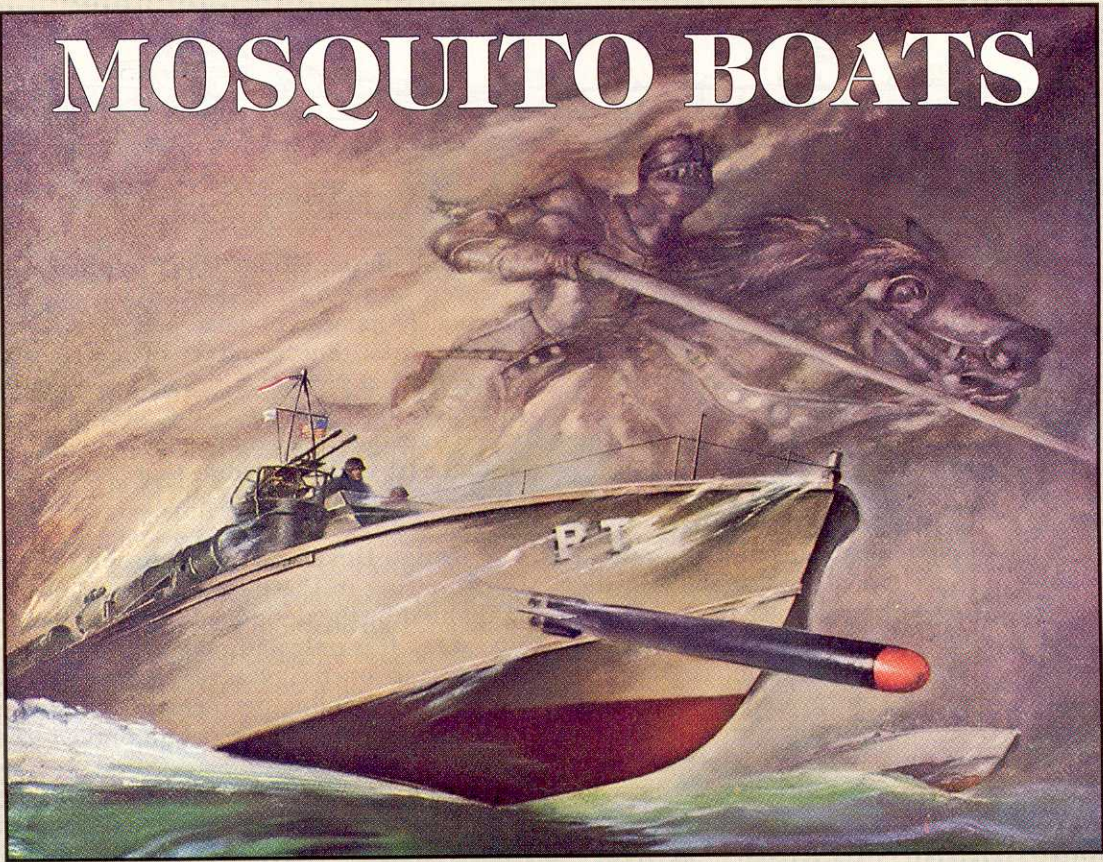


MOSQUITO BOATS



“Charging full tilt into combat, often against tremendous odds, the men who ride the Elco PTs are modern versions of the fearless knights of old. Their daring and initiative, teamed with the terrific speed and offensive power of their Elco bred ‘steeds,’ have wrought vast destruction against the enemy.... Never in naval history have craft so midget in size proved so fabulously mighty in deed. Never have officers and crews more richly deserved the praises of a grateful nation.”

*—Elco Boat Co. advertisement,
The Rudder, August 1943*

Design and development of the PTs

by Jonathan K. Klopman

Echoing the stirring words of Sir Winston Churchill, the above ad copy illustrates the lore that shrouded motor torpedo (PT) boats. The colorful ads further claimed that these mile-a-minute giant killers were “Hell on Keels!,” which would soon bring the enemy fleets to their knees. To a nation eager for avenging heroes, the PT boat represented more than just another weapons system or a shallow propaganda ploy. Designed and built by private yards, often commanded by yachtsmen, and the product of a program personally overseen by FDR, the PT became a strong symbol of populism in the war effort.

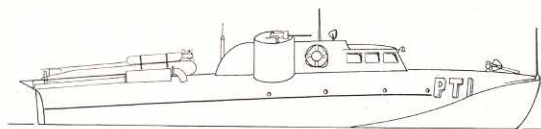
In the bleak months following Pearl Harbor, the general public was well aware that the U.S. Pacific fleet was antiquated as well as outnumbered. The prospect of

hurling our remaining capital ships into a conventional war of attrition would have seemed suicidal. However, during the desperate process of rebuilding, the average American could identify intimately with the vision of individual small craft roaring to counterattack. More powerful than might alone, the St. George imagery provided the assurance of righteous cause around which to muster the all-volunteer force.

While the PT boat is still a popular icon of World War II, many misconceptions remain regarding the type and its development. The motor torpedo boat was not born precipitously on the eve of hostilities, nor was its concept unique to the United States. The Elco and Higgins PTs represented a refined combination of hull design, power



Proposed 70' PT drawn for Gen. MacArthur



PT-1 designed by George Crouch

Jonathan Kloppman,
after Al Ross (4)

plant, and weapons that were all invented in the 19th century. Powerfully armed yet vulnerable to fire, mass produced yet of superior performance, the PTs embodied many design contradictions. That the boats could be finely tuned to meet the demands of the front lines, and still be produced at such an unprecedented rate, makes the PT program one of the greatest accomplishments of the wooden boat building industry.

