MORE ON THE HERBRANDSON TWO-STROKER

(Photo by Herb Gillespie)
The DYAD 280, designed and built by Dale Herbrandson (EAA 101853).

By Dale Herbrandson (EAA 101853)
D. H. Enterprises
4909 W. Compton Blvd.
Lawndale, CA 90260

In the March issue of SPORT AVIATION we published a picture and information on a tiny but powerful two cylinder, two stroke engine that appeared to ***have potential for use on the super light aircraft being designed by a number of EAAers. Developed by Dale Herbrandson (EAA 101853) for use in the government*** *RPV program, the engine was brought to our attention by Herb Gillespie (EAA 70419) of Burbank, editor of the* **Design Group Newsletter**.

Dale was swamped with calls and letters! Apparently, the interest in super light aircraft is far greater than anyone has realized. Dale summarizes the response he has received as follows: "Many hang glider inquiries have been received. After talking with designers such as Volmer Jensen (Swingwing) and Taras Kiceniuk (Icarus), my conclusion is to not recommend the twin for hang glider use. First of all, the 280cc twin will produce 100 to 110 pounds of static thrust. This is twice as much as needed. Secondly, the low flying speed of the hang glider would allow a pusher installation to fry the engine for lack of cooling air. The inexpensive 125cc fan cooled engines are better suited for a power assist on a hang glider.

"The majority of the inquiries were more suited to the operating characteristics of the twin. These builders are constructing super-light aircraft which, to me, are powered sailplanes. They have full controls and landing gear. Many designs resemble the **Birdman** *aircraft. A few fellows are building sleek single-place super-lights which would use two of the engines. Other inquiries were from glider pilots who have become disenchanted with the waiting involved to have their aircraft towed to soaring altitude. They are looking for a way to motor their way to altitude with only an hours fuel on board.*

"The potential use of the twin in the super-light area looks promising."

The Herbrandson twin, named the **Dyad 280**, *is still under development and Dale has not had time to individually answer the scores of people who have contacted him. In lieu of this, he has prepared the following very interesting article.*

INTRODUCTION

The engine design began twenty months ago. I was doing engine consulting with two aircraft companies that were using the McCulloch 101 engine to power their mini-RPV's. These 12-foot wingspan Remotely Piloted Vehicles (RPV) were requiring all the power available from the 125cc MC101. To make a long story short, it became apparent that a larger displacement, two-cylinder, low rpm engine would do a better job in the RPVs. Since the aircraft companies had searched and not found such an engine, I simply decided to explore the possibilities of building one. As many high-production components as possible were to be incorporated into this engine. Motorcycle components were totally unsuitable because of their high-rpm port timing, heavy fins and long connecting rods.

Only the chainsaw engines had a light-weight requirement imposed on their design. With help from McCulloch engineering I was able to examine their complete collection of the world's chainsaws. Fortunately, the chainsaw with the biggest engine was also ideally suited for an RPV engine as it had removable cylinders. Stihl Incorporated of West Germany calls this chainsaw a Model 090. It has been in production

MORE ON THE HERBRANDSON TWO-STROKER

(Photo by Herb Gillespie)

The DYAD 280, designed and built by Dale Herbrandson (EAA 101853).

By Dale Herbrandson (EAA 101853)
D. H. Enterprises
4909 W. Compton Blvd.
Lawndale, CA 90260

In the March issue of SPORT AVIATION we published a picture and information on a tiny but powerful two cylinder, two stroke engine that appeared to have potential for use on the super light aircraft being designed by a number of EAAers. Developed by Dale Herbrandson (EAA 101853) for use in the government RPV program, the engine was brought to our attention by Herb Gillespie (EAA 70419) of Burbank, editor of the **Design Group Newsletter**.

Dale was swamped with calls and letters! Apparently, the interest in super light aircraft is far greater than anyone has realized. Dale summarizes the response he has received as follows: "Many hang glider inquiries have been received. After talking with designers such as Volmer Jensen (Swingwing) and Taras Kiceniuk (Icarus), my conclusion is to not recommend the twin for hang glider use. First of all, the 280cc twin will produce 100 to 110 pounds of static thrust. This is twice as much as needed. Secondly, the low flying speed of the hang glider would allow a pusher installation to fry the engine for lack of cooling air. The inexpensive 125cc fan cooled engines are better suited for a power assist on a hang glider.

"The majority of the inquiries were more suited to the operating characteristics of the twin. These builders are constructing super-light aircraft which, to me, are powered sailplanes. They have full controls and landing gear. Many designs resemble the **Birdman** *aircraft. A few fellows are building sleek single-place super-lights which would use two of the engines. Other inquiries were from glider pilots who have become disenchanted with the waiting involved to have their aircraft towed to soaring altitude. They are looking for a way to motor their way to altitude with only an hours fuel on board.*

"The potential use of the twin in the super-light area looks promising."

The Herbrandson twin, named the **Dyad 280**, *is still under development and Dale has not had time to individually answer the scores of people who have contacted him. In lieu of this, he has prepared the following very interesting article.*

INTRODUCTION

The engine design began twenty months ago. I was doing engine consulting with two aircraft companies that were using the McCulloch 101 engine to power their mini-RPV's. These 12-foot wingspan Remotely Piloted Vehicles (RPV) were requiring all the power available from the 125cc MC101. To make a long story short, it became apparent that a larger displacement, two-cylinder, low rpm engine would do a better job in the RPVs. Since the aircraft companies had searched and not found such an engine, I simply decided to explore the possibilities of building one. As many high-production components as possible were to be incorporated into this engine. Motorcycle components were totally unsuitable because of their high-rpm port timing, heavy fins and long connecting rods.

