#44 B

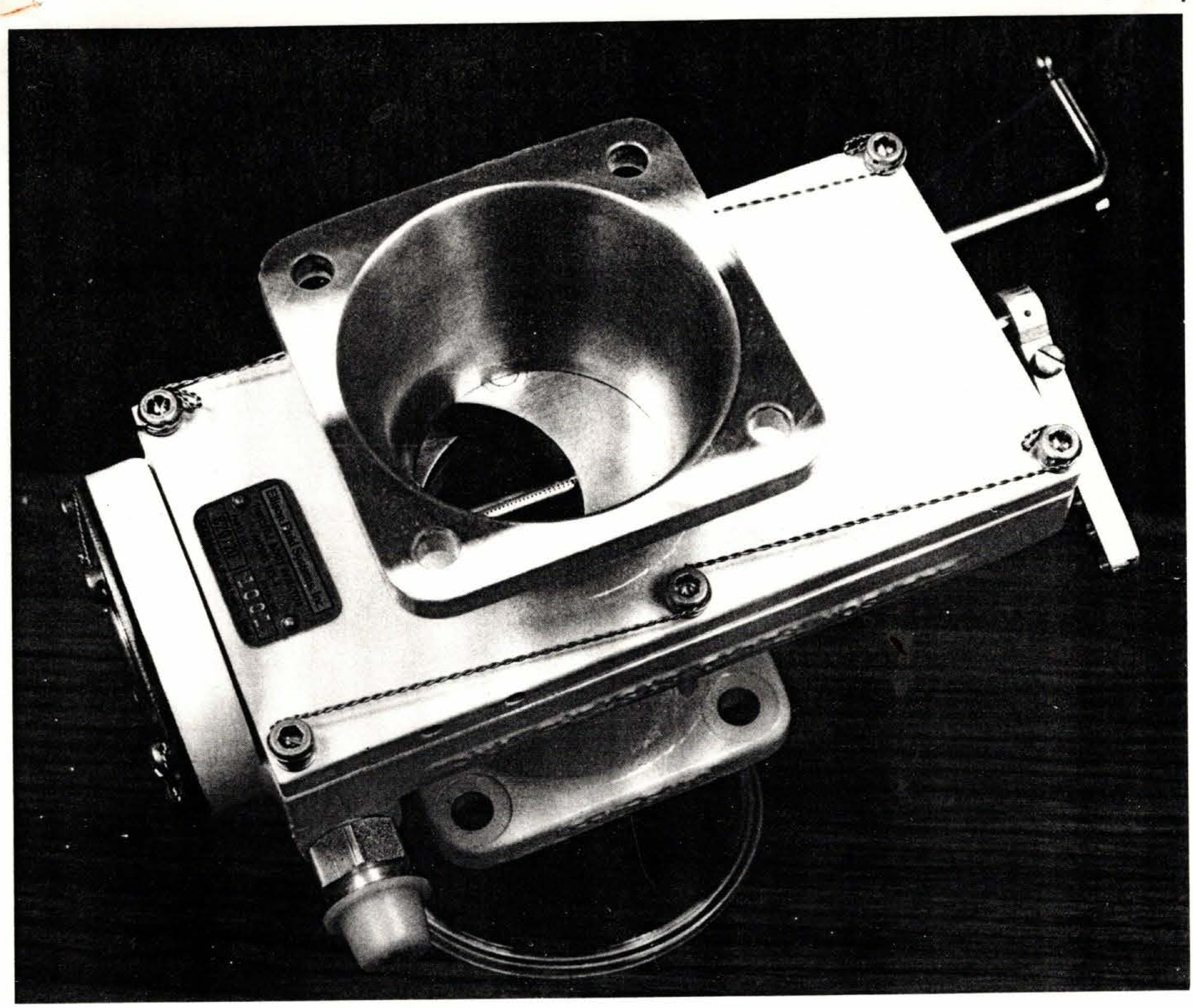


Fig. 1

NO,

it's not a POSA !!!

By Ben Ellison
President
Ellison Fluid Systems, Inc.
350 Airport Way
Renton, Washington 98055

(Reprint from Sport Aviation)

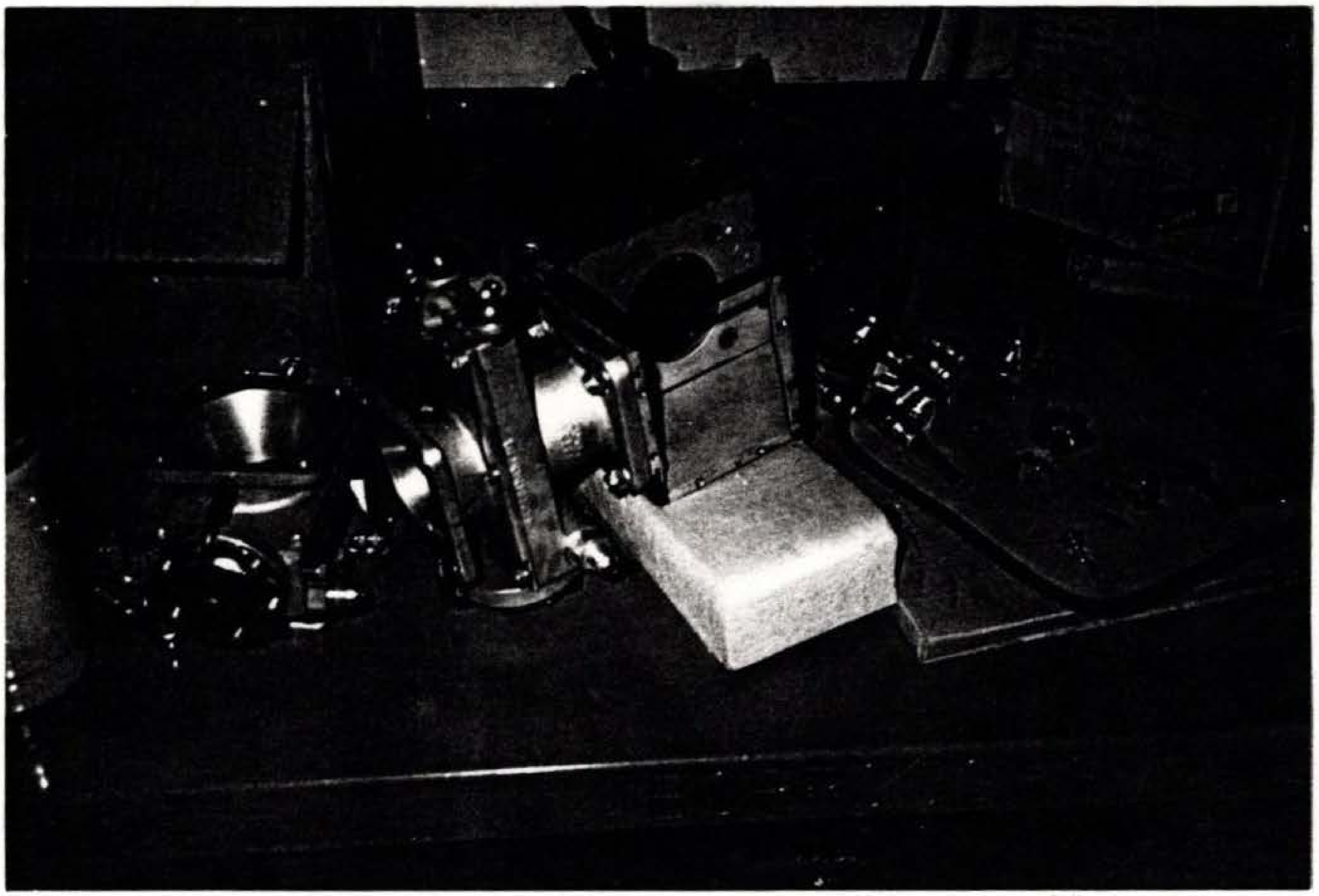
ALTHOUGH IT HAS obvious features in common with the Posa, Lake, and 200 other variable venturi brethren whose birth certificates are on file in the U.S. Patent Office, the Ellison Throttle Body Injector has enough personality of its own to earn its own certificates of legitimacy from Uncle Sam.