Origins of the Motor Torpedo Boat

The essence of the torpedo boat concept lies in radical tactical responses to conventional naval strategy. By the time of the American Revolution, accepted naval doctrine called for sending a fleet of floating wooden fortresses either to trade fire with their enemy counterparts or to blockade its ports. Blockade strategy was as tedious and stagnant as sieges in medieval Europe or trench warfare in World War I. Both of the latter static strategies were outmoded respectively by the invention of artillery to breach walls and armored tanks to span trenches.

The development of the torpedo boat was governed by advances in hull design, power plants, and weaponry. Robert Whitehead's invention of the self-propelled torpedo in 1876 along with the multiple expansion steam engine led to the first modern torpedo boats. One particularly famous example was N.G. Herreshoff's conversion of the launch STILETTO to fire a torpedo over her bow. The conventional mindset of the Navy gradually pushed for ever larger torpedo craft, a move

which led to the development of fleet-sized ships and the destroyer. At the turn of the century, one of the most influential proponents of the torpedo boat was none other than then Assistant Secretary of the Navy Theodore Roosevelt. In answering critics who dismissed the boats as dangerous aberrations, the aggressive statesman showed remarkable insight in predicting the hit-and-run role of the PT while conceding that "...they will always be as fragile as they are formidable."

Design Development Between the Wars

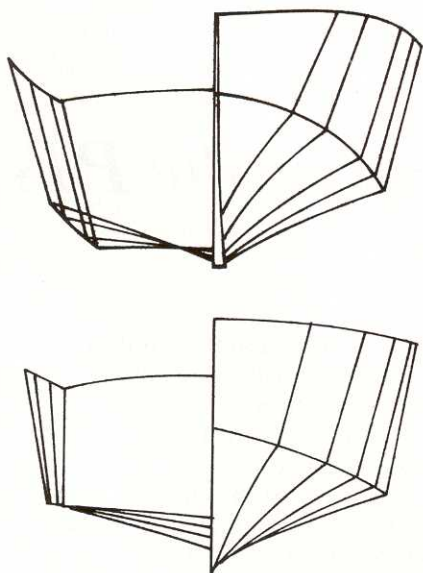
Motorboating in the depths of the Depression was highlighted by the designs of Gar Wood and the Gold Cup racers. It is only natural that these fire-breathing unlimiteds are often cited as the forebears of the PT boat. Despite their thrilling performance, these boats show little if any influence in the design of the torpedo boats of World War II.

As with the torpedo boat, the concept of the stepped hydroplane is an old idea. The hull is designed purely as a lifting body to reduce resistance. In fact, the whole thrust of the hydroplane is to deny its own element by skipping above the surface of the water. Thornycroft used the idea in World War I in designing its 55' Coastal Motor Boats. Though fast, the boats were severely limited by range, armament, and sea conditions.

While less radical, the early warped V-bottomed hulls lie at the heart of torpedo boat design. The idea is generally credited to yacht designer William H. Hand, Jr., in around 1902. His adaptations of Chesapeake deadrise hulls possessed the unique combination of high speed, comfort, low power, and good seakeeping ability. By World War I, Hand's larger boats were reaching 35 mph and winning ocean races. The British Admiralty took note of the designs and ordered a series of 40' patrol launches.

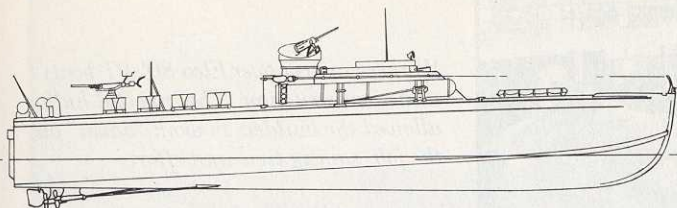
Ironically, the U.S. Navy showed little continued interest in small attack craft during the '20s and early '30s. General Douglas MacArthur, then commander of Philippine forces, foresaw an escalating threat of invasion and proposed a program to build a squadron of 30 motor torpedo boats to defend the islands. The 70' all-aluminum design presented by MacArthur's naval assistant, Lt. S.L. Huff USN (retired), followed the well-tested lines of a 45' Luders crash boat. However, preliminary studies showed that the horsepower necessary to bring the boat to 40 knots would be enormous. The approved propulsion plan proposed jamming six 550-hp Hall-Scott engines into the tight engine room. No boats were built to Huff's design.

With the support of Secretary of the Navy Admiral Pye, the U.S. initiated its own design program in December 1937. This testing produced three 25' half-scale boats, each powered by two 140-hp engines. The boats all varied in angle of deadrise, height of chine at bow, transom immersion, and location of the center of buoyancy. The results of this program produced valuable data on loading and trim, handling, and other requirements needed to

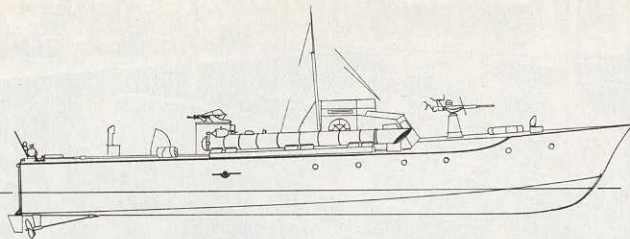


Jonathan Kloppman

The body plan for the Higgins 78' PT (Patrol-Torpedo) boat, shown at the top, displays its kinship to the sections for a William Hand powerboat (circa 1908). Hand's early experiments in modifying Chesapeake deadrise workboat hulls had a major, and largely unrecognized, influence on PT boat design.



Huckins 78' PT designed by Lindsay Lord



British 72'6" Vosper/Thornycroft MTB

get over the hump and onto plane. In July 1938, the Navy's Bureau of Construction and Repair sent out invitations for a design competition.

