



Republic P-47 Thunderbolt
The Making Of A Juggernaut

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Abstract

The Republic P-47 Thunderbolt was the most mass produced fighter in the United States in World War Two. The aircraft was a marvel of engineering, combining incredible power, strength and firepower into the heaviest yet most high performance piston aircraft to serve in the war. The following will explore the aircrafts one of a kind GE CH-5 turbo-supercharging system, as well as it's venerable Pratt & Whitney R-2800 power plant and the extremely rigid airframe that contained it all; and how the aircraft came to be one of the top fighting aircraft of World War Two.

Republic P-47 Thunderbolt

On fire and spinning out of control Robert S. Johnson attempts to bail out of his mangled P-47, but the canopy has been jammed by metal twisted and torn by twenty millimeter cannon shells that had just smashed through his plane. Johnson has resigned himself to dying in what he and his fellow pilots refer to as a "7 ton milk jug"; then miraculously the fire goes out, and the aircraft recovers from its death spiral. A glimmer of hope, the aircraft hasn't given up yet. Johnson settled in to attempt to fly his aircraft back to England, but he still had to make it out of the heavily defended "Fortress Europe". With the engine spewing oil his first worry is whether or not it will make power, cautiously he advances the throttle and find the aircraft accelerates. He finds that he still has complete control of aircraft, and points it in the direction of home. As he flies along, the hope grows that he will in fact make it home; but he and his aircraft have yet to face their greatest challenge. Johnson has been spotted by Oberstleutnant Egon Mayer, a German ace destined to reach 100 kills. Johnson's aircraft, while flyable, is in no condition to fight, he is a sitting duck. Mayer slips his aircraft into firing position and lets loose with his twenty millimeter cannons and thirty caliber machine guns. Johnson tucks himself into the cockpit, putting the P-47's armor plating in between himself and Mayer's guns. After firing Mayer pulls up alongside Johnson's Thunderbolt and surveys it, in disbelief that the aircraft is still flying. This goes on two more times, with Johnson firing back once when Mayer overshoot the Thunderbolt. After the third pass, Mayer's guns run dry, he pulls up alongside Johnson one last time, rocks his wings in salute and flies off. Johnson continues

home, and when instructed to climb, he adds power, pulls back on the stick, and his battered aircraft does as commanded. He is vectored to his home base, lowers the landing gear, touches down without incident.

After shutting down and being freed from the still jammed canopy Johnson hopped down off of the wing of his aircraft and began to count the bullet holes, including 6 in the propeller. He stops after reaching two hundred, including twenty-one from the twenty millimeter cannons; all without moving around the aircraft. The aircraft had battle damage over every part of it, but managed to bring him home. Johnson stated the following in his autobiography Thunderbolt!, "The airplane had done her best, but she would never fly again".

This is one of the most incredible tales of the P-47s rugged characteristics. Other accounts include the aircraft returning home missing entire sections of wing, cylinders off of the engine, and control surfaces shot off. Many airmen owe their lives to the P-47, and the characteristics that earned it names such as "The 7 ton milk jug", "The Juggernaut", and its official name, "Thunderbolt".

The Airframe

The P-47 was the largest and one of the most powerful aircraft of world war two. The design of the aircraft is in fact, the brainchild of two Russian immigrants, forced out of Russia during the Bolshevik Revolution. Alexander De Seversky and Alexander Kartveli have the distinction of designing the only aircraft built around a turbo-supercharging system. The great size and weight of the aircraft are in fact the direct result of the required use of a giant General

Electric designed turbo-supercharger and the ducting to feed it. But, as the Thunderbolt's incredible combat record shows, structural integrity of the entire aircraft was not compromised.

The fuselage is a semi-monococque design, using all metal stress-skinned mated to transverse bulkheads and longitudinal stringers. The fuselage is actually two parts, a top and a bottom half that are mated together, and the empennage section is in turn mated to the fuselage. One of the most prominent features of the fuselage, other than the turbo-supercharging system is the armored cockpit and three and a half inch thick steel wing hinge braces. The overall dimensions of the fuselage are; it is fifty-three inches wide, eighty-eight inches long, and four hundred and thirty-eight inches long including the engine mount.

