THE OIL burning Diesel is going out from the ponderous power plant to become a speedy, compact airplane motor. And tragic death has stalked both the inventor of the Diesel and the man who did most to remake it for use in the air.

We Are Taking Wing With Engines That Burn Fuel Oil

Aviation—Engineering

By Watson Davis

THERE is a new breed of engine taking to the air, feeding on fuel oil, scorning carburetor, magneto and spark plugs, eliminating the fire hazard of aviation and promising cheaper air travel.

Thank Rudolf Diesel, German engineer, who late in the last century patented the type of internal combustion engine now inseparably linked with his name. But even more thank Capt. Lionel M. Woolson, Packard aeronautical engineer, whose tragic death during a blinding snowstorm while flying in an airplane powered with his own Diesel aircraft engine is mourned by the aeronautical industry.

Even in his death Capt. Woolson proved conclusively one advantage of the Diesel aircraft engine. When the airplane carrying him and two pilots to the New York airplane show met disaster due to the weather, there was no fire from fuel such as is usually the case when a gasoline powered airplane crashes.

As Capt. Woolson was fond of demonstrating to his engineer friends, that Diesel fuel oil, such as is burned in many home heating furnaces, cannot be ignited or exploded by a lighted match tossed into it. It will actually extinguish a flame when poured over it. Only when properly atomized, as it is when it is sprayed into the cylinders of the engine, does the oil ignite and furnish power.

"Thousands of hours of ground and flight testing have conclusively proved that it is impossible to accidently ignite the fuel oil used in the engine," Capt. Woolson said a few days before his death. "It is virtually essential to atomize this fuel into a very fine spray before it can be ignited at all, and at no time has it been possible to start a fire under any conditions simulating the result of an airplane crash or accidental breakage of the fuel line in flight."

The adapting of the Diesel engine principle to aeronautical use through Capt. Woolson's efforts represents a spectacular leap of the oil engine from the field of heavy duty power and marine use to the air where the lightest and most mobile of machinery is necessary.

In Air First

No automobile commercially available in America is powered by a Diesel engine. Diesels in ships and powerplants weigh many pounds for each horsepower they produce. And yet the Packard Diesel, nursed by Capt. Woolson's effort and genius, weighs only 2.26 pounds for each of the 225 horsepower it pours into the propeller. Diesel is in the air before it travels over roads.

To the casual observer the new engine resembles the conventional sort of air-cooled radial airplane engines that burn gasoline and now carry the bulk of the world's air traffic. Closer inspection will show that its nine cylinders have fewer accessories on them; there is no electrical ignition and each cylinder has but a single valve.

Diesels and ordinary gasoline engines have different modes of action. When the gasoline internal combustion engine sucks in a mixture of air and gasoline, the Diesel four-cycle engine is taking in ordinary atmospheric air only. Then when the air-gasoline mixture in the conventional engine is compressed into smaller space by the piston moving upward, the equivalent action in the Packard Diesel so compresses the air in the cylinder that it

Woolson, left, one of the inventors tragedy stalked, and Walter Lees, test pilot, in front of their Diesel-motored plane "after six hours and fifty minutes uneventful flight consuming four dollars and sixty-eight cents worth of furnace oil."

heats up to a temperature of 1,000 degrees Fahrenheit.

The next step in the case of the gasoline engine is for an electric spark to ignite and explode the compressed fuel mixture, driving the piston downward and applying power to the crankshaft. Up to this point in the Diesel operation there has been no fuel in the engine at all and that is the next thing that happens.

A spray of fuel oil is injected into the top of the cylinder and spontaneously ignites from the heat of the compressed air. Thus the necessity of an electric spark is eliminated. One of the secrets in successful Diesel operation is the exact timing of the oil spray in such a way that the oil is injected and burned gradually during the stroke of the piston. The next upward stroke of both engines pushes the burnt gases out of the cylinders, and in the Diesel the same valve that admitted the air in the first stroke also serves as the exhaust exit. This dual use of a single valve makes for simplicity of design.