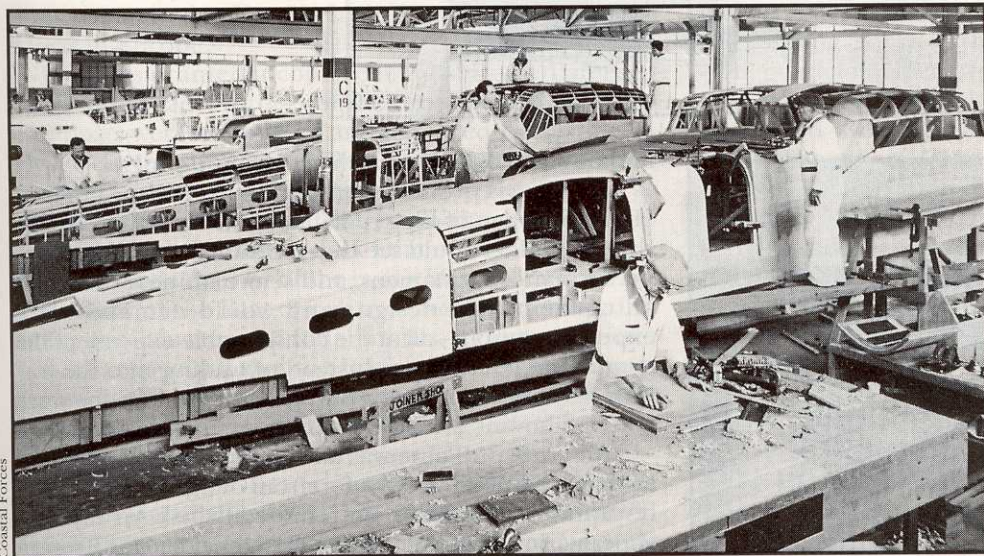
Scott-Paine, Sutphen, and the Plywood Derbies

The designers only had two months to submit entries. Finalists would be awarded \$1,500, and the contract winners \$15,000. The competition was for two designs: a 54' boat that could be easily loaded onto a mother ship, and a 70' boat with increased range. Entrants submitted 24 designs for the smaller boat, and 13 for the larger.

Speedboat professor George Crouch was working for Henry B. Nevins, Inc. at the time, and won the competition for the 54' boat. Not unlike his earlier racers, the boat had a pronounced barrel back and a flat, hollowed-out underbody. The torpedoes were launched by sliding off rails over the stern, an idea borrowed from Thornycroft

in England. This flawed concept meant that the boat would have to be up on plane to fire its tubes, so it could accelerate and swerve out of the way of its own torpedoes. However, this meant that the torpedoes would start their run in turbulent water behind the PT, and could easily veer off course. Plagued by construction problems, lackluster performance, and the decision to scrap the small boat/mother ship concept, only four of the Crouch designs were built.

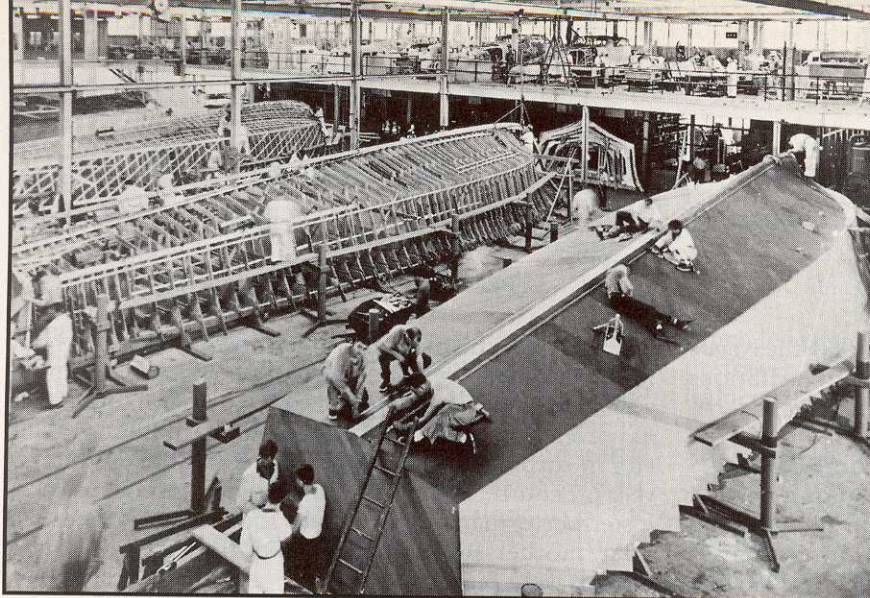
Sparkman & Stephens won the design competition for the 70' boat. Two prototypes, PTs 5 and 6, were to be built at Higgins Industries in New Orleans. The design was unique as probably the leanest of the PTs, with only a 5:1 length-to-beam ratio. Veteran builder Andrew Jackson Higgins predicted the hull design's poor lift and low top speed of only 33 knots. Higgins successfully petitioned the Navy to dump the prototype by selling it to Britain,



Left—Workers at the Bayonne, New Jersey, plant assemble elegant, but complex, deckhouses for the early Elco 70' PT boats. These aircraft-like cabins were replaced by simpler plywood houses on the Elco 80' boats.