The wing is a semi-monococque design reinforced by "extruded angle stringers" built around two main wing spars. The wing is designed to house four, fifty caliber machineguns on each side, as well as the three hundred and fifty rounds of ammunition for each gun, in addition other munitions hard-points were designed on the bottom of the wing. Other wing structures include the wheel well and landing gear trunnion attachment points. The gear interestingly enough, is designed so that upon retraction, the legs shorten by nine inches. This requirement comes from the placement of the gear on the wing, so as to not interfere with the machineguns, yet still be long enough for the propeller to clear the ground. The wing area is an enormous three hundred square feet with a span of forty-one feet.

The engineering of the P-47's airframe paved the way for the legend of an aircraft that was considered nearly indestructible. Stories are told, such as the example of Robert S.

Johnson, of pilots returning to base and landing safely, never realizing just how much of their airplane was missing. The Thunderbolt's airframe allowed for it to achieve incredible performance, while sustaining "g-loading" that would destroy other aircraft. In one particular case, a very notable P-47 pilot by the name of "Hub" Zemke attempted to use a P-47 escape tactic in a P-51 Mustang, and ripped the wings off of it. In one case during testing, the P-47 reached an indicated airspeed in excess of seven hundred miles per hour and held together.

Even with the great weight and size, the aircraft was maneuverable enough to be an effective dogfighter, although it was not its ideal fighting style. Weighing in excess of fourteen thousand pounds, the Thunderbolt remained nimble enough to tangle with the best of her opponents, but as stated, the ideal use of this aircraft not to "turn and burn" but to "zoom and boom"; a tactic in which, using the great diving speed of the Thunderbolt, a pilot would dive on an enemy, fire at him and then, using the excess energy and speed, climb up and away from opponent to set up for another attack. But, the P-47 is not so much known for her dog fighting as she is for being the first true, close air support aircraft. Thunderbolts were continuously in the thick of the ground war, as close as it came to being "in the trenches" while in an airplane. In many cases, the pilots of Thunderbolts would communicate directly to the troops on the ground and coordinate with them to take out enemy positions. Even General Patton himself, while not a believer in airpower, complimented the P-47 by admitting that the 9th Air Force's P-47s kept the Germans from attacking his right flank during his race across Europe. It is even documented that entire German ground units surrendered to 9th Air Force units! This would not have occurred, nor been possible, had the P-47 not been rugged enough to operate in any conditions, and go toe to toe with any enemy, take damage, and still return home.

The Engine

The P-47 was powered by variations of the legendary Pratt & Whitney R-2800 radial engine. The engine has two rows of nine cylinders, as well as an internal supercharger. It is a twenty-eight hundred and four cubic inch displacement engine that made a range of power from two-thousand to twenty-eight hundred horsepower. The compression ratio is a moderate 6.7:1 with the four blade propeller geared to spin at half of the engine's speed. The propeller is a gigantic thirteen foot diameter Hamilton Standard constant speed design, this allowed for only six inches of ground clearance. The engine is fed by a Stromberg fuel injection carburetor in conjunction with the GE turbo-supercharging system.

The R-2800 took full advantage of the turbo-supercharger that the aircraft was designed to house, making an incredible fifty-two inches of manifold pressure at top operating altitudes. This was attainable in what is called "war emergency power" or WEP. With WEP engaged a water mixture was injected into the cylinders to prevent detonation, which would otherwise be caused by the high pressure of the intake air, and the turbo-supercharger is set at full blower, the engine could make up to two thousand eight hundred horsepower; an incredible one to one ratio with displacement with a manifold pressure of seventy-two inches of mercury at normal operating altitude (38,000ft). Even at the normal power output of two thousand horsepower, if it is broken down to each cylinder, each cylinder creates an incredible one hundred and twelve horsepower. It is prudent to mention that in experimental testing Republic Aircraft engineers ran a R-2800 at thirty-six hundred horsepower for two hundred and fifty hours, on 100LL fuel, without any failure.

