Frank Walker - “What can I do about this problem?”

By Kimble D. McCutcheon

A lone Republic P-47 “Thunderbolt”, affectionately known as the “Jug” because of its rotund shape, was cruising in the bright sky of Germany. In one of the numerous skirmishes of the day, the Jug had become separated from its group. Now its pilot was headed home, low on ammunition and not exactly brimming with fuel. He had pulled the big Pratt & Whitney R-2800 back to less than half power and it was now sipping fuel at a rate of only 65 gallons per hour. To avoid any further enemy contact, he was flying at about 15,000 feet, in and out of the top of a broken overcast that hid him from the view of enemy fighters most of the time.

The P-47 “Thunderbolt”

Encountering one of the clear spots, the Jug pilot rapidly scanned above him and was shocked to see a couple of German Focke-Wulf Fw 190 fighters a few thousand feet above him and ahead by about a mile. “No threat”, he thought. Looking around still more, he now saw the object of the Fw 190’s interest – a lone B-17, trailing smoke from its number two engine, and heading for the cover of the same overcast the Jug pilot was using.

It was evident to the Jug pilot that the B-17 could not make the other side of the clear area before the Fw 190s caught up. Knowing he had no time to spare, the Jug pilot flipped a switch on the top of his throttle and simultaneously pushed the propeller ,throttle and supercharger controls forward to the stops. Moving the stop aside on the throttle control, he continued to push the throttle and supercharger controls to the War Emergency Power setting. The mighty R-2800 sprang to life, delivering over 2300 hp. The Jug pilot felt the exhilaration of the rapid acceleration.

He was now burning over 275 gallons of fuel per hour, but he knew this would not be necessary for more than a few minutes. He raised the nose of the Jug until it was slightly above the horizon and then pushed it gently forward until he was very light in his seat, but not yet weightless. Freed of the induced drag, the Jug accelerated even faster. He was overtaking the Fw 190s. They were now within range of his eight .50 caliber machine guns. The Jug pilot did a quick check of the B-17s location and decided he could delay firing just a bit longer, thereby assuring a better chance of a kill.

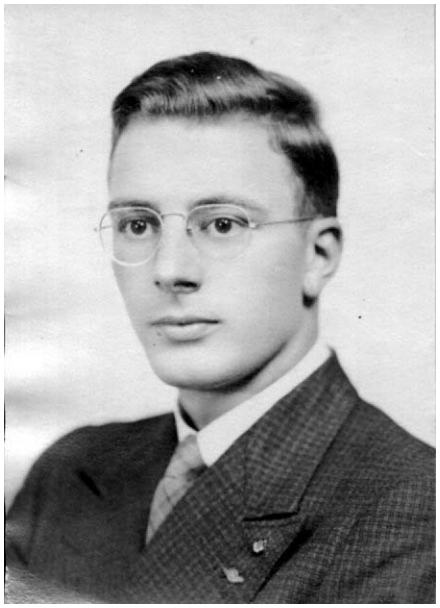
Finally, the Jug pilot sensed he could wait no longer. Ever so slowly, he raised the nose of the Jug, up past the horizon and finally to where the lead Fw 190 came into his gun sights. He aimed for an area just aft of the engine and squeezed the trigger. Eight machine guns simultaneously shook the Jug as three short gun bursts sent streams of lead in the direction of the lead Fw 190. With a slight tug on the stick, the Jug pilot adjusted his aim as tracer rounds made visible the path of his fire. He saw a small stream of smoke grow into flame which rapidly spread. The lead Fw 190 broke off the attack as its pilot bailed out. The Jug pilot maneuvered to sight the other Fw 190, but it was reversing direction, running for home.

The B-17 tail gunner had witnessed the whole thing. He had seen the Fw 190s, called their position, and was waiting for them to come within gun range. Once the Fw 190s were dispatched, he announced to the rest of the crew that they had probably just been saved by the P-47.

The B-17 crew did not know it, but they also owed their lives to Frank Walker, the number three son of a Florida banker. Frank was the Pratt & Whitney test engineer who had developed the water injection that allowed the Jug to win the chase. As important as it was, water injection was just another of the many contributions Frank made to the War effort, and just one of the still more numerous contributions that would follow the war.

EDUCATION and MARRIAGE

Frank can not remember a time when he was not fascinated by all things mechanical. Unlike his brothers who followed their father in the family banking business, Frank was more interested in working sixty hours per week at the local garage. For each long week, Frank received the grand sum of **seven dollars.** Although he considered himself the “black sheep” of the family because of his engineering interests neither his father nor brothers were anything other than supportive.



Frank Walker, circa 1941

Frank J. Walker was born March 20, 1919 in Pittsburgh, PA. He moved with his family to Florida in 1925 and attended Ponce de Leon High School. Initially missing the application deadline for the Massachusetts Institute of Technology, Frank spent a year and a half at Rollins College in Winter Park, Florida. He was finally accepted at MIT and received a Bachelor of Science in Mechanical Engineering in early June of 1941. Instead of staying for his graduation ceremony, Frank drove directly home to marry Judy Woodward on June 12, 1941.

Judy had worked as a switchboard operator and stenographer at the First Federal Savings and Loan of Miami, the bank owned by Frank’s Father. She met Frank while he was home from MIT during the summer of 1940. A mutual friend set up their first date. “I was not at all impressed”, remembers Judy. “His clothes were too big and he wore both a belt and suspenders.” But Frank was persistent, insisting on dates, showing up at 7:00 AM to drive Judy to work and hanging around the employee entrance to the bank at lunch time and after work.