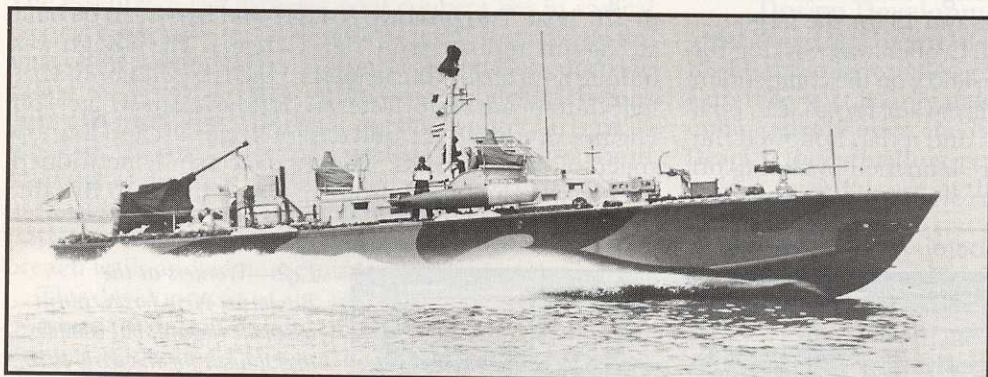
Below—PT-10, an Elco 70' running at speed. Note the enclosed gun turrets.





Coastal Forces

Workers swarm over Elco 80' PT boats under construction. The inverted hulls allowed the builders to work "down" on the job, saving time and effort.



Coastal Forces

Left—An 80' Elco PT shown at full speed during time trials.

Below—Officers' quarters aboard an 80' Elco—spartan by most standards, plush for a PT boat.



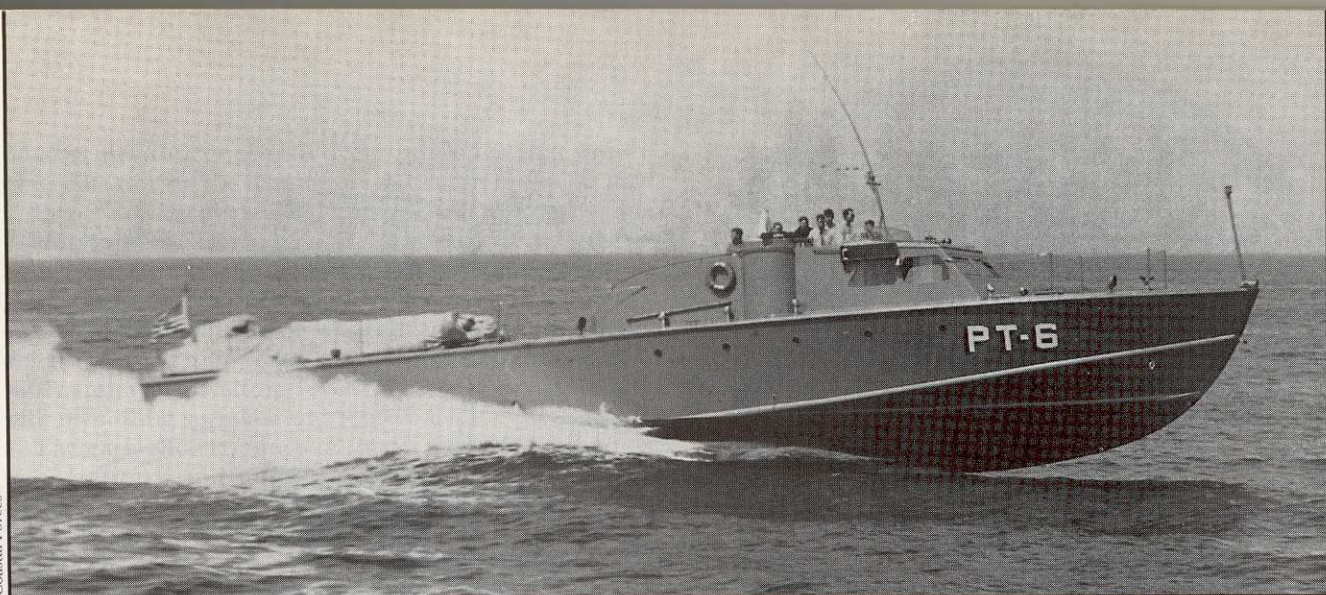
Coastal Forces

and he started from scratch on his own designs.

Amidst this proliferation of designs and prototypes, Henry Sutphen of Elco remained notably removed. The shrewd builder could see that meeting requirements for performance, armament, and seaworthiness exceeded all conventional designs and would demand more experimentation—all at the considerable expense of the competing contractors. Instead of wading into the fray with his own set of plans, Sutphen focused on the work of a flamboyant British entrepreneur.

Hubert Scott-Paine was an eccentric and a visionary who threw himself into the forefront of the transportation revolution in the 1920s. He founded British Airways and Supermarine Aviation, whose 1934 Schneider Cup Trophy-winning float plane was to become the prototype for the Supermarine Spitfire. No less consumed by speed on the water, Scott-Paine founded the British Powerboat Company and campaigned a series of boats against Gar Wood and his supercharged Packards. In 1935, Scott-Paine designed and built 22 air-sea rescue (crash) boats of 64' LOA. With the renewed interest in heavily armed torpedo boats, he expanded this plan in 1938 to a design for a 70' boat carrying four torpedoes and powered by three 900-hp Merlin engines. Though the boat reached 44 knots on trials, Scott-Paine lost the contract to Thornycroft Vosper. The controversy surrounding the Admiralty's decision left the designer bitter and in search of a buyer for his ideas.

The superior performance of the Scott-Paine boat was not lost on Assistant Secretary of the Navy Charles Edison. By January of 1939, virtually all of the domestic private and government proposals had proven flawed.



Higgins PT-6 during trials—a strong boat, but slower than the Elcos.

But, however desperate the Navy might have been to begin production, it did not want to appear to be selling out American boatbuilders by throwing in with the British Powerboat Company. In a clandestine meeting, Edison sought out Sutphen to act as a straw man to buy the Scott-Paine prototype and ship it back to the U.S. for trials. The boat arrived in New York two days after the outbreak of war in Europe.

