Fort Drum (El Fraile Island), also known as “the concrete battleship,” is a heavily fortified island situated at the mouth of Manila Bay in the Philippines, due south of Corregidor Island. The reinforced concrete fortress shaped like a battleship, was built by the United States in 1909 as one of the harbor defenses at the wider South Channel entrance to the bay during the American colonial period. It was captured and occupied by the Japanese during World War II, and was recaptured by the U.S. after igniting oil and gasoline in the fort, leaving it permanently out of commission.

The now abandoned fort was named after Brigadier General Richard C. Drum, who served with distinction during the Mexican–American War and the American Civil War and died on October 15, 1909, the fort’s year of construction. The island and the other former harbor defenses of Manila Bay fall under the jurisdiction of the City of Cavite in Cavite province.

The Board of Fortifications chaired by William H. Taft recommended that key harbors of territories acquired by the United States after the Spanish–American War be fortified. Consequently, El Fraile Island was fortified and incorporated into the harbor defenses, Manila and Subic Bays.

Initially Fort Drum was planned as a mine control and mine casemate station. However, due to inadequate defenses in the area, a plan was devised to level the island, and then build a concrete structure on top of it armed with two twin 12-inch guns. This was submitted to the War Department, which decided to change the 12-inch guns to 14-inch guns mounted on twin armored turrets. The forward turret, with a traverse of 230°, was mounted on the forward portion of the top deck, which was 9 ft below the top deck; the rear turret, with a full 360° traverse, was mounted on the top deck. The guns of both turrets were capable of 15° elevation, giving them a range of 19,200 yards. Secondary armament was to be provided by two pairs of 6-inch guns mounted in armored casemates on either side of the main structure. There were two 3-inch mobile AA guns on “spider” mounts for anti-aircraft defense.

Overhead protection of the fort was provided by an 20-foot thick steel-reinforced concrete deck. Its exterior walls ranged between approximately 25 to 36 ft thick, making it virtually impregnable to enemy naval attack.

Construction

Construction began in April 1909 and lasted for five years. The rocky island was leveled by U.S. Army engineers and then was built up with thick layers of steel-reinforced concrete into a massive structure roughly resembling a
battleship, 350 ft long, 144 ft wide, and with a top deck 40 ft above water at mean low tide. The 14-inch M1909 guns and their two custom built turrets, dubbed Batteries Marshall and Wilson, were delivered and installed by 1916. The secondary 6-inch M1908MII guns, Batteries Roberts and McCrea, were installed the same year.

Searchlights, anti-aircraft batteries, and a 60-foot lattice-style fire control tower were mounted on the fort's upper surface. The living quarters for the approximately 240 officers and enlisted men along with the power generators, plotting rooms and ammunition magazines were located deep inside the fort.

World War II
Philippines Campaign (1941–1942)

The successful invasion of Luzon by the Japanese Imperial Army in late December, 1941 quickly brought land forces within range of Fort Drum and the other Manila Bay forts. Just before the outbreak of war in the Pacific on December 7, 1941, Fort Drum had been staffed with men and officers of the 59th Coast Artillery Regiment (E Battery). The wooden barracks located on the fort's deck were dismantled to provide an unobstructed field of fire for Battery Wilson. On January 2, 1942, Fort Drum withstood heavy Japanese air bombardment. On January 12, 1942, a Model 1906 3-inch seacoast gun with a pedestal mount was installed at Fort Drum to help protect the fort's vulnerable "stern" section from attack, and it was dubbed as Battery Hoyle. The very next day on January 13, before the concrete emplacement was fully dry and the gun had been bore-sighted or checked for assurance level, it became the first American battery of seacoast artillery to open fire on the enemy in World War II when it drove off a Japanese-commandeered inter-island steamer apparently bent on a close inspection, until that time, of Fort Drum's vulnerable rear approach (the cage mast control tower masked the fire of the rear main turret, while the height of the gun above water created a dead space even had the field of fire been clear).

The first week of February 1942 saw the fort come under sustained fire from Japanese 150mm howitzer batteries positioned on the mainland near Ternate. By the middle of March, the Japanese had moved heavy artillery into range, opening fire with 240mm siege howitzers, destroying Fort Drum's 3-inch antiaircraft battery, disabling one of the 6-inch guns, and damaging one of the armored case-mates. Sizeable portions of the Fort's concrete structure were chipped away by the shelling. The armored turrets were not damaged and remained in service throughout the bombardment. Counter-battery fire from Fort Drum's 14-inch guns and Fort Frank's 12-inch mortars were ineffective. With the collapse of American and Filipino resistance in Bataan on April 10, only Fort Drum and the other harbor forts remained in U.S. hands.

On the night of May 5, the 14-inch batteries of Fort Drum opened fire on the second wave of the Japanese forces assaulting Corregidor, sinking several troop barges and inflicting heavy casualties. Fort Drum surrendered to Japanese forces following the fall of Corregidor on May 6.
1942, and was subsequently occupied by them until 1945. The 20-ft thick reinforced concrete roof enabled Fort Drum to withstand the concentrated and long continued pounding it received from the Japanese from about February 15 to May 6, 1942. No U.S. personnel on Fort Drum were killed during the siege and only five were injured. The four 14-inch turret guns were never out and were still firing effectively five minutes before the fall of Corregidor. The surrender of the Manila Bay forts marked the end of U.S. resistance in the Philippines.

Philippines Campaign (1944–1945)

In 1945 during the offensive to recapture Manila, the heavily fortified island was the last position in the bay that was held by the Japanese. After a heavy aerial and naval bombardment, U.S. troops gained access to the deck of the fort on April 13 and were able to confine the garrison below. Rather than attempting to break in, the troops and engineers adapted the solution first used some days earlier in the assault of mortar forts on Fort Hughes. There, the troops pumped two parts diesel oil and one part gasoline into mortar pits, stood off, and ignited it with tracer bullets.

At Fort Drum, a similar technique was employed, utilizing air vents on the top deck, but a timed fuse was used rather than tracer fire. Upon ignition, the remaining Japanese were annihilated; the flammable mixture kept a fire burning in the fort for several days. It took 14 days before the fortress could finally be examined. With the Manila Bay forts neutralized, including Fort Drum, Japanese resistance in the Bay area ended.

The Fort Today

The ruins of Fort Drum, including its disabled turrets and 14-inch guns, remain at the mouth of Manila Bay, abandoned since World War II. The fort is being desecrated by looters since the 1970s seeking scrap metal inside the fort for reselling later. The activity is still going on according to a report in 2009.

An automated light was recently installed by the Philippine Coast Guard on the top deck for guiding ships entering the South Channel of Manila Bay.
Serving on the “Concrete Battleship”

The Ship That Couldn’t Sink

By Carolyn Younger
Staff Writer, St. Helena Star.

More than 60 years ago Calistogan Jack Cole served aboard the USS ‘No Go’ the army’s only “battleship” in the Pacific Theater during World War II or any theater of war for that matter. Known officially as Fort Drum, it was originally a coral island at the entrance to Manila Bay in the Philippines. Called El Fraile, it had Spanish fortifications set up in 1898. Between 1909 and 1919 the island was cut down by Americans forces and covered in a concrete shell made to resemble a ship.

Fort Drum, part of the Army’s network of harbor defenses of Manila and Subic bays, was considered impregnable. But with the fall of Bataan and nearby Corregidor on May 6, 1942, Cole, and other members of Battery E 59th Coastal Artillery, learned otherwise. “If we’d had water we could have lasted three or four years --we had the food,” Cole said as he recalled the days before he and the 428 men were taken prisoner.

“See, all the water that came in was brought on water tenders from Caballo Island. Without water we were done for. We had water all around but none we could drink.” Cole, 82, a longtime Calistoga hairdresser and antiques dealer, sports three tattoos, two of them nearly 70 years old. He’s a little hazy on their origins but he thinks the unicorn was done at a state fair in Indiana when he was just barely in his teens and living with his grandparents. Another, a heart with the word “Mother,” stems from the time he ran away to Los Angeles at 13 “to see the wild west.” Instead he spent the night playing checkers with the desk sergeant in a Glendale police station before being sent home. The third and newest of the lot is a sentimental depiction of a dark-haired girl in a polka dot scarf, a tattoo he got while stationed in the Philippines.

And then there are the war memories. He signed up in 1939 and when the U.S. entered the war, he was stationed at Fort Drum, more commonly called “the concrete battleship.”

“The first time I got there was at night and you could hear the diesel motors,” Cole recalled. “You would swear you were on a ship. Everything was designed like on a ship.” There was even a 60-foot fire control cage mast used to direct missiles. “I was spotting planes on the middle of it one time with missiles going right past me,” Cole said. “I was lucky. A missile dropped on the deck about 30 feet
from me and I couldn't hear for about two days.”