Only the chainsaw engines had a light-weight requirement imposed on their design. With help from McCulloch engineering I was able to examine their complete collection of the world's chainsaws. Fortunately, the chainsaw with the biggest engine was also ideally suited for an RPV engine as it had removable cylinders. Stihl Incorporated of West Germany calls this chainsaw a Model 090. It has been in production for many years and is completely reliable because of steady design improvements. This 137cc engine uses a 66mm bore and a short 40mm stroke. In contrast, the popular 125cc McCulloch MC101 uses a 57.1mm bore and a 46.6mm stroke.

With help from Stihl's California distributor (Midway Dist. in Chico) engine parts were obtained and the design effort on the twin began. The design at this point was strictly for the military RPV applications. Several configurations using two cylinders were examined. The final choice was an opposed cylinder layout with a common crankcase. Both cylinders fire at the same time, making a single carburetor, single ignition, and single exhaust outlet possible. Such a layout is light in weight and easy to service.

Because this twin is like a single in many ways, a decision was made to officially call the engine a Dyad 280. Your dictionary defines Dyad as a "complementary pair". The 280 part of the name is the displacement in cc. The two-cylinder engine now uses a 66mm bore and a 41mm stroke. This short stroke allows use of short connecting rods for a compact crankcase, and a narrow engine width.

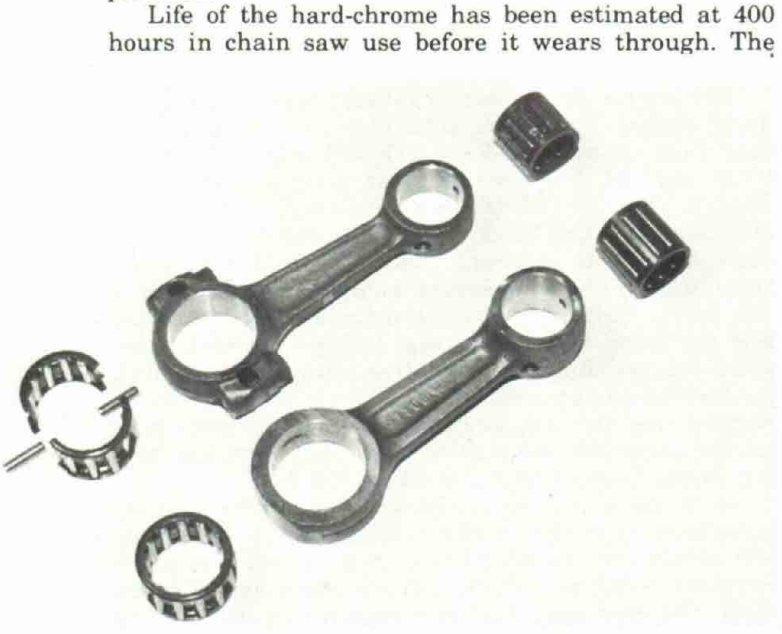
Four engines of an early design are running. One in the air — the other three are test bench workhorses. Ten more prototypes of the final design are in progress. The differences between the designs will be explained farther along in this discussion.

Let's examine each engine component separately in an effort to explain the design philosophy. Since the cylinder and piston selection determines the characteristics of the engine, they make a logical starting point.

CYLINDER AND PISTON

Mahle in West Germany manufactures the 090 Stihl cylinder and piston. They are high quality. The Schnürle scavenged cylinder has an integral head and uses a hard-chrome bore. The thin hard-chrome surface offers a substantial weight reduction over a cast-in or pressed-in iron liner. The hard-chrome, of course, cannot be rebored. The bare cylinder weighs two pounds. It comes standard with a compression release, which I feel is not of any value on the twin. Production cylinders for the Dyad 280 will be imported without this extra complication.

Life of the hard-chrome has been estimated at 400 hours in chain saw use before it wears through. The area just above the exhaust port is where the wear is the greatest. Possibly the life will be greater in aircraft use because of the relatively clean intake air. The replacement price of the matched cylinder, piston, rings and wrist pin is around $95.00 from a Stihl chainsaw dealer. Rings are available separately, but not pistons.



(Photo by Herb Gillespie)

FIGURE 1 — Comparison of single-piece con rod with two-piece design.

The cylinders and the pistons are graded into A, B, and C sizes. They are shipped A with A, and B with B, etc. to give a consistent piston-to-cylinder clearance of 0.0025-inch. This tight tolerance is possible because the cylinders are all aluminum, except for the hard-chrome plating on the bore. This design allows the cylinder to expand at the same approximate rate as the piston.

DH modifies the pistons with a pair of ½-inch diameter holes near each wrist pin boss. This removes 14 grams of weight from each piston — which also reduces the amount of crankshaft counterweight required. The modified piston resembles some of the McCulloch chainsaw pistons. This design allows part of the cool air/fuel mixture to flow past the wrist pin boss on the way to the transfer passages.

The single, rather narrow, exhaust port opens 104° after tdc, with the two transfer ports opening 12° later. The total inlet duration at the stock inlet port is 138°. These mild porting figures give us an engine which can perform well at low rpm. The loss of power incurred by operating at low speed (below 6500 rpm) is partially compensated for by the increased propeller efficiency. At this low engine speed and wide open throttle the brake specific fuel consumption is in the 0.7 to 0.8 lb./hp-hour range.

