

The Link

BULLETIN OF THE NATIONAL CRYPTOLOGIC MUSEUM FOUNDATION, INC.

VOLUME 5, NUMBER 2

Summer 2002

FOURTH GENERAL MEMBERSHIP MEETING

The first General Membership Meeting of the NCMF took place in NSA's William F. Friedman Auditorium in October 1998, as did the second. The third was held in the auditorium of the Research and Engineering building. The fourth would have been held in the latter location in the fall of 2001. Instead, for reasons that are clear to all, the fourth meeting was not held as planned, for the Agency "buttoned up" for a three month period after "9-11." But, in the spirit of the times, NCMF leadership was determined to press on, so a delayed Fourth General Membership Meeting was held on 14 June 2002. Even the venue had changed, to the Kossiakoff auditorium of the Applied Physics Lab south of Laurel, Maryland. One aspect remained unchanged, however: "DIRNSA," - Lt. Gen. Michael V. Hayden, USAF - took precious time to journey across the way and address the session.

Introduced by Gen. Morrison, the Director was, as always with the Foundation, openly appreciative of its contribution to the mission of the National Cryptologic Museum, and, in turn, solidly committed to the role of the Museum in Agency life. Raising his sights over the next ten years, he spoke of the raised profile of NSA, increased funding by the Congress, and Agency preference that it tell its own story. "This Museum," he said, "is the absolutely critical step," as it moves to "the next level." He spoke of the Museum's role as an "engine" for math courses in the schools, and placed foreign languages as the next logical outreach. He

recounted the Hall of Honor additions this summer, and the anticipation of the opening of the Information Assurance section of the Museum in late summer. In the public eye, he noted the movie *Windtalkers* and the appearance of former NSA official ~~and~~ Jacobs on the CNN television show, "Larry King Live." These were examples, he said, of there being "a window on us," and that "we owe the people a clear appreciation of what we do."

President Bush's visit to NSA, as part of his "appreciation" visits to the agencies of the Intelligence Community in the aftermath of 9-11 was extraordinary, Gen. Hayden said. What was intended as a brief visit turned into three hours. The President insisted on "working the rope line" that held back admiring NSA employees, and he spent 45 minutes in that process.

The presence of Army linguists alongside the Special Forces troops in Afghanistan was "the latest star" for the Cryptologic family, Gen. Hayden concluded. (Subsequent to the meeting and as this issue was being prepared for publication, it was learned that Gen. Hayden has been extended an additional year as

Director, NSA.) Keynote speaker for the occasion was Mr. Rich Haver, Special Assistant to the Secretary of Defense for Intelligence. A former Navy (VQ-1) pilot, Mr. Haver is firmly committed to procuring an EC-121 for the National Vigilance Park alongside of the National Cryptologic Museum. Mr. Haver noted that we

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OVERVIEW

Back in August, while walking down the main corridor of the Museum, I was stopped by Connie, the lady who keeps this place in first class shape. "General, do you get paid for your work at the Foundation?" she asked unabashedly. Responding without inquiring about her interest in the matter, I said "No. Only two of our staff, our two administrator ladies, receive wages." We have many others who provide a great deal of their time to Foundation endeavors without compensation of any sort other than job satisfaction and for that we are most grateful. Connie's inquiry prompted me to think about others who might be curious about compensation for those serving the Foundation. Hence this brief message to our members.

While thinking about our administrative staff, I am most pleased to welcome to our ranks a new addition, Ms. Betty Ferrone. Since the departure of Jan Leake, noted in the last issue of *The Link*, Sherri Legere has labored mightily to do the work of two (maybe I should say three or four, for she normally does more than the work of one!). Sherri and I are happy to welcome Betty, a retired sixteen-year Agency employee, and you must drop by to say "welcome" when you next visit us.

On a very different note, I regret to announce the departure of Robert E. Rich, our Vice President. Bob has served me and our Foundation from the beginning, and he has served us superbly, both as my right arm and as Chairman of our Executive Action Committee. We wish him Godspeed as he responds to other demands on his time and energy. A fellow "plank owner," Eugene Becker, who served as our first Membership Chairman and, most recently, my Special Assistant, assumes the office of Vice President. Gene will ensure a smooth transition as we face the challenges ahead.

The Agency has arranged for the Museum to be open again on Saturdays, but with some restrictions: It is now open on the first and third Saturdays of the month, and with revised hours. Please note the times and telephone numbers on the back page of this issue, and feel free to call ahead to ensure your planned visit can be accommodated.

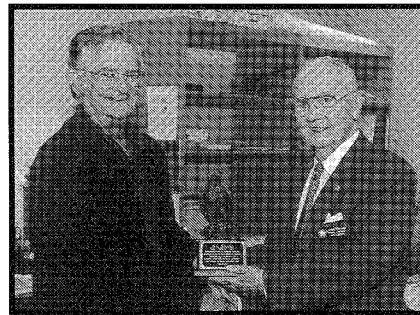
You are doubtless aware that, since the ninety-day hiatus in operation of the Museum last winter, we have not been able to hold seminars, lectures and other NCMF functions "inside the fence" at NSA. Julie Wetzel and her Program Committee have thus far been quite successful in finding alternative locations, either here at the Museum or at off-site locations, such as the Johns

Hopkins Applied Physics Laboratory (APL), a quiet, bucolic atmosphere closed to the general public. We are fortunate to be able to use such a pleasant location, and express our appreciation to the administration and our thanks to Julie.

I also want to thank fellow member Lou Kruh for a highly favorable "review" of our calendar. A long-time co-editor of the quarterly *Cryptologia*, he is also editor of *The Cryptogram*, newsletter of the American Cryptogram Association. In the current issue he spoke highly of the calendar and noted that all profits benefit the Museum. We look forward to increased sales from his readers, who appreciate his knowledge and judgments. (For others of you, it isn't too late to order. These special NSA 50th Anniversary Commemorative Calendars span October 2002-December 2003, illustrated and marked with people, places, and events in cryptologic history. They are most attractive. You'll want one for yourself and as gifts - great historic keepsakes. We're looking into sales on eBay ourselves, before opportunists get a jump on us. And a special note of thanks to Fred Demech, our PAO, who conceived and executed this project: BRAVO ZULU, Fred!)

John E. Morrison, Jr.
President

JIM BOONE: A TOKEN OF APPRECIATION



Jim Boone (left) receiving Eagle service award from Gen. Morrison

In token of his foresight and progressive leadership of the Acquisitions Committee, former Committee Chairman James Boone was presented with an American eagle sculpture, on behalf of the NCMF by Gen. Morrison. Apart from individual items donated to the Museum by the NCMF on his watch, Jim Boone was an effective and "pro-active" voice for the Board of Directors, challenging them and the NCM with what they could become. His primary contribution lay in the establishment of a

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JIM BOONE: A TOKEN OF APPRECIATION

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mutually beneficial relationship with the University of Maryland's Graduate School of Architecture to design proposals for a modern, new replacement facility for the converted motel now housing the NCM. (See "With a View to the Future" in *The Link*, Spring 1999.) He was instrumental in acquiring the hand-held personal guide, the INFORM system, our first major project (*The Link*, Summer, 1998). He promoted expansion of exhibit space devoted to computers and Information Systems Security, only recently achieved. Although he continues to be involved in a yet-to-be realized emphasis on communication and computer security, still "in the works," Jim has had to turn over the reins of his committee responsibilities. He'll be sorely missed. Veteran cryptologist Robert A. Highbarger has taken them in hand. We wish Jim well and look forward to working with Bob.

