons concerned with weapon development, for this information cannot be compartmentalized without harming development.

The Division of Research and Development will consider the suitability of the various proposed development missions and study their comparative merits. Once general suitability has been determined, the second step will be to submit the proposed course of action to the Office of Naval Research for judging its feasibility. The Office of Naval Research and Development will rely on the advice and studies of the various research agencies of the Navy, outside agencies including the Army, the Joint Research and Development Board, and individuals. When this has been done, the Office of Naval Research and Development will report on official evaluation of feasibility to the Division of Research and Development and make suggestions regarding the choice of the development agency. The Division of Research and Development will then make a new decision based on the evaluation of suitability and feasibility.

If the combined suitability and feasibility is found sufficient, the third step is the preparation and transmittal of a directive on development to the appropriate Navy bureau together with complete information on the pertinent part of the Fleet mission and all details of the operational problem. In the fourth step, the Navy bureau will choose a research and development agency (or more than one if necessary), preferably one of its own service labora-

tories, for the development mission.

In the fifth step, the laboratory chosen will conduct the desired research and development and its own development tests using outside agencies when needed. If development is unsatisfactory, reasons will be submitted to the bureau and thence to the Division of Research and Development. If the development is satisfactory, pilot production will be recommended to the bureau and thence to the Division of Research and Development for a final review of suitability. If the weapon is still desired, the Division of Research and Development will authorize pilot production.

The sixth step is by the bureau production subdivision, which will institute the supervise pilot production. As the seventh step, the bureau test subdivision will test the pilot production with observers from the research and the production subdivisions present. If tests are unsatisfactory, the project will be returned to the research subdivision. If successful, the test subdivision will authorize small-scale production.

In the eighth step, the bureau production subdivision will proceed with small-scale production, including the initial manufacture of the necessary tooling for production. When small-scale production is completed, the Navy bureau will issue the material to the development task force together with all necessary training material and accompanying instructions. All information relating to weapon characteristics should be provided jointly by the research and test subdivisions.

In the ninth step, the development task force will carry out Fleet tests under operational conditions. If these are successful, the development task force will so report to the Division of Research and Development, recommending adoption, and will describe in complete detail the operational characteristics of the new weapon and its tactical use. The Division of Research and Development will then review again the weapon's suitability and feasibility for general use. If the decision is favorable, Fleet production will be authorized.

In the tenth step, the Navy bureau will initiate and complete Fleet production and will prepare and name all necessary material for training. In the eleventh step, the Fleet will train its personnel in use of the new weapon and will evaluate its practical performance in war games and practice. The Fleet will then report these results to the Division of Research and Development.

If the results are favorable, the weapon, in the twelfth and final step, will be declared standard issue by the Division of Research and Development until it is superseded or made obsolete by other developments. If made standard issue, continuing production for Fleet training and practice will be authorized. When the weapon is made standard issue, the Navy bureau will initiate and supervise the complete tooling which may be necessary for full-scale war production, if such tooling would require such time as to be

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disadvantageous in war. Such tooling would be scrapped when the weapon is abandoned. A safe and economical way to prepare for war is to prepare for full-scale production of all needed weapons without carrying it out for each one. This preparation will be many times as valuable and economical as full stockpiling of every weapon. The Navy bureau, with the advice or direction of the Chief of Naval Operations, should also make all of the other logistic and training plans in preparation for full-scale use.

The role of independent civilian agencies, such as the great industrial research laboratories or the universities, has not been included explicitly because these agencies do not and should not have a primary interest in the development of military weapons during peacetime. Their part should remain secondary in weapon development since the overall strength of the country in research and industrial potential depends upon the development of the universities and industry along normal lines. This growth will occur naturally, but sometimes outside agencies should engage in research, development, and production for the services under the general direction of the service laboratories, or in rare cases directly for the Navy bureaus. This contract research should be spread as widely as possible over the available universities and industry to educate them in cooperative development and to maintain functioning liaison.

In each case, the outside research and development agencies should be given all of the pertinent operational and research development information to complete the assigned developmental mission. They should participate in all of the other steps discussed above just as though they themselves were part of the Naval Research Organization. A fundamental advantage of this method of operation would be that technical supervision of all of the Navy's research and development work would have real continuity because of the permanence of the service laboratory's technical staff, which would be involved in the supervision of these research and development contracts. If these contracts are supervised directly by the Navy bureaus, direct developmental knowledge will be at a minimum because an enormous technical staff would be required and because bureau officer personnel have such brief tours of duty. The bureaus instead of building a large technical staff should employ only a sufficient number of top caliber civilians to insure adequate *policies* in research and development to obtain the desired performance by the service laboratory.

Coordinating agencies such as the Joint Army and Navy Research and Development Board play an entirely different role from that of the research and development organization outlined for the Navy. This board can certainly assist in evaluating the developmental missions of the military establishments taken as a whole, and can make certain that there are no serious gaps in the overall developmental mission. It can furthermore help to maintain the efficiency of the services by eliminating unnecessary dupli-

cation yet insuring sufficient duplication to check on the otherwise unique work of isolated groups. But such a board cannot be responsible for carrying out the detailed developmental mission of each service.