CRANKSHAFT & CONNECTING ROD

The first engine design concept used a high production single-piece connecting rod which required us to make a 3-piece pressed together crankshaft. The rods were in production on the latest 090 Stihl chainsaw engine. The design never got off the drawing board. An inquiry sent to Germany resulted in a reply stating that Stihl Machinenfabrik did not (and would not) sell the rods separate from their pressed together chainsaw crankshaft. This lack of high production con rods almost killed the project. Rather than give up, the aircraft crankshaft was reluctantly redesigned after months were spent on the layout using the desirable one-piece rod. A redesign was possible as Stihl used a 2-piece connecting rod on their first 090 engines. The rods were available in the USA as spares, so the engine project proceeded without the blessing of the factory in Germany.

Because the 2-piece rods are bolted together around the crankshaft, a single-piece crankshaft could be used. The crankcase became heavier because of the space required for the bosses and screws on the sides of the con rod. The crankshaft, however, became lighter than the previous design by eliminating the heavy bosses required for the press fitting. The paper engine was beginning to look as though it would be a good unit. A big step was taken.

Wood patterns were made to sand cast the crankcase, and four crankshafts were carved from 4620 bar stock. Special tooling blocks were required to rough cut the crankshaft throws. Another set of tooling blocks were required to allow the cranks to be finish ground. The cranks were carburized and heat treated to Rc62 before the finish grind. The counterweights were bolted onto the finished crankshaft to allow them to be easily changed while optimizing the balancing. The counterweight is required to balance all of the crankpin, all of big end weight of the rod, plus half of the small end weight and piston weight. This method balances the for many years and is completely reliable because of steady design improvements. This 137cc engine uses a 66mm bore and a short 40mm stroke. In contrast, the popular 125cc McCulloch MC101 uses a 57.1mm bore and a 46.6mm stroke.

With help from Stihl's California distributor (Midway Dist. in Chico) engine parts were obtained and the design effort on the twin began. The design at this point was strictly for the military RPV applications. Several configurations using two cylinders were examined. The final choice was an opposed cylinder layout with a common crankcase. Both cylinders fire at the same time, making a single carburetor, single ignition, and single exhaust outlet possible. Such a layout is light in weight and easy to service.

Because this twin is like a single in many ways, a decision was made to officially call the engine a Dyad 280. Your dictionary defines Dyad as a "complementary pair". The 280 part of the name is the displacement in cc. The two-cylinder engine now uses a 66mm bore and a 41mm stroke. This short stroke allows use of short connecting rods for a compact crankcase, and a narrow engine width.

Four engines of an early design are running. One in the air — the other three are test bench workhorses. Ten more prototypes of the final design are in progress. The differences between the designs will be explained farther along in this discussion.

Let's examine each engine component separately in an effort to explain the design philosophy. Since the cylinder and piston selection determines the characteristics of the engine, they make a logical starting point.

CYLINDER AND PISTON

Mahle in West Germany manufactures the 090 Stihl cylinder and piston. They are high quality. The Schnürle scavenged cylinder has an integral head and uses a hard-chrome bore. The thin hard-chrome surface offers a substantial weight reduction over a cast-in or pressed-in iron liner. The hard-chrome, of course, cannot be rebored. The bare cylinder weighs two pounds. It comes standard with a compression release, which I feel is not of any value on the twin. Production cylinders for the Dyad 280 will be imported without this extra complication.

Life of the hard-chrome has been estimated at 400 hours in chain saw use before it wears through. The area just above the exhaust port is where the wear is the greatest. Possibly the life will be greater in aircraft use because of the relatively clean intake air. The replacement price of the matched cylinder, piston, rings and wrist pin is around $95.00 from a Stihl chainsaw dealer. Rings are available separately, but not pistons.

The cylinders and the pistons are graded into A, B, and C sizes. They are shipped A with A, and B with B, etc. to give a consistent piston-to-cylinder clearance of 0.0025-inch. This tight tolerance is possible because the cylinders are all aluminum, except for the hard-chrome plating on the bore. This design allows the cylinder to expand at the same approximate rate as the piston.

DH modifies the pistons with a pair of ½-inch diameter holes near each wrist pin boss. This removes 14 grams of weight from each piston — which also reduces the amount of crankshaft counterweight required. The modified piston resembles some of the McCulloch chainsaw pistons. This design allows part of the cool air/fuel mixture to flow past the wrist pin boss on the way to the transfer passages.

The single, rather narrow, exhaust port opens 104° after tdc, with the two transfer ports opening 12° later. The total inlet duration at the stock inlet port is 138°. These mild porting figures give us an engine which can perform well at low rpm. The loss of power incurred by operating at low speed (below 6500 rpm) is partially compensated for by the increased propeller efficiency. At this low engine speed and wide open throttle the brake specific fuel consumption is in the 0.7 to 0.8 lb./hp-hour range.

(Photo by Herb Gillespie)

FIGURE 1 — Comparison of single-piece con rod with two-piece design.

CRANKSHAFT & CONNECTING ROD

The first engine design concept used a high production single-piece connecting rod which required us to make a 3-piece pressed together crankshaft. The rods were in production on the latest 090 Stihl chainsaw engine. The design never got off the drawing board. An inquiry sent to Germany resulted in a reply stating that Stihl Machinenfabrik did not (and would not) sell the rods separate from their pressed together chainsaw crankshaft. This lack of high production con rods almost killed the project. Rather than give up, the aircraft crankshaft was reluctantly redesigned after months were spent on the layout using the desirable one-piece rod. A redesign was possible as Stihl used a 2-piece connecting rod on their first 090 engines. The rods were available in the USA as spares, so the engine project proceeded without the blessing of the factory in Germany.