FIFTIETH ANNIVERSARY POSTAL CANCELLATION

An official U.S. Postal Service pictorial cancellation has been created for the 50th Anniversary of NSA on 4 November 2002. On that day, a representative from the Fort Meade Post Office will be collecting mail and applying the cancellation inside the National Cryptologic Museum from 10:00 a.m. to 4:00 p.m. Bring your properly stamped items to the postal substation, which will be located just inside the main entrance to the Museum. In order to leave sufficient space for the cancellation, addresses should be at least 2 1/4 inches from the top or 1 3/4 inches from the right. The Postal Service also requires a 5/8 inch margin at the bottom. If requested, cancelled items will be handed back instead of entering the mailstream. In this case, the items do not need to be addressed, but still must be stamped.

The pictorial cancellation can also be obtained by mail. Send your stamped and addressed items to:

*National Cryptologic Museum Foundation
50th Anniversary Cancellation
Box 1682
Fort Meade, Maryland 20755*

Requests must be received by 4 November.

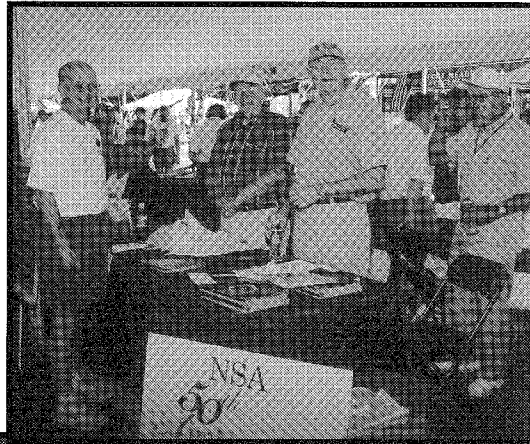


WOMEN IN THE SECRET WAR

On 5 September, the Foundation was pleased to present Karen Kovach of the History Office of the U.S. Army Intelligence and Security Command (INSCOM) on the subject, "Breaking Codes – Breaking Barriers: The WACs of the Signal Security Agency, World War II." This is also the title of a companion monograph researched and written by Mrs. Kovach, under the guidance of James L. Gilbert, command Historian, and INSCOM Staff Historian Dr. John P. Finnegan, which provided the essence of her presentation, augmented by interviews and additional photographs from the National Archives and INSCOM History Office files. As she pointed out, women have always had an active role in the wars of the United States, but never before on a scale and in the forms offered in WWII. American women were needed in defense industries, in the civil service, and in a variety of clerical roles. But women in uniform, women as a component of the Armed Forces, was a new and highly controversial concept, when President Roosevelt authorized the establishment of the Women's Army Auxiliary Corps (WAAC) on 14 May 1942. Later reorganized as the Women's Army Corps (WAC), they constituted the Army's counterpart to uniformed women in the Navy (WAVEs) and elsewhere. Only as classified material has been released in recent years has their role in cryptology emerged in the public eye. Not only in traditional secretarial and clerical roles, but as Morse intercept operators, traffic analysts, and cryptanalysts and, in fact, in virtually all facets of cryptologic operations, these women had an unsung role newly recovered and saluted by INSCOM research. They were assigned to Arlington Hall Station and Vint Hill Farms in Virginia, Two Rock Ranch in California, and elsewhere with the Signal Security Agency (formerly the Signal Intelligence Service, and forerunner of the postwar Army Security Agency). Among those in attendance were Mary Bromble, a WWII Army "codebreaker" (and one of the subjects interviewed) and her husband, Ed. For those viewing the selected photographs and slides, many memories came flowing back – one would swear that some of those very desks of 1943 were still serving the Armed Forces Security Agency of 1949 and the National Security Agency of 1952 at Arlington Hall's A and B buildings. And they'd probably be right!

COMMEMORATIVE CALENDAR

*Capt. Fred Demich and
Sherri Legere
selling calendars on
NSA Family Day*



*Bill, Ed, Gene &
Gen. Hayden*



*Calendar Sales at June
NSA Family Festival
(standing) Fred Demech,
Sherri Legere, (seated)
Bill Arrington, Ed
Jacobs*

*Bill Arrington
Ed Jacobs
Gene Becker*

As a special fund-raiser for the Museum, Fred Demech undertook the funding, design, and promotion of a major project for the NCMF – a pictorial calendar dedicated to the Fiftieth Anniversary this year of the National Security Agency. Underwritten by Eagle Alliance, a joint venture of Computer Sciences Corporation and Northrop Grumman Corporation – to whom we extend again our thanks – and with the cooperation of NSA (concept and historical reference material from the Center for Cryptologic History, design and

layout by NSA Creative Imaging, and sponsorship by the National Cryptologic Museum) the 18-page, 8 1/2 x 11 full color calendar opens to a “picture from the past” at the top and monthly calendar (annotated with some events in cryptologic history) at the bottom. Introduced at NSA’s Family Festival in June, they quickly became a “hot item,” for use, as gifts, and as keepsakes. Selling for a modest \$3.00 (plus shipping and handling), details are given on the NCMF web site. (See back page.) Better get a second one – these are too pretty to use. ■

FOURTH GENERAL MEMBERSHIP MEETING

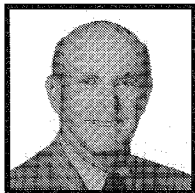
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were still experiencing some “hang-overs” from the Nineties, when cut-backs resulted in squabbles over resource allocation. There was the perception in some quarters that “SIGINT’s best days were behind it.” On the contrary, he said: the future of SIGINT is bright. “The opportunity has never been better than over the next decade or two. The need has never been so great.” But he cited the “triple whammy” of fiber optics, advanced communication encryption, and sheer volume, and the reluctance to take risks through investment, which could only lead to mediocrity. At the same time, he cautioned, we should never fail to “expect the unexpected.” As tests or evidence of the decline in the previous administration, he asked the rhetorical questions, “how many times did the SecDef and DCI meet on intelligence matters?” (Answer: No meetings for 3¹/₂ years.) “What happened to the money the prior Bush administration [of which Mr. Haver was a part] projected?” (Answer: 80% of the “bite” cutting back on the Intelligence budget came from the National Reconnaissance Office and NSA, including money for “the NSA basement” – its large computers. What happened was that “the world changed faster – twice as fast,” and our entire system slipped back. This had resulted in a great deal of “counter-punching,” having to explain, to educate, and to counter the “Tom Clancy novels” conception of the Intelligence Community and intelligence production.

Pre-noon Session

NCMF Facilities Chair Rod Sorokin then introduced participants in a panel discussion, “Moving Toward a World Class Museum: Where We Are.” Panelists were Prof. Ralph Bennett of the University of Maryland School of Architecture (*The Link*, Spring 1999); NCMF Board member, scholar and author, Dr. David Kahn (“Telling the Story”), and Gen. Morrison (“Raising the Money”).