The Throttle Body Injector was originally developed as a solution to the hot starting problems encountered in fuel injected Pitts aircraft, but subsequent testing has revealed advantages that go far beyond start reliability. These advantages will be discussed in detail later in this article.

The unit pictured in Fig. 1 is our model EFS-4-5. The numbers in the model designation (EFS-4, EFS-4-5, etc.) refer to the SAE flange and bore configuration. This is similar to the nomenclature used by Marvel-Schebler (MA-4-5) and Bendix (PS-5, RSA-5, etc.). The letters EFS denote Ellison Fluid Systems Incorporated, the corporation formed to develop and market this product.

The Throttle Body Injector is a variable venturi device in which the fuel injection always occurs in the plane of maximum airflow velocity. Fuel injection occurs through a matrix of very small metering jets located in a tube extending across the entire width of the airflow passage. Fuel is admitted to this metering tube by a demand regulator designed to maintain a slightly negative fuel pressure. The metering tube is positioned in a bore through

Clear glass was to see flow during
tests,
note venturi goes away from engine



#44

ELLISON FLUID SYSTEMS, INC.
350 Airport Way . Renton, WA 98055

Price List / Order Form

July 1, 1985

PRICE LIST

Model	List Price	Exchange Price *
EFS-2	$299.95	N/A
EFS-3	$899.95	$599.95
EFS-4	$1,049.95	$749.95
EFS-4-5	$1,299.95	$999.95

Optional throttle cable clamp
to accommodate 3/8" Morse cable....$29.95

CUSTOMER INFORMATION

Name: ______________________

Address: ______________________

City, State, Zip ______________________

Phone - Day (_____) ______________________

Phone - Eve (_____) ______________________

Engine type: ______________________

Aircraft type: ______________________

* All orders should include payment at the List Price shown above. A rebate will be paid when a serviceable exchange core is received by EFS. Exchanges are accepted on Marvel-Schebler or Bendix fuel systems for the EFS-3 and EFS-4 only. Contact EFS for list of exchange units acceptable for the EFS-4-5.

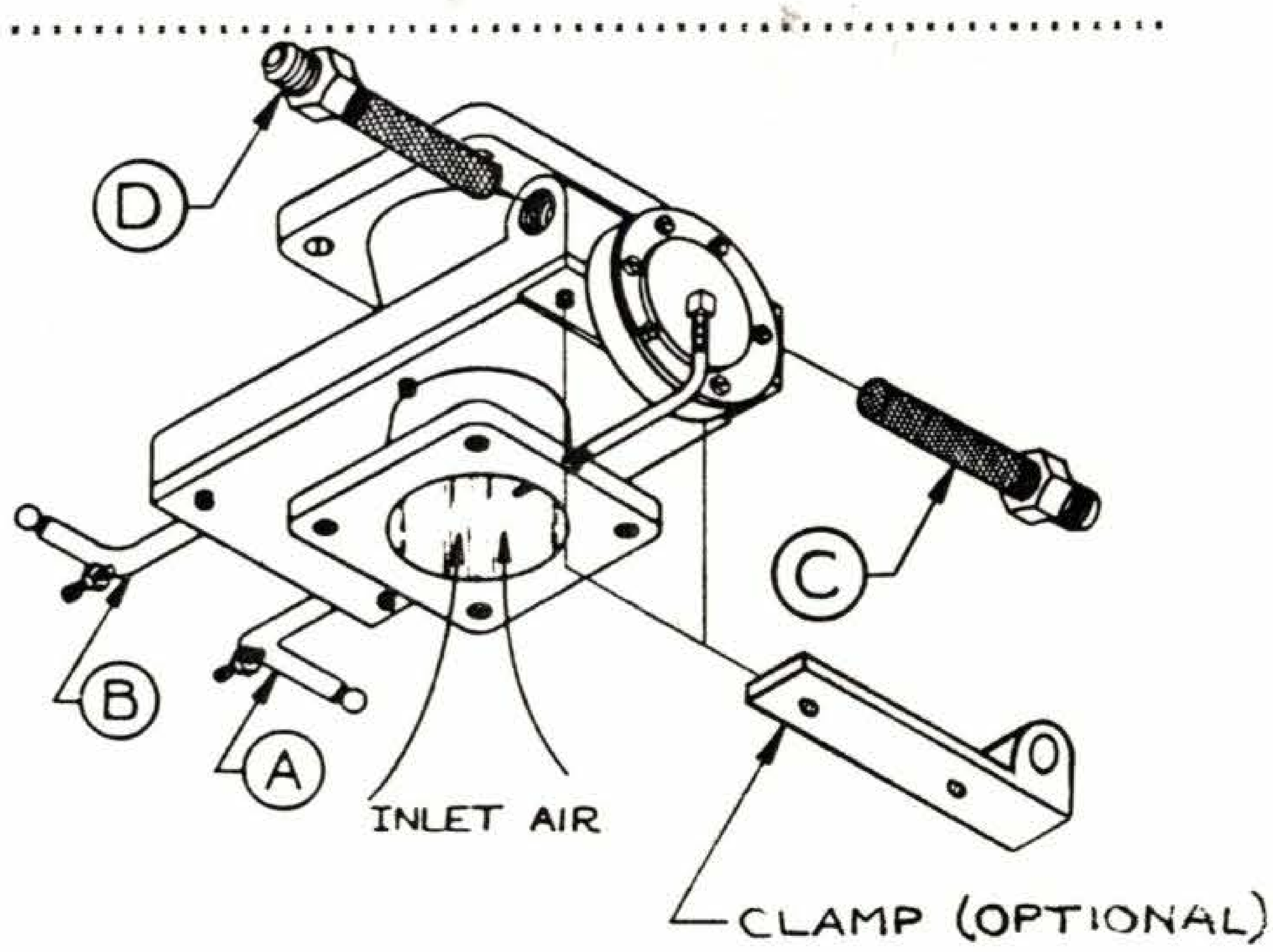
....

