5. The mounting pad on the accessory case for the **OFA** should be like the drawing in Figure 1, Figure 2, or Figure 2A. If the mounting pad is different, **DO NOT** use this adapter. Call B & C Specialty Products at (316) 283-8000. The B&C **OFA** is not compatible with 76 series engines or on accessory cases with "Dual Magneto" mounts (two magnetos in one case with a single drive).

If installing the **OFA** on an IO-720 engine, it requires the use of a spacer (Lycoming part number LW-12775) to properly align the oil passages. This spacer should already be on the engine if a Lycoming oil filter adapter was previously installed and may be re-used under the B&C **OFA.**

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6. Check the fit of the **OFA** on the accessory pad. Temporarily screw the oil filter onto the adapter and hold the adapter in place on the accessory case. Make certain that the oil filter will clear the engine mount, cowling, and any other fixed structure in the engine compartment by at least ½ inch. The installer is responsible for assuring that the oil filter and **OFA** will have adequate clearance to other structures during maximum engine mount deflection. Installation kits are available to space the filter away from the accessory case if required:

B&C P/N	Spacer Length	Description, P/N	Qty
FK502-.75	.75"	Spacer, 700-303-.75 Gasket, Accessory Case, LW12795 Lockwasher, Int. Tooth, 1/4", AN936A-416 Bolt, Hex, Gr. 8, 1/4-20 x 1.75 Lg., S879-28	1 1 4 4
FK502-1.4	1.4"	Spacer, 700-303-1.4 Gasket, Accessory Case, LW12795 Lockwasher, Int. Tooth, 1/4", AN936A-416 Bolt, Hex, Gr. 8, 1/4-20 x 2.37 Lg., S879-38	1 1 4 4
FK502-2.5	2.5"	Spacer, 700-303-2.5 Gasket, Accessory Case, LW12795 Lockwasher, Int. Tooth, 1/4", AN936A-416 Bolt, Hex, Gr. 8, 1/4-20 x 3.5 Lg., S879-56	1 1 4 4

On this Installation Kit (FK502) the oil cooler return line must have a 45• •fitting going into the accessory case port located directly above the left magneto (for proper clearance of the oil filter).

AMT
Aircraft Maintenance Technology
MANAGING FOR SAFETY, RELIABILITY AND PROFITABILITY

Old Faithful

The Marvel(ous) Schebler carburetor

By Randy Knuteson

Everything is simpler than you think and at the same time, more complex than you can imagine. These words were spoken some 200 years ago by a philosopher - not an aircraft technician straining to understand what went wrong with his carbureted engine.

A quick glance at a Marvel Schebler Carburetor might lead some to believe that these units are far too simplistic for today's modern aircraft. The obvious advantages associated with fuel injection (even fuel/air distribution, no carb icing concerns, etc.) seem to overshadow the value of the much-maligned carburetor. However, a closer, more scrutinizing look reveals an intricate relationship between various sub-systems within these carburetors. The details that comprise these systems vary from model to model. It is only when the functions of these systems are fully understood that one gains a renewed appreciation for their elegantly simple designs. These units have continued to serve us well through the passing of time.

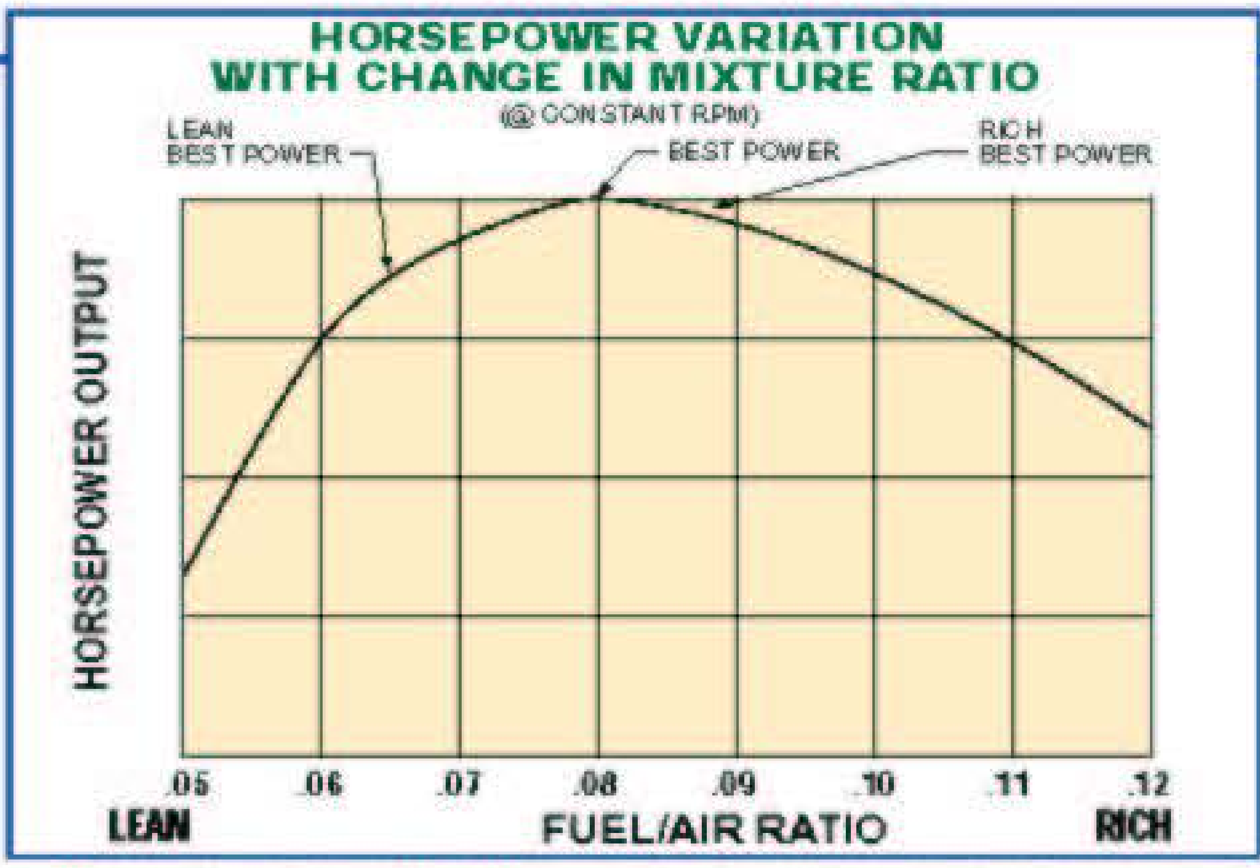
Principles of operation

In the most simple of terms, an aircraft carburetor is a device for introducing and mixing a metered amount of fuel to the cylinders. Unlike direct injection that provides a precise and uniform delivery of the charge directly into the intake port of each cylinder, the atomized fuel from the carburetor seeks the path of least resistance as it travels through the induction tubes. Fuel distribution is far from exact as indicated by split CHT and EGT readings. According to Lycoming, a variance of 150 degrees is not at all unusual. The job of the carburetor is to perform two very basic functions:

1. It measures out an appropriate amount of incoming air
2. It mixes that air with fuel to assure that a proper charge enters the cylinders under all operating conditions.

