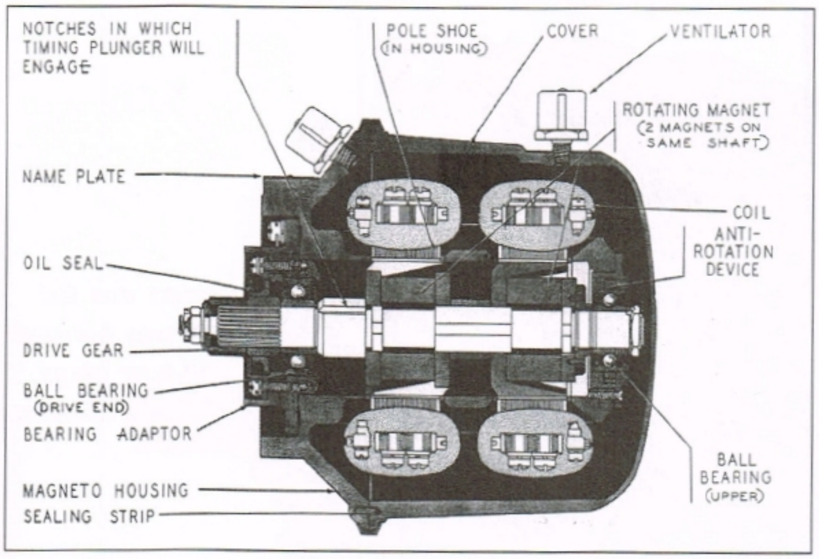

Fig. 4.61 Cross section through a DLN-10 low tension magneto fitted to many later R-2800s. (Bendix-Scintilla Aircraft Magnetos Types DF18RN, DF18LN Service Instructions, February 1943. Courtesy of Al Marcucci.)

distributors fed this 300 volts to the appropriate cylinder; however, it was not fed to the spark plug. Instead, the 300 volts fed into a step-up transformer mounted on the cylinder head **(Fig. 4.62)**. This is where the transition to 20,00 volts took place. Two output leads from the transformer fed the, now high tension, to the front and rear plugs. Not only high altitude woes were overcome but maintenance was now incomparably easier due to the lower voltage being produced inside the magneto. Items like ignition points lasted considerably longer. Only "CA" and "CB" series engines enjoyed the advantages of low tension ignition because by the time this superior ignition system had been developed the "A" and "B" series were considered obsolete. All R-2800 low-tension ignition systems were manufactured by Bendix/Scintilla and designated DLN-10. In a similar fashion to the DF18R/LN high tension system, the DLN-10 is four-bolt, flange mounted double tandem magneto and two pairs of coils. Gear ratios are the same as the DF18R/LN, i.e., 1¹/₈ crankshaft speed. Placement of the breaker points marks a significant difference between the low tension and high tension systems; the low tension system mounts the breaker points in the distributors, the high tension mounts them in the magneto. **Fig. 4.63** shows a CB16 with low-tension ignition.

Anti-Detonation Injection (ADI) (Ref. 3.7)

Frank Walker optimized the ADI system for R-2800s. As early as pre-World War I, experiments had been carried out with injecting metered amounts of water into the fuel/air mixture. However, it was with the advent of supercharged engines running at high boost pressures that water injection came into its own. By reducing the temperature of the compressed charge and cooling the flame front, water was a surprisingly simple but effective method of quelling detonation. Consequently, water had the effect of raising the performance number of the fuel being used. Although wonderful for detonation prevention, ADI did nothing for preignition.

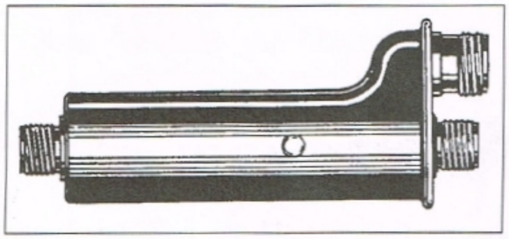

Fig. 4.62 The coil illustrated here was bolted to each cylinder head. Low tension was fed from the magneto via a shielded lead which terminated at the coil. Low tension was boosted to high tension in the coil. Two shielded leads fed high tension to the front and rear plugs. (Bendix-Scintilla Aircraft Magnetos Types DF18RN, DF18LN Service Instructions, February 1943. Courtesy of Al Marcucci.)