Because the 2-piece rods are bolted together around the crankshaft, a single-piece crankshaft could be used. The crankcase became heavier because of the space required for the bosses and screws on the sides of the con rod. The crankshaft, however, became lighter than the previous design by eliminating the heavy bosses required for the press fitting. The paper engine was beginning to look as though it would be a good unit. A big step was taken.

Wood patterns were made to sand cast the crankcase, and four crankshafts were carved from 4620 bar stock. Special tooling blocks were required to rough cut the crankshaft throws. Another set of tooling blocks were required to allow the cranks to be finish ground. The cranks were carburized and heat treated to Rc62 before the finish grind. The counterweights were bolted onto the finished crankshaft to allow them to be easily changed while optimizing the balancing. The counterweight is required to balance all of the crankpin, all of big end weight of the rod, plus half of the small end weight and piston weight. This method balances the crankshaft perfectly, and also opposes 50% of the rocking couple created by the offset pistons. The method is standard balancing procedure.

By the time the four experimental crankshafts were finished, they had incurred a production cost of around $700 each.

These crankshafts proved to be stout and were readily adaptable to a forging. Forging drawings were sent out and quotations received. Stihl was contacted at their USA headquarters in Virginia as we needed to purchase a quantity of the 2-piece con rods for future production. All was looking well when crushing news came from Stihl — the 2-piece rod could not be purchased in the quantities needed. Production of spare parts was halted because of the popularity of the pressed together crankshaft with the one-piece rod. We now had no engine for lack of con rods. One finds that only so many parts can be custom made for a specialty engine before the price gets out of hand. There was no way to justify building the rods from scratch. Fortunately, the head of Stihl imports for the USA (Reiner Glockle) is an aviation minded ultra-light enthusiast. Rather than have the engine die for lack of con rods, he made special arrangements to secure the desirable one-piece rod from the factory in Germany. This was good news! Although we were to now get the best con rod, the engine took a major setback time wise. Tooling for machining the crankshaft and the crankcase had been completed for the design using the 2-piece rod. Most of this hardware was now useless.

We are currently building tooling to manufacture and assemble the 3-piece pressed together crankshaft. Another round of prototype testing will be required before any production is attempted. Ten prototypes will be built and made available to a select few in the ultralight aviation field.

Figure 1 compares the original one-piece rod against the 2-piece rod. There is no doubt which is the stouter design. The 2-piece rod requires a crankpin diameter of 18mm, while the one-piece rod uses a 19mm crankpin. The tolerance on the crankpin holds a given diameter within 0.00032-inch using Durkopp recommendations.

The gain in reliability between the two designs centers around the big end bearing. The one-piece bearing cage made possible with the pressed together crankshaft is the best possible design. The continuous bearing support keeps the rollers from skewing, which is estimated to double the usable life of the bearing. I don't know the MTBO for the lower end, but it seems doubtful that any weekend pilot could find enough time to wear one out.

We found that much care was required when assembling the 2-piece con rod. They are supposed to go back together perfectly because of the indexing action of the ragged surface formed when the rod is fractured creating the two halves. A jewelers eye loupe was required to carefully inspect and adjust the interface of the two halves when being assembled. Only then could the con rod be relied upon to run freely. With the new one-piece con rod this task is not required — the precise assembly requirement is shifted to the 3-piece crankshaft.

CRANKCASE

There are many ways to part a crankcase to allow the crankshaft to be installed. To eliminate as much weight as possible, double walls and high loading at the interface between the two halves is to be avoided. The Dyad 280 crankcase halves are parted in a plane projected radially from the crankshaft axis, midway between the cylinder bores.

The main bearing bores (3 main bearings) are line bored and then honed within the 0.0005-inch total tolerance. The double lipped crankshaft seals are held in the end caps of the crankcase. The metric sized seals are purchased from Yamaha. The front cap also holds the ignition magnetic sensor — the rear cap has provision to hold the RPV's alternator drive.

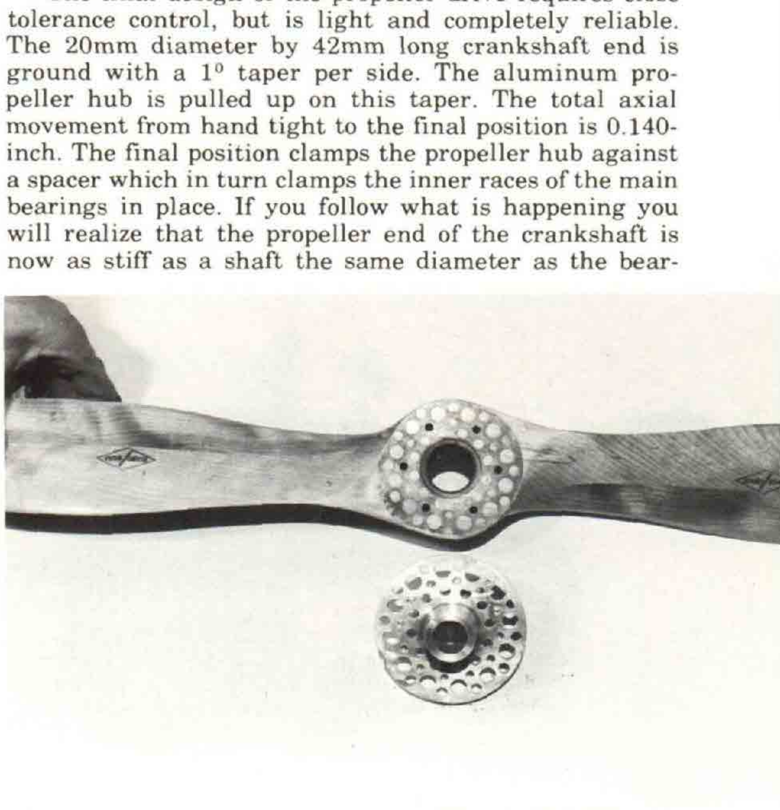
The cylinders were initially sealed to the crankshaft with O-rings. This feature made it easy to work on the engine because these seals could be used again and again without the usual sticking and tearing of a flat gasket. They were not practical, however. Close tolerance was required when using the book values of groove depth and diameter. The O-rings also had the habit of weeping oil — and they were expensive. Also much cylinder heat was undesirably conducted to the crankcase because of the metal to metal interface. The fix was to use a conventional base gasket under the cylinder.