“Since he would not go away, I decided to try insulting him, but that didn’t work either”, says Judy. “As I got to know him, his personality started to grow on me and I began to like him in spite of his funny clothes. Then when he returned to MIT in the fall, he wrote a letter every day and expected one in return!”

Once the wedding festivities were over, Frank and his new bride drove straight back to Connecticut to begin his new job at Pratt & Whitney Aircraft. Their honeymoon was the drive north.

Pratt & Whitney was gearing up for the impending conflict of World War II, and housing was scarce in Hartford. The couple finally located a third-floor apartment that rented for sixty dollars per month. That was quite steep, considering that Frank only brought home $130.00 per month! The engineering market was extremely soft at that time and wages were low. Frank recalls that painters in the Pratt & Whitney plant made over twice what Test Engineers did.

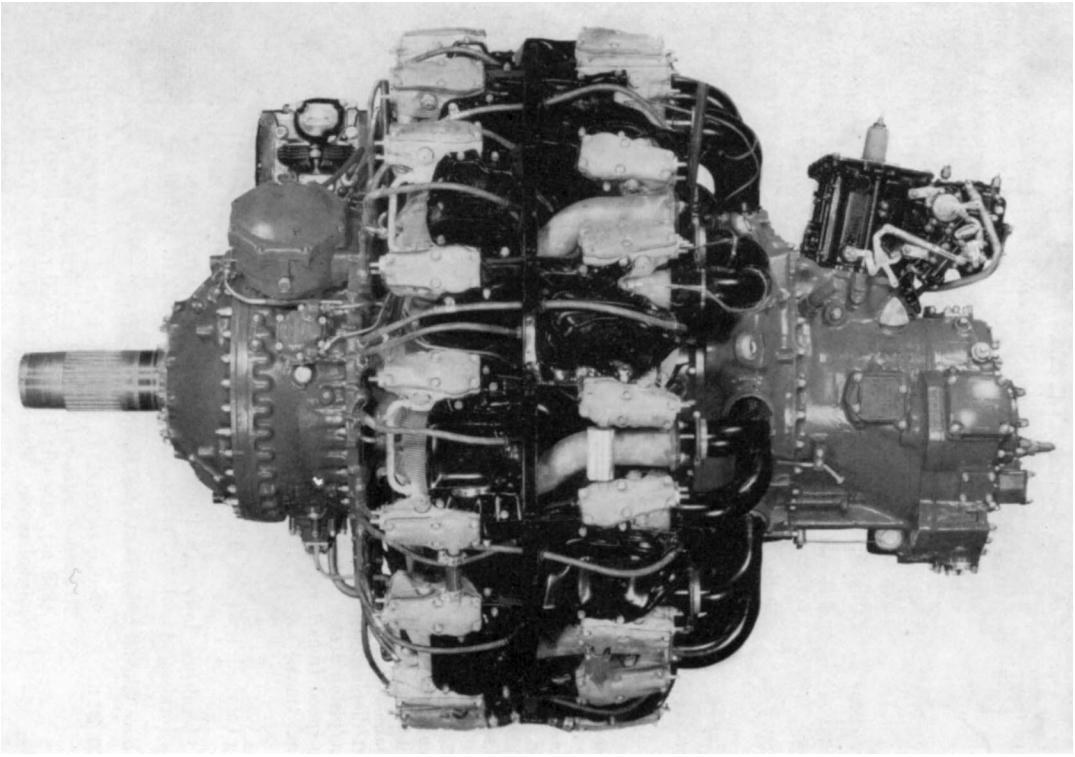
Despite economic considerations, Judy ran a successful and efficient household. The Walkers rapidly made friends in the Hartford area, and this group of friends all pitched in to help one another as the horror of World War II unfolded with its rationing and restrictions. When asked about what he thought were his greatest accomplishments, Frank replies without hesitation “marrying Judy and water injection”.

Frank and Judy Walker, circa 1942

PRATT & WHITNEY

While at MIT, Frank had been offered a position at both Wright Aeronautical and Pratt & Whitney. His work on variable valve overlap for Professor C. F. Taylor had gotten the attention of several engine builders. He chose Pratt & Whitney largely because of a Test Engineer named Barney Schmickgrath who was making the college recruiting rounds. Schmickgrath told Frank what being a Test Engineer was all about, and Frank was sold. Arriving at Pratt & Whitney, Frank participated in a six-month orientation that covered all aspects of engine development and production. Frank then joined the Experimental Test Department as a Test Engineer.

His first job was in single-cylinder development of the forged cylinder head of the R-2800 “C” series engines. Rather than being cast in place as was the usual practice, cooling fins for this cylinder were made by gangs of saws that cut grooves into the forging. After initial problems with cracked fins, loose spark plug thread inserts, and leaky rocker box cover leaks, the new cylinder head entered service and remained essentially unchanged through the remainder of R-2800 production.



The Pratt & Whitney R-2800

After Pearl Harbor was bombed, Frank tried to enlist in the U.S. Army Air Corps, hoping his flying skills would aid the war effort. He had been a private pilot since 1939. The recruiter told him, “First of all, if you get in you will be a regular soldier just like all the others, with no special consideration due to your flying experience. Second, you are one hell of a lot more useful to us making good engines than getting shot at.”