As with many aspects of R-2800 development, its use came about due to an emergency situation. When German FW 190s powered by the BMW 801 radial engine entered the fray in 1941, their superior performance took everyone, particularly the British, by surprise. RAF Spitfire Mark Vs were outclassed resulting in heavy losses. The same fate befell P-47s when they first tangled with this formidable German fighter. The situation was so serious, Major General Oliver P. Echols visited Wright Field for a session with Army Air Force Engineers. T.E. Tillinghast of Pratt & Whitney was also in attendance at these meetings. Tillinghast was a former Army Air Force pilot and prior to joining Pratt & Whitney, was in charge of Wright Field's power plant laboratory. The meetings got nowhere. Tillinghast then met with his old friend "Opie" Chenoweth who suggested the use of water injection. From there, the rest is, as they say, history. Rather surprisingly, Col. Charles A. Bassett designed a water injection system at Wright Field in 1934. He found that water injection not only suppressed detonation but cooled the engine and saved fuel. As proof that his system worked, Bassett boosted a standard R-1340 from 550 horsepower to 768 horsepower (Ref. 4.37). At the conclusion of his experiments, Bassett wrote a report that simply gathered dust for eight years. One reason Wright Field did not wholeheartedly embrace water injection was the fact 100 octane fuel was becoming readily available and it was thought that this would be the panacea against detonation. As it turned out, both solutions would be required: water injection and high performance fuel.

Initial tests were performed with plain water, which of course was a wonderful detonation suppressant. Problem is, water freezes at a relatively high temperature, certainly higher than the extremely cold temperatures experienced at the altitudes R-2800 powered aircraft were capable of achieving. A conventional antifreeze such as ethylene glycol was out of the question because it does not burn. Experiments with various alcohols yielded mixed results. But ethanol and methanol worked just fine when mixed fifty-fifty with water. Isopropyl alcohol, on the other hand, did not work. Isopropyl alcohol later caused serious problems with Eighth Air Force Republic P-47s fitted with ADI flying out of England. Bill Closs, Frank Walker's boss was scheduled to fly over to England to investigate this rash of P-47 engine failures. Just prior to his departure, Frank reported to Closs with his findings using isopropyl alcohol. Sure enough, when he arrived in England he found out that the ground crew was formulating its ADI from de-icing fluid, isopropyl alcohol. With the use of ethanol, not surprisingly,