The crankcase is completely machined on the inside to take up as much clearance as possible around the crankshaft. This was not done to create a high crankcase compression ratio. Weight reduction was the reason. Considerable bulk could be removed from the 356-T6 aluminum crankcase by keeping the overall size of the unit as small as possible. The pair of bare crankcase halves after finish machining have a combined weight of 1.5 pounds.

PROPELLER HUB

On most small two-cycle engines converted for ultralight aircraft the propeller mounting is a hassle. Taper diameters are too small, keyways and keys suffer from fretting, and there is even concern for the crankshaft failing for lack of outboard bearing support. The Dyad had to completely overcome these problems so that the propeller drive would be above reproach. The interface between the crankshaft and the propeller hub must be tapered. How much taper and how long was the subject of several weeks effort.

The final design of the propeller drive requires close tolerance control, but is light and completely reliable. The 20mm diameter by 42mm long crankshaft end is ground with a 1° taper per side. The aluminum propeller hub is pulled up on this taper. The total axial movement from hand tight to the final position is 0.140-inch. The final position clamps the propeller hub against a spacer which in turn clamps the inner races of the main bearings in place. If you follow what is happening you will realize that the propeller end of the crankshaft is now as stiff as a shaft the same diameter as the bear-



(Photo by Herb Gillespie)

FIGURE 2 — Lightening holes in the hub also provide a positive drive against the wood propeller.

ing inner races. Also, by controlling the amount of stretch in the propeller hub when it finally is forced against the spacer, we can control the hoop stress in the aluminum propeller hub. The design stress is 75% of the yield of 7075-T6 aluminum. Around 40 ft.-lbs. of torque on a ⅜-24 cap screw is required to seat the hub on its 1.65-inch long taper. Once in place, the cap screw and its thick washer can be removed and the drive will continue to perform — this is not recommended however.

Figure 2 shows the propeller hub and a 30-inch diameter x 14-inch pitch propeller. The many lightening holes in the hub are also used to drive the propeller. When clamped down, the wood sinks into the sharp edged holes to form a positive drive.

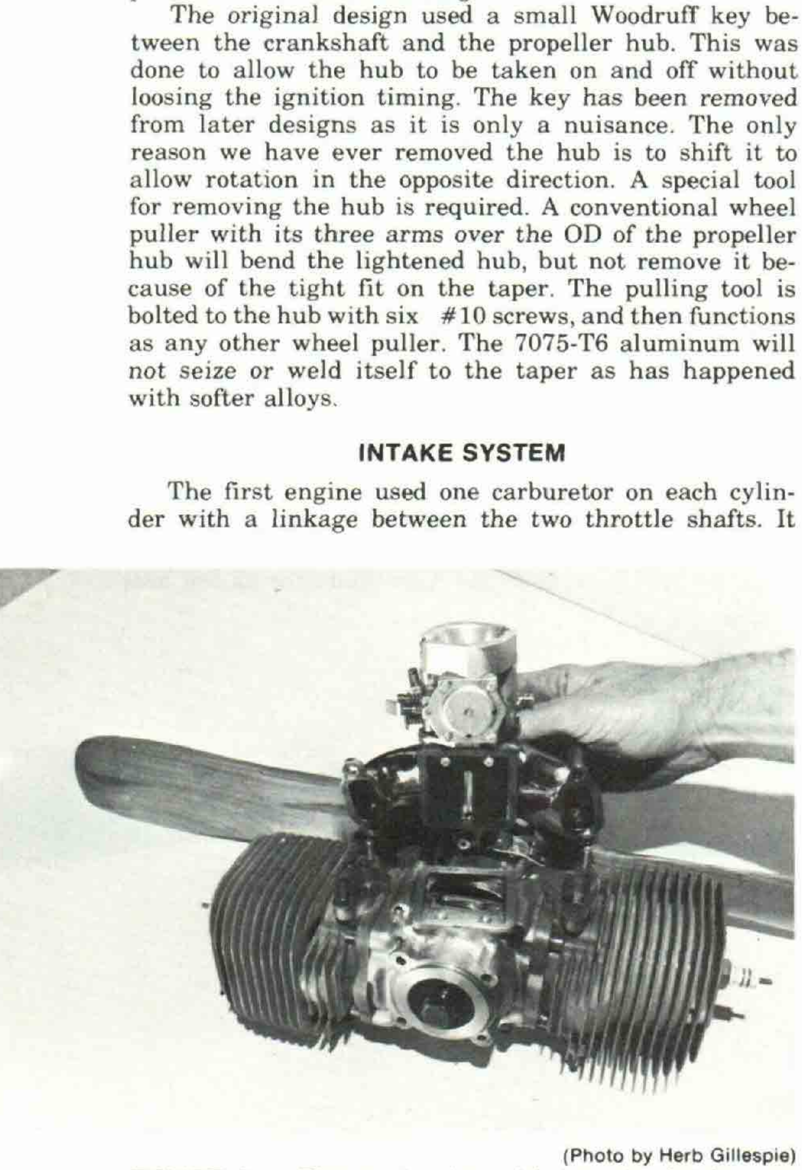
The 3.5-inch diameter hub also holds the ignition pole piece. Precise longitudinal positioning of the hub is required to maintain a close magnetic air gap for easy starting. The tolerance on this close distance is maintained by a snap-ring ball bearing under the crankcase end cap. Thrust in either direction from the propeller load leans against this captured bearing.