WRIGHT PARKINS

At the time Frank Walker came to Pratt & Whitney, Wright Parkins was the mid-level manager responsible for getting new versions of the R-2800 into the air. As Engineering Manager Parkins had to coordinate the myriad activities associated with solving development problems. He had a reputation for being a tough taskmaster.

"Parkins struck terror in the hearts of test engineers, and some of the guys even claimed he ate nails for lunch", remembers Frank. "He made me go to Ford River Rouge plant over the Fourth of July in 1942 because they were having trouble getting some of their "B" engines to produce rated power[1]. When I arrived, I met with a team and asked them to pull a production engine at random and install it in the test cell. I was really impressed, because they had it ready to run in about half an hour. Back at Pratt & Whitney, it took us half a day to do the same thing. We ran the engine, and it produced 1950 HP." "Pull another", said Frank. It produced 2050 HP. Not wanting to give the Ford guys a chance to find out just how new he was to the engine business, Frank figured he had better do something to get out of there as fast as he could. "Gentlemen", he said, "what we see here is the normal power output spread of engines in production. You don't have a problem". "Let's try another", said a Ford Engineer. "No need", said Frank. "I've seen all I need to see".

With that he returned East Hartford to face the fiery Wright Parkins. Frank tried to avoid Parkins, but was soon found. "**Wallll-kerrrrr!**" bellowed Parkins as he pursued Frank across the shop floor, "What the hell is going on up at Ford?" Frank shakily explained what he had found and what had done. Parkins smiled and said, "Son, you did the right thing."

THE WORK ENVIRONMENT

Test Engineers planned and oversaw developmental testing of engines. There were operators in the engine test cells as well who handled most or all the engine controls while the test engineer and a helper took data and sequenced the test.

Today, using computers, a single operator can simultaneously monitor a dozen test cells. In those days it was a bit more labor intensive. For example, each temperature measurement was made by adjusting a precision potentiometer until a meter read zero. The physical position of the potentiometer was then recorded and the temperature associated with that potentiometer position looked up in a table, recorded on a chart, and later plotted onto a graph.

Within the Experimental Test Department, tear down and assembly mechanics would build an engine to a certain specification before a test and would tear it down, inspect the parts, and help with gathering data for reports once the test was completed.

Three kinds of reports were issued. Pratt & Whitney Aircraft (PWA) reports were formal reports that marked the termination of major projects. A PWA report would be published when a particular engine model passed its Type Test. Memorandum Reports (MRs) were less formal but still polished and reviewed enough to allow

[1] Ford was licensed by Pratt & Whitney to build R-2800s during World War II.

outside the company. Short Memorandum Reports (SMR) were strictly internal reports, never seen outside Pratt & Whitney, that were used primarily to communicate results of studies and tests to those involved on the project. It is these reports that sixty years after the fact allows some insight into the day-to-day activities associated with engine development.

There were few formal meetings among those working on a given project. Discussions over lunch or while passing in the hall made good use of everyone's time. A Test Engineers would report to his Assistant Project Engineer each morning to review results from the previous day (and usually night as well). They would then plan the tasks to be accomplished that day. Test Engineers had enormous freedom to pursue solutions on their own, without necessarily consulting the design or engineering departments. If they observed a flaw in the design of a part that had not faired well during testing, they would sketch a fix and send it to the Experimental Machine Shop. There, Joe Ballard, head of the machine shop, would somehow manage to juggle the schedule enough to produce the desired part rapidly.

Ballard lived in constant fear of Wright Parkins and the "Hey, **Joe!**" that he would yell to get everyone's attention upon entering the shop. Ballard did a remarkable job of making sure the Experimental Test Department kept pace with Pratt & Whitney engine development.

CAPTURED GERMAN ENGINE EVALUATION

Frank read a German report on a captured R-2800 that had been test run, torn down, and meticulously analyzed. Allied spies, operating under deep cover in Germany, had somehow managed to get the report and smuggle it out. With typical German thoroughness, each part had been measured and analyzed. The master rod bearing were of particular interest, because a Pratt & Whitney tiger team had worked around the clock back in 1938 to develop a master rod bearing that was practically indestructible. It consisted of a steel shell that was plated with silver, then lead, and finally indium. The silver offered excellent fatigue resistance, the lead was easily wetted with oil, and the indium kept the whole assembly from corroding once the engine oil was contaminated with the organic acids that build up in used engine oil. The team had spent countless hours getting the process and proportion of materials just right. Discovery that indium should be the final layer had been a particularly vexing problem. Ultimately, the team produced a bearing so good that the Army Air Corps insisted it be used in all large radial aircraft engines, regardless of make. So as Frank read the report, he was fearful that the secret would be discovered and give the Germans a bearing advantage. When he finally got to the analysis of the master rod bearing he was delighted to find the following:

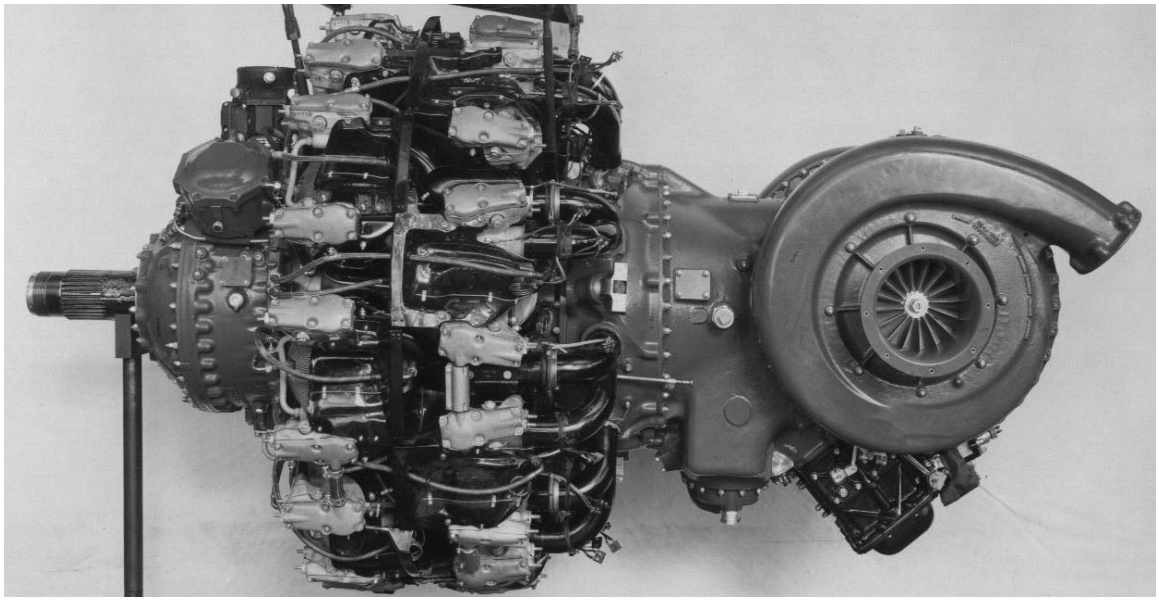
COMPOSITION OF MASTER ROD BEARING

Silver –97%

Lead – 3%

Indium – Trace – thought to be an impurity!

SUPERCHARGER TROUBLE



Test Engineers usually worked exclusively on one project and rarely had any formal connection to the projects of their peers. There was some cross-pollination in lunchrooms and around water fountains. Once, over lunch, Frank's friend and fellow Test Engineer, Elton Sceggel, was having a bad day. He was working on the new "E" model of the R-2800 which featured two large superchargers, one on either side of the rear accessory case. These were driven through variable-speed hydraulic fluid couplings rather than the usual clutch and two-speed gear train. It was the first and only Pratt & Whitney engine to feature supercharger impellers that were mirror images of one another. "I don't understand it, Frank", said Sceggel. "I have been testing all morning and can't even get 1000 HP out of this pig. Manifold pressure is low, and the superchargers are making a devil of a racket". Frank stared off into the distance. "Scege", he said, "is there any chance the impellers are switched?" "No way", replied Sceggel. By then, lunch break was over and the two engineers went their separate ways. Later they passed in the hall. "Frank!", cried Sceggel, "you were right! We reversed the supercharger impellers and the thing ran just fine!"

WATER INJECTION

In early 1943, word came down from the front office that a means must be found to get additional power from existing engines without redesigning either the engine or airplane it was in. While Pratt & Whitney was working around the clock to complete the 3000HP R-4360, it was still years away and could not be fitted into existing aircraft.

The shortest path to more power is always more manifold pressure. Since the P-47 had a turbo-supercharger which could produce surplus manifold pressure, it seemed a good candidate for more power. The rub was that with the additional compression of the inlet air came heating of the inlet charge which resulted in power-limiting

detonation. With the 130 PN[2] fuel than available, Pratt & Whitney was already getting all the power that was possible with the R-2800. Someone in the front office suggested that water injection be tried. Perry Pratt was the Project Engineer.

Frank acquired a stock R-2800 “B” engine, serial number 5275, directly from the production line. The only modification to the engine was a longer hollow bolt to accommodate a second banjo fitting that supplied water to the fuel inlet of the supercharger. Frank performed all of the initial water injection calibration by manually adjusting the throttle, supercharger, propeller, and water injection settings. Once the behavior of the water-injected engine was understood, Frank presented data to the carburetor group which, under the direction Dick Coar, designed and developed a water injection regulator and the associated carburetor modifications.

Frank got 2150 HP the first night. This was up from the 2000 hp the engine normally produced and was the sole result of being able to use a leaner mixture at take-off power. Until then, the engine had to be run very rich at take-off power to prevent detonation, actually using fuel to cool the engine. It was running so rich in fact, that it was producing less than ideal power. In later experiments, manifold pressure was increased to simulate the output of the turbo-supercharger, and horsepower increased dramatically.

Ultimately, the maximum power achieved on the “B” series was 2800 HP at 2700 RPM. Maximum power ever achieved on the “C” series was 3800 HP at 2800 RPM. The maximum manifold pressure ever recorded was a staggering 150 inches of mercury (inHg)! This was up from dramatically from the 49-inHg maximum manifold pressure originally allowed in the R-2800 “A” series of engines.

Water injection worked by reducing cylinder inlet temperature, thereby delaying the onset of detonation. As the water evaporated in the induction passages of the engine, it providing a prodigious amount of cooling to the fuel charge due to the latent heat of vaporization of the water. Cylinder inlet temperatures went from about 350°F to about 100°F. This increased the detonation margin to the point that up to 150 inHg of manifold pressure could be used. When water injection was in use, the engine was markedly smoother, and the interior of the combustion chambers stayed extremely clean with no carbon or varnish build-up on the piston crowns, valves, or ring packs. Frank remembers that “There was no hard carbon whatsoever. You could clean the top of a piston down to bare metal by wiping it with a cloth”.