Fuel from the wing or header tanks is fed either by gravity or by a low-pressure pump to the inlet of the carburetor. The actual pressure available from a gravity feed system is about one PSI for each forty inches of head of fuel (as measured in distance from the surface of the fuel in the tank to the point of discharge into the carburetor). Low-wing aircraft or "Turbo-normalized" aircraft requires as much as six to nine PSI of pressure to perform at altitude. These installations would require a gravity feed of approximately some 240 inches of head pressure. Such distance renders the gravity-feed method impractical if not impossible.

As fuel rises in the float bowl chamber, it lifts a float that is hinged to the throttle body. The float fulcrum lever carries a needle valve, the point of which extends into a seat at the inlet of the carburetor. When the fuel level rises far enough in the bowl, the needle valve begins to partially restrict or close off fuel flow. The height of the fuel in the discharge nozzle is controlled by the position of the float and the needle valve in the float chamber. As fuel



This curve shows the relationship between power output and mixture ratios (based on weight, not volume). Combustion can occur with mixtures as rich as .125 (1 to 8); and as lean as .062 (1 to 16). Lean best power (economy) setting is 0.075, while rich best power is 0.087. Best performance is approximately 0.080. The exact shape of this curve varies from engine to engine.

is discharged from the carburetor, the float lowers and allows more fuel to fill the bowl. In this manner, optimum fuel level is always maintained so long as the float level has been properly set at overhaul.

A partial vacuum created by the piston during the intake stroke draws air through the carburetor. The air passages in both the carburetor and the manifold are designed to admit a sufficient amount of air to fill the cylinders by the end of the intake stroke. The throttle plates' function is to regulate the admission of air to the cylinders, thereby controlling the power output of the engine.

Basic Bernoulli

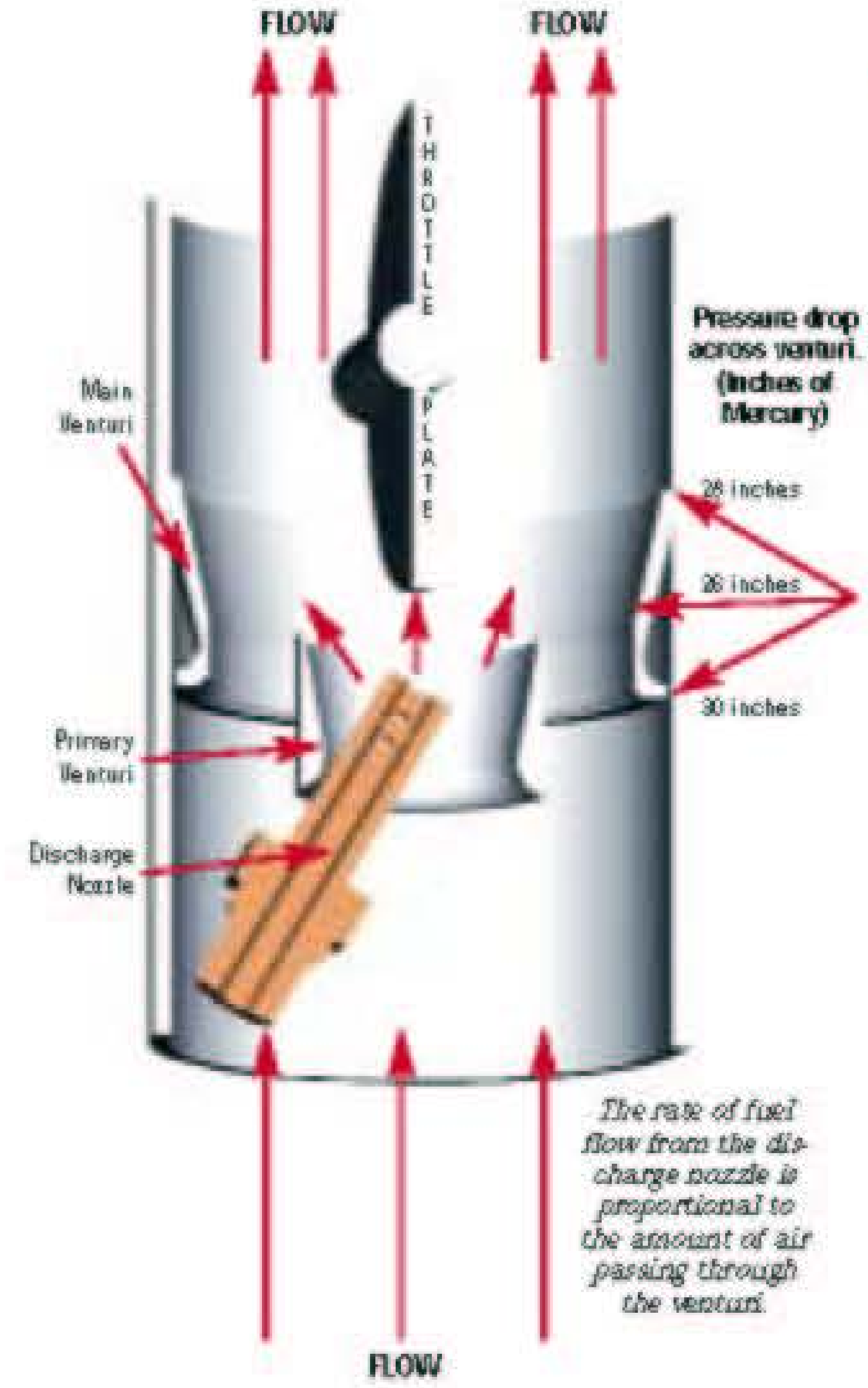
Two pressures work together to discharge fuel from the carburetor bowl. The atmospheric pressures in the bowl chamber exert a downward force on the fuel within the bowl. And there is also a drop in pressure (a vacuum) at the neck of the discharge nozzle caused by the action of the venturi in the throat of the carburetor. The resulting pressure-differential works to create a push/pull action on the fuel.

Proper fuel metering is accomplished by the strategic placement of the discharge nozzle in the venturi tube. The venturi is situated in the intake airstream at the point of mean velocity immediately upstream of the throttle valve.

Imagine an aircraft wing rolled into a cylinder, dramatically reduced in size, then placed into the bore of a carburetor. In essence, you have formed the aircraft wing into a venturi. The basic law of physics discovered by Bernoulli is as active in the throat of a carburetor as it is across the surface of an aircraft wing. A venturi tube correctly positioned in the throat of a carburetor causes air to move at a much faster rate as it passes through the constriction **(See diagram, right)**. As air velocity increases, a reduction in static pressure (pressure drop) causes a suction force to draw fuel up the discharge nozzle. The amount of fuel drawn up the discharge nozzle is dependent upon the speed and condition of the air sweeping through the venturi. The greater the velocity, the greater the suction on the fuel in the discharge nozzle.

Unimpeded Airflow

The onrush of air through the throttle body serves to mix and atomize the fuel as it makes its way to the cylinder intakes. This mixing of fuel and air in the throat of the carburetor helps to convert much of the liquid fuel into a gaseous state. Engine speed, efficiency and power are greatly influenced by the quantity and nature of this homogenous charge. Because of this, its extremely important that airflow be unimpeded by sharp bends in the induction or gasket material protruding into the airstream. Such obstacles can produce



The rate of fuel flow from the discharge nozzle is proportional to the amount of air passing through the venturi.

unsteady or turbulent airflows directly affecting the fuel metered through the discharge nozzle. The quality of the airstream directly influences the metering of fuel. A small piece of gasket material, a damaged or restricted air filter, a loose venturi, or any foreign object lodged in the carburetor throat can ruin the metering ability of the carburetor.