The writer is definitely opposed to the idea that a national research foundation should itself engage in the supervision or actual development of military weapons. Such work would certainly be too remote from the users and too independent of the military services. The services which will actually use the weapons should dominate the guidance of each development. This is best done if the responsibility and authority remain within each service. During peacetime, civilian development of military weapons carried out with a minimum of military guidance would be weapon development, who consider themselves available development of weapons directed exclusively by officers untrained in research.

The conclusions are that the overall program for weapon development should be controlled by regular officers of the Navy; that all of the work involving administration or technical direction should be carried out completely by civilians, given responsibility and authority within the Naval establishment. Further, research and development are best done in the service laboratories themselves. A definite procedure is required to insure that weapons development is successful, and the structure of a suitable organization has been outlined in detail.

PROGNOSIS

It has been the historical American attitude to shun all thoughts of war in the times between wars. Many scientists and engineers, acting under the same influence, turn their backs on military development during peacetime as a job someone else can do. They consider themselves on call, if needed, but meanwhile many feel they have other work to claim their attention.

The extent to which this limits the number of competent men available for weapon development is hard to determine. It is natural and best for the general progress of the country that most scientists and engineers take up again their work in pure research and civilian development which was interrupted by the war. There are many scientists, however, keenly aware of the role which peacetime plays in weapon development, who consider themselves available and can be tapped if they feel their work would be fruitful. This number is probably adequate and is apt to grow as the need grows, and shrink as popular or governmental awareness of international tension shrinks.

But availability is not enough, because professional pride and a sense of futility will keep the best of the interested men from such work if they feel their efforts will be wasted and their time spent in struggling with procedural and organizational difficulties. This obstacle can be met *only* if an effective partnership between military and

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technical personnel, on the level of high responsibility and mutual understanding of each other's needs and skills, is developed; and if fundamental changes are made in service laboratories so that they can attract and hold competent scientific personnel.

The prognosis is not good. Most organizational traditions are developed for purposes which help nourish the organization, and they become self-perpetuating even though the need for them is past. The effect of Civil Service, which repels the best scientists and engineers by the rigid application of unsuitable personnel methods, is a major instance of the damage such tradition can do. Even those good scientists who have remained with Government laboratories since the end of World War II are beginning to show the effects of an encroachment of Civil Service criteria on their previous high standards. Most of them have fought bitterly, and some with small success, to change the rules, but at the same time the rules have slowly altered their own approach.

There can be no blame attached. Every human being carries the mark of his environment. But it means that improvements are apt to grow less and less important and never cause the necessary fundamental changes. Changes must be basic, promulgated from a high level, and effected in the not-too-distant future before we will have all been lulled again to unawareness of national danger.

Nor have the regular Navy officers had any change of heart which has caused them to lend a helping hand to changes which might jeopardize their jealously guarded control of every function of the Navy. One of the most brilliant regular Naval officers of the writer's acquaintance said to him, "When we get back from the wars, we'll damn well make sure no civilians run the Navy's research." The troubled remark of another regular Navy friend was both warning and explanation. "When you get back to Washington, Johnny," he said, "don't forget you won't ever be able to rely on the help of any of your old friends from the Fleet in anything controversial. The only thing that counts towards promotion in our career is our record afloat. Ashore, our aim has to be not to get into trouble. That means avoid controversy, and the best way to do that is to support the regular policy or do nothing." Few regular Navy officers can be expected to have the courage to buck the tide when it probably means smothering their careers.

Neither do the "free" scientists outside the Navy help their colleagues within the Navy. Convinced, *a priori*, of the futility of government service, their main contribution is to

share in the Navy's grants to research. Some make a fierce attempt to take over the entire job of weapon development. Others merely think the problem a hopeless one so they retreat to the ivory tower until called forth in time of war.

While it is the writer's estimate that competent personnel — and therefore a change in Civil Service method for technical personnel — is the most important improvement needed, the writer feels that the regular Navy holds the key in its hand. The Navy has a fair amount of autonomy in its handling of Civil Service, and unfortunately has used its power flavored by suspicion of the civilian personnel. In effect it has added *more* rules and regulations to make certain that Civil Service rules and regulations are carried out according to the letter. The Navy will hold its own in the tightening competition between the services only if it moves forward, and only if the Navy moves forward can the nation hold its own in future dangers. The Navy can maintain its superiority in technical competence, and therefore its spirit and its service to the country, only if it takes full and efficient advantage of what modern science has to offer. This it can do only by relaxing its control over what is essentially a civilian function — research, maintaining, at the same time, its control of what it wants and what it will use.

There is a happy theory current that science won the war, it can do it again, and all that is needed is a sufficiency of money, men, and equipment. This may produce weapons, but it will not make certain that the weapons are useful or available when needed. Science helped win World War II, but there may not be time again to even help if we go about military research and development in the slapdash way we have done heretofore. If our political and diplomatic strategy fails its mission, and we are once again drawn into war, the winning of it will have its roots in what we do now, and science has a crucial part to play.

Yet, by early 1947, we are all indulging in wishful thinking once again. Each profession, undaunted by the record, feels that it alone has the intelligence, the ability, and the know-how to do the job. The partnership which had its intelligent beginnings during the war years is dissolving and becoming bankrupt. This volume is a warning of the dangers of permitting such a dissolution, and a history of its previewed effects. Planned research and development for weapons holds one of the most important keys to national military security.