ORDER FORM

You may choose to have the throttle actuating arm on either side, A or B **; fuel inlet fitting can be configured on side C or D.

The Throttle Body Injector can be installed either vertically (up draft) or horizontally (side draft). Specify either V or H.

Note: For Horizontal mount (side draft) indicate on this diagram with an arrow which side will be facing down.



Quantity	Model	Throttle Position A or B **	Fuel Fitting C or D	Mounting Position V or H	List Price	Amount
	EFS-					
	Clamp				29.95	
	Total					
	State & Local Tax					
	Shipping, Insurance & Handling				$12 /unit	
	Balance enclosed					

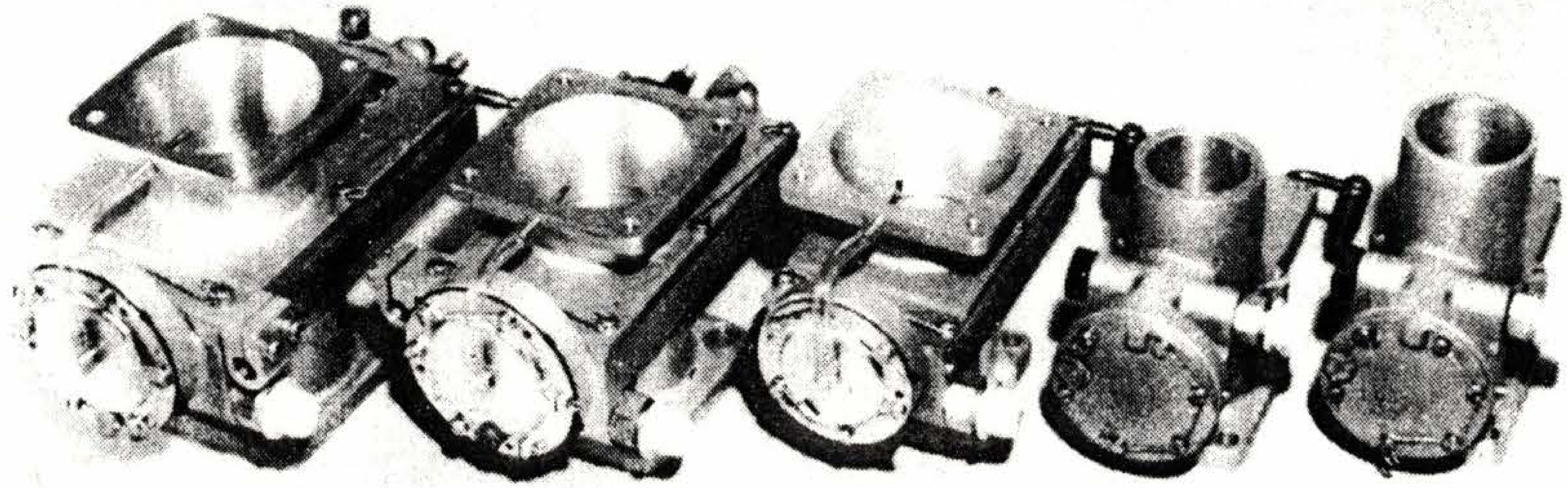
Release of Liability on reverse side must be completed and signed before this order can be processed.

** EFS-3 available only in Position A.

ELLISON

VARIABLE VENTURI THROTTLE BODY INJECTOR

Diaphragm Controlled Fuel Metering System



FEATURES

* Uniform Fuel Distribution
* Inverted Flight Operation
* Few Moving Parts
* Instantaneous Response
* Easy Starting
* Light Weight
* Low Maintenance

MODEL	EFS-4-5	EFS-4	EFS-3	EFS-2-1.35	EFS-2-1.50
AIRFLOW CAPACITY*	400 CFM	350 CFM	250 CFM	150-200 CFM	----
FUEL REGULATION	Dual Valve Diaphragm Controlled	Single Valve Diaphragm Controlled	Single Valve Diaphragm Controlled	Single Valve Diaphragm Controlled	Single Valve Diaphragm Controlled
APPLICATION	180 - 260 HP Aircraft	145 - 160 HP Aircraft	100 - 145 HP Aircraft	40 - 100 HP Aircraft	20 - 70 HP 2 Cycle
FUEL PRESSURE REQUIREMENTS**	2 - 6 PSI	2 - 6 PSI	2 - 6 PSI	2 - 6 PSI	2 - 6 PSI
CONTROLLABLE MIXTURE	Yes	Yes	Yes	Yes	No