Mixture Control

Fuel is always metered in relation to the weight, not the volume of air passing through the carburetor. As the aircraft ascends in altitude it passes through atmosphere that is constantly changing. Pressure, temperature, and density steadily declines. Since thinner air is less dense, each pound of air occupies a greater volume of space. So, as the airplane gains altitude, the volume of air passing through the carburetor will continue to remain proportional to suction in the manifold, but the weight of the air will decrease as ambient air density decreases. Since the air is less dense, a nat-

Left: Brass discharge nozzles. Top nozzle is of the pepper-box design. This atomizing design is frequently installed in the smaller TCM carbs to correct erratic fuel flows associated with the installation of the single-piece venturi (Precision S.B.s MSA-7, MSA-8, MSA9).

Right: Kelly Aerospace Power Systems manufactures discharge nozzles from a single piece of stock (top). Older discharge nozzles are welded where the neck meets the wrenching flats. Heavy porosity or a side load on the neck may compromise these welds. Visually inspect the integrity of the nozzles to assure that the neck will not separate from the body. The neck of the nozzle would be ingested into the engine if such a separation occurred.

ural richening of the fuel/air ratio occurs. A manual mixture control enables the pilot to alter the ratio of fuel to air. At any given throttle setting, the mixture may require some adjustment to compensate for ever-changing conditions from sea level to altitude. The mixture control also provides a secondary function of completely closing off fuel flow at ICO.

Idle Circuit

At low rpms, the idling system is independent of the main metering jet. At idle speeds and up to approximately 1,000 to 1,300 rpm the main jet has little or no fuel passing through it. This is because the throttle valve is almost closed and there is little air swept past the discharge nozzle. At this point, fuel is drawn up the idle bleed tube in the bowl and then through the idle emulsion channel within the throttle casting to ports adjacent to the upper edge of the throttle valve. As the throttle valve is opened, suction at the idle mixture port decreases and the main jet takes over entirely. Fly-holes in line with the mixture port aid in the smooth transition from idle to full power. As the throttle opens it progressively unveils these secondary and tertiary bleed ports. Any sudden opening of the throttle results in a lag between the time the idling circuit stops functioning and the main jet takes over. This is because there isn't sufficient air flowing through the carburetor throat to draw fuel from the main discharge nozzle. An accelerator pump is used to compensate for this delay and eliminate sudden flat spots created by temporary lean mixtures. The accelerator pump is mechanically linked to the throttle and discharges fuel through a tube adjoining the main nozzle. The accelerator tube protrudes into the airflow just inside the primary venturi in the smaller carbs and inside the main venturi in the larger carbs.

Looking up the throat of the MA-4SPA Carburetor. This vantage point reveals the proper placement of the pump discharge tube. The tube must be positioned just within the center ring of the primary venturi.

Any fuel-borne contamination or corrosion latently within the carburetor can migrate to these idle passages and create a lean condition at low power settings. If the contamination is significant, it will not allow for proper fuel/ air ratios at idle. At sea-level, mixture rise as indicated on the tach should be approximately 25 to 50 rpm. At higher field elevations of 5000-ft. or more, the mixture rise will be more in the neighborhood of 75 to 100 rpm. An idle adjustment screw that requires more than four turns out to achieve a proper mixture rise at ICO is a good indication of contamination in the idle circuit.

Don't touch that jet!

A restriction at the base of the discharge nozzle serves as the main jet in MA series carburetors. In HA-6 (horizontal side-draft) series carburetors, the power jet in the base of the bowl performs the same function. Some well-meaning technical writers have instructed mechanics to hone these jets in an effort to cool cylinder head or exhaust gas temperatures. Apparently they believe this to be a "cure-all" for lean running engines. A mechanic would be ill-advised to follow such instructions since no process approval exists for opening these jets in the field. Furthermore, tampering with the jet size could mask other serious problems. An induction leak, an incorrectly sized economizer jet, an incorrect float setting, or perhaps even the wrong choice of carburetor could all contribute to a "lean" running engine. Another problem with this mode of attack is that the jets vary in design. Some jets are straight, while others are contoured or stepped. A mechanic who takes a drill bit, a ream, or sandpaper to the entrance of a stepped opening may soon regret that decision. Fuel flows could exponentially increase by merely breaking the stepped edge and thereby creating a venturi entrance. By contouring a stepped jet we've managed to decrease the pressure and increase the velocity of the fuel through the jet.

When you start boring out nozzles, several things can happen. As you begin to see appreciable results - the tendency is to take out more and more material. "If a little bit is good, a lot may be better." Wrong!

Carb Icing

Carburetor icing remains a serious problem for light aircraft as evidenced by the number of incidences reported annually. Charles Lindbergh experienced icing while crossing the continental divide in The Spirit of St. Louis as he prepared for his historic flight across the Atlantic. To correct this problem, Lindbergh's mechanics equipped the plane with a carburetor air heater.

The formation of ice on the throttle shaft and plate is a natural byproduct of the pressure drop across the venturi when certain atmospheric conditions exist. The typical temperature drop within the throat of the carburetor is 40 to 60 degrees. This temperature drop causes the dew point to drop and the air to become increasingly dense. Moisture in the air forms into water droplets that adhere to the cold surfaces in the throat of the carburetor. Carb icing can readily occur when outside air temps are as high as 90 degrees. In fact, it is often at these OATs that carb icing is most menacing because warm air is capable of sustaining more moisture.

A 1971 report by the National Research Council (NRC) of Canada revealed that Carburetor ice could be reduced by the use of gasoline soluble inhibitors. The study selected temperatures, humidity and throttle plate settings that would cause the most severe icing conditions. It was found that the positioning of the throttle plate at approximately 40 deg (70 percent of max opening, or approx. cruise configuration) produced the optimum build-up of ice. Manifold vacuum readings were used as a means of assessing ice build-up. Visual observations provided a secondary form of measurement. The study determined that "ice formation occurred preferentially on the edges of the throttle plate and spread progressively across the plate face." The use of ethylene glycol monoethyl ether at 0.15 percent proved an effective deterrent to ice build-up. Of more interest however, was the discovery that coating the throttle plate and shaft with 0.00125 layer of Teflon "produced a marked reduction in ice formation." "The throttle plate was virtually clear." What is not clear is why in the ensuing years the manufacturers never utilized this data.

EGME is currently available under the name "Prist® PF205 Low-Flow", and is said to be a practical anti-ice additive. A device called a carb temp probe is also available. The probe enables the pilot to monitor temps within the carburetor and to detect when conditions are most conducive to icing. For additional information regarding carb-ice formation refer to *Pilot Precautions and Procedures to be Taken in Preventing Aircraft Reciprocating Engine Induction System and Fuel System Icing Problems* (FAA AC-20-112) and consult your POH.

Photo shows a collapsed brass float. Never introduce shop air to the inlet fitting, discharge nozzle, or fly holes in the throat of the carburetor — the high pressure might collapse the float.

Sure, your high-end fuel flows begin to look better and so do your CHTs and EGTs. But unfortunately, mid-range fuel flows may become exceedingly rich. This rich condition is especially apparent as you transition between idle and full power. An engine that bogs down rich may surprise a pilot forced to do a go-around when on short final. Actuating the throttle causes the pump plunger to spray an additional slug of fuel into the carb throat. Thoughtful engineers have carefully tailored the idle circuit, the accelerator pump, and main jet for optimum performance. A modified nozzle jet may cause the air/fuel ratio to be overly rich. There is a point of diminishing returns, where high-end fuel flows no longer increase but mid-range fuel/air ratios become too rich. And once this occurs, your wallet becomes increasingly lean as you shell out additional dollars for a replacement nozzle!