There are twelve threaded holes (10-24) in the hub. Six are used to clamp the propeller. The extra set of holes allow handier positioning (every 30°) of the propeller. This is done for the power assisted glider installations that need to have the propeller stop in a particular position to minimize air drag.

The original design used a small Woodruff key between the crankshaft and the propeller hub. This was done to allow the hub to be taken on and off without loosing the ignition timing. The key has been removed from later designs as it is only a nuisance. The only reason we have ever removed the hub is to shift it to allow rotation in the opposite direction. A special tool for removing the hub is required. A conventional wheel puller with its three arms over the OD of the propeller hub will bend the lightened hub, but not remove it because of the tight fit on the taper. The pulling tool is bolted to the hub with six #10 screws, and then functions as any other wheel puller. The 7075-T6 aluminum will not seize or weld itself to the taper as has happened with softer alloys.

INTAKE SYSTEM

The first engine used one carburetor on each cylinder with a linkage between the two throttle shafts. It was an interesting arrangement as the carburetors did not have to be balanced or tuned together because of the common crankcase. The engine would even run acceptably on just one carburetor. This system worked quite well as far as carburetion was concerned. The system itself was awkward looking because of the two carburetors standing directly in the high velocity air stream. Curved velocity stacks on top of the carburetors looked correct, but ruined the performance because of the extra intake length upstream from the carburetor venturi. Another reason for abandoning the dual carbs accrues from their close location to the propeller. This writer has lost small screw drivers into the propeller while tuning the dual carbs. Two incidents scared me enough to call it quits.



(Photo by Herb Gillespie)

FIGURE 3 — The reed valve added to the intake system resulted in 10% more power.

A bifurcated manifold was built and fitted with one of the Walbro "cube carburetors". The layout allowed the carb to be oriented close to the crankcase, reducing the frontal area, in a safe tuning position. Power decreased 5%, when using this manifold and one of the original carburetors. The original power could be restored by using this manifold and a large carburetor taken from the 101 McCulloch engine. This carb was much larger and twice as heavy as the original ½ pound WB-2 Walbro carb. In an effort to come close to the performance of the 101 carb, the WB-2 carb was bored out from a 22mm diameter venturi to 27mm. The throttle bore and throttle plate were also enlarged. This modification improved the power to within 1% of that obtained with the big 101 carb, which is also made by Walbro.

Rather than work toward additional air flow with a larger (and heavier and more expensive) carburetor, an increase in the inlet duration was tried. A reed valve (which DH has in production for their motorcycle reed conversions) was added to the inlet manifold as shown in Figure 3. The theory is that the reed opens before the piston timed intake ports are uncovered, thereby improving the breathing. The timing would be unsymmetrical as the reed could open early in the intake cycle and then close whenever the crankcase pressure rose above the inlet manifold pressure.

Bear in mind that the 138° stock inlet duration requires the crankshaft to rotate 111° from bdc before the piston-timed port opens. During this time of decreasing crankcase pressure the reed is free to function, while the piston controlled ports are completely sealed.

The idea worked. When using the bored out WB-2 carburetor, the reed engine out-performed any combination previously tested. We now could use a small carburetor oriented in a safe position close to the crankcase, out of the air stream, and still have acceptable power. We have not tried the big MC101 carb with the reed.

A reed valve combined with a piston-timed intake port is not new. McCulloch used this configuration in the early 1950s on their chainsaws. Honda and Suzuki motorcycles also use the reed in addition to the piston timed inlet. The motorcycle jargon calls the design "case induction".

It is interesting to note that when a 0.019-inch thick reed of epoxy/fiber-glass was used in the first test run, the power actually decreased vis-a-vis the conventional piston-timed intake. By progressively decreasing the petal thickness the power steadily improved. The thinner the petal, the better the power. A 0.014-inch thick petal improved power 10% above the original base line figure. A compromise between the expected life of a thin petal and the power produced, is necessary. The probable thickness will be around 0.014 to 0.016-inch. The petal should last 50 to 100 hours at WOT with a replacement cost of 50c.

The carburetors mentioned here use a metering diaphragm to control incoming fuel, rather than a float and bowl, for all position operation. Metering, however, is more precise when the fuel diaphragm is mounted below the venturi. The carburetors also have a diaphragm fuel pump, operated from the cyclic crankcase pressure. The pump will lift the fuel several feet. The life of the rubber diaphragm is many hundreds of hours when using gasoline/oil mix as a fuel.

EXHAUST

The RPV people usually let the exhaust empty directly from the cylinder. This noisy approach makes a reliable package as there are few parts involved. Such an arrangement is intolerable for man-carrying aircraft. In addition to damaging the pilot's hearing, the racket makes the aircraft an undesirable visitor.