German engineers tried water injection (Wassereinspritzung) on their gasoline engines, but with limited success. Germans, who were very good at building high-precision pumps, had perfected direct fuel injection for their large aircraft engines. German engineers injected water directly into the cylinders as well. Since the water did not have time to evaporate and cool the induction air, the large cylinder inlet temperature reduction was not achieved. Frank learned of this while reviewing a report on a captured German aircraft engine.

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[2] Fuels with detonation characteristics better than those of pure iso-octane are correctly rated by Performance Number (PN) rather than octane rating.

The Government had specified a particular test regime to qualify an engine at “War Emergency Power”. This was a rating higher than take-off power and usually assumed anti-detonation injection. First the engine was run for five hours in five minute cycles alternating between War Emergency Power and a fast idle. Then it was run for two and one-half hours at a steady War Emergency Power rating. The Government thought this was a tough test, but Pratt & Whitney routinely ran its engines for 100 hours straight at War Emergency Power. The seven and one-half hours required by the Government was no problem whatsoever.

In spite of the ease with which the engine passed these Government-mandated tests, Frank remembers the one on May 10, 1945 with particular clarity. The test had been scheduled months in advance, a Government representative was on hand to witness, and the test had to be completed on schedule. The test team was in the middle of the five hours of five-minute intervals of War Emergency power and fast idle. During one of the idle intervals, Frank rushed to the telephone to call the Hartford Hospital. He learned that he had just become the proud father of Frank J. Walker, Jr. When the Government witness learned of this, he said “You guys go on without me. This is just too much confusion – engine on, engine off, babies being born, noise, smoke, fire…” With that, he stalked out of the test cell.

Initial tests were with plain tap water from the East Hartford municipal water supply. Later, when flight tests were pondered, alcohol was added as an antifreeze agent. Three alcohols were tried: ethyl, methyl, and isopropyl. Along with the tank car of ethyl alcohol came U.S. Treasury Agents and instructions that the engine was not to be run without a Treasury Agent being present. After a couple of weeks, the Treasury Agents retired to the Engineering Office where they drank coffee and flirted with the engineering aides and secretaries. They found no one was interested in drinking their alcohol and were tired of the heat, noise, and confusion of the test cell.

It was discovered that a mixture of about 50 per cent ethyl alcohol was required to prevent the water from freezing at high altitudes. Once tests on the ethyl alcohol were complete, a similar battery of tests was run on methyl alcohol. There was virtually no difference between the two alcohols. On the drive home for dinner, Frank considered not even running tests on the isopropyl alcohol, thinking that “alcohol was alcohol”. Later that evening, he started feeling guilty for not completing the battery of tests on isopropyl alcohol and went back to the test cell to begin the last of the tests.

To his utter amazement, Frank could not even get take-off power when using isopropyl alcohol. The engine ran terribly, missing, , spitting, shaking, and spewing flames thirty feet long from the exhaust stacks. At midnight, Frank gave up having reached the conclusion that the isopropyl alcohol was useless.

At 8:00 AM the very next morning, Frank’s telephone rang. It was his boss, Bill Closs. W. J. Closs was called “Bouncing Bill Closs” by his employees because of how he walked with a spring in his step. Closs said “There is a C-54 outside waiting to take me to Europe where they are about to ground the entire P-47 fleet. The pilots are afraid to use water injection because every time they do, the engine blows. I

haven't a minute to waste. Tell me how the alcohol testing went last night." Frank quickly related the story of the miserable failure of isopropyl alcohol.