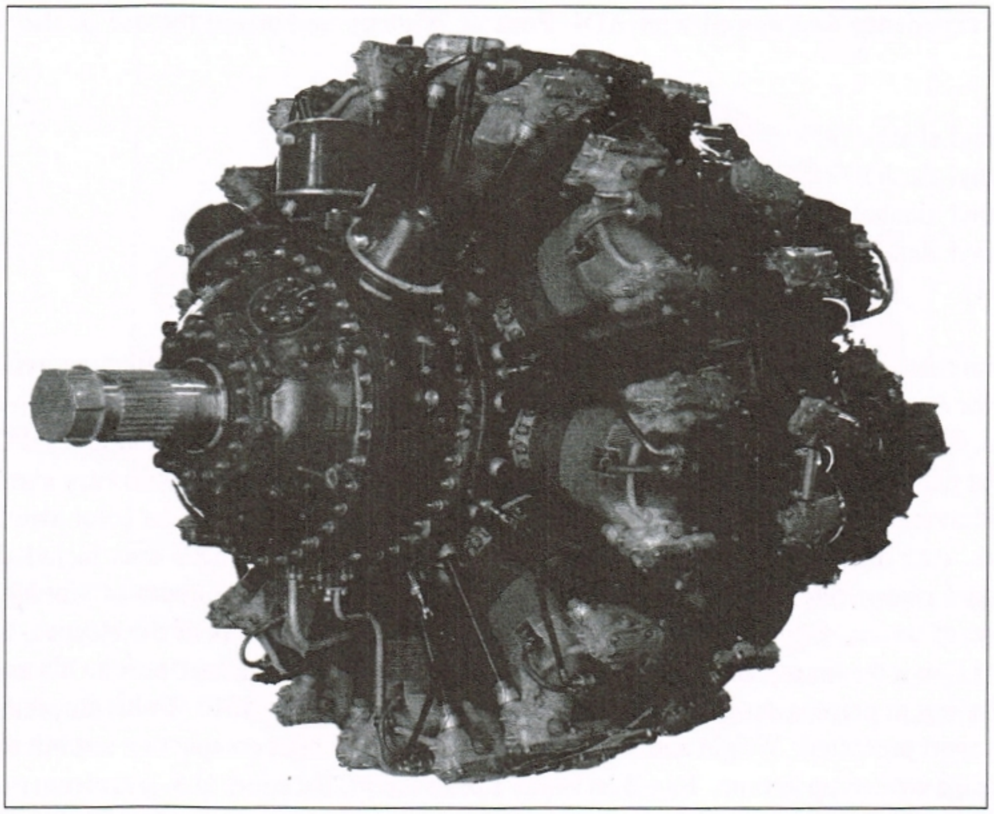

Fig. 4.63 A CB16 fitted with low tension ignition. Ignition boost coils are visible bolted to the sheet metal cooling baffle on top of each cylinder head. (Courtesy of Pratt & Whitney.)

the problems went away (Ref. 3.10). During Frank's experiments in East Hartford with ethanol and methanol, the stuff was consumed in huge quantities. Federal Agents always escorted these shipments of alcohol to make sure no one drank it! (Refs. 3.10, 4.38, 4.39, and 4.40).

If an R-2800 was set up to use ADI the letter "W" was added as a suffix to the dash number. However, this only applied to the military versions, no such identifier was used for civilian R-2800s. As an example, a CB-16, even though it was equipped with ADI, did not have a "W" suffix. Many military R-2800s were modified in the field for ADI; therefore, even though an engine may not have a "W" suffix, it does not mean that it never had ADI.

ADI flow varied as to how much power was being developed. The following table illustrates typical flow rates:

Horsepower	**ADI Flow Rate**
2400	9.2 pounds per minute
2500	11.5 pounds per minute
1900 in high blower	7.8 pounds per minute

As more experience was gained with ADI, Pratt & Whitney authorized the use of the following mixtures:

(i) methyl alcohol 50% and water 50%,
(ii) methyl alcohol 60%, water 40%,
(iii) methyl alcohol 25%, ethyl alcohol 25%, water 50%, and
(iv) methyl alcohol 60 parts, water 40 parts, and one part anti-corrosion oil
(Ref. 4.41).

As an interesting aside, our indomitable Frank Walker also had a profound effect on aviation fuel used by the Army Air Force during World War II. After a grueling and sleepless seventy-two hour marathon, Frank tested three aviation fuels for the Office of Petroleum Coordination (OPC). Even though the performance number or octane number may be the same, fuels could vary significantly. Many additives are added to fuel such as bromides for lead scavenging, dyes for color identification, stabilizers, etc., all of which affected the fuel and its performance. These tests included various mixture and power settings. A clear winner emerged after about 100 hours of testing. At the conclusion of testing, Frank hastily wrote a three-page report. Time was of the essence, which did not afford Frank the luxury of writing a more detailed report. Nevertheless, despite his embarrassment at having to prepare such a hurried report he presented it to the OPC. To his surprise, his was the only report presented. Wright and Allison had performed a similar comparison test but did not get their findings written up in time. Based on Frank's brief report, the entire U.S. petroleum production for the Army Air Force was modified to produce the most desirable aviation fuel (Ref. 3.7).