Museum Curator Jack Ingram presented an update on the NCM. He noted that internal responsibility for the NCM had been shifted from the Center for Cryptologic History to the Agency’s Public Affairs Office to emphasize its role in outreach. He recited some of the visiting groups that had profited from tours – the Smithsonian; some 48 schools; the Presidential Classroom; the National Youth Forum; military,



Capt. Forrest “Tex” Biard with John Callahan, Julie Wetzal, and NCMF member “Mike” Levin

the Intelligence Community, and Congressional staff; as well as veterans and senior adults.

Gene Becker, Special Assistant to the President, led a presentation of the actions and status of the Foundation, highlights of which

have been reported in *The Link*. Considering recent dissatisfaction over shortcomings in the financial accounting of corporations, it was comforting to hear from our Treasurer, William T. Kvetkas, Jr., that the NCMF had weathered its first independent audit, and passed with flying colors.

Lunch was then held in the Kossiakoff Center itself.

Afternoon Program

A special treat in the afternoon was an illustrated lecture by CAPT Forrest “Tex” Biard, USN (Ret.), “Breaking of Japanese Naval Codes: Pre-Pearl Harbor to Midway.” With all of the authority of a participant in those stirring events, and still spry in his early nineties, CAPT Biard recalled that Admiral Nimitz once spoke of a time when “twelve men held the fate of the nation.” He proudly identified himself as one of those twelve, and the only survivor; he spoke of legendary “greats” of the Navy cryptologists in the Pacific, including CDR Joe Rochefort, his boss.

ROAD CONSTRUCTION

As noted in the Spring issue of *The Link*, extensive work is underway on Route 32, the east-west road that crosses the Baltimore-Washington Parkway near the Museum. This is an extensive project, from the old Tipton Airfield, past the entrance to Fort Meade and the National Security Agency, to the Parkway. Target date for completion of the entire project is 2006. After seeing some of the details and the work already in progress, comes this simple suggestion: if you’ve been putting off a visit (or re-visit) to the Museum, go now. Don’t delay. The Museum will continue to be in operation and will always reward your patience in getting there, but why make it more difficult for yourself?

MUSEUM DEVELOPMENTS

A large, new, educational exhibit in the Museum relates the story of the Zimmermann telegram, an incident that arguably represents America's entry into the world of *Realpolitik* and led directly to the establishment of a modern cryptologic enterprise. (The encoded cable from the Imperial German Foreign Office – brought to U.S. attention by British authorities – enraged official Washington and then the American people by raising the prospect of returning historic Mexican land to that nation, in return for assistance to Germany in what became WWI – the “Great War.”) Curator Jack Ingram and Jennifer Wilcox, Assistant Curator (who researched the newspapers and photographs incorporated into the display), have been at work on the exhibit for a year, interrupted by events subsequent to 11 September 2001. A revamped display highlights the role of Herbert O. Yardley and his “Black Chamber” that continued America's introduction to cryptology in the First World War. The display features a large portrait of “HOY” on loan from David Kahn, showing a most handsome Yardley at the peak of his game.

The Information Assurance “wing” has been completed, incorporating the SIGSALY mock-up and a wide range of security devices. After five years' gestation and one year of labor, it was opened with virtually no fanfare, but it promises to become a regular visitor attraction.

Props used in the movie, *Windtalkers*, are on loan in the Museum from the filmmaker; others, we hear, were sold on eBay.

Donations from the NCMF recently have included a WWII Nazi-era Baumuster “T-1” radio-telegraph hand key (which may lend itself to an Enigma exhibit) and a large U.S. Army recruiting post, c1905, which, among other features, shows a man involved in visual (flag) signaling in one corner and a man using a field telephone in another – an appropriate display of old and new, as electrical communications were starting to supplant visual.

After the 90-day hiatus last fall and winter, Museum statistics reveal the result, much of which can be attributed to the Saturday closures until recently. The first seven months of 2002 (January-July, inclusive) show 29,101 visitors, 7,360 fewer than the same period in 2001. There were no Saturday openings until July, which had one. This especially

impacted on Scout groups, which prefer Saturdays. (Saturday opening has been resumed on the first and third Saturdays of the month. The consideration now is budgetary, rather than security, and our overworked docents have actually benefited.) Despite the gross figures, tour groups increased – 761 (against 709 in 2001), school groups 56 (vs. 51). There have been 14 media tours.

The Museum is now working to do its part in the forthcoming NSA Fiftieth Anniversary celebration in October and November. The NCM will treat five “eras” with video and “legacy” exhibits. Aided by the NCMF, the Museum is also exploring the refurbishing and opening up of “the back room” – the old motel kitchen – for additional exhibit space.

FORTHCOMING EVENTS

25 October 2002

(National Cryptologic Museum - Time TBA)

A special Museum exhibit will commemorate NSA's Fiftieth Birthday.

16 December 2002 – 1600-1800

(Location TBA in invitation to membership)

“Corregidor: The Cryptologic Story.” In its annual salute to the WWII cryptologists, the Foundation will present a panel of veterans to discuss the final fall-back in the Phillipines and the withdrawal to Australia in face of the Japanese advance.

24 April 2003 – 1600-1800

(Location TBA in invitation to membership)

Former Soviet MG Oleg D. Kalugin will be returning to the NCMF forum, this time accompanied by former KGB COL Vasily Aksilenko. NSA's Robert “Lou” Benson will facilitate. They will discuss KGB strategy against the United States and the Soviet experience in Afghanistan.

Please watch the NCMF Web Site for changes and additions, or contact the NCMF office for information. Due to NSA security considerations, events will continue to be offered “off-site” at other locations, as available and appropriate. If you are interested in attending any of these events, please email or call the NCMF office to sign up.

DEATH OF MEREDITH GARDNER



Meredith Gardner (left)

A talented multi-linguist, an extraordinary code-breaker, the name of Meredith Knox Gardner is enshrined with the story of his greatest conquest, Project VENONA. On 9 August 2002, Gardner died at 89, a victim of Alzheimer's disease. Fluent in German, Old and Middle High German, Sanskrit, Latin, Greek, Lithuanian, Slavonic, Spanish, French, Italian, Russian, and Japanese, Gardner was a native of Mississippi, and had been a university teacher of language until World War II, when he came to Washington and entered the Army's Signal Intelligence Service, a predecessor of the Army Security Agency and a forerunner of both the National Security Agency and the U.S. Army Intelligence and Security Command (INSCOM). Shy and quiet in manner, he worked with both German and Japanese communications during the war. At war's end, he shifted to the study of the communications of a new adversary, the Soviet Union. His work on what became VENONA, – unveiled a scant few years ago, brought him out of retirement from NSA in 1972 into the public eye. His FBI alter ego, liaison officer Robert Lamphere, worked hand-in-glove with Gardner to decode and identify Soviet agents working in the United States, including the Rosenbergs and British spies working deep inside the U.S.-British intelligence establishment – Kim Philby, Guy Burgess, Donald Maclean, and Anthony Blunt, as well as Bill Weisband, a Russian émigré and occasional co-worker.