Latest Application

The principle of the Diesel engine goes back in history thirty-five years to the time when Rudolf Diesel took out his German patents. Since then heavy oil engines have invaded successfully nearly every power field except the automotive. The U. S. Shipping Board spent $25,000,000 in 1923 in converting its steamers to Diesel motorships.

Diesel engines have come into use for driving locomotives of a new type. The lightest of such engines weighs dozens of pounds for each horsepower produced. To the airplane builder looking for power for his craft they seemed impossibly clumsy and heavy. It remained for Capt. Woolson and his staff, headed by Dr. Hermann Dorner, Diesel designer from Germany, to apply Diesel's principles to an airplane engine.

Engines had been Capt. Woolson's companions since the days of 1905, when fresh from a London schooling, he began servicing Mercedes automobiles in this country. Born in Los Angeles, educated in Seattle's public schools, Capt. Woolson received his secondary school education in London because his parents moved there.

The years 1908 to 1912 found Capt. Woolson in charge of a large fleet of trucks at West End, N. J., and in those days of less perfect automobiles that was a job that is more difficult than it would be today. This led to motor appliance design and when America entered the World War, Capt. Woolson was one of the famous group of engineers at Dayton who put the power into Uncle Sam's war wings. He was in charge of experimental ground and flight testing of aircraft engines at famous McCook Field. With the war over he became research engineer for the Packard company.

A Famous Designer

Before his successful production of his heavy oil aircraft engine, Capt. Woolson had been at the forefront of gasoline engine design. He is the man who made possible present lightweight water-cooled gasoline engines by a new type of cylinder construction and a shortening of the engine. He built powerful aircraft engines which at the time held world records. His engines were used in motorboats, to power the U. S. Airship Shenandoah, and to propel U. S. Army tanks. The Packard X intended for Lieut. Al Williams' racing plane was at the time Capt. Woolson produced it the most powerful aircraft engine. Its four banks of six cylinders each gave 1,500 horsepower.

With such a record of experience, Capt. Woolson tackled the problem of putting the compression-ignition engine into the air. There was no fanfare of engineering trumpets when he and his engineering staff began their task three years ago. Not until the engine had been flight tested did rumors as to accomplishments emanate from Detroit.

Other efforts toward light-weight Diesels were based upon the idea that satisfactory results could be obtained in an aircraft compression-ignition engine only if the pressures, and consequently the stresses in the engines, were kept comparatively low. Pressures of from 500 to 800 pounds per square inch were believed to be the limit. But Capt. Woolson's design allows maximum cylinder pressures somewhat in excess of 1,200 pounds per square inch.

There is nothing slow about the engine when it is operating at normal load, for it whirls 1,950 revolutions per minute. Nevertheless it can be throttled down to run only 250 r.p.m. The pump that injects the fuel oil into the cylinder operates under the high pressure of 6,000 pounds per square inch and it has only four thousandths of a second in which to shoot the charge into the hot, highly compressed air. Some of the parts of the pump need to move with nearly incredible swiftness and accelerations reach 15,000 feet per second per second or nearly 500 times that of gravity.

$4.68 Success

When last year Capt. Woolson took the Packard Diesel on its first long cross-country flight from Detroit to Langley Field, Va., where aeronautical engineers were gathered for the annual inspection of the National Advistory Committee for Aeronautics laboratories, he telegraphed his success laconically: "Arrived O.K. after six hours and fifty minutes uneventful flight consuming four dollars and sixty-eight cents worth of furnace oil."

Since then the engine has been given extensive flight tests at the factory and in actual use and it has won its badge of engineering respectability, the Department of Commerce Approved Type Certificate.

One of the first things that laymen and engineers noticed when they observed the Diesel in flight was a trail of black smoke from the engine. Like all smoke it was an indication of incomplete combustion of the fuel, but by wasting some fuel the engine can be overloaded and be made to give a tenth more power for a fifth more fuel. This is very useful to the pilot in taking off or climbing.