The distance of six decades has tempered Cole's wartime memories and added spice to the telling of otherwise horrific adventures.

Fort Drum, 350 feet long, 144 feet wide with a top deck 40 feet above low water, had exterior walls 25 feet to 36 feet thick. It was Cole's home for nearly three years. During the six-month siege, from December 1941 to May 1942, Corregidor — whose guns were being used to support Filipino and American forces on Bataan — was hit with more than 16,000 rounds in one 24-hour period before its fall. Enemy guns were also pounding away at Fort Drum, knocking at least 15 feet of concrete off the decks. “Towards the end there, the whole structure would shake,” Cole recalled.

The end came May 6, 1942, at noon. On the commander's order, the concrete battleship was flooded, the guns drained of recoil oil and fired one last time, the colors lowered and burned. Members of the 59th were either killed, missing in action, or taken prisoner. “I heard there were 428 of us taken,” Cole said. “As far as I know just 28 of us returned.”

Cole and the remaining members of the 59th were taken in fishing boats to the Cavite side of Luzon and from there to Cabanatuan prison camp where men were dying daily from malnutrition, malaria and dysentery.

“People ask me why I didn't try to escape,” Cole said. “It was impossible. On one side was a Japanese military installation. On the other, unchartered territory. Even the Japanese wouldn't go in there, so where were you going to go even if you did escape?”

At Cabanatuan, Cole and other prisoners worked in the fields planting casaba roots and Japanese sweet potatoes. “We ate the vines, they ate the casabas. We'd eat them raw
when we got the chance but it was dangerous because they used night soil for fertilizer.” Food was foremost in their thoughts — its scarcity, and how and where to get it. Cole remembers eating the branches of papaya trees, trimmed of bark and sliced. And eating python. “Six of us captured a python about 16 feet long,” he said. “The Japanese let us take it to camp. So we carried it four or five miles. We ate it. It was good — the python tastes more like chicken, and we craved protein.” “I’d eat anything that didn’t eat me first,” Cole explained, “except rats.”

It didn’t pay to be squeamish, he said. “Some guys said they wouldn’t eat rice because it had rice worms. Now a rice worm is a mournful looking thing, but I ate it all.”

After two and a half years, Cole was sent with others on a prison ship to Japan. Three hundred men or more were lined up in the hold with only a bamboo slop bucket for a toilet, he recalled. “They let us out every so many hours and rinsed us off with salt water but the smell was awful.

The only issue on the ship was coconuts and garlic and most of us had dysentery. That was something.”

Cole worked forced labor in a steel mill between Yokohama and Tokyo then was moved to a copper mine near Hondo. He and his fellow prisoners knew the war had ended when Navy planes began flying over and dipping their wings. Later, planes dropped 50-gallon drums of food. The first drum he came across was filled with chocolate bars and fruit cocktail.

“For a long time I hated chocolate,” he recalled. “I ate so much I was sicker than a dog ... I hadn’t had chocolate for years and the fruit cocktail didn’t help.”

Looking back, Cole doesn’t dwell on why he survived when others didn’t. But he does think about the war — although he knows that he’s losing bits and pieces of those times — and sometimes he dreams he is back in the prison camp. “We had to live by our wits,” he said. “If I didn’t live by my wits I wouldn’t have made it.”

“But,” he added, “I guess my time wasn’t up. I always say, ‘I’ll live ’til I die.”
Retaking Of Fort Drum

YANK (The Army Weekly), August 3, 1945.

The day President Roosevelt died, USS LSM 51 proceeded on a mission described in Time Magazine as one of the oddest of the War. The earlier taking of Caballo was the inspiration for the plan by which the 38th Division cracked Fort Drum. Caballo was a horse-shaped rock and most of its garrison had been knocked off within a few days. A band of 60 survivors, however, had been able to take refuge in two huge mortar pits which resisted all efforts of infantry, engineers and artillery. They were of reinforced concrete and at least 20 feet thick, another case of an installation built by Americans and improved by the Japs. A plan was formulated by LTC Fred C. Dyer of Indianapolis, IN, G-4 of the 38th. An LCM was fitted with a centrifugal pump and two tanks capable of holding more than 5000 gallons of liquid. A special mixture of two parts Diesel oil and one part gasoline was mixed and then pumped into the tanks. The mixture of oil and gas - 2400 gallons of it, was then pumped in the pits. Tracer bullets were fired and set fire to the pits. Only charred Japs were found when the flames died down.

This was the plan selected by BG Robert H. Soule, assistant division commander, as the best for reducing Drum. Training and preparation for the landing were begun a week before Drum D-day. On Corregidor a reinforced platoon of riflemen from Company F, 151st Infantry and a platoon of demolition men from Company B, 113th Engineers, made repeated dry runs to school each man for his individual job when he stepped aboard Drum. On the Corregidor parade ground the surface of Drum's deck was simulated. Dummy guns and air vents were built and each rifleman was assigned to cover a specific opening in the surface of the fort. every gun turret, every air vent, every crack in the surface was to be under the sights of an M1 or a BAR so that no enemy would be able to come topside. The men went through the dry run until they could do it in their sleep.

Some engineers practiced planting explosives at strategic intervals on the rock. Others went through the motions of dragging a fire hose from the LCM to the deck of the battleship-fort. The LCM was scheduled to pull alongside Drum in the same manner used in the Caballo operation. The sally ports were ruled out as possible points of entrance when a naval reconnaissance force, attempting a landing from a PT boat, ran into machine-gun fire from the tunnel. This made it necessary to work from a ship larger than an LCM, so the 113th Engineers went to work on an especially designed wooden ramp, running like a drawbridge from the tower of an LSM. The ramp was necessary since the 40-foot walls of the island would prevent troops from landing in the usual manner.

Three sailors had been killed in the attempted PT landing and this got the Navy's dander up. To pave the way for the taking of the fort, dive bombers were called in to knock out the large guns on its top deck. On Wednesday, April 11, a cruiser steamed up and bombarded the 6-inch gun emplacements with AP shells. The cruiser broadsides weren't enough to breach the fort, but they did shut up the remaining guns.

April 13 - a Friday - was the day selected and H-hour was set for 1000. At 0830 the troops loaded from Corregidor's south dock walking a narrow plank from the pier to an LSM. The engineers carried 600 pound of explosives and the infantrymen were loaded down with rifles and bandoliers of ammunition. In the crow's nest, towering above the landing ramp, a BAR man kept lookout and below him a light machine gun was set up on an improvised platform. The BAR and the machine gun could give covering fire to the men who were to land. At 1000 hours on the nose, the LSM pulled alongside Fort Drum. It was a ticklish job to maneuver the squat, bulky ship snug and tight against the island and to hold it steady there.
As the LSM inched up on the port side of Drum, three LCVPs manned by naval personnel came up alongside her, bows first and with motors racing pushed against her side and shoved her as flat as possible against the cliff side.

As soon as the LSM was close alongside the fort, sailors standing in the well deck let down a ramp by means of a block and fall. Other sailors (Milton C. Browne and William B. McGuffie) rushed ashore across the ramp, carrying lines which they fastened to the Jap-held gun turrets or any other available projections. The LSM was made secure. These sailors were the first Yanks aboard Drum. Just after them came the infantry riflemen in single file up the circular ladder to the tower and from there, helped by sailors, onto the ramp and across it to the flat top of the fort.

Despite the strong lines from ship to fort and the pushing of the LCVPs, the LSM pitched and rolled and the ramp scraped precariously back and forth over the concrete. The operation was at its touch-and-go stage. The LCM which had been used in the Caballo invasion was brought in behind the larger LSM. A line attached to a fire hose was thrown up to the engineers on the LSM and relayed by them to the deck of Drum where other waiting engineers grabbed it and pulled up the hose.

The infantrymen had deployed according to their previous briefing on Corregidor, each man covering his objective. Every vent had its rifleman. No Jap could raise his head above the surface of the deck without running the risk of having it blown off, and the engineers went to work. They planted their explosives to do the most good in the least time. Particular attention was given to the powder magazine which lay below the surface of the first level, protected by a 6-inch armor plate under a layer of reinforced concrete.

All this while the same Diesel oil mixture that had been used on Caballo was being pumped from the LCM into the fort. It was like a high colonic enema given at sea to some ugly, gray Jap monster of the deep. As minute piled on minute, more and more oil - 3,000 gallons in all - was squirited into the bowels of Drum. In 10 minutes, the job of the engineers was finished. Thirty-minute fuses were lighted and the engineers and riflemen began to file back onto the LSM. Suddenly an unidentified engineer shouted, “The oil line’s busted!”; By this time all the men were back on the LSM.