Elco was granted a contract almost immediately to build two squadrons (24) of the Scott-Paine 70-footers. The boats were completed and deployed for testing in Florida in the summer of 1940. Some severe structural problems surfaced shortly after testing began. The decks had a tendency to crack at the beginning of the superstructure, and the hull-to-deck joint of one boat zipped open for over a quarter of the boat's length. The forward underbody of the boat also proved weak and needed to be reinforced with additional frames. At the same time, it became apparent that the British 70' design was overloaded by the larger U.S. 21" torpedoes. This prompted Elco to modify the molds of the boat by adding 7' to the transom for the second production run.

By the spring of 1941, a number of other prototypes had become available for testing. However, the structural defects that had been uncovered with the early Elcos only emphasized that there would be no opportunity to alter a design after it entered full-scale production. There was a proposal to run all of the new designs through a rigorous sea trial that July in Long Island Sound, with the winner being awarded the contract.

While the Navy was to test the boats for many practical details such as habitability, communications, and production standardization, it was generally understood that they intended to take fully loaded boats and kick the stuffing out of them in order to select the survivors. The sea trials culminated with a 190-mile run around Block Island, the Fire Island Lightship, Montauk Point, and back to New London that has become known as "The Plywood Derby." What was originally intended as a conventional endurance run became a free-for-all in 15' seas.

The leader, an Elco 77, managed to finish in just under six hours for an average speed of over 39 mph.

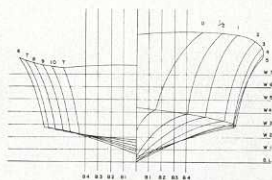
Surprisingly enough, the small boat was able to hammer through the rough conditions and cross the line only minutes behind the destroyer WILKE, which had been sent out to pace the fleet at full speed. Virtually all of the leaders suffered some damage. Though they were fast, the Elcos pounded so badly that their decks buckled and cracked. Later models were fitted with large stringers on deck running alongside the house and onto the foredeck.

Higgins had fielded two entries that competed against each other. Veteran designer Graham Haddock had engineered the new PT-6 that replaced the failed S&S design. Though structurally superior to virtually all the other entries, it couldn't keep up with the lighter Elcos. The other Higgins boat, the 72' PT-70, was designed by the builder's son. The new boat used lightweight construction with plywood topsides and deck and matched the speed of the Elco 77s. However, the plywood shattered early on in the race, forcing the boat to withdraw. Higgins decided to build a larger version, using some of Haddock's structural innovations (Haddock himself was pulled from the project and relegated to steel construction).

The Huckins entry proved to be an unexpected disappointment. The 72' PT-69 was notable for its plumb stem with deep forefoot, and a sharp entry that warped to only six degrees of deadrise at the transom. While she was able to reach a fairly good speed, the boat was reputed to have an handling problems. The Huckins boat was unique in being powered by four Packard engines rather than the customary three, a complexity that the Navy did not consider favorably. Ultimately, only two squadrons of the Huckins boats were built, and these were consigned to defending the Panama Canal.

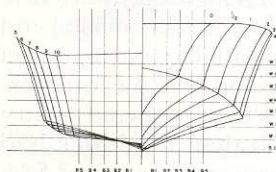
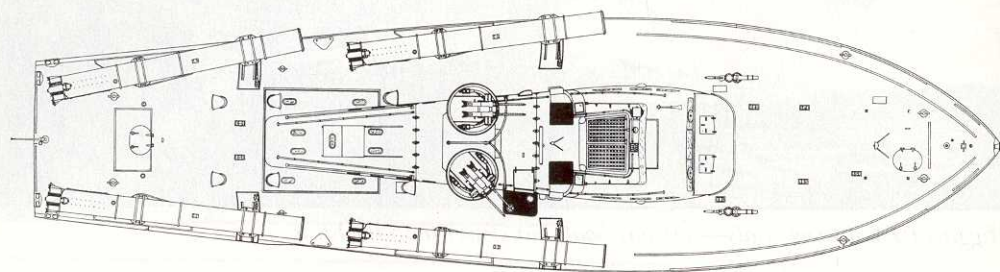
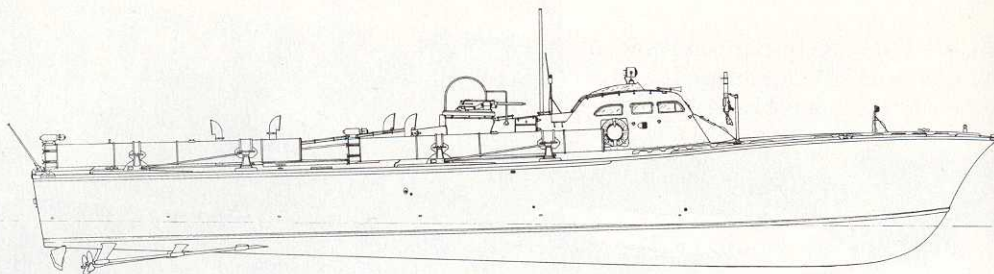
The First Elcos in the Pacific

With their clipper bow, reverse sheer, and swept-back superstructure, the early Elco boats possessed the most flamboyant aesthetic character of all the PTs. The styling and structural details of the boats embodied the aero design concepts of the era—to the point that the first squadrons were fitted with domed plexiglass machine gun turrets. Armed only with their torpedoes and several defensive guns, the boats and their crews seemed to