FOR THE BOOKSHELF

The first issue of the NCMF bulletin, *The Link*, in the spring of 1998 recalled the 1967 Israeli attack thirty years earlier on USS *Liberty*. The second issue introduced the *Liberty* Veterans' Association, along with a recital of the controversial circumstances of the attack – controversial only among those not directly involved. Their story had been told by *Liberty's* Electronic Material Officer, retired Lieutenant Commander James M. Ennes, Jr., in his 1979 book, *Assault on the Liberty: The True Story of the Israeli Attack on an American Intelligence Ship* (Random House – six editions:

Ballantine Books, 1986). A 1993 doctoral dissertation by John E. Borne, *The USS Liberty: Dissenting History vs. Official History*. Dr. Borne (PhD, New York University) probed the circumstances and frustrations that Ennes encountered in trying to have his book advertised and made available in book stores. NSA's own classified study of the "incident," published internally in 1981, was subsequently declassified, and expanded by Aegean Park Press in their illustrated version. In the Winter, 1986, issue of the *Naval Law Review* (Vol. 36), "A Juridical Examination of the Israel, attack on the USS *Liberty*," by Lieutenant Commander Walter L. Jacobsen, JAGC, USN, appeared. His scholarly exposition concluded that the attack was deliberate and "in violation of international law." Now, another doctoral dissertation has been published, *The Liberty Incident: The 1967 Israeli Attack on the U.S. Navy Spy Ship*, by A. Jay Cristol. The author, drawing on his experience as a navy pilot and JAG lawyer, albeit not involved in the incident three decades earlier, was drawn to the subject and defended his thesis – that the incident was, as Israel claimed, a most unfortunate accident, a case of "friendly fire." The Cristol book was received in some circles as the last word on the subject.

Ironically, the Ennes book of 1979 was being reprinted and updated by Reintree Press (2002). It comes with a 19-page addendum, in which the author recounts his involvement with the book and the controversy that it stirred. Taken with the Cristol dissertation (which has been criticized by Dr. Borne, although he had not seen the published version at the time), the two works are stirring the pot as never before. By no means the only voice of the survivors, Ennes has become identified as a spokesman. He is co-manager of a Web site, <http://www.usliberty.org> devoted to their story, and he fields a large volume of e-mail, acting as a clearing house of information. (Both the web site and his e-mail have been subjected to manipulation and "jamming," he has stated, with Israeli sources identified as the perpetrators. Similarly, fellow survivors claim to have been "hooted down," ignored, or escorted out of attempts to rebut Dr. Cristol at public events. Their repeated complaint is that he formally interviewed few survivors, and that he depended heavily on Israeli Navy friends and – since discredited, or at least questioned – American investigating and review panels.)

Among the features of the web site is a memorial for the lost. Contrasting pictures of tombstones and hearty young men are juxtaposed. The bulk of the dead

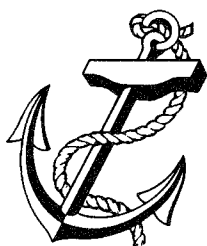
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FOR THE BOOKSHELF

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bear the same notation, "Died in research." No longer as sensitive as it once was, the euphemistic "Research" is clear to all cryptologists. Twenty-five of the thirty-four killed died "in Research". Others were among the 172 wounded – a casualty toll of 69%. They – and their ship – were the target. (The one thing that made the "accident" excuse so unbelievable was and has been the extremely high regard in which the IDF was held in the West – that they didn't make mistakes.)

The survivors still feel that they were deserted by their beloved Navy and by their country, and that the Congress never conducted an investigation as in other such cases – that of the *Pueblo* the following year, for example. Rather than quieting the discontent, Dr. Cristol's book may serve to re-invigorate the argument. Positions have hardened; the sides are polarized, and political agendas abound. If you can, visit the web site, read the books, and decide for yourself.



SOLVING THE ENIGMA: HISTORY OF THE CRYPTANALYTIC BOMBE

Part 3

America Joins the Secret Battle

The complete cessation of Ultra intelligence concerning U-boats in the Atlantic coincided with the devastating attacks on shipping by U-boats off [U.S.] coasts. In fact, the outlook during the summer of 1942 was rather gloomy.¹⁰

Despite its involvement with the British convoys, the United States took none of the precautions learned by its allies. Merchant ships came up the east coast of the United States without the benefit of convoys or escorts. Sailing alone, there were no other ships to come to their defense when attacked by the U-boats. To make matters worse, ships were in plain sight even at night. The United States did not initially require its citizens to black out their homes and businesses at night as the British did. Hence, ships coming up the coast were silhouetted against the bright lights of the cities they passed. The U-boats had no trouble seeing them and sinking them. Add to this the fact that the German cryptologic service, B-

Dienst, could read the Allied Naval Cipher No. 3 used for convoy communications. By reading the convoy messages, the Germans learned of changes and movements in Allied shipping. This enabled them to easily respond and continue to follow and attack the ships. The Germans referred to the spring of 1942 as the "Happy Time." Between January and March they sank 216 ships off the east coast.

The United States didn't begin sending its ships in convoys or require blackouts on the east coast until May 1942. Unfortunately, even these measures made only a small improvement. The Allies still could not read the U-boat four-rotor machine's messages, so there were few ways of knowing where the U-boats were located. The Allies did make use of direction-finding and other reconnaissance measures. This provided limited information, but was no substitute for the valuable Ultra messages.

Bletchley Park and BTM began work to redesign the Bombe for a fourth rotor and promised the United States that a solution would be available by August or September. The U.S. waited, somewhat impatiently, for assistance. Neither the U.S. Army nor Navy had made any breaks into the Enigma problem. Prior to entering the war, the United States was not intercepting large volumes of Enigma messages and had not seriously worked to break it. Assistance from the British would be required if the United States hoped to combat the U-boat attacks off America's coast.

Representatives of both the U.S. Army and Navy visited Bletchley Park prior to the United States' entrance into World War II and knew of Britain's success against the Enigma messages. GC&CS agreed to share information concerning the Enigma, but it was not completely forthcoming in 1941. This may have been due to security concerns. GC&CS was not confident that the United States services would be able to keep the Enigma secret. However, the adaptations to the British three-rotor Bombe were not progressing satisfactorily, and members of the U.S. cryptologic services continued to press Britain for further information.