The noise is created by energy being dumped into the air. There is around 50 psi remaining in the cylinder when the exhaust port suddenly uncovers. A properly designed exhaust system uses this energy to enhance the engines breathing. The result is low noise and improved engine power. In fact, hp per pound in the engine package can be unchanged when using an expansion chamber. Power available at the propeller vs. total aircraft weight is much improved with the quiet expansion chamber.

A simultaneous firing twin with a common crankcase has problems running smoothly at low engine speed, say just above an idle. With open exhaust stacks at low speed, the cylinder that fires the hardest also scavenges the best, taking more mixture from the crankcase that also feeds another cylinder. The overall result is that the two cylinders take turns running properly. A common exhaust system helps the two cylinders to run in harmony as intended. The improvement when fitting an exhaust system is easily detected when running on a propeller test stand.

The current exhaust system has a total length from piston face to tip of around 39 inches. A silencer on the end of the tuned chamber will add another 8 inches to this long length. Once the geometry has been optimized we will offer the exhaust system dimensions to anyone interested.

For applications not requiring a lot of power, a short restrictive muffler could replace the long expansion chamber. The single muffler would be at the end of a "Y" shaped exhaust header. This system would be 15 to 20% lower in power as compared to the expansion chamber.

IGNITION

The RPV's for which this engine was originally designed, have a 28 volt power source on board. A self-contained magneto ignition is therefore not required. Their ignition requirement is for a high spark energy, fast rise time, low power input and long shelf life. A capacitor discharge ignition satisfies these requirements. The prototype engines currently use a CDI powered by a constant loss 12 volt battery to avoid the inconveniences of 28 volts. Current draw approaches 1 ampere. A simple change inside the black box was required to operate the 28 volt CDI at the 12 volt level. This ignition work introduced me to the fact that two 12 volt lead-acid batteries at full charge give 28 volts.

Pointless ignition timing is accomplished by passing a rectangular steel pole piece mounted on the propeller hub past a magnetic sensor. When the steel approaches the wound magnet, a positive voltage is generated — a negative voltage occurs as the pole piece passes the magnetic sensor. When starting the engine, a retarded spark is accomplished by a toggle switch which forces the black box to trigger on the trailing edge of the pole piece. During normal running, the toggle is switched to RUN, making the ignition sense the leading edge of the pole piece. There is 11° between the advance and the retard spark positions. For a secure feeling when hand cranking the engine, the retard position of the toggle switch must be used. Because both cylinders fire together it takes a lot of muscle to crank the engine through on full advance. The retard position allows a cold engine to be started with a couple of two-handed flips of the propeller. There is much ignition energy available with the CDI. Hand starting is easy, even when the side electrodes are cut completely off the spark plugs. This advance-retard, which is an aid for hand starting, could also be accomplished by shaping the rotating pole piece, thereby eliminating the toggle switch. There are pros and cons for the safety afforded by the two methods of spark control.

The output from the CDI black box is 300 volts. A coil is required to transform the energy at low voltage to high voltage which will jump the spark gap. The present solution uses a 12 volt coil from a Honda motorcycle. This single coil has two high tension leads, which suits the aircraft engine nicely. The spark plug caps have an integral 10,000 ohm resistor incorporated to reduce ignition noise. A small coil which is taken from a Bosch magneto is on test as a light weight coil solution for the CDI.

A pointless "CD magneto" from an 045 Stihl chainsaw has been tested but has been rejected because it simply could not produce the energy to fire both plugs at the same time. FEMSA in Spain (which produces a magneto with an internal rotor and external coils) has been contacted to see if they have a magneto ignition for the Twin. In the future, a magneto ignition or the 12 volt CDI will be available on the Dyad 280. Twin engine installations with counter-rotating propellers would favor the CDI. One 12 volt source fires both engines. A self-contained magneto would probably be better for the simpler, single engine installations.

The spark advance recommended by Stihl fires the plug when the piston is 3mm (0.120-inch) before tdc. The engine produces more power with additional spark advance. However, this is not recommended. When the engine is timed with more spark lead and is fully warmed up, one can hear the detonation on 94 octane automotive gasoline. Gas to oil ratio is 32. Rather than work with higher octane fuel, it is more practical to leave the spark advance at this recommended 3mm figure. High octane aviation gasoline, of course, can be used if desired.

CONCLUSIONS

The engine shown in Figure 1 weighs 12½ pounds. The 30" diameter propeller adds another 1¼ pounds. A small 12v battery pack and coil will also be required.

The engine torque has been measured on a propeller test stand. The value ranges from 15 to 17 foot pounds at an engine speed of 5500 to 6200 rpm. Calculated power has ranged from 14 to 19 hp depending upon the carburetor size and exhaust system used. Twenty hp at around 6500 rpm will easily be achieved. All work currently is aimed around 6000 rpm.

What will they cost? The production engines (less propeller) will retail for $500 to $600. The exact figures will depend on how the expensive tooling is amortized.

SPORT AVIATION will keep you posted on the progress and availability of the Dyad 280. Do not send for literature for several months, until the ten prototypes are debugged. A performance graph, propeller mounting and thrust data, a full size 3-view drawing and installation data, etc. will be made available in a $5.00 package from: D. H. Enterprises, 4909 Compton Blvd., Lawndale, CA 90260.

and bowl, for all position operation. Metering, however, is more precise when the fuel diaphragm is mounted below the venturi. The carburetors also have a diaphragm fuel pump, operated from the cyclic crankcase pressure. The pump will lift the fuel several feet. The life of the rubber diaphragm is many hundreds of hours when using gasoline/oil mix as a fuel.