**Elco 77' PT Boat
Particulars**

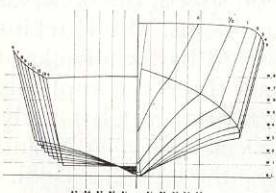
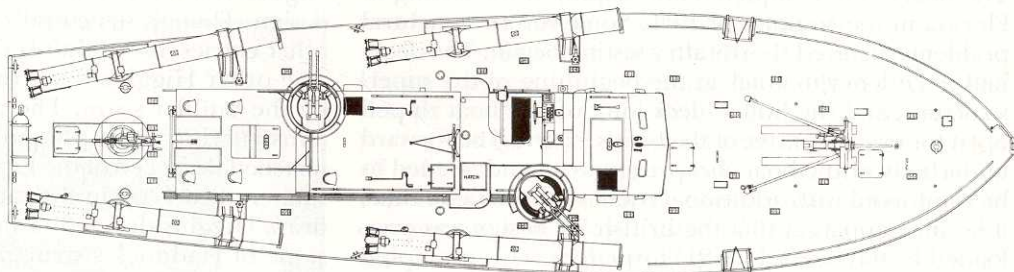
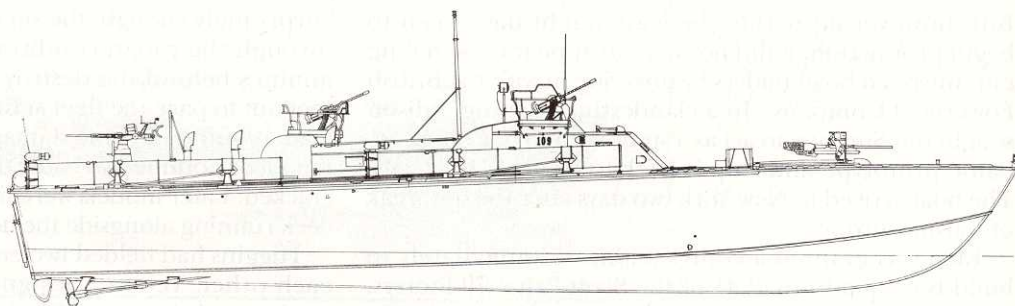
LOA	77'
Beam	19'11"
Displacement	92,000 lbs
Power	(3) 1,200-hp Packards
Top speed	42-44 knots



**Elco 80' PT Boat
Particulars**

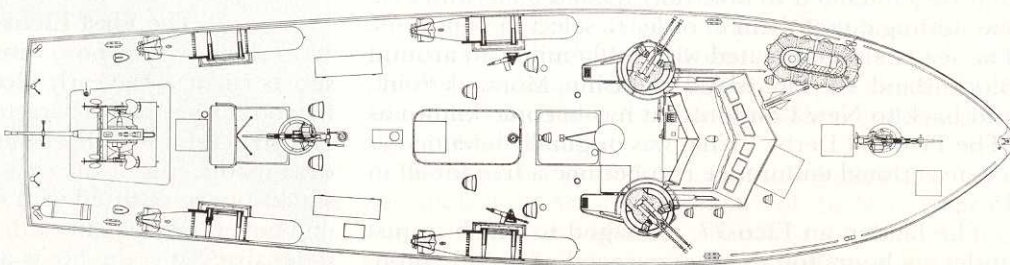
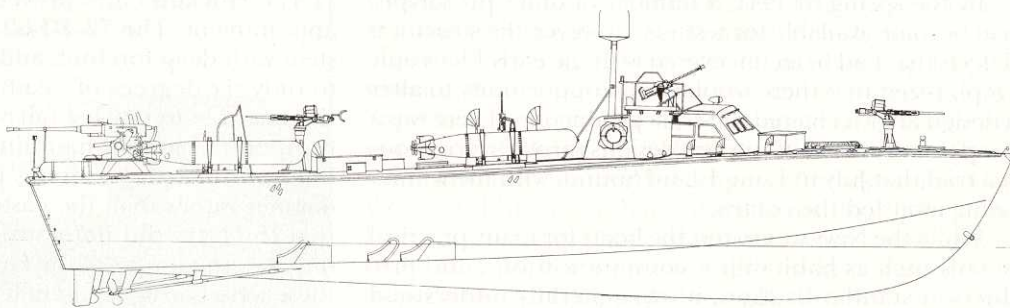
LOA	80'
Beam	20'8"
Displacement	106,000 lbs
Power	(3) 1,350-hp Packards
Top speed	40-43 knots

(PT 109, an 80' Elco commanded by John F. Kennedy, was rammed and sunk by IJN DD AMAGIRI on August 2, 1942.)



**Higgins 78' PT Boat
Particulars**

LOA	78'6"
Beam	20'1"
Displacement	121,000 lbs
Power	(3) 1,350-hp Packards
Top speed	39-43 knots



possess an innocence and overconfidence that would evaporate during the first bitter campaigns in the Pacific.

Elco PTs were dispatched immediately to buttress the Pacific fleet. In fact, there are accounts of men from Squadron Two who fought off Japanese planes at Pearl Harbor while their boats were still stored on shipping cradles. Squadron Three was sent to aid in the futile defense of the Philippines. Faced with a determined and vastly superior invading force, the boats struggled on with dwindling supplies and spare parts.

The early shortcomings in the PT program were due to operational and support problems rather than hull design. The small boats were not self-supporting, and so had to be deployed with mobile bases that would include engine shops, floating drydocks, and massive fuel and ammo dumps. This interdependent network compares more closely to an airfield than it would to most naval detachments deployed at sea. The maintenance was typical for any wooden boat, and the construction actually lent itself to quick field repair and modification.

PT actions during the defense of the Philippines in the spring of 1942 and off Guadalcanal later that year proved that the boats were ideally suited for hit-and-run tactics. Teams of four boats would set out after dark on long-range patrols. Each boat ran on a single muffled engine. After contacting the enemy (often at ranges well under 400 yards), a PT would fire all torpedoes simultaneously, light up all three Packards, and throw the boat into a series of evasive maneuvers to escape.

Plagued by poor communications, only fair support, and notoriously defective torpedoes, the PT sailors would come to prize performance as their greatest defense. In fact, the boats were so hard to hit that by the end of the war, only eight PTs had been lost due to enemy fire. (By comparison, 18 boats had to be scuttled to prevent capture following grounding. Enemy aircraft were a greater threat than surface ships, for they could home in on the phosphorescence thrown off in the PTs' wakes.)