Of course, an engine of this much power is not the most efficient when it comes to fuel consumption. The P-47's Pratt & Whitney is fed by a "wet" wing fuel tank with a three hundred and seventy-five gallon capacity, and additional drop tanks ranging from seventy-five to two hundred gallons. Even at the aircraft's economy fuel settings it still consumed one hundred and fifty-three gallons per hour. The water injection system mentioned in the previous paragraph was fed by a thirty gallon tank that is attached to the firewall, providing pressurized water beyond the carburetor and therefore raised the octane rating of the fuel-air mixture; this occurred without a rise in manifold pressure and therefore, with water injection engaged, the Turbo-supercharger control is "fooled" into allowing the blower to spin at the RPM needed to provide the WEP boost.

The R-2800, like all radial engines, is known as an oil slinger. It is a fact that radial engines consume oil at a rate that would alarm an operator of an in-line type engine. This is partly the reason that the R-2800 is fed oil in a "dry sump" design from a nearly twenty-nine gallon oil reservoir. The reservoir is strapped to the engine mount and incorporates a pendulum in the tank to insure that oil is provided during inverted flight, so long as the inverted flight was only sustained for a limited time.

The Pratt & Whitney R-2800 has an incredible legacy, not only as one of the most widely used radial engines, but also as one of the most reliable. It is even ventured by some aviation columnists that the R-2800 may be piston engine perfection. The engine served with distinction on many US aircraft, including the F4U Corsair, F6F Hellcat, and B-26 Marauder. But, nowhere else was its ruggedness and reliability showcased, than when it was strapped to the front of a P-

47. An airframe as tough as the Thunderbolt would not have gained the reputation it had if the engine was unable to sustain damage. Some combat reports indicate that pilots would return to base complaining that the engine was running a little rough, but when disembarking their airplane, found entire cylinders missing from the crankcase. The R-2800 was able to sustain damage that would cripple other engines yet still run with enough power to allow the pilot not only to fly home, but to perform evasive action if attacked. This is a testament not only to the Thunderbolt, but to Pratt & Whitney, and Republic for bringing them together.

As a side note to the P-47 and its power plant, it must be mentioned that during the development of the Thunderbolt, Chrysler entered the competition with its IV-2220 engine; unique because of its hemispherical cylinder heads. Even though this sixteen cylinder inverted-vee engine lost out, cited as ineffective given its weight, it is important for the reason that this is the first instance of a "Hemi" engine. Although it was never used for a production aircraft, all Chrysler and Dodge Hemi owners, you can thank the P-47 for the research and development.