EXHAUST

The RPV people usually let the exhaust empty directly from the cylinder. This noisy approach makes a reliable package as there are few parts involved. Such an arrangement is intolerable for man-carrying aircraft. In addition to damaging the pilot's hearing, the racket makes the aircraft an undesirable visitor.

The noise is created by energy being dumped into the air. There is around 50 psi remaining in the cylinder when the exhaust port suddenly uncovers. A properly designed exhaust system uses this energy to enhance the engines breathing. The result is low noise and improved engine power. In fact, hp per pound in the engine package can be unchanged when using an expansion chamber. Power available at the propeller vs. total aircraft weight is much improved with the quiet expansion chamber.

A simultaneous firing twin with a common crankcase has problems running smoothly at low engine speed, say just above an idle. With open exhaust stacks at low speed, the cylinder that fires the hardest also scavenges the best, taking more mixture from the crankcase that also feeds another cylinder. The overall result is that the two cylinders take turns running properly. A common exhaust system helps the two cylinders to run in harmony as intended. The improvement when fitting an exhaust system is easily detected when running on a propeller test stand.

The current exhaust system has a total length from piston face to tip of around 39 inches. A silencer on the end of the tuned chamber will add another 8 inches to this long length. Once the geometry has been optimized we will offer the exhaust system dimensions to anyone interested.

For applications not requiring a lot of power, a short restrictive muffler could replace the long expansion chamber. The single muffler would be at the end of a "Y" shaped exhaust header. This system would be 15 to 20% lower in power as compared to the expansion chamber.

IGNITION

The RPV's for which this engine was originally designed, have a 28 volt power source on board. A self-contained magneto ignition is therefore not required. Their ignition requirement is for a high spark energy, fast rise time, low power input and long shelf life. A capacitor discharge ignition satisfies these requirements. The prototype engines currently use a CDI powered by a constant loss 12 volt battery to avoid the inconveniences of 28 volts. Current draw approaches 1 ampere. A simple change inside the black box was required to operate the 28 volt CDI at the 12 volt level. This ignition work introduced me to the fact that two 12 volt lead-acid batteries at full charge give 28 volts.

Pointless ignition timing is accomplished by passing a rectangular steel pole piece mounted on the propeller hub past a magnetic sensor. When the steel approaches the wound magnet, a positive voltage is generated — a negative voltage occurs as the pole piece passes the magnetic sensor. When starting the engine, a retarded spark is accomplished by a toggle switch which forces the black box to trigger on the trailing edge of the pole piece. During normal running, the toggle is switched to RUN, making the ignition sense the leading edge of the pole piece. There is 11° between the advance and the retard spark positions. For a secure feeling when hand cranking the engine, the retard position of the toggle switch must be used. Because both cylinders fire together it takes a lot of muscle to crank the engine through on full advance. The retard position allows a cold engine to be started with a couple of two-handed flips of the propeller. There is much ignition energy available with the CDI. Hand starting is easy, even when the side electrodes are cut completely off the spark plugs. This advance-retard, which is an aid for hand starting, could also be accomplished by shaping the rotating pole piece, thereby eliminating the toggle switch. There are pros and cons for the safety afforded by the two methods of spark control.

The output from the CDI black box is 300 volts. A coil is required to transform the energy at low voltage to high voltage which will jump the spark gap. The present solution uses a 12 volt coil from a Honda motorcycle. This single coil has two high tension leads, which suits the aircraft engine nicely. The spark plug caps have an integral 10,000 ohm resistor incorporated to reduce ignition noise. A small coil which is taken from a Bosch magneto is on test as a light weight coil solution for the CDI.

A pointless "CD magneto" from an 045 Stihl chainsaw has been tested but has been rejected because it simply could not produce the energy to fire both plugs at the same time. FEMSA in Spain (which produces a magneto with an internal rotor and external coils) has been contacted to see if they have a magneto ignition for the Twin. In the future, a magneto ignition or the 12 volt CDI will be available on the Dyad 280. Twin engine installations with counter-rotating propellers would favor the CDI. One 12 volt source fires both engines. A self-contained magneto would probably be better for the simpler, single engine installations.

The spark advance recommended by Stihl fires the plug when the piston is 3mm (0.120-inch) before tdc. The engine produces more power with additional spark advance. However, this is not recommended. When the engine is timed with more spark lead and is fully warmed up, one can hear the detonation on 94 octane automotive gasoline. Gas to oil ratio is 32. Rather than work with higher octane fuel, it is more practical to leave the spark advance at this recommended 3mm figure. High octane aviation gasoline, of course, can be used if desired.

CONCLUSIONS

The engine shown in Figure 1 weighs 12½ pounds. The 30" diameter propeller adds another 1¼ pounds. A small 12v battery pack and coil will also be required.

The engine torque has been measured on a propeller test stand. The value ranges from 15 to 17 foot pounds at an engine speed of 5500 to 6200 rpm. Calculated power has ranged from 14 to 19 hp depending upon the carburetor size and exhaust system used. Twenty hp at around 6500 rpm will easily be achieved. All work currently is aimed around 6000 rpm.

What will they cost? The production engines (less propeller) will retail for $500 to $600. The exact figures will depend on how the expensive tooling is amortized.

SPORT AVIATION will keep you posted on the progress and availability of the Dyad 280. Do not send for literature for several months, until the ten prototypes are debugged. A performance graph, propeller mounting and thrust data, a full size 3-view drawing and installation data, etc. will be made available in a $5.00 package from: D. H. Enterprises, 4909 Compton Blvd., Lawndale, CA 90260.