These early clashes with the destroyers of Rear Admiral Tanaka's Tokyo Express also demonstrated that any argument regarding the fragility of the wooden, gas-powered PTs was essentially moot. While riding into combat on top of 3,000 gallons of aviation fuel hardly inspired confidence in PT crews, they knew that the rapid-fire 5" cannons mounted on the Japanese destroyers would be able to track a larger diesel boat and would vaporize it just as quickly. It is for this reason that continued PT design efforts concentrated on seeing that the boats would not get hit in the first place.

Elco and Higgins—The Great Rivalry

The early experience of Squadron Three in the Philippines proved that the 77' Elco hull needed several major modifications. The boats were still subject to structural failure, primarily buckling at the deck and clamp, due to the severe compression loads incurred from hammering through seas with a full warload. Without stopping production, Elco reengineered the design and eventually launched the first Elco 80, PT-103, in May 1942.

The new boat had a radically different profile from her forebear. The clipper bow of the smaller boat was given up for a simpler raked, spoon stem. The plans show



Jonathan Klopman

The insignia for PT Ron (squadron) 29. Each boat in the squadron carried the name of a character from Al Capp's L'il Abner comic strip. The author's uncle commanded DAISY MAE (PT-556).

that the extra length was gained by adding a station at the bow. The chines were swept up to the new stem almost 4' above the waterline. The "nose job" gave the Elco 80 a finer entry with more deadrise, all in an effort to smooth the pounding of the original Scott-Paine design. However, the deadrise from the transom to approximately three-eighths of the boat's overall length (that portion of the hull where the underbody sections are still fully immersed when the boat is up on plane) remain precisely the same as the 77' Elco. This is interesting in that, while the new boat displayed wider beam at the chines and deck throughout, there was an obvious attempt to retain the speed and planing characteristics of the original.

The outboard profile of the Elco 80 is marked by a simplified, low-profile, stepped house mounted well aft. By 1945, the deck profile was cluttered with a myriad of deck guns, radar, and auxiliary equipment. Despite its similar underbody, the 80' boat bore none of the streamlined aesthetics of the Scott-Paine design. This purely functional aspect of the Elco 80 design is borne out of the fact that virtually every design change was the result of field experience, and demands that the PT boat fulfill a wider spectrum of roles. The end consequence of these modifications was that, while the first operational 77' Elcos displaced 46 tons, the last Elco 80s tipped the scales at more than 60 tons.

With over 300 boats built, more Elco 80s were produced than all other designs combined. The reason for the design's popularity is that Elco was able to fill every contract ahead of schedule, modify the boats on a continuing basis (to the point of overloading), and still come close to original performance criteria. The boats were liked by their crews, in no small part due to the well-laid-out accommodations as well as performance.

Nevertheless, the Elco 80 retained several notable weaknesses. The new boat was not nearly so maneuverable

Designed late in World War II, the 70' Higgins Hellcat proved fast (57 mph) and refined but never entered service.



Coastal Forces

as the Higgins, it still tended to pound, and it was several knots slower than the smaller Elco. The success of the boat rested in its ability to strike the best compromise. Given the distinctly unforgiving demands placed on the PT fleet, it is no surprise that the design with the fewest vices took the lead.

The Higgins design bore no resemblance to the Elco 80. Where the Elco boat gradually evolved from the original Scott-Paine design, the Higgins 78' was designed in-house by Frank Higgins and Teddy Sprague. The Higgins 78' was the second major PT design to see operation, with close to 200 commissioned by the end of the war. As with Elco, Higgins had come out with a smaller prototype, the 72' PT-70. The Higgins 78 was designed not only to answer the Navy's request for a larger boat, but also to redress the serious structural problems of the prototype. The improved Higgins boat was planked with double-diagonal Philippine mahogany on the topsides and decks, where the earlier boat had used sheet plywood. The internal structure of the boat was heavily reinforced, especially on the bottom. Most underbody members were tied together with bolted galvanized steel angle or plate.

While the new boat was extremely strong, it was also more than 20,000 lbs overweight. Unable to make the Navy's requirement for a top speed of no less than 39 knots on shakedown cruises in September 1942, Higgins was forced to suspend production. By June 1943, the Higgins testing facility in Miami reported that boats with a full load were still limited to only 33 knots. Though engineers continued to develop a "crash diet," the Higgins 78 would always be plagued by lower top speed than the Elco boats.

The Elcos and the Higgins designs had straight buttock lines aft with a deadrise of 14° under the center of gravity at the engines. This agreement on the shape of the planing hull is most likely attributable to the Navy's 1937 tests on warped, stepless V-bottomed hulls. The Higgins underbody had sharper deadrise forward, and carried it farther aft. This striking difference of the Higgins forebody allowed it to drive through much heavier seas. It is probably this virtue (along with the failure of the first boats to reach an adequate top speed) that led the lucky

sailors of Squadrons 13 and 16 to be stationed in the Aleutian Islands.

At the same time, the deeper vee of the Higgins kept it from burying its lee chine forward when the boats were thrown hard over into a turn. The Higgins could turn much tighter than the Elco. As evasive tactics were the single greatest defense of the PT, it is not surprising that the Higgins crews touted their maneuverability compared to the Elco boats. Even the steering arrangements of both designs showed a different philosophy. The Elco had three small elliptical rudders, while the Higgins used two larger, squared blades. Although the larger rudders of the Higgins were more effective in initiating a turn, the tip vortices detracted from high-speed performance and contributed to stalling.