R-2800 vs. R-4360

As an interesting footnote in the development of the R-2800, during World War II Frank Walker was charged with the task of testing the ADI system developed, in an emergency, for the R-2800. During the same time period Pratt & Whitney was testing early development versions of the R-4360 **(Fig. 4.64)**. Frank regarded the R-2800 as his baby and consequently wanted to prove to the world there was still life left in it. He made it a personal goal to keep up with the power output of the R-4360 with "his" R-2800. When reports came through that 3000 horsepower had been achieved with the R-4360 he met that challenge by boosting the R-2800 to ever higher manifold pressures and feeding it additional ADI fluid. With these changes, Frank met the 3000 horsepower challenge. Then the R-4360 reached 3500 horsepower. No problem, Frank ran his R-2800 up to an amazing 140 in. Hg manifold pressure and fed as much ADI fluid as the engine could tolerate. Again, he matched the R-4360's 3500 horsepower. When the 3800 horsepower threshold was achieved by the R-4360, Frank ran his R-2800 to a stratospheric 150 in. Hg to match the 3800 horsepower benchmark. However, Frank had to call it quits at 3800 horsepower; it would have been a difficult explanation to make to his superiors if he had blown up his R-2800 in the test cell. What makes this story even more remarkable is the fact that Frank's R-2800 was a lowly "B" engine! And as Frank found out, not unnaturally, there is no replacement for displacement. Even so, for a while he gave the R-4360 and its development team a good run for its money. It would be difficult to imagine this kind of friendly rivalry and comradery in today's corporate, "design by committee" environment.

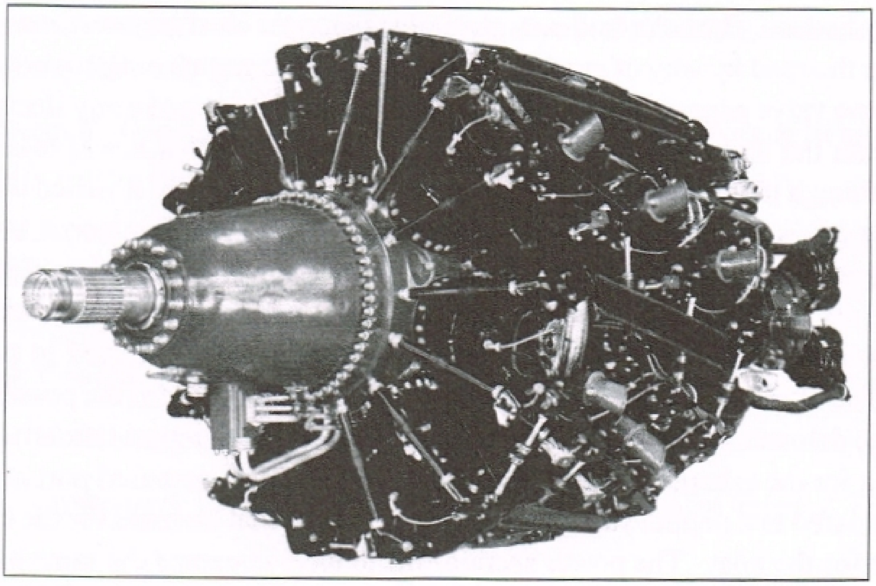

Fig. 4.64 The first R-4360 built. This engine differed greatly from production engines. As a proof of concept development engine, Pratt & Whitney engineers used off-the-shelf components. Twenty-eight "B" series R-2800 cylinders were used and an H-3170 sleeve valve engine nose case was fitted. Still, it proved that a four-row, air-cooled radial was feasible. (Courtesy of Pratt & Whitney.)

As a further endorsement of the R-2800's sound and rugged design, Frank made regular test runs of 3000 horsepower for one hundred hours (Ref. 3.7).

ADI Installation

A storage tank, typically 15 gallons, holds the ADI solution. An electrically driven pump delivers the water/methanol mix to the engine. The water regulator with an integral solenoid, usually mounted on the left side of the blower, meters water to the engine at a rate that depends upon fuel and air flow through the carburetor. Fuel and water are discharged together into the induction system via the impeller slinger ring. An external line between the water regulator and carburetor is necessary in order to operate the de-richment valve. This de-richment valve is designed to reduce fuel flow when the engine is operating with ADI. Of course, a water/methanol mixture is a very corrosive one; therefore, battling corrosion is an ongoing maintenance headache with ADI systems (Refs. 4.40 and 4.42).