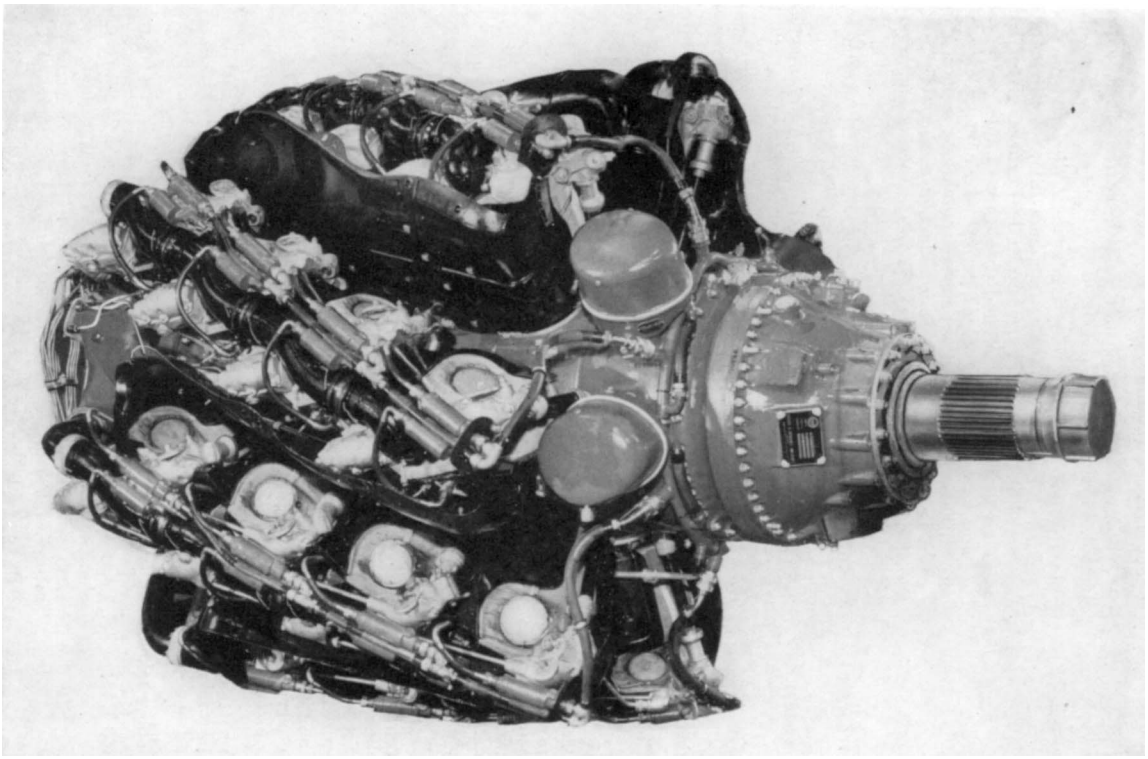
Two days later, Frank got another telephone call from Closs who had just returned from England. There he was met by a General and a whole bevy of Colonels, Majors, and Lieutenants who all wanted to know "What the hell are you going to do about these P-47 engines?" Closs said, "What kind of alcohol are you guys using?" "What difference does that make?" barked the General. In typical military fashion, the General turned to the Colonel, the Colonel to the Major, the Major to the Lieutenant, and the Lieutenant to the Tech Sergeant, each repeating Closs' question. The Tech Sergeant said "De-icing alcohol, Sir!" "What kind of alcohol is that, Sergeant?" bellowed the General. "Isopropyl, Sir!" said the Tech Sergeant. "Well, there is your trouble, General", said Closs, "you must use a mix of either ethyl or methyl alcohol. Isopropyl just won't work". Frank believes there were many such serendipitous events that occurred during World War II that allowed the Allies to prevail.

Frank did not know it at the time, but the isopropyl alcohol would not work because it was making the mixture too rich. Alcohol had been added to water in sufficient quantities to keep it from freezing, about fifty percent by volume. Any flammable material has a minimum and maximum amount that can be mixed with air and still burn. These amounts are called the Lower Explosive Limit, or LEL and Upper Explosive Limit, or UEL, respectively. While the mixes of methyl and ethyl alcohol were both below the LEL of each compound, the mix of isopropyl alcohol was not. As a result, the isopropyl alcohol was trying to burn, making the mixture too rich to run very well at all.

One interesting test that Frank ran in conjunction with water injection development was called a "drowning test". Here, the amount of water was increased beyond what was required to suppress detonation. Eventually the amount of water was increased to the point that water was pouring out about half the cylinders, but the engine was still running. Finally, when power had dropped to about 600 HP the test was terminated. There were no ill effects to the engine.

RACING THE BIG GUYS

Early in 1942, work began at Pratt & Whitney on the R-4360, a secret monster engine that was destined to have nearly twice the power of the stock "B" series R-2800s that were by then in production. Pratt & Whitney used the time-honored experimental development methodology of "Run 'em, bust 'em, fix 'um" where prototype engines were rapidly cobbled together and gotten into a test program to find the weak points. Such was true of the R-4360. The team suffered their share of false starts and blown engines as they made slow progress at making the engine increasingly powerful.



The Pratt & Whitney R-4360

By the time the R-4360 team was getting 2800 HP out of the prototypes, Frank was well into water injection development with the R-2800 “C” series engines. Unknown to the R-4360 guys, Frank was regularly running his R-2800 at 2800 HP for 100 hours at the time. The reader must realize that each new power milestone in R-4360 development was ending with a damaged engine as each of the many parts found its respective limit. Frank could not resist rubbing in the failures.

When the R-4360 team surpassed 2800 HP, Frank brought them over to his test cell and extracted 2800 HP from his “little” R-2800. A month later, when the R-4360 first produced 3000 HP, Frank summarily bettered their result at 3200 HP. Ultimately. Frank drove the R-2800 to a whopping 3800 HP. The R-4360 team eventually surpassed that mark, and went on to 4000 HP. Frank was tempted to try for 4000 HP on the R-2800, but finally decided against it. He did not have a good feeling about pushing the engine past 3800 HP.

NEVER BLEW AN ENGINE

Frank was legendary among the engine operators for his “feel” of the engines under test. He never once damaged an engine during his entire career as a Pratt & Whitney Test Engineer! He once had a harrowing experience that came close. Frank used a special test cell that was rigged to provide the extreme boost pressures necessary for water injection testing. These boost pressures were so high that standard mercury manometers were unsuitable. Instead, special pressure gages were installed that were capable of accurately displaying high manifold pressures. On the roof of the test cell was a gigantic electric motor that was hooked to a huge

blower. Ducting from the blower went through the ceiling of the test cell and into the air intake of the R-2800.

Engine testing was a real balancing act. The roof-mounted compressor was capable of blowing the ducting completely apart and wrecking the test cell. The operator had to carefully match the output of the blower with the air requirements of the R-2800 under test. If things went wrong, it took time to simultaneously spin down both the engine under test and the electric motor driving the blower. If the timing was not perfect, something broke.