The topsides of the Higgins 78 are conical in section and show no flare. The only understandable reason for such a lack of shape points to the prototype, PT-70. The original boat was noted for its lightweight plywood topsides and deck, which would require a conical mold. When the 78 was built, it appears that the topsides were not redrawn to add beam at the forward deck. The result was that the Higgins was slab sided and would throw spray straight up over the foredeck and into the cockpit (which was situated well forward). This helm location was also noted for poor visibility to the sides, as it was flanked by the machine gun turrets.

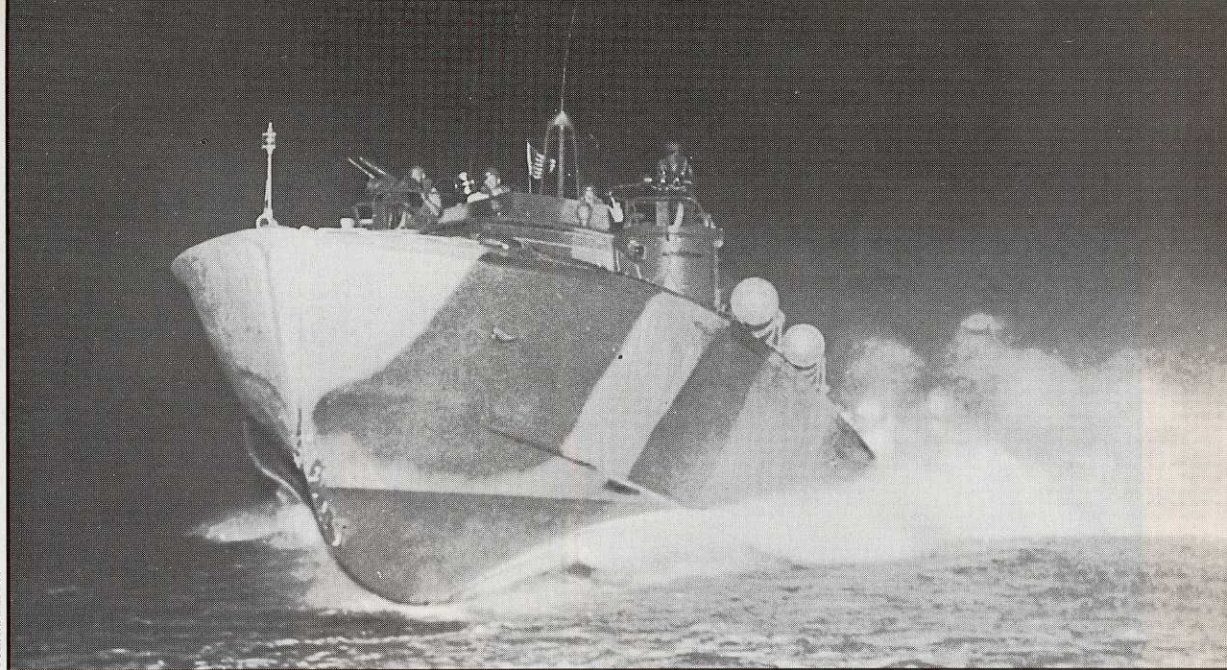
The argument of maneuverability versus speed and accommodations still rages between Elco and Higgins PT veterans. I learned early on in my research that it wouldn't be a good idea to point out design shortcomings of their own boats, or attributes of the other boats, to anyone who had fought on either PT.

Variants and Adaptations

The role of the PT gradually evolved, requiring a boat that could cut off enemy supply lines and reinforcements. The result was that the PTs became armed more as gunboats than as pure torpedo boats. Whether modified at the factory or literally strapped on deck by the crew, every manner of mortar, rocket, bazooka, or cannon was tested to increase firepower. The adaptability of the hulls and

Wearing wartime camouflage, a Higgins 78' PT boat roars out of the darkness.

Coastal Forces



their ability to perform even after severe overloading explains why PTs saw action in every theater.

Higgins continued to refine the torpedo boat concept with its introduction of the 70' Hellcat later in the war. The new boat reached speeds of 57 mph, and could reverse direction in a third of the time of its predecessors. Though certainly the finest small attack craft of the war, the Hellcat was simply too small and could only act as a pure torpedo boat. The Navy decided against disrupting current production lines to put the Hellcat into service.

Elco continually modified its boats to maintain performance levels. Two fascinating innovations were the addition of the Elcoplane and Elco "slipper." The Elcoplane consisted of a series of wedge-shaped steps that were fastened to the underbody, a modification that made the boats' top-end speed jump from 42 mph to 56 mph! However, this came at the price of substantial turbulence when the boat was off plane. The slipper was a set of plywood bottom panels that extended past the transom. The panels were adjusted up and down with screws to alter trim and attitude, probably the first set of high-performance trim tabs.

Epilogue

The Navy was faced with the daunting prospect of mothballing and maintaining the PT fleet at the end of World War II. With their mission complete, most of the boats from the Mediterranean were given to the U.S.S.R. under lend-lease, and the Pacific boats were gathered and torched on the beaches of Samar in the Philippines. While this seems a particularly tragic end for such charismatic craft, it only underscores that the boats were indeed expendable.

With their extravagant design and high profile, it is easy to overlook that one of the greatest assets of the wooden wonders was that they were inexpensive. For the price of one destroyer, the Navy had been able to build three full squadrons of PTs (36 boats). Given its relatively low budget, the PT boat program made a major impact and lasting impression. It serves as a symbol of the achievement made in mobilizing the labor and resources of the wooden boat building industry.

The refinement of high-performance V-bottomed hulls continued in the postwar years, with milestone designs from such names as Huckins, Rybovich, and Ray Hunt. This development chronicled the scientific approach to studying powerboat performance and loading. The details of this evolution, as well as its legacy in naval architecture, ironically have been overshadowed, though the aura of the PT boat has been enshrined in modern mythology. ■

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Further Reading

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