Choosing the correct carburetor

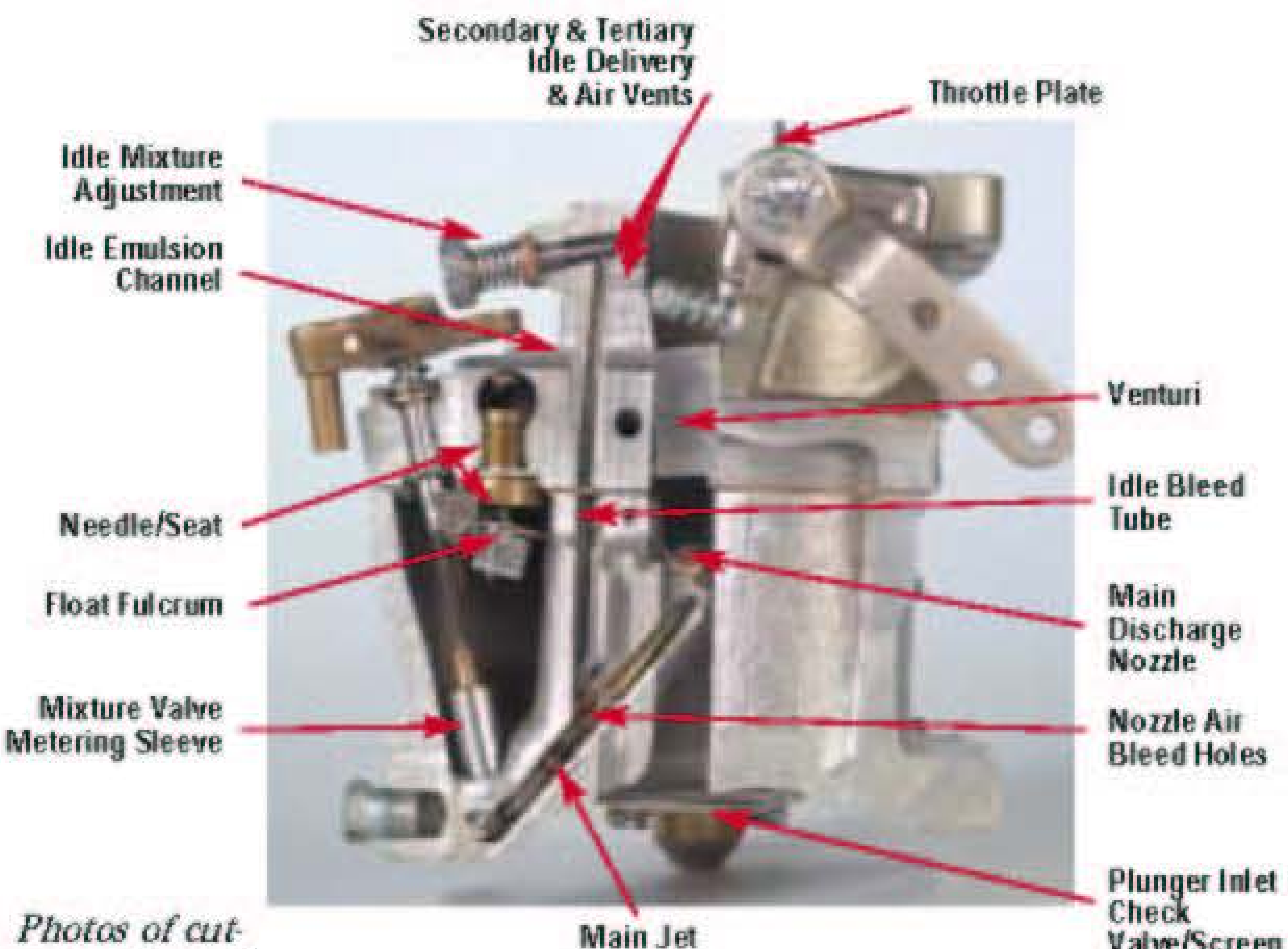
A common misunderstanding through the years has been that an engine/carburetor combination that works well in one airplane will function as well in another style airframe. Additionally, it is believed that if the system performs well in a test cell, then it will perform equally well in flight. Unfortunately, to the chagrin of many a homebuilder, this is not always the case. Airframe performance, cowling configurations, baffling, and choice of air-box, all contribute dramatically to fuel/air ratios and to engine cooling.

Venturis. The two-piece venturi (above left), is subject to annual and 100-hr. inspections as per AD 98-01-06. Single piece venturi (above right) requires no recurrent inspections. Carburetor data tags with 'V' stamped on them indicate that the single piece venturi has been installed.

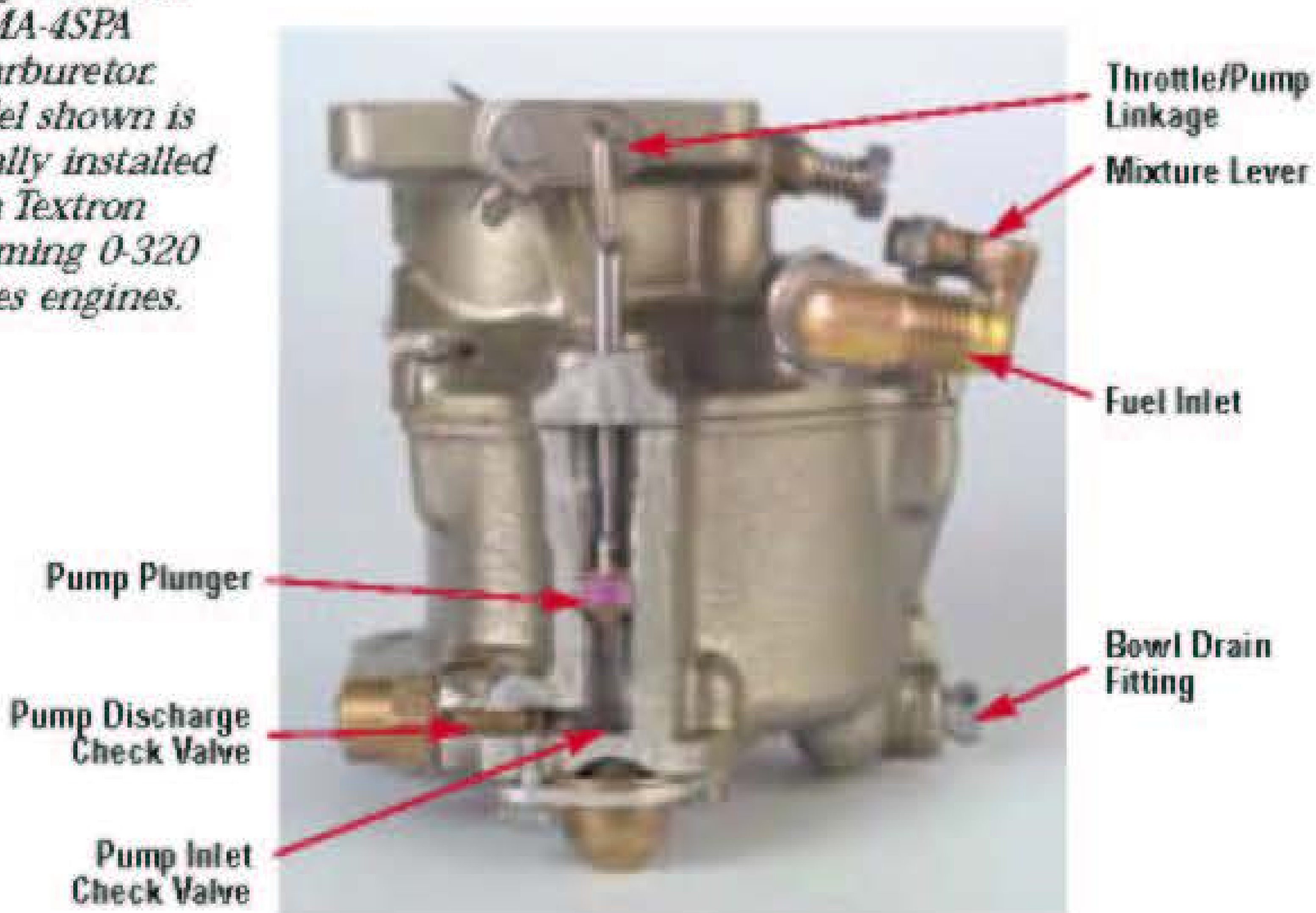
When selecting a carburetor for your engine, always refer to both the engine and airframe type certification listings. Many have made the critical mistake of selecting a carburetor based solely on the part number(s) listed in the engine manufacturers parts and overhaul manuals. Some have selected a carburetor based on the part number currently installed in their airplane or on an airplane of the same model tied down on their airfield. Others have chosen a carb based on the OEM's application guide. All these methods will narrow down your search, but they will not with any certainty guarantee that you have selected the right unit for your particular airplane. Incomplete engine logs, the swapping of engines to airframes, and the uncertain history of some engines mandates a reliance on type certification data when deciding on the appropriate carburetor for your particular application.