One night while conducting an endurance run on an R-2800 producing 3200 HP, Frank noticed a slight drop in the nose case oil pressure. He knew that this was probably due to some trouble in the reduction gearing. Frank had seen the aftermath of failed reduction gears at high power settings. When a nose case gave way, the engine ran away in the blink of an eye and destroyed itself either by exploding the supercharger impeller or the power section. In the first case, flying debris from the supercharger impeller would literally cut the engine in two just ahead of the engine mounts. In the second case, cylinders, rods and pistons would be sent flying in all directions. The end result was always the same: a smoking, oily heap of engine parts on the floor at the rear of the test cell; at the other end, the still-spinning propeller walking around the inside of the front of the test cell until it ran out of momentum. Frank had seen magnetos thrown halfway through the plate glass of the test cell window. He had personally fought the fires resulting from test cell mishaps.

When he saw the dip in nose case oil pressure, Frank immediately shouted for the operator to slooooowly bring down the power of the blower motor on the roof while Frank started reducing power on the R-2800 under test. They rapidly got both the roof-mounted blower and the R-2800 under test safely shut down. Subsequent inspection of the nose case revealed that a planetary gear bearing was indeed in the process of failing. Another ten seconds and the engine would have been reduced to scrap.

FUEL STUDIES

One day in early 1942, Frank was informed that the front office needed to test three different fuel formulations and prepare a report for a meeting of engine makers, fuel suppliers, and at the Washington Office of Petroleum Coordination (OPC). OPC had to choose a fuel that would power the entire Allied aerial war effort. Frank went looking for a test engine. The only one available was X-80, an experimental nine-cylinder engine consisting of one row of an R-2800. X-80, having just completed an unrelated series of tests, was in bad need of overhaul. However, there simply was not time to rework the engine. Frank began a grueling seventy-two hour testing marathon, using up nine engine operators and nine helpers in the process. He never slept or rested during the entire period. This testing was done at high power settings to determine how much manifold pressure an engine could tolerate at different altitudes and induction air temperatures. This meant that the engine was always running on the very edge of detonation. Detonation testing was especially difficult because no detonation detection instrumentation was available. One had to intently watch the exhaust stacks for small puffs of smoke and sparks of white-hot carbon

that broke loose from the piston and cylinder at the onset of detonation. When this showed up, the engine had to be immediately throttled back, or it would be destroyed.

Numb and exhausted from the noise, vibration, and stress of the ordeal, Frank hastily authored a terse three-page report that showed one of the three fuels to be clearly superior. He forwarded the report to Pratt & Whitney fuel guru, Earl Ryder, who was also the Pratt & Whitney representative to OPC. Frank then went home and collapsed into bed.

Frank found out later that Ryder was ashamed of this admittedly meager offering. Having no other choice, Ryder trudged off to the meeting fully expecting to be embarrassed by both Wright Aeronautical and Allison. The meeting began and it was soon time to present results. Only Ryder had anything at all to show. Neither Wright nor Allison had even completed the tests, and both representatives had come to the meeting empty-handed. Based on seventy-two hours of testing by a twenty-three year old test engineer, the fuel formulation used for the remainder of World War II was selected.

Another interesting series of tests that Frank performed using X-80 attempted to quantify just how lean the engine could be reliably run. Frank discovered that with proper leaning the range of an airplane could be nearly doubled. However, the procedure for running so lean was one so critical and difficult that Frank thought it beyond the scope of what was to be expected of the average pilot. Years later, both Pratt & Whitney and Wright Aeronautical used these same techniques on airline engines to achieve ocean-hopping range. The addition of a torque meter on each engine allowed the flight engineer to lean the engine with great accuracy and achieve the range that Frank's earlier experiments had predicted.

AFTER THE WAR

NATIONAL AIRLINES

When World War II ended, Pratt & Whitney had thousand of engines on hand and no market. Frank thought Pratt & Whitney would shut down. Being a Florida boy, Frank had never really gotten used to the New England cold. He moved his family back to sunny Florida where he took a job as Director of Engine Maintenance for National Airlines out of Jacksonville Municipal Airport. He worked mostly with Wright R-1820s on Lockheed Loadstars. There were so many surplus engines that if parts were needed, perfectly serviceable ones came from a huge scrap heap. Finally, National Airlines obtained five brand new DC-4s with Pratt & Whitney R-2000s. Frank lured numerous test engineers with R-2000 experience away from Pratt & Whitney and started to build an organization. However, he was bored with the job at National. After all he had seen and done with engines during the War, the gig at National must have seemed pretty tame.

TOMATO FARMING

In 1947, Frank formed a partnership with his father and three brothers. Together they bought 650 acres of land with the intention of farming tomatoes. Frank had grown garden tomatoes during the summer months back at Pratt & Whitney. Now he

wanted to explore design and construction of the specialized equipment necessary for the volume tomato farming of South Florida. He endured three years of miserable weather, never got any machinery built, and ultimately decided he had had enough tomato farming. Fortunately, he was able to sell his land at a very tidy profit. There were at least two other bright spots from this period – Frank and Judy had a daughter, Nancy, on April 24, 1947 and a son, Doug, on September 11, 1949.