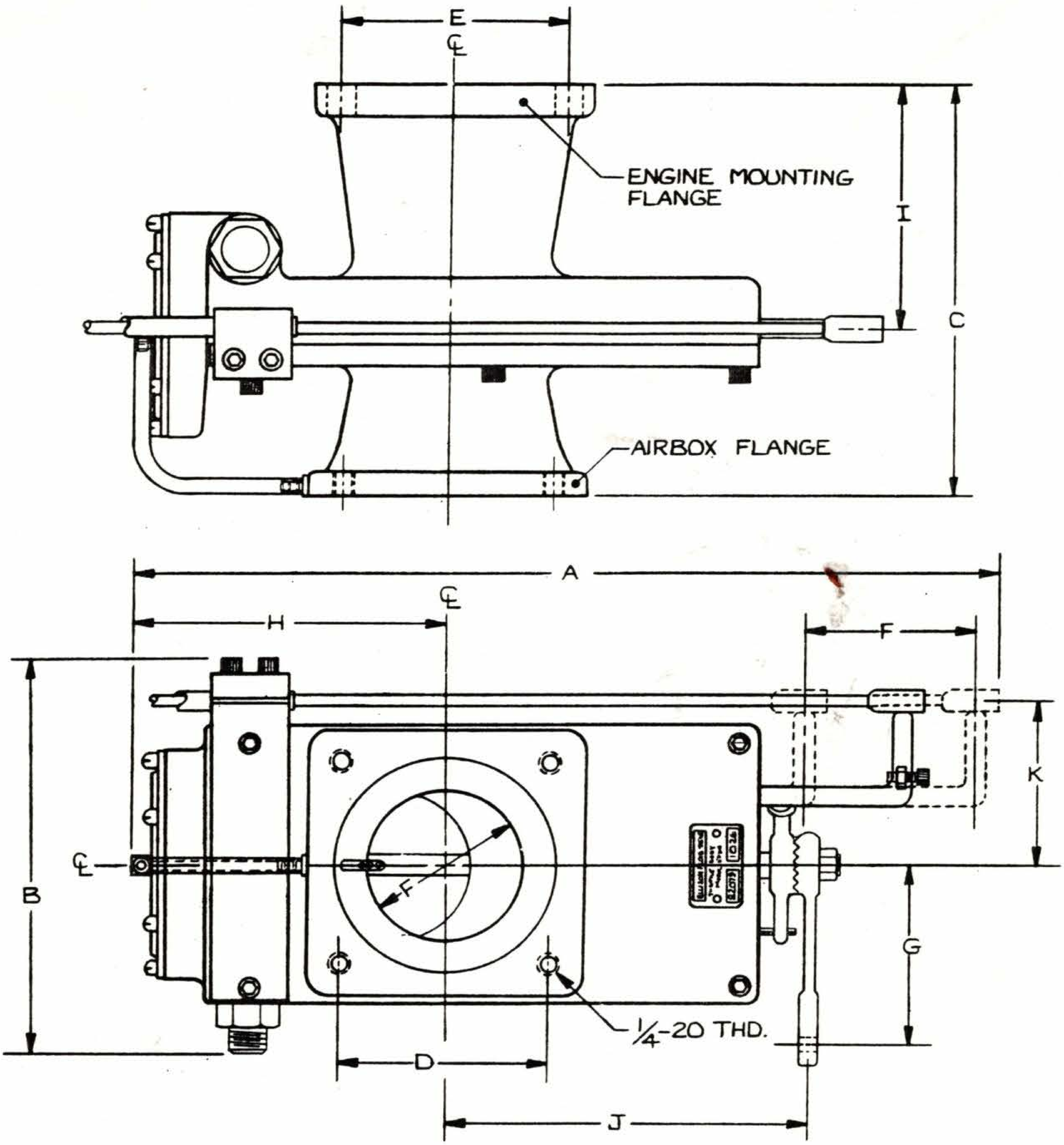
* Rated at 2" HG loss

** May be configured for gravity feed on special order

Ellison Fluid Systems, Inc.

350 Airport Wa

Renton, Washington 98055



ALL DIMENSIONS IN INCHES

	A	B	C	D	E	F	G	H	I	J	K
EFS-4-5	9 1/2	5 1/16	4 7/8	2 1/2	2.34	1 7/8	2	3 5/8	2 13/16	4 3/8	2
EFS-4	8 7/8	4 5/8	4 1/8	2 1/2	2.34	1 3/4	2	3 7/16	2 7/16	3 3/4	1 3/4
EFS-3	8 1/2	4 3/8	4 1/16	2 1/2	1.94	1 5/8	2	3 3/8	2 7/16	3 5/8	1 5/8
EFS-2-1.35	6 1/2	3 7/8	4 1/2	1 3/4*	1.94	1.35	2	2 3/8	1 15/16	3	1 3/4
EFS-2-1.50	6 1/2	3 7/8	4 1/2	1 3/4*	1.94	1.50	N/A	2 3/8	1 15/16	N/A	1 3/4

*No intake flange on models EFS-2-1.35 or EFS-2-1.50. Dimension D shown is for neck diameter.

RELEASE OF LIABILITY

THIS AGREEMENT is made this _____ day of ___________, 198_, between Ellison Fluid Systems, Inc., a Washington corporation, (Seller) and _____________________ (Buyer).

WHEREAS the Seller is the manufacturer of an aircraft Throttle Body Injector which is an experimental device and which has not been approved by the FAA for aircraft use, and

WHEREAS the Buyer is the builder or operator of amateur or experimental aircraft, and

WHEREAS it is the Buyer's intention to carry out flight test evaluations of the Throttle Body Injector, and

WHEREAS Buyer understands and appreciates the experimental nature of the Throttle Body Injector and that Seller has no control over Buyer's application or use of said product, and

WHEREAS Buyer is in the unique position to determine the adequacy of the Throttle Body Injector as a fuel metering system for his aircraft, and

WHEREAS Buyer relies solely on his own skill and judgment in the evaluation of the Throttle Body Injector, and is solely responsible for its use, NOW, THEREFORE,

In consideration of the covenants and conditions stated, Buyer agrees to hold Seller harmless and indemnify Seller as follows:

1. Buyer agrees to hold Seller harmless from, and Buyer hereby assumes the entire responsibility and liability for, any and all damage or injury of any kind or nature whatever, including death, as to all persons, whether Buyer's employees, agents, or otherwise, and as to all property, including Buyer's own property, caused by, resulting from, arising out of, or occurring in connection with, the use by Buyer himself or any other person, of the Throttle Body Injector.

2. If any person shall make a claim for any damage or injury, including death, resulting from the use of the Throttle Body Injector sold to the above buyer, whether based upon Seller's alleged active or passive negligence, or based upon principles of product liability, or based upon any alleged breach of any statutory / contractual or common law duty or obligation Seller may have, Buyer shall indemnify and save harmless Seller, its agents, servants, and employees, from and against any and all loss, expense, damage or injury that Seller may sustain as a result of any such claim.

Dated this _______ day of __________________, 198_.

ELLISON FLUID SYSTEMS, INC. (Seller)______________________________

(Buyer)______________________________

Rev. D

the throttle slide so that movement of the slide controls fuel flow as well as airflow by changing the number of jets exposed to the airstream.

Rotation of the metering tube through a maximum angle of 90 degrees changes the orientation of the fuel metering jets with respect to the airflow. This rotation serves as the pilot's mixture control. Idle cut-off occurs when the jets are facing directly into the on-coming airflow, and a progressively richer mixture is obtained as the jets are rotated away from the zero angle of attack position.

Because the fuel pressure in the metering tube is maintained below ambient pressure, fuel will not flow from the metering jets unless air is flowing through the induction system. This feature permits the engine to be shut down without the necessity of turning off the main fuel valve.

Idle fuel is dispensed through a separate jet remote from the metering tube and is adjusted by a conventional needle valve. Idle fuel flow is cut off when the pilot's mixture control is placed in the full lean position, thus providing conventional idle cut-off behavior. Idle throttle setting is adjusted by a screw attached to the throttle control arm.