In March 1942 the U.S. Navy contracted with the National Cash Register Company (NCR) in Dayton, Ohio, to work on the development and construction of other specialized machines. This contract established the Naval Computing Machine Laboratory (NCML). Lieutenant Commander Ralph Meader acted as the liaison between the Navy and NCR. National Cash Register's engineer, Joseph Desch, became the NCML's

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SOLVING THE ENIGMA: HISTORY OF THE CRYPTANALYTIC BOMBE

Part 3

Continued from page 8



*Joseph Desch, designer of U.S. Navy Bombe circa mid-1940s
(Courtesy: Debbie Anderson, daughter)*

research director. The public knew of some of the work conducted by NCML including the production of bomb fuses, shell casings, and aircraft carburetors. However, it would be decades before the people of Dayton, or even his family, learned of the work Joseph Desch did for the Navy. The Navy did an extensive background investigation on him because of his German heritage and relatives still in Germany. He even “jokingly claimed that the Navy had found relatives that he had never heard of.”¹¹ With his background in radio and computing machinery, Joe was indispensable to the Navy’s research in building its own Bombe. Because of the secret nature of the work the Navy needed Joe Desch to do, he was forced to disassociate from all his Dayton relatives, except his mother. “The war demanded immediate, unrelenting research in areas for which Joe Desch was qualified, and he had no choice but to accept the responsibility that the Navy asked of him.”¹²

Meanwhile, in Washington, communication continued with Britain. In April 1942, Colonel John Tiltman from GC&CS visited OP-20-G, the U.S. Navy’s cryptanalytic office, and sent a message back to England: “In view of the fact that [the U.S. is] now at war and have a vital interest in submarine traffic, they are entitled to results . . .”¹³ He also stressed, “Unless a rapid and satisfactory solution is found . . . the high command will insist on their Naval cryptanalysts attempting to duplicate our work on ‘E’.”¹⁴

In July 1942 two U.S. naval officers went to Bletchley Park with the intention of studying BP’s research organization. They had additional orders to acquire more details about the Enigma solution. They learned much about the British Bombe and returned with wiring diagrams. After studying the information, the Navy decided that the development of a high-speed four-rotor Bombe should be designed differently than the British plans indicated. The fact that the British weren’t making much progress with their own design supported this decision.

As the summer of 1942 progressed, it became apparent to Navy officials that the British would not be able to meet the August/September deadline for a four-rotor Bombe. Joseph Desch and other NCR engineers, working with the Navy and Lieutenant Commander Meader, looked for alternative designs to the British plan. They investigated the possibility of both an electromechanical design and an electronic design. They were forced to use the electromechanical plans because of the power requirements of the electronic design and material shortages brought on by the war. By the end of August, the Navy concluded that their design showed sufficient promise to continue and inaugurated their own Bombe program.

Captain Hastings of GC&CS protested. He argued that Britain had lived up to the agreement arranged by Colonel Tiltman in April that stated the U.S. would be given results “or a detailed statement as to why this traffic cannot be read . . .”¹⁵ Since the British had provided a detailed statement, Captain Hastings felt they had met their obligations.

The situation in the Atlantic, however, was of such importance that the U.S. Navy decided they could not accept Captain Hastings’ answer. The German U-boats continued to attack Allied shipping throughout the Atlantic. It was imperative that either Britain or the United States make a break into the four-rotor Enigma machine. With that in mind, Commander Wenger, deputy chief of OP-20-G, officially requested funding for the Bombe project on September 3, 1942. With the consent of the chief of OP-20-G, Admiral Redman, the Bombe project proposal was approved the following day.

Once they learned of the Navy’s intentions, GC&CS sent Commander Travis to the United States for a visit with the Navy. They drew up another formal agreement. This one proposed that the United States take the dominant position in the Pacific Theater, while Britain continued to conduct most of the work in the European/Atlantic Theater. They did agree, however, to share full collaboration on the German submarine problem. Britain did analyze Japanese codes, and the U.S. worked against German and Italian codes despite the agreement. However, the separation of emphasis worked effectively for the remainder of the war.

Just as the Navy drew up the contract with the National Cash Register Company to work on the production of the Bombe, Britain found a way into the four-rotor Enigma messages.

On October 30, 1942, two men from the HMS Petard

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gave their lives retrieving an Enigma and documents from a captured U-boat, U-559.

Several British ships located U-559 in the Mediterranean near Port Said. They tracked, followed, and depth-charged the submarine for hours. The last of more than 100 depth charges caused significant damage to the sub, and the U-boat commander, Hans Heidtmann, ordered the sub to surface. As the German crew abandoned the U-boat, the *Petard* ceased firing and pulled within sixty feet of the floundering craft. They prepared a boarding party. Lieutenant Anthony Fasson and Able Seaman Colin Grazier removed their uniforms and dove into the choppy waters. As they swam toward the conning tower, another young man, Tommy Brown (who had lied about his age to join the Royal Navy), followed.

When Fasson and Grazier reached the sub, they saw it was riddled with holes and taking on water. Quickly they climbed into the control room. Fasson broke into the captain's room and opened a locked drawer. He removed the documents inside and passed them to Tommy Brown, who had followed them down the conning tower. Brown climbed back up to deliver the secret documents to a waiting whaler that had rowed over from the *Petard*. He made the trip again to retrieve more materials Fasson and Grazier had found. The water rapidly filling the sub, he returned for a third trip even as those on deck called for the men to come out. Fasson refused to leave without the box he desperately tried to pry free. It contained what appeared to be important equipment. Tommy Brown carried out one last batch of papers, but did not go down again. Fasson and Grazier finally released the box and tied it to a line to be hauled out of the sub. Brown called down to them twice, "You'd better come up." Just as the men began to climb up the conning tower, the sub suddenly sank. Brown and the others on deck jumped off and were picked up by the whaler. However, Anthony Fasson and Colin Grazier did not make it out of the sub. Their loss was not in vain, for the material they collected in turn saved the lives of many Allied and German men.

The documents Tommy Brown transferred from U-559 proved vital to the cryptanalysts at Bletchley. They included codes for the Short Weather Cipher and the Short Signal Book. The books, combined with a German

communications security error, allowed the British to find a break in the four-rotor messages. The Germans' shore weather stations could read only a three-rotor message. On December 13, 1942, the British team discovered that when the U-boats sent weather messages, they set the fourth rotor into a neutral position. This caused the machine to mimic a three-rotor Enigma. BP needed only to find the three-rotor settings in the usual manner. To find the daily setting of the fourth rotor for nonweather "Shark" messages, they then tested each of the twenty-six places on the fourth rotor.

Suddenly, BP could read "Shark" messages with a slight delay. The actual results were usually delayed thirty-six hours on 70 percent of the days,¹⁶ but were occasionally delayed as long as ten days.¹⁷ Nonetheless, GC&CS was quite pleased with its accomplishment. Once again, the Allies could track the German U-boats with a fair degree of accuracy. For the next several months, the Allied ships played a cat and mouse game with the German U-boats. As BP learned of the subs' locations, ships were rerouted to avoid them. The B-Dienst, reading the Allies' convoy cipher, then rerouted their subs. And again, the Allies altered their shipping route. Across the Atlantic, ships and submarines moved and countermoved, interspersed with attacks.

However, delays in reading Enigma messages resulted in Allied losses. The U.S. Navy, convinced the Bombe designed by Joseph Desch would dramatically reduce the delay, continued its plans to build a high-speed four-rotor Bombe.