Some Diesel engines are particularly hard to start but the Packard Diesel starts about like a gasoline engine. An inertia starter, now common equipment on less novel airplane engines, is used and the energy stored up by hand cranking the small fly wheel of the starter is sufficient to turn over the engine several times and set it going. In the early days of flight testing, Capt. Woolson experimented with several other types of starters, especially one that used the explosion of a blank shotgun shell to kick off the engine.

With radio becoming a necessity in aircraft operation and with the extension of radio beacons and communication between air and ground, great care is needed in shielding spark-ignition gasoline engines so that they will not interfere with the radio signals. As compression-ignition of the Diesel eliminates all electrical sparks, there is no interference. As Capt. Woolson wrote:

"The fact that (*Turn to page* 92)

Diesel Airplane Engine—*Continued*

no electrical ignition equipment is used in the operation of the engine removes one of the most troublesome obstacles to extensive radio use in airplanes. With the gasoline engine it is necessary to adopt shielding means for all magnetos, spark-plugs, high and low-tension wiring, and so forth; and these shielding means reduce the efficiency of the ignition system and render it far more liable to failure.

"The Packard experimental cabin plane is equipped with radio transmitter and receiver, and in this way it has been definitely proved during extensive flight-testing that, in regard to both transmission and reception, there is complete absence of any interference."

Chief among the contributions this engine has made to aviation are the following, as stated by Capt. Woolson:

"It will reduce the cost of flying, through greater economy of operation and lessened cost of fuel oil.

"It will carry greater 'pay loads' or travel farther than a gasoline engined plane with an equal amount of fuel.

"Continuous ignition is assured through high compression inherent in the design.

"It will not stop through too 'lean' or too 'rich' a 'mixture.'

"It will fly upside down as well as right side up."

His Diesel aircraft engine was introduced to the engineering public and its secrets revealed only this year about a month before Capt. Woolson's death. It was the sensation of the Detroit Air Show.

Not for long is the Packard Diesel likely to be alone in the air. In other countries, Germany, France and England, research is in progress upon other heavy oil engines for aircraft use. The Junkers engineers in Germany are experimenting. The British R-101 is driven by heavy oil engines of the Beardsmore type but the fact that these weigh about eight pounds per horsepower does not put them in the class with the lighter Packard.

At the Langley Memorial Aeronautical Laboratory of the National Advisory Committee for Aeronautics at Langley Field, Va., much fundamental work is in progress on the essential facts of Diesel operations.

By using some of the tricks of the Diesel in spark ignited engines it is possible to run modified gasoline engines on fuel oil. A Pratt and Whitney engine has been changed by its makers so that instead of the usual carburetor and intake systems there are fuel injection pumps capable of delivering the gasoline or oil mechanically into the cylinder. There it is fired, not by the heat of the compression as is the case of the Diesel cycle, but by the usual spark ignition. This type of engine has the advantage of burning furnace oil which is cheap, but its efficiency is not so high as one that operates on a true Diesel cycle.

Diesel's Disappearance

There is a strange similarity in the deaths of Diesel, heavy oil engine pioneer, and Woolson, pioneer of the aircraft Diesel. Both died just at the time that their engines were about to receive the acclaim of the world. Both had received the plaudits of engineers but neither lived to see his mechanical creations spread widely over the face of our mechanical civilization.

There is mystery in the death of Rudolf Diesel which probably never will be solved. On the night of September 29, 1913, he took passage from Antwerp on a channel steamer which arrived at Harwich, England, the next morning with the famous inventor missing. So much the world knows. Everything else is speculation. Did he fall overboard accidentally? Did he commit suicide? There seems to be no reason for such an act.

At that time the World War was brewing and it has been suggested that German or British agents pushed him overboard or kidnapped him. Some even held that he was alive after the time of his reported death and that he was in the service of the British government during the war.

Whatever Diesel's fate, his principle of engine operation promises to bring more economical and safer power to the air as it has to the sea and land. And with this conquest of the air by the Diesel, the name of Woolson will be firmly linked.

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Some fairly pure glass sand deposits are known along the Pacific coast, but because of the large amount of iron in the sand it is used only for brown and amber glass.