LTC William E. Lobit, CO of the 151st called for volunteers. “Six men, up here. Let’s go.” More than six men fell in behind him and took off up the ladder and across the ramp to the island. The oil, still pumping from the LCM which had pulled about 100 yards away, shut off the instant the hose connection broke apart. The LCM pulled in again and engineers hung over the side and repaired the break. By good luck, the hose was still above water, held up by a floating oil drum to which the next to last section had been lashed.

Col. Lobit and his men snuffed the fuses and stood by to re-light them as soon as the break could be repaired. It was while they were waiting that the first and only opposition to the combined oil enema and demolition job developed. An evidently near-sighted Jap sniper, hidden in one of the 6-inch gun turrets on the port side opened up. His aim was bad on the first two shots and gave away his position without doing any damage to the Yanks. Sailors, manning the LSM’s 20-mms were ready and anxious to spray the turret, but a red-headed (Ens Treece) yelled from the bridge for them to hold fire. Oil was leaking from an aperture in the turret and if a shell ignited it, our own landing party, the LSM, the LCM and the LCVPs would probably all be blown to hell along with the Japs. The sailors held their fire.

The sniper opened up again and a bullet cut through the fatigue jacket of SGT Mack Thomson of Springfield, MO, the colonel’s driver and radio operator. Thomson had been standing amidships unaware that he was a target. The bullet made seven holes, passing through the outside of the jacket, the baggy pocket and a sleeve. Thomson wasn’t even scratched. Another sniper bullet grazed the back of CPL Vincent Glennon’s right hand. Glennon, an aid man from Gary, IN, had dropped behind a ventilator for protection at the
first sniper shot. The bullet went through the light, thin metal of the ventilator and creased his hand, drawing no more blood than a pin scratch. A sailor, Steve Bukovics, a PA native, had worse luck. A Jap shot split the fittings that connected the three air hoses to the gyroscopic sight of his 20mm gun and several pieces of the scattered wreckage were embedded in his throat. Army and Navy medics teamed up to give him an immediate transfusion and to dress his wounds. He, Glennon and Thomson were the only casualties. A bargain-basement price to pay for Fort Drum.

By now the leak had been repaired. Col. Lobit and his men relit the fuses on the island and got back safely to the ship. The lines from the LSM to Drum were cut and all the ships pulled away. Drum had received its quota of oil and the late invaders stood off in the bay to watch the show. In 30 minutes there was a slight explosion, not much more than a 4th of July token. Nothing else happened. Disappointment was written on the face of the GIs and the sailors. The job would have to be done over. But before they could even phrase a gripe, the second explosion came. In the time of an eye wink it seemed as if the whole island of El Fraile were blown out of the sea.

First there was a cloud of smoke rising and seconds later the main explosion came. Blast after blast ripped the concrete battleship. Debris was showered into the water throwing up hundred of small geysers. A large flat object, later identified as the 6-inch concrete slab protecting the powder magazine was blown several hundred feet into the air to fall back on top of the fort, miraculously still unbroken. Now the GIs and sailors could cheer. And they did. As the LSM moved toward Corregidor there were continued explosions. More smoke and debris.

Two days later, on Sunday, a party went back to try to get into the fort through the lower levels. Wisps of smoke were still curling through the ventilators and it was obvious that oil was still burning inside. The visit was called off for that day.

On Monday the troops returned again. This time they were able to make their way down as far as the second level, but again smoke forced them to withdraw. Eight Japs-dead of suffocation- were found on the first two levels.

Another two days later another landing party returned and explored the whole island. The bodies of 60 Japs-burned to death- were found in the boiler room on the third level. The inside of the fort was in shambles. The walls were blackened with smoke and what installations there had been blown to pieces or burned.

In actual time of pumping oil and setting fuses, it had taken just over 15 minutes to settle the fate of the “impregnable” concrete fortress. It had been a successful operation in every way but one: The souvenir hunting wasn’t very good. Story filed by SGT Thomas J. Hooper, Field Correspondent. Other war correspondents coming on board included Walter Simons, Chicago Tribune, Lindesay Parrod, New York Times, Frank Kelly, New York Herald Tribune, Guy Richards, New York Daily News.
The Proximity Fuze

History of Communications-Electronics in the United States Navy, Captain Linwood S. Howeth, USN (Retired)

Editor's note: The development of the proximity fuze is possibly one of the greatest inventions from the Second World War and is still in use today. Many point to its development as critical to the victory in the war. This article was written in 1963.

THE NAVAL FIRE-CONTROL PROBLEM

The control of projectiles fired from a moving and unsteady platform is one of the most difficult procedures of warfare. The difficulties increase rapidly with range and motion of target and are still further increased when a very small high-speed target is capable of motion in both vertical and horizontal planes and can make radical course and speed changes. The problem must be solved instantaneously and produce absolutely correct course, speed, range, bearing, and position angle, otherwise the predicted point of contact of projectiles and target will be in error and the target will continue undamaged. A duck hunter instinctively takes these variables into account when he takes a lead on his fowl, but he does not have to determine the instant of exploding his charge for that is done at the time of firing, and his charge goes out covering a space that increases rapidly until its range is reached. In long-range firing against aircraft this variable, the time of flight of the projectile until it reaches the proper position in relation to the target, must be considered. At the instant it reaches this position the fuze must detonate the projectile.

With a visible target on a steady course at constant speed, the bearing and position angle can be continually supplied the fire-control equipment electrically. Prior to World War II and the concurrent development of radar, an approximation of range was made by optical equipment and supplied manually to the fire-control equipment. With these three variables the fire-control equipment could determine course and speed and predict future position. However, there was the required estimation of fuze setting, any error in which created a corresponding error in burst. The development of fire-control radar increased range accuracy and allowed it to be fed electrically to the fire-control equipment. There were still inaccuracies in fuze settings which increased with the shorter and shorter solution periods brought about by increased target speeds. Even with extremely accurate bearing, position angle, and range being provided the fire-control equipment to permit it to generate predicted position and to provide gun-laying data, the errors in fuze settings necessitated saturation

Powered or unpowered threat

anti-air munition with proximity fuze

Surface vessel
firing. This was not too effective a defense and its effectiveness decreased more than proportionally with the number of different directions in which the attacking planes came in.

The requirement for a fuze which would detonate a projectile when its target was within its burst range (approximately 70 yards for a 5-inch projectile) was obvious, the means of accomplishing this were not. The ultimate solution is a tribute to the Navy, American scientists, and the American electronics industry.

EARLY ATTEMPTS TO DEVELOP A PROXIMITY FUZE

For a decade prior to World War II, the Navy's Bureau of Ordnance had considered the possibility of developing an infrared fuze which could be triggered by the heat developed by an aircraft engine. The complicated engineering problems involved had proven too great an obstacle to its development.

In the summer of 1940 improved capabilities of aircraft and the precarious international situation necessitated exploration of the entire scientific field, with the highest priority, to the end that a fuze be developed which would detonate a projectile when in proximity of an aircraft. During July meetings a group, constituted of members of the National Defense Research Committee and the Navy Department Council for Research, decided that the development of such a fuze was possible by utilizing either electronic or photoelectric devices. There were no stipulations as to the techniques to be investigated. One month later, the Bureau of Ordnance gave influence fuzes top priority over all projects that it had requested the National Defense Research Committee to investigate.

Later in that month, it was learned that two of our largest electronics manufacturers were providing the British with thousands of vacuum tubes and photoelectric cells. This led to the belief that they were being used for some type of proximity fuze. Following the arrival, in September 1940, of the British Technical Mission, headed by Sir Henry Tizard, this suspicion was confirmed by a presentation of a summary of their unsatisfactory progress in that field.

During August 1940, Section T of the National Defense Research Committee was established under Dr. M. A. Tuve of the Carnegie Institution. Arrangements were made for the research to be conducted at the laboratory of the Department of Terrestrial Magnetism of the Carnegie Institution, Washington. In November 1940, the Bureau of Standards joined section T on the project and for a few months both of these activities conducted independent research, each working on a variety of devices applicable to a wide range of projectiles. Since the Navy's basic and urgent requirement was for a fuze for antiaircraft projectiles, fired from rifled guns, the work of the two activities was separated in July 1941. Thereafter, Section T devoted its entire energies to this problem, while the Bureau of Standards concentrated on influence fuzes for nonrotating projectiles.

In November 1941, the Bureau of Ordnance contracted with the Crosley Corp. to conduct independent research in fuze construction under the technical supervision of the National Defense Research Committee. This industrial concern was expected to provide realistic engineering design rather than development. Meanwhile, the National Defense Research Committee had made and was continuing to make contracts with numerous companies and universities. The pace of development was so rapid that it exceeded all available research facilities.