GENERAL CONTRACTING

Frank then began general contracting business, specializing in commercial construction including Howard Johnson restaurants. He standardized all of the kitchen appointments, and could build one cheaper and faster than anyone else. This business was so successful that Frank was able to retire at the age of forty-seven. Retirement, however, did not set well with his fertile mind. After sitting around for about two weeks, Frank got a call from a Miami banker looking for help with a construction project he had under way.

Banking was really taking off in South Florida, requiring the construction of lots of branch banks. In the old days, bank managers oversaw the details of construction, and the process drove them crazy. They were ill-equipped to handle the many details and loose schedules of the multiple contractors involved in construction. They also often had to be very clever about where banks were placed. New highways, strip malls, and larger shopping outlets sprang up with great rapidity, and bank placement to take advantage of these new markets was a real art. Frank offered the branch managers a very valuable service: The branch manager would contract with Frank, and Frank would handle all of the details using high-quality factory-manufactured structures that could literally be assembled and ready to open over a weekend. The final product, called “Porta-Branch” was attractive and cost effective. The branch managers loved it and Frank prospered. The real beauty of the concept is that the buildings could be moved! If rents became too high, or if the business moved elsewhere, Frank and his crew could move the branch bank to a new location almost as fast as it had been built in the first place.

This was possible because Frank made heavy use of his Twin Navion airplane, allowing him to travel rapidly all over the Southeast from one job site to another. Despite the success of the Porta-Branch, Frank found he was working far too hard. Overhead was tremendous and it was hard to get good help. Frank’s business was at the end of a bureaucratic chain that involved large banks and Federal Regulators. There was either too much business or too little. He remembers one occasion after the business had become quite successful when several months went by without any new construction orders. Numerous proposals were on the street, but there were no firm orders. Unwilling to string out his suppliers, Frank decided he would close the business instead of bankrupting it. One morning, he told his treasurer that if there was no new business by noon, they would close the doors. At about 11:50, Frank got a call requesting immediate construction of a 7-section Porta-Branch for C&S Bank in Atlanta.

The turmoil of the Porta-Branch business finally came to a head when one afternoon he got into his airplane and literally could not decide whether to go to Atlanta, Ft. Lauderdale, or home. He had an offer from Diebold, the bank safe maker, and decided to sell. All told**,** nearly thirty of these banks were constructed before the concept was sold to Diebold.

Despite getting away from active participation in branch construction, Frank continued to do periodic consulting for his friends in the banking industry. He served as a director of the Community Savings and Loan of North Palm Beach, Florida for over twenty years. At the request of the governmant, He also served as temporary director of two other troubled Savings and Loan institutions during the Savings and Loan Crisis of the 1980s.

The Porta-Branch Bank

COMMERCIAL PILOT

Frank has been flying since 1939 when he first soloed in an Aeronca Chief. He holds a commercial pilot certificate with multi-engine and instrument ratings. After his final retirement from construction, he followed his love for flying into an aircraft charter service. He regularly flew executives of the Royal Castle Hamburger Chain, Pepsi Cola, First National Bank and First Federal Savings and Loan. When Florida State Senator Richard B. Stone ran for Florida Secretary of State it was Frank who piloted Stone’s Twin Bonanza on the campaign trail. Later, during Stone’s successful bid for the US Senate, they upgraded to a Beechcraft Queen Air. Frank ultimately got out of the aircraft charter business when drugs got to be big business in South Florida.

INVENTIONS

With time on his hands while waiting for executives to finish their meetings or while waiting for the next charter customer to call, Frank turned his mind to inventing things. His first invention, called “Alti-Pacer” was a means of providing vertical guidance on non-precision instrument approaches. This device consisted of overlays for the Altimeter and Vertical Speed Indicators that indicated minimum descent altitude and “paced” the descent at a rate that assured terrain clearance. This was in the days before modern radio aids like glide slope receivers when even airliners regularly crashed while making non-precision approaches. The Alti-Pacer was patented and sold to Jeppeson, the aviation instrument approach chart producer. Unfortunately, the Arab oil embargo of 1973 knocked the wind from the aviation industry, and the Alti-Pacer never caught on.

In addition to the Alti-Pacer, Frank holds over fourteen patents on a diverse collection of items including:

A tennis racket with a shock absorber in the handle and a sweet spot the size of a dinner plate;

A gadget for checking the oil in marine drive unit gear boxes;

A means of detecting when an oil well pump runs dry and stopping it before it is damaged;

A non-slip stacked paper fastener;

A urinary tract catheter that allows flushing and treatment of the prostate gland.

Frank perfected all of these concepts in a machine shop and electronics laboratory he built in his own home.

Frank in his Laboratory

On April 1, 1993, Frank left Florida for Huntsville, Alabama so he could be nearer his grandchildren. He still resides there with his wife Judy. They will celebrate their fifty-ninth wedding anniversary this year.

During the past several years, Frank had been frustrated by deteriorating health. Five back operations have failed to address a condition that leaves him in constant pain. Last year, Frank was diagnosed with Parkinson's Disease. These health problems prevent him from working in his shop and lab any longer. However, they do not stem the constant flow of innovation that has become a hallmark of Frank's career. Nor do they dampen his enthusiasm for life and his love for his family, his religion, and all things mechanical.

Recent photograph of Frank and Judy

12-4-2000

POSTSCRIPT

Frank and Judy relocated to Palatka, Florida in 2004 to live near their oldest son and his wife. Frank died on March 11, 2007.