ALTITUDE ENRICHMENT:

Nearly all amateur built aircraft use either a Marvel-Schebler float carburetor or the Bendix RSA-5 fuel injection system. These two systems are similar to each other in that (a) airflow is controlled by a butterfly valve located downstream of a venturi section and (b) a venturi is used to locally accelerate the air to generate an amplified aerodynamic signal pressure. This basic configuration is illustrated in Fig. 2, and throughout the remainder of this article will be refered to as the butterfly/venturi system.

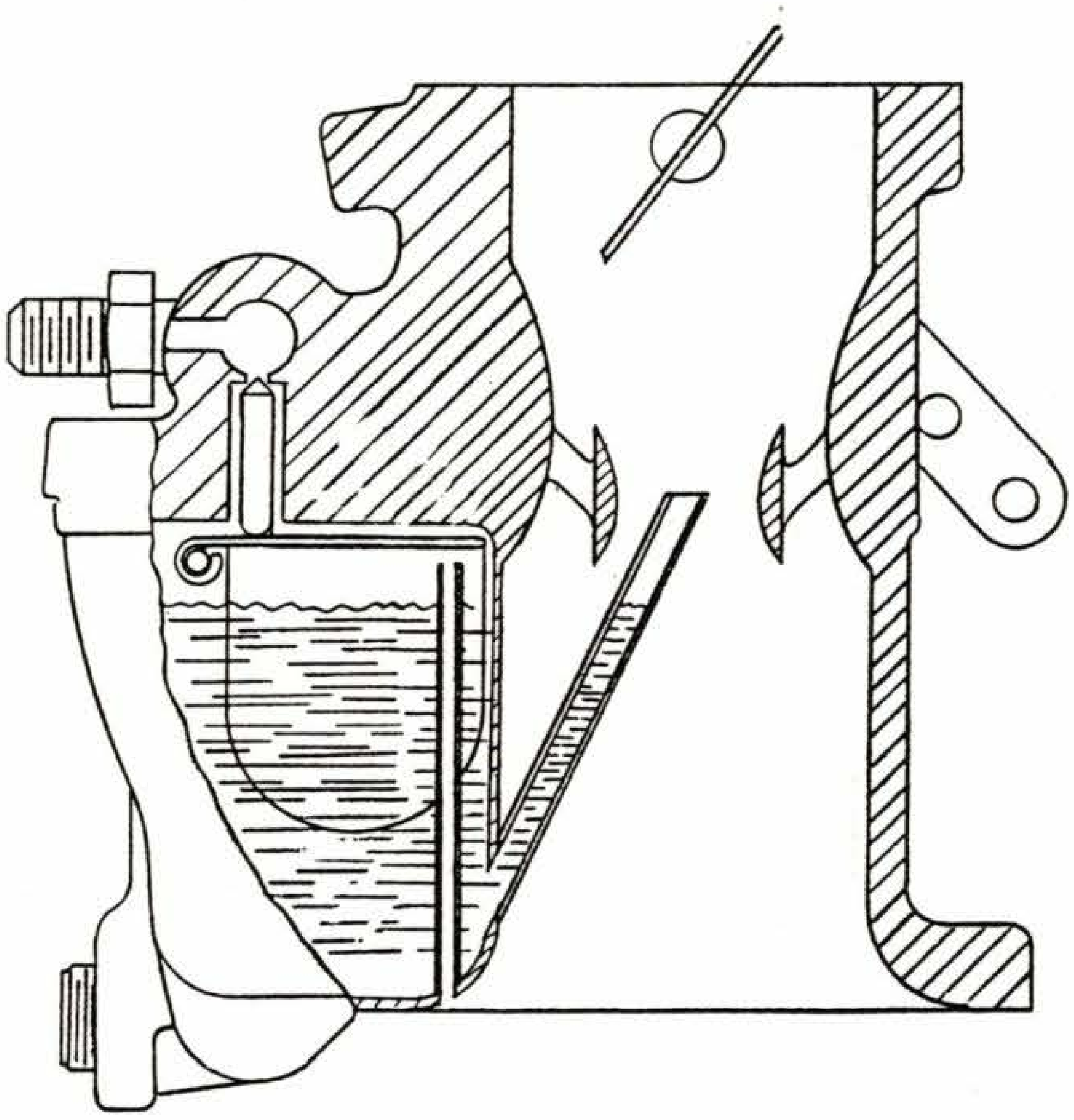


Fig. 2

In the butterfly/venturi system the venturi serves to amplify the difference between total pressure and static pressure in the carburetor throat. These signal pressures are a function of air velocity through the venturi, and are transmitted to a float chamber or a series of diaphragms, which meter fuel into the air at a rate proportional to air velocity.

As the aircraft altitude increases, the lower air density requires opening the throttle to maintain the desired engine power. Opening the throttle produces a higher air velocity through the venturi, causing the float chamber to schedule more fuel. This extra fuel, caused by the pilot's efforts to maintain the same engine power, is the source of the altitude enrichment which we correct by careful use of the mixture control.

The fluid dynamics at work inside of the EFS Throttle Body Injector is entirely different, here's how . . .

In the Throttle Body Injector, an increase in altitude requires opening the throttle to maintain engine airflow, just the same as with the butterfly/venturi system. The important difference is that opening the throttle of the Throttle Body Injector causes the air velocity to decrease rather than increase as it did in the butterfly/venturi system. This is true because opening the throttle yields a larger flow area in the plane of the metering tube. Actually, this lower velocity would result in less fuel, except that as the throttle is opened more metering jets are exposed to the airstream. When the metering tube is properly matched to the engine, these two effects cancel out giving the relatively flat altitude enrichment characteristic shown in Fig. 3. Also shown in Fig. 3 is the altitude enrichment characteristic of a typical butterfly/venturi fuel metering system.