The growth of the project was so great that it required increased administrative support. Accordingly, in March 1942, it was placed directly under the Office of Scientific Research and Development, which contracted with Johns Hopkins University to provide for its administration. The secret classification of the project necessitated the provision of secure space for this. The University established the Applied Physics Laboratory at Silver Spring, Md., a suburb of Washington. This Laboratory quickly became the focal point of the project.

During the early months acoustic, thermal, electrostatic, and magnetic types were studied and then abandoned as unsatisfactory. Considerable emphasis was placed on the utilization of photoelectric cells and one was practically completed in early 1941, but the cells failed to withstand...
the centrifugal force developed by the rotating projectile. Moreover, such a fuze was unsatisfactory since it required daylight for operation.

THE DEVELOPMENT OF THE PROXIMITY FUZE

In early 1941, all contractors supported by Navy funds were directed to concentrate on the development of an electronic fuze. Several means were immediately studied. Among these was one in which the transmission of radio waves from the ground would be reflected by the target and received by and activate the fuze. Another, more logical and the ultimately accepted approach, was to develop a fuze which was capable of obtaining its own intelligence and of using it to ignite the demolition train. In completed form, this fuze would consist of four principal components: A minute radio transceiver, complete with amplifier and capacitor; a battery; an explosive train; and the necessary safety devices. The theory was that the fuze transmitter, alone, would not produce sufficient signal intensity to trigger a thyratron tube switch. However, as the projectile approached a target the radio waves reflected by the target would gradually increase and come more and more into phase with the fuze-generated signal until by the time it was within the fragmentation pattern the intensity of the combined waves would trigger the thyratron tube switch. This would, in turn, release the energy in a charged condenser which would ignite the explosive train. Schematically, it had the appearance of a Rube Goldberg creation. Actually, it was a brilliant conception. To convert it to a workable device required the development of radio components rugged enough to withstand an accelerative force 20,000 times stronger than gravity and a centrifugal force set up by approximately 500 rotations per second, yet small enough, together with the other three components, to be contained in a space approximately the size of a pint milk bottle.

Had the requirement for miniature components of the required ruggedness been submitted to any electronic equipment manufacturer during peacetime he would have most probably shaken his head and declared them far beyond the engineering capabilities of his staff. However, the increased defense such a fuze would provide our ships and cities was sufficient to cause them to make the endeavor. Miniaturization had already had a start in the manufacture of electronic hearing aids but ruggedness was not an essential requirement of that field.

During the development period, the tubes were handmade by engineers of the Western Electric, Raytheon, Hytron, Erwood, and Parker-Majestic Cos. As might be expected, quality varied but intermittent tests conducted throughout the latter half of 1941 offered promise. Wherever weakness was found it was corrected by redesign and strengthening until eventually satisfactory handmade products which were capable of tooled mass production became available.

On 29 January 1942 a group of fuzes with miniaturized components and dry cell batteries, assembled on a pilot line, were installed in standard 5-inch antiaircraft projectiles and fired from a 5-inch 38-caliber antiaircraft gun. At the end of a 5-mile trajectory 52 percent successfully activated themselves by proximity to water. This might appear to be a low percentage but this offered protection far greater than that afforded by saturation firing. The Bureau directed the Crosley Corp. to commence pilot production of the fuzes without delay. At this
time it was given the designation VT (variable time).
During the drawing-board stage of the fuze, it had been considered that a small dry cell battery would provide a satisfactory source of energy. During the development period it was found that these batteries often failed to withstand the shock of gunfire and, moreover, were of short life under shipboard storage conditions. Especially in the South Pacific, continued use of this type would require their constant replacement and would cast doubts as to the reliability of the fuze. Parallel research to develop improved dry cells and a wet battery, wherein the electrolyte would be kept separated from the electrode until after the projectile was fired, was concentrated at the Cleveland, Ohio, plant of the National Carbon Co. The latter type proved feasible and was developed into a cylindrical battery, resembling a fountain pen, wherein the electrolyte is contained in a glass ampule at the center of a cylindrical cell of thin plates. Upon the firing of the projectile the shock breaks the ampule, the electrolyte is released and the centrifugal force generated by the rotation of the projectile forces the liquid between the plates and activates the battery. This battery was ready for experimental testing in February 1942.
Development of the fuze continued concurrently with the pilot production at the Crosley Corp. plant. In April 1942, firing tests, in which the new battery was utilized, were conducted successfully, using a small plane suspended from a barrage balloon as a target. Following this, extensive work was conducted to adapt the necessary safety and self-destruction devices to the fuze. After conducting another test, similar to the one conducted on 29 January, 70 percent of the fuzes detonated, and a decision was reached to conduct a shipboard firing test.

SERVICE TEST OF THE VT FUZE

On 12 August 1942, the first precombat service tests were made by the newly commissioned U.S.S. Cleveland, Capt. S. E. Burroughs, USN, commanding, then shaking down in the Chesapeake Bay. Radio-controlled planes (drones) were used as targets. The Gunnery Officer, Lt. Comdr. Russell Smith, USN, was an experienced fire-control officer. His guncrews consisted of approximately 10-percent experienced personnel with the remainder being newly enlisted, who were serving on their first ship. Smith, with his nucleus of experienced personnel, worked assiduously before and during the shakedown period to train his fire control and guncrews and achieved magnificent results. The tests were scheduled for a period of 2 days and were to be conducted under simulated battle conditions. All three available drones were destroyed early on the first day, while their controllers were putting them through all possible evasive maneuvers, by the bursts of four proximity fuzed projectiles. This was an astounding and pleasant sight to all who witnessed it and it was especially so to those who had served in the task force which...
had made the strikes against the Marshalls, Wake, and Marcus in the early months of 1942, and were aware of the impotency of our antiaircraft defense. Here was a device which would force enemy aviators to be more respectful of distances or else activate our fuzes to accomplish their own destruction.

EARLY PRODUCTION UNDER FLUID SPECIFICATIONS

Following the Cleveland tests fluid specifications, which permitted incorporation of later developments, were drawn up for mass production of the fuze and manufacture was commenced. Those produced were shipped to the Ammunition Depot, Mare Island, Calif., for assembly into antiaircraft projectiles. Samples of these were flown back daily to the U.S. Naval Proving Ground, Dahlgren, Va., for verification of quality.

INITIAL COMBAT USE

When, in the middle of November 1942, 5,000 rounds of proximity-fuzed projectiles were in storage at Mare Island, they were rushed to Noumea for distribution to ships of a task force in the southwest Pacific. The first ship to introduce them to the enemy was the U.S.S. Helena. On 5 January 1943, four Japanese bombers attacked the task force and the Helena downed one with the second salvo of proximity-fuzed ammunition.

SECURITY RESTRICTIONS ON USAGE

Realizing the necessity of keeping the details of the fuze from the enemy, the Combined Chiefs of Staff issued a ban against its use in any locale where a dud or live ammunition might be recovered by the enemy. This restricted its usage to naval warfare and also prevented it from being used in naval bombardment of enemy-held territories.

FULL-SCALE PRODUCTION

Following the Crosley Corp. contract, production was increased with great rapidity. Beginning in September 1942, newly established facilities commenced producing the rugged miniature tube in large quantities. In October 1942 an average of 500 tubes were being manufactured daily. After the fuze had been proven in combat the expansion of manufacturing facilities was rapidly increased. By the end of 1943 almost 2 million had been delivered. By the end of 1944, 87 contractors, operating 10 plants, were manufacturing parts of the fuze which at that time were being delivered at the rate of 40,000 per day. Pro-
Procurement contracts increased annually from $60 million in 1942, to $200 million in 1943, to $300 million in 1944 and were topped by $450 million in 1945. The increased volume and improved production techniques lowered the cost per fuze from $732 in 1942 to $18 in 1945. This permitted the purchase of over 22 million fuzes for approximately $1,010 million.

Fuze assembly was concentrated in the plants of the Crosley Corp., the Radio Corp. of America, the Eastman Kodak, and the McQuay-Norris Cos. Mass-tube production finally had to be limited to Sylvania Electric Products, Inc., since they proved to be the only firm capable of combining quality and quantity. Cost of tubes declined with increased production from $5.05 in 1942 to $0.40 in 1945.

COMBAT USAGE DURING 1943

During 1943 approximately 9,100 rounds of proximity-fuzed and 27,200 rounds of time-fuzed 5-inch antiaircraft projectiles were fired. Fifty-one percent of the hits on enemy planes were credited to VT-fuzed projectiles. Its success in repelling air attacks against fleet units reached its peak when a task group in the Pacific reported the destruction of 91 of 130 attacking Japanese planes. It was being used with like effect against the enemy in the Mediterranean and Atlantic theaters.