To some, the theory and mechanical functions of carburetors may seem rather formidable. Yet, when each subsystem is viewed separately, it becomes readily apparent that these systems are easy to understand. In spite of all the intricacies associated with them, Marvel Schebler (Precision) carburetors remain the same efficient, reliable units our fathers and grandfathers flew behind with confidence for decades. **AMT**

Randy Knuteson is Director of Product Support for Kelly Aerospace Power Systems in Montgomery, AL.



Photos of cutaway views of MA-4SPA Carburetor. Model shown is typically installed in Textron Lycoming 0-320 series engines.



The Twister duo in its new Scottish Widows livery

UL POWER IN TWISTER

Pete Wells explains why he chose UL Power's UL260 ISA engine – the company's first ever aerobatic engine – for his second Twister, after 1,000 hours with a Jabiru 2200

The Twister was always years ahead of its time, so much so that when it first came along there really wasn't an engine available to do it justice.

I built one anyway, convinced from the start that it would make a superb aerobatic display mount, and managed to operate the Jabiru 2200 for over 1,000 hours by noting intervals of failure of components and imposing 50 hours less life to those items. I was averaging about 360 hours per year; giving say a rotor arm a life of 150 hours meant I had to change it about every six months (someone doing 20 hours a year would do well to change on a calendar period). By using the red pages at the back of the engine logbook as a reminder, I ended up with almost 100% reliability and never missed an airshow. But to achieve this, I was working every week on the engine!

What I wanted was the rugged reliability of the American heavy metal (Lycoming and Continental), but with a lot better power-to-weight ratio and aerobatic oil and fuel – a tall order. I also wanted something which required minimal work to keep it reliable. The American engines are very robust in construction and rev relatively slowly at around 2,700rpm. In contrast, what I needed by definition was a lightweight, high-revving unit; a similar comparison would be to compare an old American V8 with a Formula 1 race engine.

As I had found with the Jabiru, getting as much performance out of a relatively small engine as a large one often comes at the expense of its reliability, and it's something that requires constant work. I was also horrified to find that the ignition system on the Jabiru contained parts from a 1980 Datsun, and in this day and age that's technologically from the dark ages. There seemed no chance of the engine being developed in the way we required, i.e. fuel-injected with an aerobatic inverted oil system. The company was so difficult to communicate with that we were very much on our own when we encountered any problems, and Jabiru showed little or no interest in any of the things we discovered and rectified.

OPTIONS

I started looking at various options but did not like any of them. The popular Rotax 912 is heavy, water-cooled and has two carbs to go wrong instead of one. It was ruled out for weight and complexity reasons. I was considering adding another two problematic cylinders to the Jabiru and trying the six-cylinder version, which would have meant even more of the components that failed at regular intervals.

It depressed me that small engines were so limited and technologically lacking. Then, by chance, I saw UL Power's UL260i engine at a microlight fair at Popham. It instantly struck me as being much more robust and a lot better designed and built than the opposition. Its representative was knowledgeable and keen to hear what I needed. In technology terms, with its FADEC system, it was almost at the opposite end of the spectrum from what I was operating. But I did have a few concerns about some of its features.

1 The engine control unit (ECU) is like that of a modern car. It does everything to ensure the engine works in whatever situation you are in as efficiently as it can. I worried that if this went wrong you would be up the creek without a paddle.

2 An electrically-powered ignition system means that if the wrong wire fails, the engine stops, i.e. fail is off, unlike most aircraft where fail means on. No power, no engine. (I now know it has many safety features making it probably as safe as a conventional engine.)

3 I had heard rumours that the PFA (as we were then) insisted on having a two-battery alternative power source; weight-wise that would kill this engine option.

4 If I agreed to buy one, would UL Power do as promised and build me an aerobatic version?

5 Would UL Power disappear and leave me high and dry with no support or engine parts?

Of these issues the most important was not requiring two batteries. I put forward a good argument why this should not be required and Francis Donaldson agreed that for a single-seat aerobatic aeroplane it was likely to cause more problems than it solved, so agreed to a normal, single-battery electrical system.

NEW BUILD

I went ahead and built a second Twister, modifying it to take the slightly heavier engine and moving the battery aft to keep the C of G in roughly the same place as the original. I carried out load tests on the mount and filled in lots of paperwork.

Rumours of the UL engine being no better than the Jabiru 2200 proved unfounded when we finally flew one against the other. Once early teething problems had been solved, my plan to use the Jabiru-powered aeroplane for airshows and the new one for testing for at least a year was abandoned after six months as it became obvious that the UL260i was vastly superior to and more reliable than the Jab 2200. I even used the UL-powered plane for airshows in Scandinavia, which entailed a lot of overwater flying.

The ECU has so far never given any problems. I have a spare but have never used it and the single power supply and electronic ignitions have worked faultlessly, even when very wet!

UL Power has also been as good as its word and supplied me with its first ever aerobatic engine, the UL260 ISA, which we were immediately impressed with. A very telling fact was that when we started practising for the Twister Duo late in 2009, no one wanted to fly the Jabiru-engined aeroplane once they had flown both. As formation leader I ended up flying it as it gave the Number Two the extra power to formate on me, but it grated that the other guys were in the better aeroplane. I could not wait to get two UL-engined aeroplanes.

This was achieved by mid March 2010 and almost instantly we were approached by a Turkish event organiser who wanted an air display act in Turkmenistan (which borders Afghanistan). We had about one month to test the second aeroplane and get the clearances but it would be one hell of a first show for the new team, so Guy and I shared the mountain of preparation and decided to take the booking.