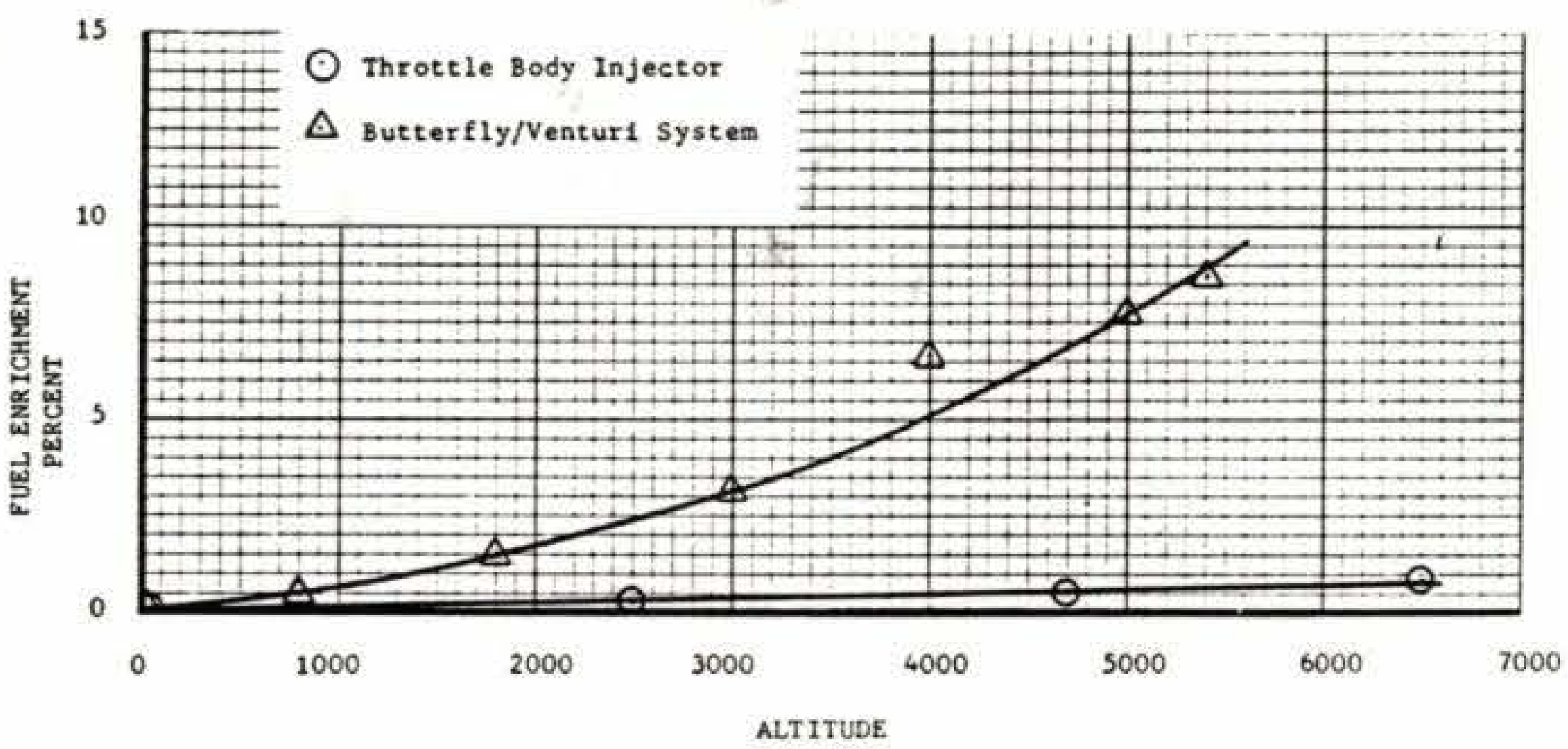


Fig. 3

FUEL ECONOMY:

The uniformity with which fuel is distributed to the different cylinders is very critical to maximum power output as well as part throttle fuel economy. Poor fuel distribution is indicated by large cylinder to cylinder variations in exhaust gas temperature. In aircraft not equipped with multiple probe EGT systems, poor fuel distribution is indicated if engine roughness is encountered before or immediately after peak power when leaning. An engine equipped with a float carburetor, operating at part throttle cruise power, usually will not tolerate leaning more than 50 RPM on the lean side of peak power. A Throttle Body Injected engine however, may be leaned 100 to 150 RPM past peak power before roughness occurs.

In conventional float type carburetors, poor fuel distribution is caused by two design deficiencies;

1. The fuel is aspirated into the airstream in the form of a dense spray emanating from a single metering jet. In most engines the flow path length between the carburetor metering jet and the fork in the road where the mixture has to decide which cylinder it will go to, is too short to allow evaporation of the fuel. The liquid droplets, under the influence of centrifugal force, are hurled to the outside of any bends in the flow path where they impinge upon the walls forming puddles of liquid fuel.

2. At any throttle setting less than wide open, the butterfuly valve functions as a turning vane, deflecting the unevaporated fuel droplets in favor of one or more

cylinders. In order to prevent the lean cylinders from being too lean, the mixture control must be set significantly richer than would be the case with good fuel distribution.

In the EFS Throttle Body Injector, fuel is emitted from the metering tube in the form of a fine mist, distributed across the entire airflow passageway. The geometry of this flow pattern is not altered by changes in throttle opening. Fig. 4 illustrates fuel discharging from the metering tube of an EFS-4 installed on a Lycoming O-320 engine.

The operational benefits of these improvements over conventional carburetors is that the extra fuel that was originally keeping the rich cylinder rich, now remains in the fuel tank. Herb Sanders, who has been running an EFS-4 on his Long-EZ, N81HM, for over a year, claims fuel consumption reductions at cruise of 1 to 1.5 gallons per hour. He reports the ability to lean 150 RPM on the lean side of peak power without encountering engine roughness.