REMOVAL OF SECURITY RESTRICTIONS AND COMBAT USAGE DURING 1944

During 1944 happenings of dire nature in the European theater of operations necessitated the lifting of the ban against the use of the fuze where it might be recovered by an enemy. On 12 June 1944 the first “buzz bomb” fell on London and it was followed by steadily increasing numbers. The all-out valiant effort of the Royal Air Force failed to cope with the new weapon. The Combined Chiefs of Staff reluctantly agreed upon the necessity of using the proximity fuze in the defense of London. Large numbers of antiaircraft guns were moved to the channel coast where they could fire at the bombs over water. Success in destroying the bombs by gunfire increased proportionally with the increase in the use of VT-fuzed projectiles. In the last month of the terrifying 80 days, 79 percent of the bombs engaged were destroyed as compared with the 24 percent destroyed during the first week of the attacks. On the last day of large-scale attacks only 4 of 104 bombs succeeded in reaching their target. Some of the 100 destroyed are credited to the Royal Air Force and to the barrage balloons but the major-
ity were victims of proximity-fuzed projectiles. There was little profit to the enemy with such a minute percentage of success so he turned the weapon on the port of Antwerp which at that time was vital to the Allied supply lines. In the autumn of 1944 the devastating damage wrought while the Allies were redeploying antiaircraft guns threatened to close the port. As the number of guns firing the proximity fuze increased, the damage decreased and the Allies were able to move their guns closer and to assume the offensive against the aerial targets. The defense of Antwerp resulted in the Combined Chiefs of Staff removing all bans against the use of the fuze and this was most fortunate. In late December 1944, von Rundstedt launched a counterattack which developed into the Battle of the Bulge. The use of the fuzes entered a new field, that of artillery fire against ground forces. The results of this usage were devastating to German troops and put fear into their hearts. No longer were their foxholes havens against shrapnel burst for with the use of the “funny fuze,” as it was termed by General Patton, the shrapnel bursts occurred before the projectiles hit the earth, showering areas with high-velocity fragments.

EPILOG

The proximity fuze was one of the major contributions of American scientists, engineers, and manufacturers to the winning of the war. Security prevented them from receiving the plaudits they so well deserved but they had full payment in the knowledge of their own great contributions. General Benjamin Lear, USA, described it as “the most important new development in the ammunition field since the introduction of high-explosive projectiles.” General George Patton, USA, likewise paid tribute to its developers, stating, “I think when all armies get this shell we will have to devise some new method of warfare.” Patton’s prophecy might well have come true except that within the year, this great electronic achievement of combined United States science, industry, and naval endeavor was dimmed by the development of greater and more damaging concentrated explosive power than the world had ever experienced. Even this development necessitated the continued use of the proximity fuze in the control of its point of detonation.
The Best Heavy Anti-Aircraft Weapon

Bofors

Probably the best heavy MG AA weapon of World War II, Bofors guns of this type remained in service long after the war ended. This weapon was used on almost every major USA and UK warship of World War II and was a very potent AA gun. The Germans used Norwegian-produced Bofors guns which they designated as the 4 cm/56 Flak 28 and the Japanese copied a British Army air-cooled Bofors captured at Singapore to produce their 4 cm/60 Type 5.

This weapon traces its roots back to a 1918 Krupp design - the Bofors Company was partly owned by German interests until 1930 - but the finished product was entirely a Bofors design owing little or nothing to Krupp influence. The first Bofors prototype was finished late in the summer of 1930 and the first automatic shots were fired on 17 October 1930. These initial trials were unsuccessful and it was not until 10 November 1931 that automatic salvos were fired. Official trials for the Swedish Navy took place on 21 March 1932. The weapon was further refined and the Model 1936 was adopted for production.

The British Army first showed interest in these guns in 1933 and placed an order for 100 of them in 1937. First Royal Navy shipboard use of air-cooled guns was in late 1941 aboard the battleships Prince of Wales and Nelson and on the cruisers Manchester and Erebus, although some ships had earlier been temporarily armed with Army air-cooled guns that had been “rescued” during the evacuation of the Norway invasion forces in 1940. The British water-cooled version was developed by copying the Dutch Hazemeyer mounting which had arrived in Britain in 1940 aboard the Dutch minelayer Willem van der Zaan. The first issue of locally produced water-cooled Bofors guns was to the Black Swan class sloop HMS Whimbrel in November 1942.

The total number of air-cooled guns built by Australia, Britain and Canada is not accurately known but was somewhere between 2,100 and 2,800 plus about 200 to 400 guns supplied from the United States. Water-cooled guns are better documented with 442 Mark IV and 342 Mark XI in service at the end of the war plus 786 water-cooled guns supplied by the USA. These USA weapons had been sent to Britain as a part of Lend-Lease or else were installed on ships refitted in USA shipyards.

The US Army was also interested in this weapon and tested a single air-cooled model in 1937. In 1940 the Chrysler Corporation agreed to begin manufacturing air-cooled guns utilizing British blueprints. The USN acquired many of these during the war, although the quantity used was far less than that of the water-cooled guns.

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gen demonstrated these weapons to USN observers in a test off Trinidad. BuOrd formally obtained Swedish licenses in June 1941, although some manufacturing actually started prior to that time. Terms of the license included $500,000 for the manufacturing rights plus $100,000 for two Bofors engineers to help set up production. The two engineers were never sent, so as a result this $100,000 was not paid. Bofors delivered a complete set of metric drawings as part of their end of this contract.

It should be noted that the USN considered the original Bofors Model 1936 design to be completely unsuitable for the mass production techniques required for the vast number of guns needed to equip the ships of the US Navy. First, the Swedish guns were designed using metric measurement units, a system all but unknown in the USA at that time. Worse still, the dimensioning on the Swedish drawings often did not match the actual measurements taken of the weapons. Secondly, the Swedish guns required a great deal of hand work in order to make the finished weapon. For example, Swedish blueprints had many notes on them such as “file to fit at assembly” and “drill to fit at assembly,” all of which took much production time in order to implement - there is a story that one production engineer supposedly remarked that the Bofors gun had been designed so as to eliminate the unemployment problems of the Great Depression. Third, the Swedish mountings were manually worked, while the USN required power-worked mountings in order to attain the fast elevation and training speeds necessary to engage modern aircraft. Fourth, the Swedish twin gun mounting supplied to the USA for evaluation was air-cooled, limiting its ability to fire long bursts, a necessity for most naval AA engagements. Finally, the USN rejected the Swedish ammunition design, as it was not boresafe, the fuze was found to be too sensitive for normal shipboard use and its overall design was determined to be unsuitable for mass production.

US manufacturers made radical changes to the Swedish design in order to minimize these problems and as a result the guns and mountings produced in the USA bore little resemblance their Swedish ancestors. For example, all but the earliest US guns were built to English measurement units rather than to metric units. To give one additional example of the design differences made for USA produced weapons; the Chrysler Corporation redesigned ten components to suit mass production techniques and this was claimed to have saved some 7,500,000 pounds (3,402,000 kg) of material and 1,896,750 man hours during a year’s production, as well as freeing up 30 machine tools for the production of other components.

For ammunition, the fuze designed and produced in Britain was adopted as an interim measure by the USA, but this was considered to be of an unsafe design and unsuitable for mass production techniques. Fortunately, this fuze was almost immediately replaced by one designed by R.L. Graumann of the Naval Ordnance Laboratory. This fuze was simple in design and “ideally suited to mass production.” The new fuze, designated as the Mark 27, was found to be 99.9 percent efficient in ballistic acceptance tests, a record not equaled by any other fuze of the time. Both the US Army and the British adopted this fuze for their own production lines. The USN estimated that the
adoption of the Mark 27 saved some $250,000,000 during the war.

One firm rule adopted early in the redesign process was that any new Allied munition for these weapons needed to be completely interchangeable with existing designs. This allowed ammunition produced by any American or British ordnance manufacturer to be used with any weapon produced by either country, thus greatly simplifying the logistics problems of a world-wide war.

The first USN pilot twin was completed in January 1942 and the first quad in April 1942. The first shipboard quad installation was on the gunnery-training ship (ex-battleship) USS Wyoming (AG-17) on 22 June 1942, and the first twin installation was on the destroyer USS Coghlan (DD-606) on 1 July 1942. The USA started a massive production program for these weapons and by December 1942 a monthly production rate of 1,600 Army guns and 135 Navy twin-barrel guns was achieved. A total of about 42,895 guns were built by the end of the war, distributed as 23,897 for the Army, 10,019 for the Navy and Coast Guard, and 8,979 for export to other nations. Even so, the demand was not fully met until well into 1944. By that time, the pre-war 1.1” gun had been almost totally replaced by Bofors guns. To illustrate how many of these weapons were produced by the USA, note that out of the more than 400 destroyers built for the USN between 1934 and 1946, only the four destroyers of the pre-war Gridley class (DD-380) and those destroyers sunk early in the war did not receive at least some Bofors guns.