I think that trip was the ultimate test of this engine, involving about 70 hours of flying over some of the most inhospitable terrain on the planet. Due to the fact we were doing 400-mile legs with nowhere to land in-between, we knew we would probably encounter some bad weather. We were not disappointed; we flew for hours in driving rain at or below 600ft over the sea, and at other times climbed to over 15,000ft to clear terrain. We did legs in formation in terrible visibility to stay together and Guy and I came away from the trip with great admiration for this amazing little engine. It never missed a beat.

Pilots are always complaining that the technology we use is archaic and yet they are very reluctant to try anything new. The result is that new technology like the UL 260 ISA will always elude them – unless someone else takes the bull by the horns and shows them what they are missing.

UL Power has provided light aviation with one of the best new powerplants for decades, and it also supports its products and customers.

I now consider its engine to be as close to a baby Lycoming as it is possible to get and am very grateful to UL Power for keeping its word and developing this great little engine.

The installation of the aerobatic UL260 ISA is extremely neat and tidy

Testing the engine mount for side-loading

Twister Duo pilots Guy Westgate (left) and Pete Wells (right), with the UL260 engine designer, Lionel D'Hondt

New cowlings had to be designed and built

Twisters with the UL Power engine – a perfect combination

Belleville Washer Installation
For 1/2 prop bolts on a 7" dia. hub

Chase thread in both the drive lugs and prop bolts so they can be easily turned by hand

Lubricate the drive lug threads with engine oil

Install prop so the prop is vertical when any piston is at TDC

On each prop bolt stack 2 belleville washers (Solon Mfg P/N 828131) in series (outside diameters touching) and one AN960 steel washer. The steel washer will be bearing against the cr ısh plate and the outer most Belleville washer will contact the bolt head.

Torque each bolt in sequence to 15 ft #s. This will seat the prop

Back off all prop bolts and tighten each bolt so the belleville washers can be just rotated by hand. This becomes the starting reference point.

Mark with a felt tip pen the 12 o'clock position of each bolt.

In ¼ turn increments tighten each bolt in sequence until 1 3/8 turns are achieved for all 6 bolts

Lockwire the bolt head per Mil procedures.

Jeff Rose
105 Gardner Street
Chattanooga, TN 37411
(423) 622-8825

ELECTROAIR
DIRECT IGNITION SYSTEM

Electroair Ignition System
EIS-1

Instruction Manual

Jeff Rose
105 Gardner Street
Chattanooga, TN 37411
(423) 622-8825

Note

Electroair Electronic Ignition System was designed to be used as an experiment on combustion engines and is in no way certified for use on any type of aircraft. This device should be used in compliance with all F.A.A. Federal Regulations. The purchaser by placing this order with Electroair agrees that all parts purchased will be used solely at purchaser's risk.

Table of Content

Introduction

The Electroair Ignition System (EIS) is the result of years of development and represents a major breakthrough in engine control technology. The system is a single, easy to use, easy to install package that contains everything to control engine ignition.

The EIS has several advantages over the standard systems and some very impressive benefits:

1. No mechanical parts to wear
2. No spark distribution losses
3. High-energy spark
4. Longer spark durat
5. Automatic dwell adjustment
6. Fully adjustable timing
7. High Accuracy of Timing

The EIS uses two coils. Each coil fires two cylinders simultaneously. One cylinder is on its compression stroke and the other on its exhaust stroke. This is called a "waste spark system" because one of the sparks is "wasted" on the exhaust stroke cylinder. The EIS eliminates the need to distribute the spark to one plug at a time, doing away with the distributor and all the other energy robbing components of a traditional Kettering ignition system.

The coils fire directly into the spark plugs, delivering all the energy they have generated. The delivered spark is of longer duration than other system giving you the following benefits:

1. Hotter spark
2. Cleaner plugs
3. Less chance of plug fouling
4. Better engine efficiency
   -Smoother running
   -Better fuel economy
5. Higher resolution timing

The heart of the EIS is a digital integrated circuit chip. A timing housing replaces the magneto. The chip receives electrical impulses from the timing housing and fires the coils in the proper sequence. A calibration circuit works with the chip to determine the RPM and compute the spark advance. Controls are provided allowing you to optimize the timing.

Theory Of Operation

Dual Magneto System

On a traditional dual magneto system both magnetos are timed to fire at 25° before Top Dead Center (TDC). When starting the engine, the ignition switch grounds the "P" lead to the right magneto stopping it from firing. Meanwhile the left magneto with the impulse coupler still can fire. The impulse coupler causes the magneto to fire at TDC, and will continue to fire at TDC until the engine reaches about 200 RPM. At this time the impulse coupler disengages and the magneto falls back to 25° before TDC. Once the ignition switch is released the right magneto also begins to fire. From now on no matter what the RPM or the power setting the engine timing will remain at 25° before TDC.

At lower altitudes, a cylinder on the intake stroke draws in fuel and air. On the compression stroke (as the piston moves up) 25° before the piston reaches the top TDC the spark plug fires lighting the fuel. The objective is to have the peak pressure built up by the time the piston reaches 11 degrees past TDC.

As altitude increases, thinner air reduces the oxygen available for the proper fuel-air mixture creating more space between molecules. When the spark plug fires at 25° before TDC the thinner fuel-air mixture burns slower. Therefore the peak pressure point occurs much later than 11 degrees after TDC hence a loss in power. By advancing the timing, the peak pressure point can be maintained much closer to 11 degrees after TDC.

Electroair Ignition System

(EIS)

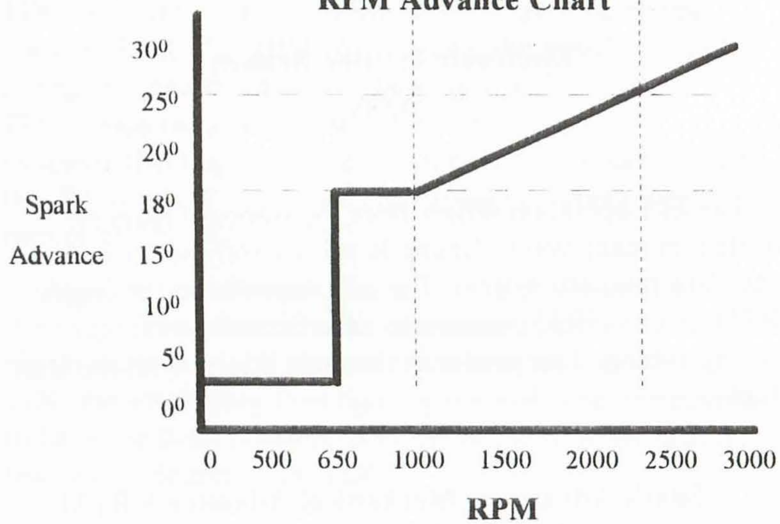
The EIS operation differs from the standard magneto system in many ways. Timing is permanently set in a standard magneto system. The EIS depends on the engine RPM and manifold pressure to determine the optimum timing setting. This produces the most power with the least fuel.

Spark Advance = Mechanical Advance + RPM Advance + Vacuum Advance

Mechanical advance is set during the installation of the EIS timing housing. This is usually 0^0 TDC.