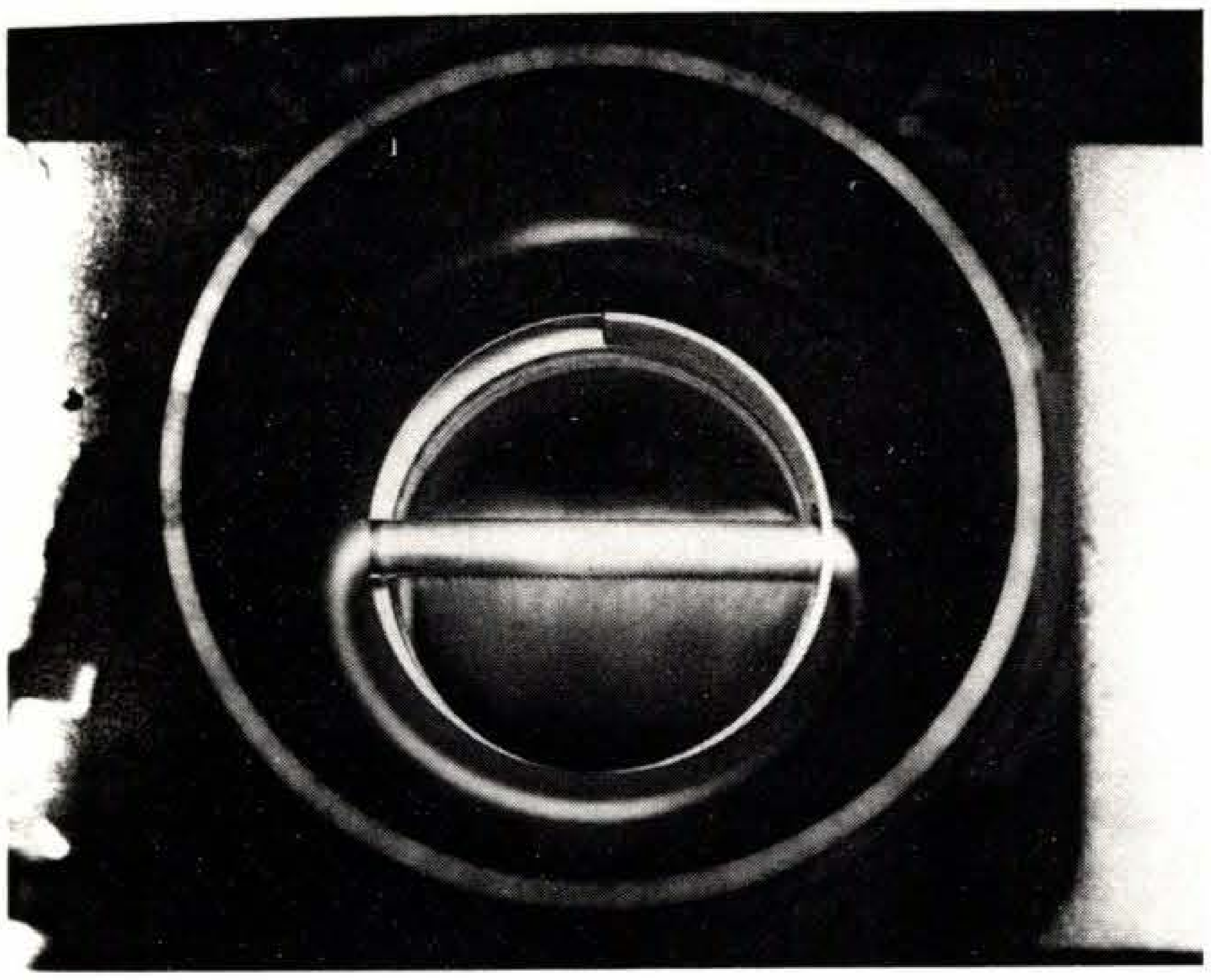


Fig. 4

HIGHER FULL THROTTLE MANIFOLD PRESSURE:

In conventional carburetors, the venturi diameter is defined by the minimum signal pressures required to draw fuel from the float chamber at low, off idle throttle settings. Fuel metering in the Throttle Body Injector is accomplished with unusually low signal pressures, permitting a larger throat diameter than used in either the MA series of carburetors or the Bendix injectors. This larger inlet area results in a measurable increase in full throttle manifold pressure at the engine's maximum power rating. This benefit is apparent in the following back to back test data taken with a MA-4 carburetor and then repeated with an EFS-4.

Long-EZ
Lycoming O-320 160 HP
Full Throttle Level Flight

Alt.	IAS MA4/EFS4	RPM MA4/EFS4	MP MA4/EFS4	OAT
3000	186/190	2990/3060	24.9/26.1	+4C
5000	178/181	2950/3010	23.4/24.2	0
6000	174/176	2940/3000	22.5/23.2	−1
7000	171/171	2910/2980	21.6/22.5	−3
8000	166/168	2890/2960	20.9/21.5	−4
10000	154/158	2840/2940	19.2/19.8	+1

The above engine installation operates at RPMs which greatly tax the breathing capacity of the MA-4 carburetor. In installations which respect the 2700 RPM redline limit of the engine, a Throttle Body Injector would provide about ½ inch increase in manifold pressure at maximum power and RPM.

In verification of this extra power, Fig. 5 shows inlet pressure loss of the EFS-4 Throttle Body Injector compared to the Marvel-Schebler MA-4 carburetor. These curves can be related to manifold pressure at the full throttle, red line RPM flight condition as follows:

For a comparison of the EFS-4 with the MA-4, the inlet loss for each unit is read from Fig. 5 at the engine's maximum airflow. For the Lycoming 150 HP O-320 engine the maximum air consumption is 1050 lbs. per hour at sea level, full throttle, 2700 RPM. At that condition the inlet loss for the MA-4 is 15.0 inches of water while the loss for the EFS-4 is only 7.8 inches of water. The difference in loss between these two systems is:

15.0 - 7.8 = 7.2 inches of water.

This difference is divided by 13.6 to get its equivalent value in inches of mercury.

7.2 / 13.6 = .53 inches of mercury

This shows that an increase in full throttle manifold pressure of about 0.5 inches of mercury would be obtained by removing a MA-4 carburetor and replacing it with a EFS-4 Throttle Body Injector.