Late in World War II, the USN started replacing 20 mm Oerlikon guns with the Bofors 40 mm guns, as the smaller weapon was found to be ineffective against Japanese Kamikazes. However, even the Bofors was determined to be inadequate against suicide attacks by early 1945, and as a result Bofors guns were in turn replaced during the late 1940s and 1950s with the new rapid fire 3”/50 (7.62 cm) designs. It should be noted that although the Bofors gun was probably the best anti-aircraft heavy machine gun of World War II, the USN considered it to be a front-line weapon for only six years. It did remain in service in the USN until the 1970s on auxiliary and non-modernized ships, primarily because the 3”/50 RF (7.62 cm) replacement program was never fully funded.

Early versions of the twin mounting used friction-coupled drives, which quickly wore out on naval ships due to salt contamination. Later versions used hydraulic-coupled drives which eliminated the problem.

The development of the Mark 51 director system gave the USA weapons greatly improved accuracy. For example, half of all Japanese aircraft shot down between 1 October 1944 and 1 February 1945 were credited to the Bofors/Mark 51 combination. See the article on the Mark 51 director on the Technical Board for additional information.

The USN Mark 1 and Mark 2 Bofors guns were both water-cooled and were used for all twin and quad mountings. The Mark 1 was a left-hand weapon while the Mark 2 was a right-hand weapon. Except for the barrel assemblies, the components were not interchangeable. These weapons could be fired in single-shot or automatic mode via a selector switch on the side of the slide.

The M1 was an air-cooled version originally produced for the US Army. The barrel assemblies for the M1 were interchangeable with those of British and Canadian produced air-cooled weapons. All USN single mountings used a modified version of the Army M1.

These guns are recoil operated and use a monobloc barrel with a detachable breech ring, breech casing and automatic loader. Breech block is a vertical sliding type. Although often listed as being 60 calibers long, all of these guns except for the Japanese version were actually 56.25 calibers in length.

Designation (see Note 1)
Sweden: Bofors 40 mm/60 (1.57”) Model 1936
Germany: 4 cm/56 (1.57”) Flak 28
Japan: 4 cm/60 (1.57”) Type 5 (Model 1945)
UK: 40 mm/56.3 (1.57”) QF Marks I, III, IV, VIII, IX, X, XI, N and NI/I
USA: 40 mm/56 (1.57”) Mark 1, Mark 2 and M1

Ship Class Used On:
Almost all major US and British warships of World War II
German Cruisers and S-Boats


Date In Service: Sweden: N/A, Germany: 1944, Japan: Not in service, UK: 1941, USA: 1942.

Gun Length oa Germany: N/A, Japan: N/A, UK: 145.3 to 145.5 in [depending upon Mark], USA: 148.8 in

Rate Of Fire (see Notes 2 and 6)
120 rounds per minute per barrel nominal
140 to 160 rounds per minute when firing horizontal (gravity assist)

Notes:
1) The official designation for British guns was Ordnance, Quick Firing (usually abbreviated as OQF) 40 mm Mark (whatever). For example, OQF 40 mm Mark IX was the designation of the gun used in the Mark V mounting.
2) A modification kit was produced around 1970 which increased the rate of fire to 180 rounds per minute and the magazine capacity to 20 rounds by using a banana feeder fed by standard four-round clips.
3) USN Mark 1 guns fed from the left while the Mark 2 guns fed from the right. Manually loaded M1 guns fed from the left.
4) The standard automatic loader holds two four-round clips. When the first four-round clip is inserted into the feeder, the clip itself is stripped off and falls out onto the deck (the clip chute is a cut out just below the loader; left side for a left gun and right side for a right gun). The second clip is then dropped into the loader and pushed down so that it forces a round through the loader star wheels and onto the rammer tray. This first round only had to be manually pushed through when the gun was initially loaded, the loader will automatically feed rounds from new clips. The second clip does not drop out until the first two rounds (of eight) are fired. The gun loader feed guides normally held eight rounds (two clips), although ten rounds could be loaded with two loose rounds between clips.
5) To get the gun ready to fire the first round, a cocking lever is used to manually move the rammer to the cocked position, rotate the star wheels a quarter turn which drops a round onto the rammer tray and lower the breech block. Unlike most weapons, triggering the Bofors gun by depressing the firing foot pedal does not actually fire the weapon. Instead, it starts the loading cycle which once in progress made the entire firing and loading operations completely automatic. At the start of this cycle, the spring-powered rammer is released, pushing the round on the rammer tray into the breech which automatically closes when the cartridge case rim strikes the actuator. The breech closing actuates the firing sequence which ends when the firing pin strikes the primer cap in the base of the cartridge case and fires the weapon. Recoil then opens the breech block, pushes the rammer back into the cocked position and the extractor arms pull the cartridge case out and back over the rammer tray and down a semi-circular chute that guided the spent case out under the gun barrel. As the breech block moves back during recoil, it causes the star wheels in the autoloader to make a quarter turn which drops the next round onto the rammer tray. In automatic mode, this cycle will repeat as long as the firing pedal is depressed and ammunition is in the autoloader. Mark 1 and Mark 2 guns had a loader interlock which automatically halted firing when there were only two rounds remaining in the loader, one on the rammer tray and one in the star wheels. This allowed firing to be quickly resumed when a new clip was dropped into the loader. Unlike the Mark 1 and Mark 2 guns, the M1 guns had a switch on the back of the loader at the center, bottom rear. This switch disabled the
interlock so that the M1 could fire all eight rounds in the feed clips or it could be set to stop the gun when only two rounds were remaining, similar to the Mark 1 and Mark 2. If all rounds were fired, then the first loader would have to start from the beginning to drop in two clips and push on the top so that the bottom round would rotate through the loader star wheels and drop onto the rammer tray. The gun would then resume firing when the pointer pushed his foot pedal.

6) It was up to the second loader to properly orientate each clip when he handed it to the first loader so that all the first loader had to do was drop it into the loader. Since the Bofors gun cycled between 120 to 160 rounds per minute (one clip every 1.5 to 2 seconds), the first loader had to do a quick “pick up, turn, and drop” action in order to keep up with it. If the clip was not orientated properly during the hand-over, then the first loader would have to juggle it in order to position it properly before it could be dropped into the loader. Being too slow would interrupt the firing cycle - hence the reason for the loader interlock. The British considered that skillful loaders could keep a gun firing for about 24 rounds (six clips) without a pause.

7) Perhaps unusually for US guns, the bores of these weapons were not chromium plated.

8) Ammunition was percussion fired in all models.

9) In “US Naval Technical Mission to Japan report O-47(N)-2” it is stated that the Japanese in copying a captured British air-cooled gun increased the barrel length from 2160 mm (85.1”) to 2400 mm (94.57”). This dimension is usually taken as being the overall barrel length in most references (see for example “Naval Weapons of World War Two”). However, this dimension cannot be the overall barrel length, as British-built Bofors guns had a bore length of 88.578 in (2.250 m) - 56.3 calibers, while their overall length was about 145.3 in (3.691m). As the rifling length given in O-47(N)-2 for the Type 5 is significantly longer than that for the British Bofors, I believe that the dimensions given in O-47(N)-2 for barrel lengths must actually be for the bore lengths and use this assumption in constructing this data page.

10) “German Naval Guns: 1939 - 1945” by Miroslaw Skwiot says that the rifling in German Bofors guns consisted of “sixteen grooves, each 41.2 mm wide.” These figures are mathematically impossible. It is possible that the author (or the translators) made an order of magnitude error and that the actual width was 4.12 mm wide, but this dimension would still be significantly narrower than the grooves in UK and US guns.

USA-Built Mountings Designation
Mark 1 Twin, Mark 2 Quad, Mark 3 Single, Mark 4 Quad.

Weight (no shield)
9,800 - 13,000 lbs.
23,200 - 23,800 lbs.
2,440 - 4,200 lbs.
22,795 - 24,553 lbs.

Elevation
-15 / +90 degrees

Recoil 8 - 9 in

Notes on Bofors-built Weapons and Mountings
Prior to the start of World War II Bofors had produced 182 Land-Service guns for the Swedish Army and 295 for export. Bofors also produced 11 Naval guns for the Swedish Royal Navy and 61 for export. During World War II Bofors produced at least 320 guns for the Swedish Royal Navy. Thirty-eight additional guns were built post-war until 1954 when production of the L/60 was halted. Guns were of both air-cooled and water-cooled types and at least fifteen different single, twin and submarine mounting types were in service. Some of the twin water-cooled mounting types had integral 1.25 m or 2.0 m Hazemeyer rangefinders.