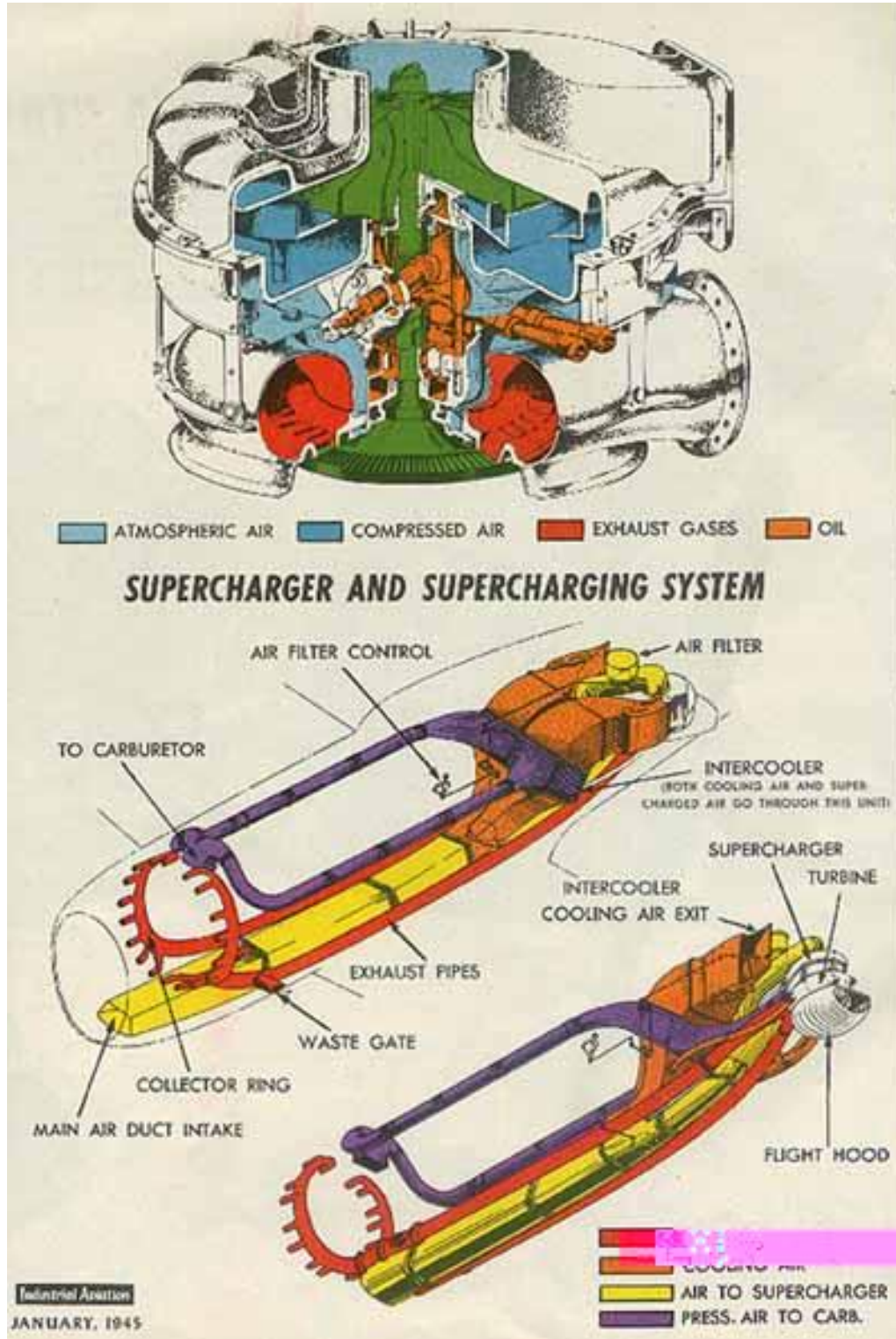
The Turbo-Supercharger System

The Thunderbolt was built around one principle system, the enormous GE CH-5 turbo-supercharger. For the P-47, the turbo-supercharger, supporting duct work, and systems were laid out then the aircraft was built around it. The aircraft was designed to be a high performance and high altitude fighter; in order to attain the performance level at the desired altitude, one of the largest turbo-superchargers in the world needed to be used. The only engine at the time capable of providing the necessary power for both the aircraft and the turbo-supercharger was the R-2800, and they would turn out to be a perfect combination.

The placement of the GE CH-5 turbo-supercharger is one of the first things that is noticed in drawings of the P-47. The placement is different than convention, with the turbo-supercharger being placed roughly twenty-two feet behind the engine. This may seem odd, if not downright wrong to many engineers, but to Alexander de Seversky and Alexander Kartveli, this was the only solution. The turbo-supercharger is fed by a ram air duct that opens at the front of the aircraft, directly under the engine. This is actually the feature that gives the P-47 its distinct "potbelly" look. The turbo-supercharger's turbine is fed from the exhaust that is collected from the engine by two collector rings, otherwise known as exhaust pipes, and is piped under the cockpit on either side of the ram air inlet, back to the turbine, and then out of the tailpipe. The supercharged air delivered by the compressor is in turn pipe up out of the turbo-supercharger and along either side of the fuselage up to the carburetor air inlet. Back by the turbo-supercharger is an air intercooler through which ram air and supercharged air flow, with the ram air cooling the supercharged air.