Bletchley Park sent Alan Turing to OP-20-G as an advisor in December 1942. Turing viewed the facilities in Washington, D.C., and the Bombe production building in Dayton, Ohio. He was not overly impressed with the American design. "The British didn't believe I would be successful," Joseph Desch later mentioned in an interview. "After the war, [the Navy] showed me the [British] reports and they weren't very complimentary."¹⁸ In Turing's report on his visit he says, "It seems a pity for them to go out of their way to build a machine to do all this stopping if it is not necessary."¹⁹

Despite Turing's opinion, the Navy moved forward with its plans. In April 1943 Navy personnel began arriving at the National Cash Register Company in Dayton. Eventually 200 sailors and 600 Waves²⁰ worked with the NCR civilians to build the Bombes. To explain the sudden influx of sailors and Waves, the official story claimed personnel came for training on tabulating machines. One sailor, Robert Shade, recalls that "Our

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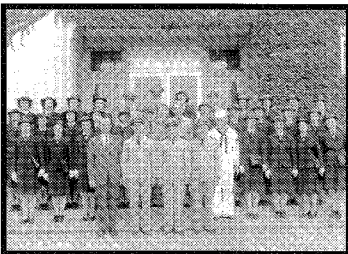
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standard explanation was we were looking for submarines on the Miami River in a rowboat.”²¹ In truth, even the sailors and Waves didn’t know what they were working on. Bob Atha, a sailor in Dayton, said, “The exact function of the Bombe equipment was not explained to me. Because of the strict need-to-know practice imposed, this total knowledge was probably known to only a few analysts and design engineers.”²²

The work Joseph Desch did was so secret Navy security personnel followed him to and from work. He wasn’t supposed to know about the extra protection, but he realized he was being followed. On one occasion, Mr. Desch took his guards on a roundabout route, only to return home without making any other stops. On another occasion he cheerfully waved to the secret men in the car outside his home. They never acknowledged his greeting.²³

Because of the secrecy of the work, Waves had to show their identification to the Marine standing guard. Marines guarded the different rooms inside the building as well. Waves were not allowed to see any other rooms unless they could prove to the Marine they had a reason to go inside. “We only knew what was being done in our assigned work area, but we never were told the implications or the importance of our work. We had no knowledge that the Bombe was being conceived and built directly over our heads on floor two. There were always armed marine guards who saw to it that no one strayed from their assigned work space,” recalled a former Wave, Sue Eskey.²⁴

Waves were also not allowed to discuss their work with anyone outside their specific assignment and never outside of the building. Even the women working together rarely speculated about the purpose of the job.



Joseph Desch, and Waves in front of NCR Building #26, circa 1943. Credit: NCR Archive at the Montgomery County Historical Society.

Sue Eskey suspected that the twenty-six wires she soldered corresponded to the alphabet. Later she remembered, “If you had any intuition or deep thoughts about it you could sort of figure it out. I knew nothing about codes or anything, but I had that thought. And, of course, I didn’t share it

with anyone because we were not allowed to talk about anything.”²⁵

The war did not stand still while the engineers, sailors, and Waves worked to build a machine to break the U-boat Enigma settings. The U-boats continued to stalk the Atlantic. Losses mounted, but the tide began to change in favor of the Allies. As the United States grew stronger, it began to extend its reach beyond simply defending and escorting the convoys of ships. It began to actively seek and attack the German fleet.

May 1943 proved to be a significant time in the Battle of the Atlantic. During May, the Allies inflicted more damage to the U-boats than any time previously in the war. Germany had more submarines prowling the ocean than ever before, but because the tide had turned, they sank only fifty Allied ships.²⁶ This was fewer than the previous month and significantly fewer than their victories in March. By the end of May, Allied forces sank 25 percent of the German submarines, totaling forty-one U-boats.²⁷ Admiral Doenitz conceded the North Atlantic to the Allies and began withdrawing his subs from the area on May 22.

This Allied victory did not put an end to the Bombe project, however. Admiral Doenitz concentrated his forces elsewhere in the Atlantic and continued to be a threat. The need to know where the submarines operated and in what strength was still imperative to U.S. and Allied plans. This had been proven on March 10 when the Germans began using a new edition of the weather short signal code. The new code made the second edition, captured from U-559, useless. In this case, the cryptanalysts were fortunate, for only nine days later they were able to make use of another U-559 captured codebook, the *Kurzsignalheft*, as cribs.²⁸ However, the incident emphasized how important it was to build a machine that was not dependent on captured material.

In fact, by the end of June, the only way to break into the “Shark” messages was by machine. The British, by this time, managed to modify their three-rotor Bombe to accommodate the fourth rotor. However, it required the use of an existing three-rotor machines, thus depriving BP of Bombes needed for Army and Air Force messages. The U.S. Navy Bombe was needed.

Construction of the Bombes proceeded in National Cash Register’s Building 26 in Dayton. Newly arriving Waves learned soldering, how to read electrical graphs, and the general aspects of an electrical education. After that the Waves’ daily routine included eight hours of

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soldering wire. Three shifts of women worked throughout the day: 8:00 a.m. to 4:00 p.m., 4:00 p.m. to midnight, and midnight to 8:00 a.m. Each woman was given a graph to follow and several different pieces of colored wire. They didn't know it at the time, but the Waves were wiring rotors to match those on the Enigma machines.

National Cash Register's assistant engineer, Robert Mumma, played a role in helping to keep the wiring secret. He designed the graphs the women followed and selected the colors of the wires. To make it more difficult for a women to recall the wiring system, he selected colors from a choice of twenty-eight, not twenty-six. He also labeled the commutators and graphs zero through twenty-five rather than one through twenty-six.

The work was tedious and the hours tiring. For her eight-hour shift, a woman wired rotors. When she finished one rotor, another was immediately placed before her. Over 6,000 rotors had to be wired to meet the necessary initial requirements for the Bombes. Also, additional rotors would be needed as replacements. Wave Ronnie Mackey Hulick believed she had failed the battery of tests she had taken when she first entered the service. Surely this was why she had been relegated to such a monotonous task. The importance of the work became apparent only when the Navy transferred her to Washington, D.C., to operate the Bombes.²⁹ Wave Jimmie Lee Long agreed: "The work at NCR was tiring and there was no room for the slightest mistake. Now I understand why."³⁰

Other Waves and the sailors sent to Dayton constructed the rest of the Bombe. They completed the prototypes, named Adam and Eve, around May 1. Members of the maintenance crew, Radio Technician Phil Bochicchio and Radioman K. P. Cook, began working on the machines. They checked the wiring and fixed the oil leaks. After three weeks of inspections, the Bombes were finally ready for operational test runs.

Cryptanalysts in Washington forwarded set-up instructions to Dayton. Like the British Bombes, the American machines required assumed text for cribs. The assumed message corresponded to the cipher and created the settings for the Bombe.³¹ These menus gave Phil and K. P. instructions for setting the dials and rotors on the machines.

On May 28, 1943, on the second floor of NCR's Building 26, Phil made a run on Adam. He set the dials and rotors following his assigned menu. Then he flipped the switch that set the Bombe in motion. The rows of black Bakelite rotors began to spin through each of the twenty-six positions of each commutator. A loud, rapid clicking noise emanated from the huge, gray machine. Then the machine slowed, stopped, slowly reversed, stopped again, and printed out some results before returning to its original forward motion. After only twenty minutes the two-ton "gray elephant" came to a complete stop.

Radio Technician Bochicchio didn't know what the numbers on the printout represented. He ran the settings again to double check it. Adam repeated its actions, printing out exactly the same results. Calling over to his buddy, K.P., Phil showed him what the Bombe had done. K.P. didn't know what the results were either, but they agreed to try the run on Eve. K.P. reset this machine's wheels and dials to match the settings on Phil's menu. Eve duplicated Adam's actions, stopping and printing the same results. If nothing else, the two machines were performing identically.³²

The men took the printout to Lieutenant Commander Meader. The commander also did not understand the meaning of the printout, but instructed the sailors to send it to Washington.