Notes on USA-built Weapons and Mountings
1) Mark 3 single mounts used air-cooled guns, which were modified versions of the US Army M1 Bofors gun. Three versions of the Mark 3 were used on surface ships, the Mod 0, Mod 4 and Mod 9, while submarines used the “wet mount” Mod 5 and Mod 6. Mod 0 was the basic Army mount and weighed 2,440 lbs. (1,107 kg) including gun and sighting mechanisms. The Mod 0 lacked power drives and so was manually trained and elevated. Crew
for the Mod 0 was usually five to six men. Mod 4 added 1 hp power drives for training and elevation and had the same crew size as the Mod 0. Submarine Mods 5 and 6 were manually worked mountings. Most single mount shipboard installations had safety rails around them to keep the gun crews from accidentally firing into the ship. The Mark 3 Mod 9 was a much later design using rebuilt M1 guns. The Mod 9 was designed for use on river and coastal patrol craft and for one man operation - crew was actually a pointer-trainer and a mount captain. This mount used integral train and elevation power drives and was stabilized. Weight increased to 4,200 lbs. (1,905 kg). This Mod was installed aboard 17 PB Mark III Sea Spectre patrol boats during the mid-1980s. Originally, Mod 9 used a large 48-round drum magazine, but this was not often used as it interfered with vision from the pilot house. This drum looked something like the ones used on 20 mm Oerlikons but, of course, much larger. During the 1980s “Tanker War” in the Persian Gulf, it was also reported that the drum did not feed reliably, so it was removed and the crews went back to manual loading.

2) All USN twin and quad mountings used water-cooled Mark 1 and Mark 2 Bofors guns. Any mod of the Mark 1 or Mark 2 Bofors guns could be used in any mod of USN twin or quad mountings; these USN guns were designed to be completely interchangeable in that regards. Twin mounts consisted of a left-hand gun (Mark 1) and a right-hand gun (Mark 2) joined together. The gun axes were 9.568 in (24.3 cm) apart. Elevation and training motors were 3 or 5 hp. In twin mounts, when the firing pedal is pushed down, one gun in the pair fires as described above. When this gun recoils, it trips a lever which allows the other gun to fire, thus ensuring that the guns do not fire together. For twin and quad mounts, the crew consisted of a Mount Captain, Pointer, Trainer, a 1st Loader for each gun and then however many ammunition passers it took to get back to the ammunition supply point. In addition to the guncrew, there was normally a Mark 51 (or later) Director crew consisting of a Pointer and a Range Setter.

3) Quad mounts were basically two twin mounts joined together, with each pair having a left-hand gun (Mark 1) and a right-hand gun (Mark 2). The gun pairs axes were 60.0 in (1.524 m) apart. Elevation motors were 5 hp and training motors were 5 or 7.5 hp. As noted above, hydraulic drive gear was used on most units. Although both pairs of guns elevated together, in some Mods the pairs could be uncoupled in case of damage.

4) There were many Mod numbers assigned to the twin and quad mountings, with most having to do with details of the power drives. An asterisk (*) indicated that the mount included a radar antenna and was used with the Mark 63 director.

5) The Mark 4 quad mount was a low-weight version that used a lighter amplidyne generator mounted below deck and a GE RPC system. This mounting had much faster training and elevation speeds than earlier mounts, but only 100 had been delivered by the end of the war.

6) US ships carried large quantities of this weapon with USS Saratoga CV-3 probably having the most with 23 quad mounts and two twin mounts for a total of 96 guns. Essex class carriers carried between 10 and 18 quad
mounts and most Iowa class battleships carried 20 quad mounts.

7) The USN built more than 2,300 quad mounts, just under 10,000 twin mounts and more than 10,000 single mounts during the war. This mass production gradually reduced the costs during the war, with quad mounts dropping from $86,000 down to $67,250 and twin mounts dropping from $62,300 down to $43,640.

8) As noted above, the USA supplied 8,979 guns to other nations as part of Lend-Lease. This is broken down as follows:

- United Kingdom and Commonwealth: 2,834
- China: 80
- Free French Forces: 448
- USSR: 5,511
- American Republics: 4
- Others: 2

Notes on British-built Weapons and Mountings

1) Serious British interest in this weapon was first shown by the Army in 1933 and was followed by an order for 100 guns in 1937. Later, a manufacturing license was purchased from Bofors. The British version is officially listed as 56.3 calibers long. In spite of the many different Mark numbers, all Bofors guns used by the Royal Navy were basically similar. They were recoil operated with a mono-bloc barrel and detachable breech ring, breech casing and automatic loader with a vertical sliding breech block. The air-cooled Marks I, I* and III differed in details of the automatic loader and were primarily derivatives of Land Service (LS - Army) guns. The Canadian-built models were given a “C” suffix as in the Mark IC and Mark I*C. The Australian-built Mark I* was identical to the British-built gun of that designation. The water-cooled Marks IV, VIII, IX, X, XI and post-war NI and NI/I all had water jackets with circulating pumps and differed only in regards to the mounting they were to be used on. Single shots could be fired in all but the Mark VIII, IX, X and probably the NI and NI/I guns. Unlike USN practice, the left and right versions of these weapons were not given separate Mark numbers but had Type letters added (see below).

This large number of variations of British Bofors guns compared to the three produced for the USN would seem to show once again the lack of interest by the Royal Navy in weapon standardization during the World War II period. The British considered the Bofors to be at least twice as effective as their own 2-pdr against torpedo bombers, but not much better than that weapon against kamikazes.

Details on the guns:

- Marks I, II and III: Air-cooled, LS guns, some of which were converted to naval use. See Note 3 below.
- Mark IV and IV/I: Water-cooled. Designed for use on the twin-gun Mark IV Hazemeyer mountings. Produced in left and right versions, with Type D being the left gun and Type E the right gun. Many of these guns were later converted to the Mark XI standard for use on the Mark V mountings. A total of 484 guns were produced with 442 in service by 1945. See Note 4 below.
- Mark V: Project abandoned
- Mark VI: Army gun issued to Crusader AA tanks.
- Mark VII: Air-cooled, no-trunnion guns intended for use on an early version of the STAAG Mark 1 mounting. 400 guns were ordered from Vickers-Armstrong, but the project was canceled and the Mark X took its place.
- Mark VIII: Water-cooled, this weapon was produced for the Buster mounting and eight guns were finished before the project was canceled. Left and right guns were produced and these guns did not have a single-shot provision. See Note 12.
- Mark IX: Air-cooled guns for the for the Mark VI six-gun mounting. Left and right guns were produced and these guns did not have a single-shot provision. See Note 6.
- Mark X: Water-cooled guns for the STAAG Mark 2 mounting. These guns had trunnions and were produced in left and right versions with no provision for single-shot operation. See Note 11.
- Mark XI: Water-cooled guns for the Mark V mounting.
Many of these were converted from the Mark IV and Mark IV/I. Total of 342 in service by 1945.

2) The USA provided 393 each of their Mark 1 (left-hand) and Mark 2 (right-hand) guns to the Royal Navy. These were used in British RP Mark I (Twin) and RP Mark II (Quad) mountings. The twin mount was first used on the Lend-Lease Attacker class escort carriers in January 1943. The quad mount was first installed on HMS Phoebe in June 1943. The USA also supplied air-cooled guns which were used mainly on LSTs.

3) The Mark III series of hand-operated single mountings were the Army design adapted for Naval use and were widely used, with some 500 in service by the end of World War II. Usually designated as LS Mark III (Land Service). The following mountings do not appear to have entered naval service, although they do appear on naval gun lists: Mark III* (hand operated with gyro sights for layer and trainer), RPLS Mark III (Remote Power Land Service) and Toadstool (joystick controlled power operation using Army components). Elevation limits for the Mark III were -5 to +90 degrees. As of June 1942, 314 Mark III mountings were in service, of which 301 were on DEMS. By May 1945, there were about 1,392 in service with 568 on DEMS. Those Army mountings modified at least somewhat for naval service were designated as Mark III CN and there were 500 of these in service at the end of the war, with 291 on DEMS. Mounting weight for the LS Mark III including the gun was 1.2 tons (1.22 mt).