The supercharging of the air is controlled, originally via pilot manifold pressure input through a level on the throttle quadrant in the cockpit. This in turn provides input to an oil operated supercharger regulator system. The regulator is a piston type, with exhaust pressure and a compression spring providing a balancing action. The spring is loaded to directly correspond to the turbo-supercharger lever in the cockpit. When the exhaust pressure deviates from the selected value, the piston moves in the direction of greater pressure; either being pushed by the spring, from less exhaust pressure, or being pushed by a higher pressure of the exhaust gases. This in turn opens a port admitting pressurized oil into the chamber, in turn actuating the waste gates, which are located just aft of the collector rings, in the direction

required to balance the piston again. The following illustration is from a January 1945 issue of Industrial Aviation, it illustrates the turbo-supercharging system setup and basic operation.



The Juggernaut

The Republic Aircraft Corporation P-47 Thunderbolt, was the largest, heaviest, and meanest single engine fighter of the second world war; bringing together an incredible engine, turbo-supercharging system, and containing airframe into one clean fire-breathing machine. The aircraft was capable of up to five hundred and five miles per hour in level flight, flying at up to forty-four thousand feet, and bringing eight .50 caliber machineguns with three-hundred and fifty round a piece along for the ride. The aircraft was the most massed produced USA fighter of World War Two, serving in every theater in which the United States was engaged serving with distinction, especially in the close air support role. For the first time providing friendly ground troops with the ability to directly communicate with and work with the pilots to achieve and objective.

The combat record of the P-47 is as impressive as the aircraft is imposing; flying an incredible seven hundred forty-six thousand sorties in Europe alone. In Europe P-47 pilots claimed three thousand seven hundred and fifty-two air-to-air kills, with six hundred and seventy-seven of them going to the 56th Fighter Group "Zemke's Wolf pack" the only group to operate P-47s throughout the war. The Thunderbolt was even able to destroy the newly developed jet aircraft, the Messerschmitt 262 and the Arado Ar-234, in air-to-air combat, including making the first jet kill in history. As the P-51 Mustang came on the scene, The P-47 squadrons of the 9th Air Force proved the Thunderbolt to be even better at ground attack than it was at air-to-air combat. Between the invasion of Normandy on June 6th, 1944 and Victory in Europe on May, 7th 1945 the P-47 units claimed eighty-six thousand rail cars, nine thousand

locomotives, six thousand armored fighting vehicles, and sixty-eight thousand trucks destroyed. The German troops were constantly harassed by Thunderbolts, in some cases, just the sight of a Thunderbolt was enough to demoralize the enemy, and sent them into retreat. P-47s carried a combination of rockets and bombs into combat in addition to their fierce armament of eight .50 caliber machine guns; allowing the Thunderbolt to destroy everything in its path, paving the way for advancing friendly ground troops.

In its service the P-47 inspired confidence in its pilots, by protecting them and bringing them home, through hell and back. Bomber pilots had their own name for the P-47, calling them Little Friends, when the Thunderbolts escorted them into enemy territory. The enemy no doubt, feared this enormous "Jabo" (German for Fighter-Bomber) which could fight through air cover and still rain hell from the sky.

Conclusion

The P-47 served in the air forces of the world from 1941 until the last were retired from service in the Peruvian Air Force in 1966; well into the jet age. Fifteen thousand six hundred and eighty six Thunderbolts were produced, in modern monetary value, at \$1.04 million; unfortunately there are only about twenty-five P-47's left flying or under restoration to flying condition. The aircraft's toughness became the stuff of legends, the performance was underrated given that in many categories the P-47 actually outperformed its thoroughbred rival, the P-51 Mustang. Although it wasn't as pretty, clean, or graceful as its counterpart, the P-47 Thunderbolt was just as, if not more important during its serve; a testament to its designers, and their ability to bring together a great airframe, engine, and turbo-supercharging system in

to one. Although not a fact, it was rumored that the following quote hung on a sign in the 56th Fighter Group's ready room, the last thing they say before leaving for a mission. " Yea though I fly through the valley of the shadow of death... I fear no evil ... for I fly the biggest, baddest, meanest, fastest sonvabitch in the whole damn valley". And that about sums up exactly what the P-47 was.

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