A secure communications line had been set up between National Cash Register and Naval Communications in Washington, D.C. The results of Adam's run were sent to Commander Engstrom, head of the OP-20-GM, a technical branch of Naval Communications. A few days passed before Engstrom replied: "That one hit paid for the entire project."³³ At that time he couldn't explain why, but the sailors learned the importance of the printout a few months later when they returned to Washington. Engstrom told them that based on the rotor settings Adam provided, the cryptanalysts in Washington broke a German U-boat message. The message revealed the location of submarines refueling at sea. As a result, the Allies attacked the "milk cow" and sank three subs.

Which subs the resulting message actually referred to cannot be verified, but beginning with the sinking of the supply sub U-118 on June 12, the U.S. Navy waged



*Phil Bochicchio
Dayton, Ohio, 1943
(Courtesy of Phil Bochicchio)*

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an all-out assault on German submarines refueling. During the summer of 1943, the Allies sank nine to twelve U-tankers. By removing the supply subs from action, the combat U-boats could no longer roam as far or as long as Admiral Doenitz had originally planned. How large a role radio intelligence played in these sinkings is debated; certainly it contributed.

It was, then, the offensive use of radio intelligence, the increased number and perfected technique and team work of carrier task groups, and the greater effectiveness through the improved radar and extended ranges of land-based [aircraft] that accounted for the destruction of the German refueling fleet in the year beginning in June 1943.³⁴

Since Adam and Eve successfully proved that the American-designed Bombes could rapidly find the four-rotor Enigma settings, construction on the Bombes continued in Dayton throughout the summer. Initially there had been some discussion about where the Bombes should be permanently located. If the Bombes stayed in Dayton, they would be near the engineers. Design changes caused by German upgrades to the Enigma, as well as routine maintenance, could be more easily implemented in Dayton. However, it was felt that Dayton was too far from those needing the information the Bombes produced. The Vice-Chief of Naval Operations ruled that the Bombes must be operated in Washington.³⁵

By the summer of 1943, construction on the new buildings to house the Bombes in Washington had not been completed. But in Dayton there would be no delay in Bombe construction or use. The machines began to line the hallways and stairwells of NCR's Building 26.³⁶ In one small room, on a few operational Bombes, some of the Waves leaned to operate the machines based on the cryptanalysts' menus. Although the machines were not fully operational, menus and results crossed the secure communication lines between Dayton and Washington throughout the summer. Finally, at a rate of four per week, U.S. Navy cryptanalytic Bombes began arriving at the Naval Communications Annex on Nebraska Avenue in Washington, D.C. Building 4 was still incomplete when Radio Technician Phil Bochicchio arrived to install the machines. The roof on the second floor, where he set up the first of the Bombes, was just a tarp. It was enough, though, and only temporary.³⁷

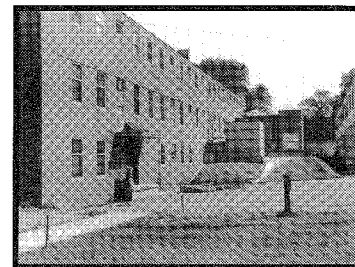
Other naval personnel transferred from Dayton to Washington with the machines, leaving only a handful in Dayton.

Originally a girls' school, the Naval Communications Annex on Nebraska Avenue in Washington, D.C., once again saw women cross its grounds. Waves returned from Dayton to newly built quarters. Other Waves just coming into the service joined them, and together they spent untold hours secretly fighting the Germans.

When the women arrived at their new station, they were taken to the chapel on the grounds of the Annex. An officer impressed upon them the importance of their work and the seriousness of dealing with classified material. This was followed by another officer many women thought to be the chaplain. Expecting to receive a benediction, the Waves were surprised to be told, "If you ever tell what you are doing, you are committing treason. And don't think that just because you are young ladies you will be treated any differently than the men who commit treason. If you ever tell, we will shoot you!"³⁸

Having received their security briefing and greatly impressed with the need for secrecy, the Waves then went to work. Rows and rows of Bombes filled the newly constructed Building 4. Eventually, 121 Bombes would be built in Dayton and housed in this facility on two floors. Divided into bays of four Bombes, each bay required four operators and a supervisor. All of the Bombe operators were Waves. Operators conducted tests on the Bombe before each run, set the Bombes according to the menu, and passed the results back to supervisors for checking. The supervisors assigned each menu, helped with the set-up, checked results, and covered during meals and breaks. Three different shifts worked throughout the day and night to keep the Bombes in constant use.

The American Navy Bombes stood seven feet high, two feet wide and ten feet long. Each weighed 5,000 pounds. The front and back of the Bombes each had eight columns of four rotors. The top wheel mimicked the Enigma's new fourth rotor while the bottom commutator represented the rightmost, or fastest, rotor of the Enigma. The bottom rotor spun at a speed of 1,725



*U.S. Navy Communications Annex,
Building 4*

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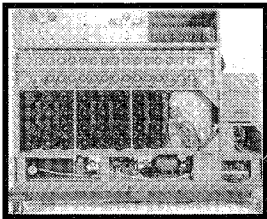
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revolutions per minute,³⁹ which allowed the machines to complete its run in only twenty minutes.⁴⁰

Like the British Bombes, the rotors spun through each of the possible rotor settings. At each contact point an electrical current tried to complete the path required in the menu. Those that could not were discarded. When the machine did locate a complete circuit, it was moving too quickly to stop at the correct location. It took three and a half to four more rotations before the machines could bring itself to a stop.⁴¹ In order to remember where the hit occurred, the U.S. Navy Bombes had "memory" in a unit called the Thyatron chassis, invented by Joseph Desch. After braking, the Bombe automatically reversed itself and returned to the correct position of the hit.

Unlike the British Bombes, the American Navy Bombes printed out the strikes automatically. They then



The Bombe

returned to the forward motion to continue scanning for other workable circuits. Like the British version, the American Bombes usually found two or three possible correct solutions.

After twenty minutes, the machines came to a complete stop, and the Wave operator gave

the printout to her supervisor. Each bay had a small machine officially called an M-9, but better known as a "checker" to the Waves. It didn't resemble an actual Enigma in appearance, but when hand-stepped, did repeat the results of an Enigma. Because the menus used on the Bombes consisted of only fourteen letters, the bombe could not find all the Stecker combinations. The supervisors used the M-9 not only to verify the results, but also to find the remaining plugboard connections. The supervisors then took the valid, complete results to an open room at the back of the Bombe deck where three loggers and the watch officer worked. After being logged, the results were sent back to the cryptanalysts.

Cryptanalysts received the Bombe results via a pneumatic tube system. Some of the Waves used the same M-9 machines to actually decrypt short German messages. They transferred longer messages to paper tape and ran them through an M-8. The M-8 was actually a converted U.S. encryption machine known in the Navy as an E.C.M.⁴² The M-8 used rotors wired to match those on the Enigma. When cryptanalysts fed the paper tape

into the machines, it automatically decrypted the message and printed it out in German. Linguists in another office translated the messages into English for use by the military commanders.