4) The Mark IV twin mounting was derived from the Hazemeyer triaxial mounting which had its origins in the 1940 arrival in Britain of the Dutch minelayer Willem van der Zaan. The Mark IV was a self-contained twin mounting that had its own rangefinder, radar and analog computer on the mount. This mounting used Mark IV water-cooled guns and utilized a track and pinion system for elevating and training which was powered via a Ward-Leonard system for automatic target tracking. The Mark IV was probably too advanced for its day and proved to be somewhat delicate for use on destroyers and sloops. The later STAAG and Buster designs were more robust, but very much heavier. According to service notes, the Mark IV was apparently used more often in manual mode than in power mode. Elevation was -10 to +90 degrees with cross-level of +/- 14 degrees with control cutting out at +/- 12 degrees. Maximum elevating speed was 25 degrees per second with the manually controlled joystick, but training and elevation via automatic control was limited to little more than 10 degrees per second. Weight was 7.05 tons (7.16 mt). The later Mark IV* mounting had a more robust radar attachment and differed in details of the controls and gyro. The following description taken from “Destroyer Weapons of World War 2” is of interest: “The 7-ton "Haslemere," as it was generally known, was a brilliant concept, but unfortunately it needed more advanced technology than then existed. It cannot claim to have been the most popular of weapons but at least it provided a little light relief on occasions. When stationary in the “power-off” mode during maintenance, a combination of training, depression and cross-roll made it look for all the world as though it was about to fall off its gundeck. Observations like “I see the Haslemere is ill again” were common."

5) The design of the Mark V twin was based upon the USN Mark 1 twin mounting adapted to use British components including some components of 2-pdr mountings and RPC gear from the 4.5” (11.4 cm) Mark V. Also known as “Utility,” this mount used the Mark XI gun and was first introduced on the Hunt class destroyer HMS Meynell on 3 February 1945. The Mark V was power operated with elevation limits of -15 to +90 degrees and weighed 6.4 tons (6.5 mt) with 12 four-round clips carried on mount. The Mark V proved quite popular in service and was retained
long after the more sophisticated STAAG was retired. Its largest drawback was the lack of a blind fire capability. The RP50 Mark V had a maximum training speed of 35 degrees per second and elevating speed of 28 degrees per second. The RP50 Mark VC (Canadian) had a maximum elevation speed of 35 degrees per second.

6) The Mark VI was a sextuple mount using the air-cooled Mark IX gun and used a 36-round ammunition tray for each gun rather than the usual four-round clips. Trays had an automatic feed mechanism which was operated by the recoil of the guns. Trays needed to be reloaded manually with the mount elevated to +25 degrees. Left and right versions of the guns were produced and the guns did not have a single-shot capability. Training and elevating speeds of the RP50 Mark VI mounting were both 30 degrees per second. This mount did not enter service until after the war. Weight was 21.24 tons (21.58 mt). This was a large weapons platform intended to be fitted primarily to battleships and fleet carriers with three hundred-twenty four being completed. The first battleship fitted was HMS Vanguard and she eventually carried a total of ten mountings although this number was rapidly reduced during her career. Aircraft carriers HMS Eagle and HMS Ark Royal carried eight. On some ships and some mountings, the lack of working space meant that the guns could only be reloaded at certain fixed bearings while on other ships the reloading could occur with the guns traversing at an automatically slowed rate.

7) The Mark VII was an adapted Army single mount with a weight of 1.40 tons (1.42 mt). Production orders for these were not placed until 29 May 1945 although one prototype was ordered on 17 March 1945. Similar in design to the “Boffin” mounting, described below, but able to elevate to +90 degrees and could train continuously as it used a slip ring for electrical power.

8) The Mark VIII was an unsuccessful variation of the Mark VII using battery power and did not enter service. 9) The Mark IX was an upgraded Mark VII mount with electric drive. The Mark IX mount used the Mark IX gun and had six ready-use clips on mount. Mark IX was used successfully during the Falklands War, with guns on HMS Fearless and HMS Intrepid shooting down an Argentine A-4B Skyhawk on 27 May 1982, probably the last aerial victory scored by the 40 mm/56. This success stimulated renewed interest in automatic weapons in the Royal Navy, eventually leading to the purchase of newer 20 mm and 30 mm weapons.

10) The Boffin mounting was a twin 20 mm Oerlikon Mark V or Mark VC mounting modified to take a single Bofors 40 mm gun. Elevation was -10 to about +70 degrees. These used an oil hydraulic system and were fitted with a gyro gunsight. Elevation was restricted compared to other Bofors mountings as the position of the elevating trunnion axis was lower, due to the smaller nature of the Oerlikon guns. Some of these were still being used by the Canadian Navy in 1990 during the Persian Gulf war.

11) The post-war STAAG Mark II twin mounting (later designated as Mark 2) using the type 262 radar was very accurate, but also very unreliable. Part of this unreliability appears to have been a result of the decision to mount the radar equipment directly to the gun mount, thus exposing it to a high level of vibration. At 17.5 tons (17.8 mt), it was also quite heavy for only a twin weapon. Used the Mark X gun. The hydraulically powered Mark II was called a “pseudo-triaxial” mounting and was unusual in that the third axis was a lateral deflection movement instead of being cross-roll. Training and elevating speeds were both 35 degrees per second. STAAG was found to be overly complicated and difficult to maintain and did not enjoy a long service life as a result. As noted, the type 262 radar was very accurate and there are stories of guns in action against towed targets where after shredding the sleeve the
radar would track up the tow wire and the tow plane would escape only by cutting the wire. Nylon rope was eventually substituted for the wire as a remedy. The Mark I was the prototype single mounting. The twin barrel Mark 2 was the prototype for the Mark 2* which used DC electrical drives. The Mark 3 used AC drives. The Mark 2** had no radar in the mounting and was used for training.

12) The Buster (Bofors Universal Stabilized Tachymetric Electric Radar) twin was another World War II attempt at a self-contained mounting, but at approximately 20 tons (20.3 mt) this weighed far too much for only a twin arrangement and the project was canceled. Used the Mark VIII gun.

13) Toadstool was a post-war attempt to convert a Land-Service gun to naval operation with joystick control. Extensively tested but did not enter service.

Notes on Australian Weapons and Mountings
Australia uses the British Mark VII mounting fitted with a locally designed upgrade package on Fremantle patrol boats. Elevation was -5 / +90 degrees and train was 360 degrees. Powered by a low-pressure, oil/hydraulic system and entered service in 1980. Training speed of 20 degrees per second and elevation speed of 40 degrees per second. Designated as 40/60 AN. A small number of these mountings were sold to Thailand.

Notes on South Korean Weapons and Mountings
South Korea has developed a modification kit for the USA Mark 1 twin mount which adds a stabilization system both to the gun mount and to the Mark 51 FCS. This kit improves their effectiveness against surface targets. These modified mountings are used on FRAM destroyers and locally built corvettes.

Notes on Netherlands Hazemeyer Weapons and Mountings
Hazemeyer was a Dutch subsidiary of Siemens Halske. Prior to World War II, this firm developed a very advanced triaxial mounting together with a tachymetric control system. As noted above, upon the Dutch defeat in 1940, this mounting was brought to Britain where it was immediately copied and introduced into production.

Notes on German Weapons and Mountings
Guns intended for naval use were manufactured at the Norwegian Kongsberg Arsenal. The Arsenal started license production of this weapon for the Royal Norwegian Navy in the 1930s and was kept in limited production throughout the war. Introduced into German naval service about late 1943 and was used to arm the cruisers Admiral Hipper and Prinz Eugen as well as some Schnellboote. As far as is known, only single mountings were ever used on warships and only HE tracer was issued. The Kriegsmarine received 578 guns for use on ships with an additional 247 guns delivered as coast-defense weapons. Naval Flak 28 mountings were set on a rotating ring attached to a round base plate that was fixed to the deck. Elevation was -6 / +90 degrees and training was 360 degrees.

Notes on Japanese Weapons and Mountings
The Type 5 (Model 1945) originated from the capture at Singapore in 1942 of 24 British Bofors single air-cooled guns in working condition and another 56 made serviceable after repairs. One of these was used to produce a Japanese copy and this underwent prototype firing trials in 1943 at the Torigasaki range of the Yokosuka Naval Arsenal. Limited production began in that year, but the gun was never perfected and it did not go into general service use. However, some 5 to 7 weapons a month were being produced in late 1944, apparently for service evaluation purposes. The main alteration from the British Bofors design was to increase the bore length to 94.49 in (2.400 m) - 60 calibers - and to add Rhiemmetall-style flash suppressors, which proved unsatisfactory. Production was at the Yokosuka Naval Arsenal and at the Hitachi Manufacturing Company. Used only in manually-worked single mountings, which had an elevation range of -10 / +95 degrees and a weight of 1,870 lbs. (850 kg). Recoil was 8.5” (21.6 cm). Major problems found by the USN after the surrender were that poor manufacturing practices and lack of quality control caused improper seating of rounds and jamming of parts and that the star wheels and extractors were frequently mismated.
Letter from the Editor

I hope you all are enjoying the stories from this issue. I am now doing both this newsletter and the Iowa Veterans Association newsletter. I may occasionally share some of the stories of interest.

The next issue will have a little humor as I include some of my own experiences and “sea stories.”

If you have anything you would like to share with our shipmates and friends, please send it in. It may take some time to get it in the newsletter, but we’ll get it in for all to see. Send your works to:
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