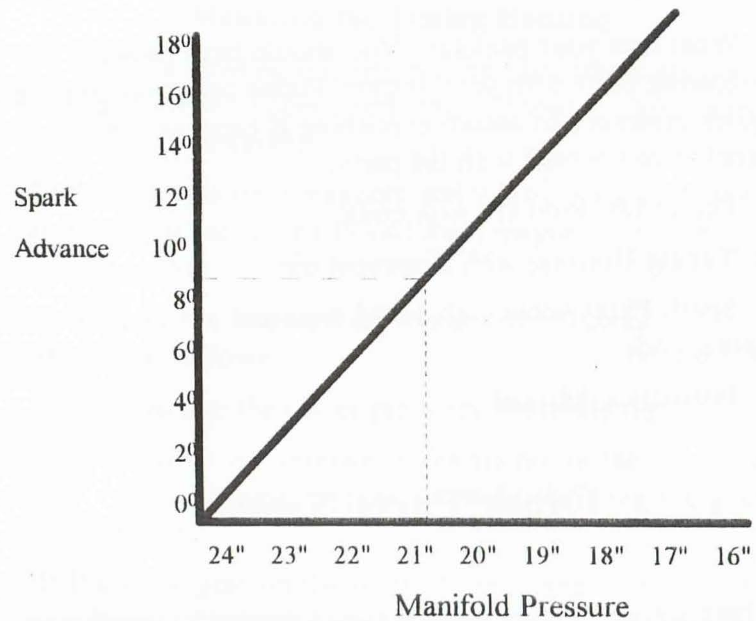
As the engine is started, the unit is set to fire the spark plugs at Top Dead Center (TDC). After reaching 650 RPM the EIS will advance the timing to 18^0 and stays at 18^0 until it reaches 1000 RPM, and then continue to advance approximately 1/4° per each additional 100 RPM. Refer to the RPM Advance Curve Chart.

RPM Advance Chart



While the timing is advanced for RPM, the manifold pressure is sensed and calculated into the total spark advance. These two measurements are used together to figure the most efficient timing setting for the engine. See the Vacuum Advance Curve chart.

Vacuum Advance Curve Chart



If the vacuum sensor option in not installed, then the vacuum advance value in the above equation will be zero.

With no vacuum sensor, the advance remains zero up to 650 RPM. At 650 RPM, it immediately advances to the inital RPM advance setting. The advance remains at the initial RPM advance setting until 1000 RPM when it will advance in a straight line to the maximum RPM advance setting. If a vacuum sensor is used, then the advance will be the same as just described plus an additional 0 to 18 degrees depending on the manifold pressure.

Parts and Inventory

What is in your package? You should have received the following parts with your system. Please take time to do a quick inventory to assure everything is there and to familiarize yourself with the parts.

1. Direct Ignition Unit with coils
2. Timing Housing with alignment pin
3. Spark Plugs wires with screw caps and spring ends
4. Instruction Manual

Other Parts Needed

There are some other parts you will needed to install your system listed below.

1. If you are replacing a Bendix Mag, you will need the mag holders used for a Slick Mag. These are used to hold the timing housing on.
2. Off/On switch and a circuit breaker
3. Parts to hook into a maniford pressure line. If you do not have a maniford presure line, you will need to install one. The connection to the manifold pressure system must end in an 1/8" tube that will connect to the DIS unit.

Basic Installation

Mounting the Timing Housing

(1) With the cowling off, remove the right lower spark plugs and the left upper spark plugs. These are associated with the right magneto.

(2) Remove the right magneto and wiring harness. Make sure you disconnect the P-lead from magneto and the ignition switch.

(3) Remove the magneto drive gear from the right magneto as follows:

- remove the cotter pin from the castle nut.
- loosen and remove the castle nut in the center of the gear. This may require carefully clamping the gear in a vise.

(4) Place the gear on the shaft of the timing housing. Be sure to align the half moon key on the shaft. Apply the washer and castle nut and tighten. Install the cotter pin with the long end, away from the nut. Bend the cotter pin slightly to get it in place. Bend the long end of the cotter pin over the end of the shaft. The short end of the cotter pin bends down over the side of the nut. If the hole does not line up properly with the castles on the nut, file a little off the washer surface or the bottom of the nut until the hole aligns.

(5) Install the gasket on the timing housing. If the magneto gasket is not torn up, it can be reused. It will probably fit better than the one supplied with the kit. If the gasket must be replaced, be sure the pad is clean.

(6) Rotate the engine to set it at Top Dead Center (TDC). This is done by holding a finger over the #1 cylinder plug hole while rotating the engine until you feel compression. Then look in the plug hole to see the piston rising. Stop rotating the engine when the piston reaches the top (just before it starts down). At TDC, the impulse coupler on the left magneto should click. In addition, there are two sets of timing marks. One set of marks are found on the fly wheel and starter. The second set is a mark on the fly wheel that should match the engine case half seam. These should now be lined up. If all of these indications are correct, the engine is now at TDC and the installation may continue. If any of these indications are not correct, repeat this step until they are. Always rotate the engine in the direction that is turns.

(7) Holding the timing housing, insert the alignment pin in the first hole. Slowly turn the drive gear until the pin drops into the second hole. The timing unit is now set at 0^0. Leave the alignment pin in the unit. Install the timing housing in the right magneto hole. Secure the timing housing using the hold down tabs commonly used with Slick mags. Tighten them to engine specifications. This sets the mechanical advance.

REMOVE THE ALIGNMENT PIN!!

The timing housing is now installed and timed.

Mounting the Direct Ignition Unit (DIU)

(1) The firewall is the most common place to mount the DIU. Try to locate the unit in a position to keep the spark plug wires as short as possible and not interfere with other maintenance. Also, make sure the hole to be drilled will not interfere with components on the other side of the fire wall. The DIU should be on a flat surface that is grounded. If the unit cannot be attached to a grounded surface, run a ground wire to the black wire on the base of the DIU. The black wire on the DIU is ground.

(2) Drill the four mounting holes and secure the DIU with four 1/4" bolts.

(3) The red and white wire is 12 volt power. Attach it with a circuit breaker to a toggle switch on the instrument panel. This toggle switch will to turn the unit on and off. The plus 12 volts must be shielded 20 gauge wire, connected at the battery not the bus bar. The size of the circuit breaker should be about 5 to 10 AMPS. **WARNING** - Make sure the toggle is turned off. DO NOT RUN the unit without the spark plug wires attached.

Install Manifold Pressure Hose

(1) If you already have a vacuum line for a manifold pressure gauge, cut the line and install a "T". Run a vacuum hose to the Manifold Absolute Pressure (MAP) sensor on the end of the DIU unit. If you do not have a vacuum line installed, you must install one to take

advantage of the vacuum advance feature. The manifold pressure line is attached to the intake of one of the cylinders. Remove the plug that is in the cylinder, attach an AN fitting and an 1/8" line that will be run to the MAP sensor. For the best results, use AN fittings for all connections.

Install Spark Plugs

(1) The spark plugs that will be connected to the DIS must be replaced with resistor spark plugs. The plug gap should be between .030 and .035. The REM37 BY plug is an example of an acceptable plug in most 4 cylinder Lycoming engines. The REM40E is a common spark plug which is very difficult to gap to .035. However they have been gapped at .025 and used successfully. If you have any problems with spark plug selection give us a call.

Install Spark Plug Wires

(1) It is essential to use a resistive spark plug wire. In the automotive world these wires are known as noise suppression wires. Also, the new spiral core wrap wires work well with the EIS. Route the spark plug wires from the DIU to the proper cylinder. See the chart for the connections. Keep the spark plug wires away from the exhaust pipes and try not to run two wires in parallel without some kind of separation. Cut the wires leaving enough length to go three inches beyond the spark plug.