In some cases the Germans double-enciphered messages. They altered the message using a specific codebook before they actually enciphered it on the Enigma. This required additional cryptanalysis by the Allies before a message could be read. To break these messages, cryptanalysts used a captured or reconstructed codebook to strip off one layer of encryption. They could then proceed in the normal routine to retrieve the actual communication.

By the close of 1943, seventy-seven of the requested ninety-six Bombes ran continuously at the Naval Communications Annex. More machines continued to arrive throughout 1944. Improvements made to the standard N-530 resulted in the N-1530. Dayton personnel also built and sent other variations of the Bombe to Washington. These machines worked on other specialized Enigma-type problems. Throughout the remainder of the war, as the Germans altered their Enigmas, the U.S. Navy and National Cash Register kept pace.

With only eighteen four-rotor machines built, and only three of those running routinely, Britain's four-rotor Bombe project never met expectations. In fact, the U.S. Navy cryptanalytic Bombes proved so successful that Britain gave up production of its four-rotor Bombes. In a dispatch to the U.S. Navy, Britain admitted, "performance of our machine is still poor and likely to remain so. In view of your 4-wheel capacity being more than adequate, priority is being given here to the production of new 3-wheel machines"⁴³ The U-boat problem fell exclusively to the United States Navy.⁴⁴

By the spring of 1944, ninety-six operational Bombes routinely broke the U-boat messages. The average delay in breaking the daily key settings was only twelve hours. As a result, the Navy could read all the Atlantic U-boat messages sent in the latter half of the day at the same time as the Germans. "In fact, during these hours the translation of every message sent by a U-boat is at hand about twenty minutes after it was originally transmitted."⁴⁵

Once the Bombes retrieved the daily U-boat keys, the machines were then set to search for non-naval settings. So many messages came out of Europe that even Britain's highly effective three-rotor Bombes couldn't keep up. Approximately 55 percent of the operational

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time on an American Bombe was dedicated to naval keys, the remaining 45 percent on non-naval, under the direction of the British.⁴⁶

To further improve the system, the British requested that the U.S. Navy manufacture fifty additional four-rotor Bombes. Their request was more to further the work done on German Army and Air Force messages than to increase the efficiency of the German naval problem. However, in early September 1944 NCR had completed only twenty-five Bombes, and the navy determined that "Current rapid developments in the prosecution of the war have made it unnecessary to complete the remainder of the fifty (50) additional Bombes."⁴⁷

Certainly, one of the developments that aided in the "prosecution of the war" was the advance knowledge of U-boat locations and activities. Because of the information learned from Enigma messages, the Navy's ability to destroy the submarines increased significantly. By the end of the war, the United States sank or captured ninety-five German U-boats.

FOOTNOTES

10 - Memorandum from OP-20-G, "Brief Resume of Op-20-G and British activities vis-à-vis German Machine Ciphers," July 15, 1944, 1.

11 - Anderson, Deborah, "Joseph Desch and Magic," *Miami Valley History* (1993), 11.

12 - Ibid.

13 - J.N. Wenger, H.T. Engstrom, and R.I. Meader, "History of the Bombe Project," OP-20-G Memorandum dated 30 May 1944, 2 (NARA Record Group 457, File #4584.) Hereafter referred to as *Bombe History*.

14 - "E" refers to the Enigma problem. (Ibid., 6.)

15 - *Bombe History*, 2.

16 - Memorandum from OP-20-G, "Brief Resume of Op-20-G and British Activities vis-à-vis German Machine Ciphers," July 15, 1944, 2.

17 - Beesly, Patrick, "Ultra and the Battle of the Atlantic: The British View," *Cryptologic Spectrum*, v.8 n.1 (Winter 1978), 7.

18 - American Federation of Information Processing Societies, *Computer Oral History Collection, 1969-1973*, 1977. Interview with Joseph Desch and Robert Mumma. (Washington D.C.: Archives Center, National Museum of American History), 116.

19 - *Bombe History*, 7.

20 - Waves were women in the U.S. Navy. The acronym WAVES stood for Women Accepted for Volunteer Emergency Services.

21 - Correspondence to the author from Robert Shade, February 11, 2000.

22 - Atha, Bob, "The Electro-Mechanical Marvel," *U.S. Naval Cryptologic Veterans Association* (Paducah, KY: Turner Publishing Co., 1996), 60.

23 - Anderson, Deborah, "Joseph Desch and Magic."

24 - Correspondence to the author from Sue (Sadie) Unger Eskey, December 20, 1999.

25 - Dalton, Curt, *Keeping the Secret: The WAVES & NCR* (Dayton, OH: self-published, 1997), 21.

26 - Winton, John, *Ultra at Sea* (New York: William Morrow and Co. Inc., 1988), 146.

27 - Helgason, Gudmunder, editor, *U-boat Fates: The Guide to all U-boat Losses*, <http://www.uboat.net/fates/may43.htm> 1999.

28 - Erskine, Ralph, "Naval Enigma: The Breaking of Heimisch and Triton," *Intelligence and National Security*, v.3 n.1 (January 1988), 171-172.

29 - Conversation between Veronica Mackey Hulick and the author, March 28, 2000.

30 - Dalton, Curt, *Keeping the Secret*, 22.

31 - For an explanation of cribs, menus, and Bombe set-up, see Appendix I. [omitted here.]

32 - Conversation between Phil Bochicchio and the author, March 20, 2000.

33 - Ibid.

34 - *Battle of the Atlantic: Vol. II U-boat Operations*, National Security Agency SRH-008, 1945, 127.

35 - *Bombe History*, 6-7.

36 - Conversation between Phil Bochicchio and the author, March 20, 2000.

37 - Ibid.

38 - Correspondence to the author from Sue (Sadie) Unger Eskey, December 20, 1999.

39 - Conversation between Phil Bochicchio and the author, November 26, 1999.

40 - M-7, M-8, M-9 Devices and CSP-890 (A) "The Standard #530 Bombe," (NARA Record Group 457, File #1738.)

41 - Notes on the chassis of the Bombe by Phil Bochicchio, undated, "Bombe" files of the National Cryptologic Museum.

42 - E.C.M. expands to Electromechanical Cipher Machine. An identical machine was used in the U.S. Army and was known as SIGABA (which doesn't expand to anything).

43 - *Bombe History*, 10.

44 - The U.S. Army also had a Bombe project, but it was not built to deal with the U-boats' four-rotor messages. For a brief description of the Army machine, see Appendix II.

45 - Memorandum from OP-20-G, "Brief Resume of Op-20-G and British Activities vis-à-vis German Machine Ciphers," July 15, 1944, 3.

46 - *Bombe History*, 9. However, the memo "Brief Resume of Op-20-G and British Activities vis-à-vis German Machines Ciphers," 3, cites the figure as 40 percent naval and the remaining 60 percent on German Army and Air Force. The memo is dated only six weeks after the *Bombe History*, so it is possible the efficiency improved.

47 - Memorandum from OP-20-G, "Contract NXs-7892 - Curtailment of," September 8, 1944.

This concludes the serialization of the monograph by Jennifer E. Wilcox (less appendices), copies of which are available in or from the museum. Her brief concluding tribute will be carried in our next issue.

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