(2) Slide the brass nut on the wire. Next, slide the rubber washer on the wire about one inch. A small amount of RTV or silicon will help the washer slide on and keep the end of the wire from pushing out after it drys. If you are using carbon core wire insert the spring in the center of the wire. If you are using the spiral core wire, the center is non-conductive, so insert the spring to the side of the center core.

(3) Attach the wire to the spark plug by sliding the brass nut down with the rubber washer inside of it. If you connect the spark plug end first, before you route the wire to the coils, this will allow the spark plug wire to twist while tightening the nut. **DO NOT** over-tighten the nut as this may cause separation in the core of the wire. Hand tighten and then turn an additional one-half turn with a wrench.

Spark Plug Wire Hookup Chart

Engine:	Coil A	B	C	D
4 Cyl.				
Continental	1&2	3&4		
Lycoming	1&2	3&4		
Rotorway	1&2	3&4		
VW	1&2	3&4		
6 Cyl.				
Chevy 2.8	1&4	2&5	3&6	
Continental	1&2	5&6	3&4	
Buick 3.0/3.8	1&4	3&6	2&5	
Ford 2.8	1&5	3&4	2&6	
Franklin	1&2	3&4	5&6	
Lycoming	1&2	3&4	5&6	
8 Cyl.				
Lycoming	1&2	7&8	5&6	3&4
Mosy GM Chrysler and AMC	1&6	4&7	5&8	2&3

WARNING:

On some engines such as Lycoming 540's the magneto drive gear is not attach to the magneto and <u>MUST BE REMOVED</u> from the Accessory Housing or it will damage the engine.

Final Installation Steps

(1) Connect the wire from the timing housing (magnetic pickup) to the wire on the DIU with the connectors supplied and installed by the factory.

(2) Reattach and reinstall any connections or parts removed or loosened during this installation.

(3) Secure all new wires, connections and lines to prevent excessive vibration failures.

(4) The Timing Housing is new and should be monitored. Watch for signs of looseness and wear. If any problems are noted, please contact the factory immediately.

Calibration

The Direct Ignition Unit has two adjustments which can be set by you, the user. These adjustments are controlled with two knobs found under a protective cover and labelled:

* INIT - initial advance adjusting idle control
* 3000 - additional advance up to 3000 RPM

The INIT and 3000 knobs have been set to standrad settings at the factory as described below.

For most Lycoming and Continental engines, the 3000 knob is set at the lowest setting, labelled 6. At this setting 6 to 8 degrees will be added to the initial advance setting while the engine is between 1000 and 3000 RPM.

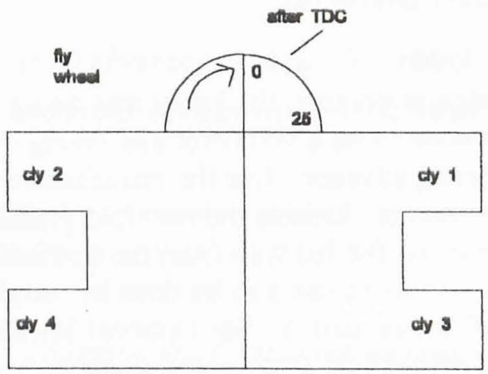
The INIT knob is set between 16 and 19. This setting results in a timing of 25 degress at 2500 RPM.

When replacing the cover, take care not to hit or rotate the knobs. There is foam rubber in the cover to keep the knobs at their settings and prevent vibration.

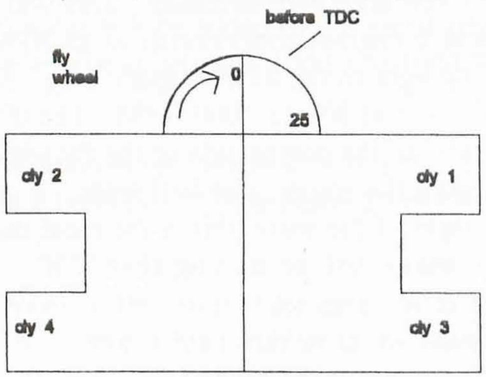
Setting Timing

The best way to check the timing is to use a voltmeter and do a static run up between 2300 and 2600 RPM. Your timing should be 25 degrees before TDC for most Lycomings and Continentals.

Due to variation in printing, the knobs may be up to 3 degrees inaccurate. Use a voltmeter and timing light to verify your timing advance. Use the manufacturer's recommended timing. Disable the manifold pressure sensor by removing the red wire from the terminal marked +5 volts. (This can also be done by installing the optional MAP sensor switch. See Optional Installations.) To determine mechanical error, place a jumper wire between the +5 volt and RTD terminals. This will cause the unit to fire at 0 degrees continuously at all RPM. Connect a timing light to the #1 EIS spark plug. Start the engine and run it at 800 to 1000 RPM. The 0^0 or TDC timing mark on the engine side of the fly wheel should line up with the engine case half seam. If your 0^0 mark is to the right of the seam, this is the most desirable situation as the engine will be starting after TDC. If the 0^0 timing mark is to the left of the seam, the engine is firing before TDC. On most Lycoming flywheels, 1/10 of an inch is equal to 1 degree of timing. **Refer to the following examples:**



0 deg. timing mark to the right , engine firing after TDC



0 deg. timing mark to the left , engine firing before TDC

OPTIONAL INSTALLATIONS

Manifold Absolute Pressure (MAP) Sensor:

The MAP sensor is located on one end of the DIU unit. A switch may be added to control power to the MAP sensor. This allows testing of the sensor. When the sensor is turned off, the engine should run rougher and rpms may drop. It also allows the sensor to be disabled in the event it malfunctions.

Remove the red wire from the +5 volt terminal and attach it to one side of the switch. Attach the other side of the switch to the MAP terminal where the red wire was attached. Install and label the switch in the instrument panel.

Electric Tachometer:

The terminal on the DIU marked TAC may be connected to an electric tachometer. Check with the manufacture of the tachometer before connecting. Be cautious attaching then EIS tach output to the electronic tach and magneto P lead. The P lead has 300 volts on it and can back feed and damage the EIS. To prevent this, isolate the EIS tach lead with a diode.

Tach output 4 cyl 2 pulses per revolution 12VDC

6 cyl 3 pulses per revolution 12VDC

Panel Mounted Advance Meter

The terminal marked ADV can be used to read timing advance when it is connected to the panel advance meter or a digital volt meter (DC volts). This may be used to indicate the spark advance with .01 volt equal to 1 degree of timing. If you are not installing a panel advance meter it is a good idea to run a wire from the ADV terminal to your panel so you can clip on a multi-meter to check your timing occassionally.

Operation in flight

Once the EIS is installed and properly adjusted it is fully automatic.

The EIS switch and optional MAP sensor may be turned off and on in flight as needed for troubleshooting.

Troubleshooting

Engine kicks back while starting -

This is due to one or more of the following reasons:

1. Weak battery
2. Weak starter
3. Bad starter cables
4. Timing set before TDC

Engine cranks but won't start -

With the ignition switch on, check voltage of the red and black wire with respect to ground. Red wire should be 12 to 18 volts. Black wire should be zero volts.

Engine fires but runs poorly -

Check spark plug wires and firing order.