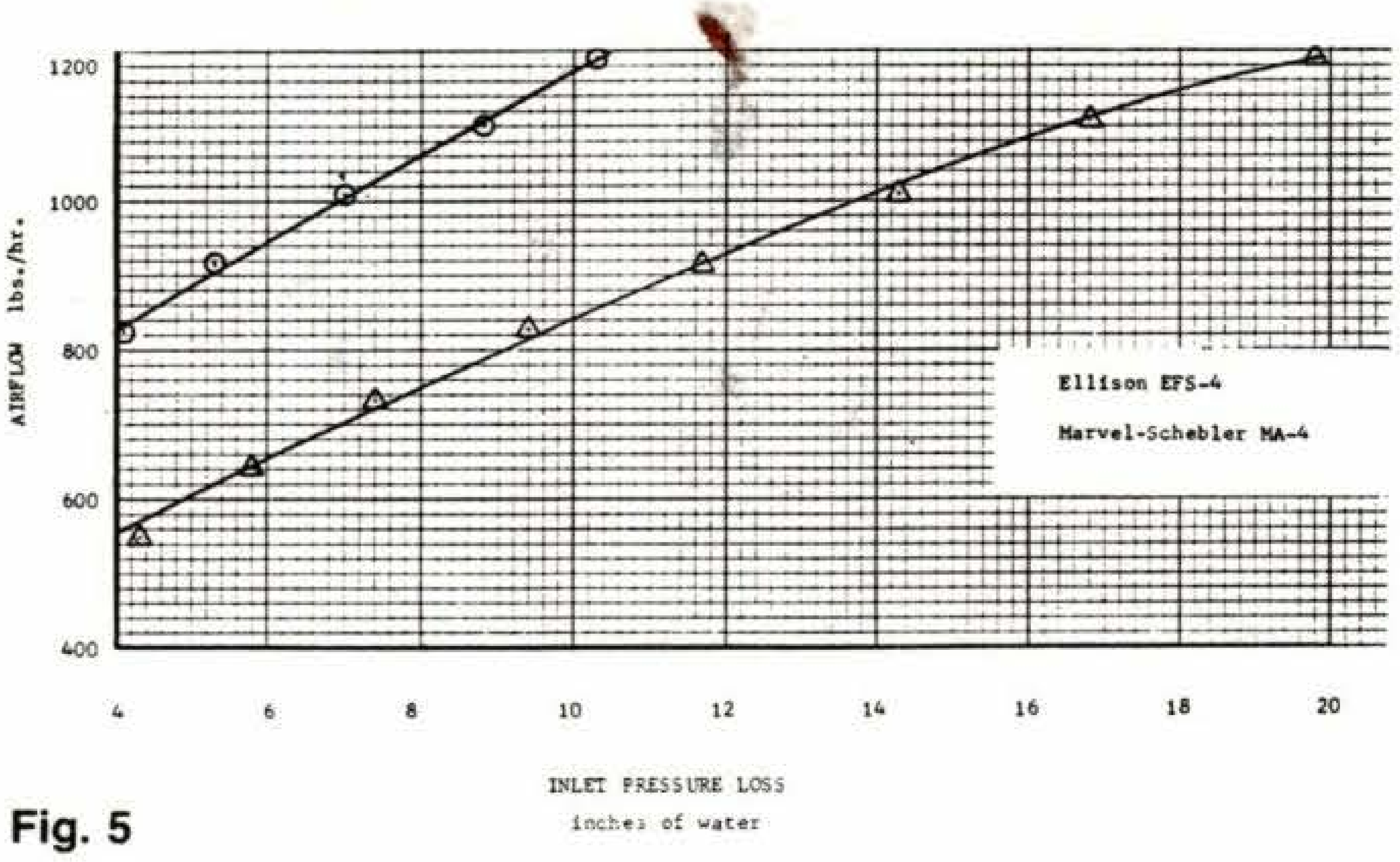


Fig. 5

STARTING:

Cold starting an engine equipped with a Throttle Body Injector requires priming the induction system with a conventional primer. The primed engine, after being pulled through 3 blades with the ignition switch off, will start on the first or second compression stroke.

Hot starts are made in the same way except that the addition of prime fuel usually is not necessary.

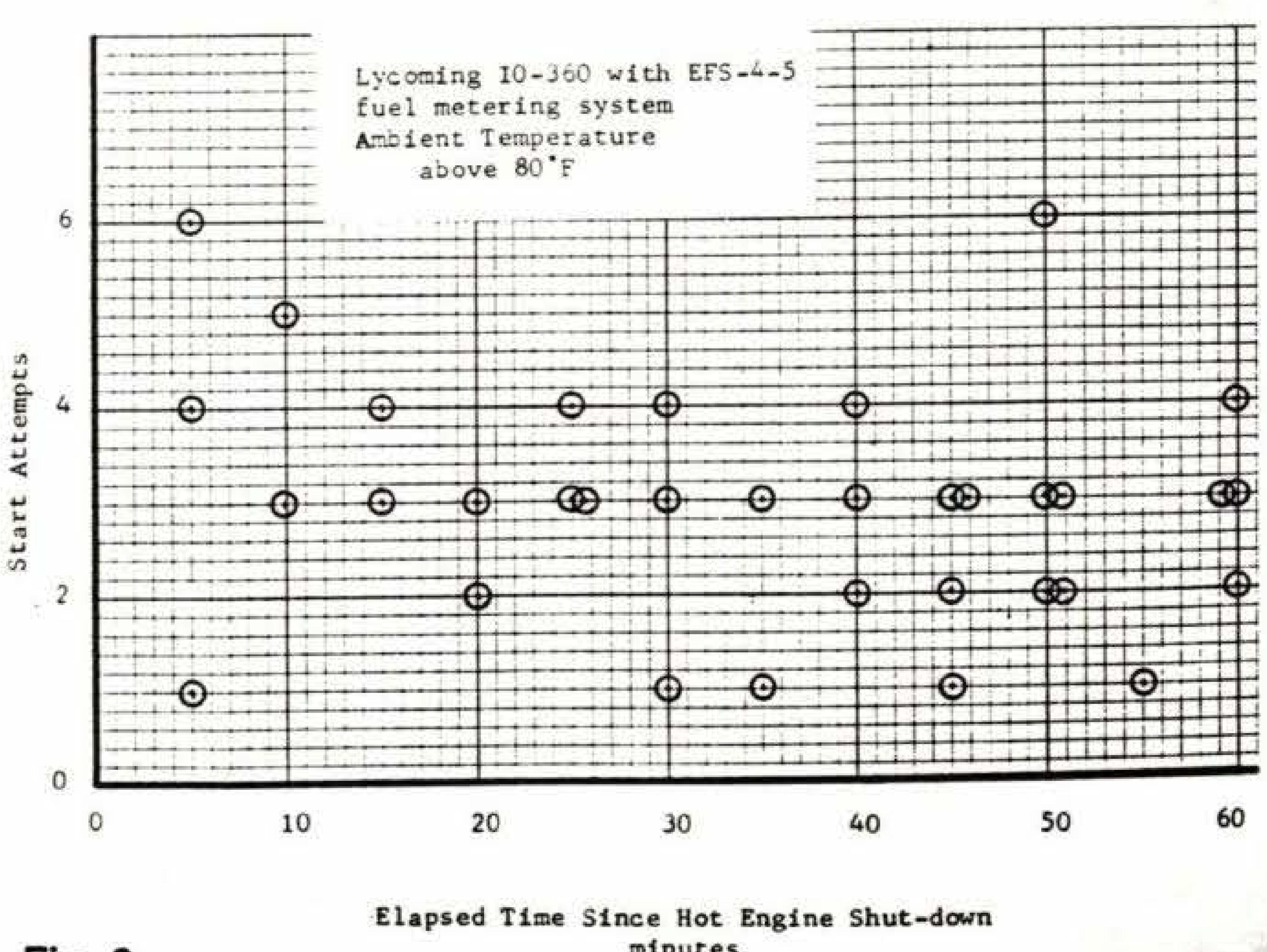


Fig. 6

To convince skeptical Pitts drivers of the system's start reliability, Fig. 6 documents 35 consecutive starts of an IO-360 equipped with an ESF-4-5. The horizontal coordinate of each point represents the elapsed time since hot engine shut-down. The vertical coordinate represents the number of propping attempts necessary for starting. Each start was accomplished after the engine had initially been flown, then shut-down and allowed to heat-soak for the time indicated. This data was taken with ambient temperatures equal to or greater than 80 degrees F.

FUEL PRESSURE:

The Throttle Body Injector is usually operated with a conventional 4 to 6 psi A/C diaphragm fuel pump. It can, however, be configured to give satisfactory performance in gravity feed fuel systems.

ALL ATTITUDE OPERATION:

Since the Throttle Body Injector operates without a float chamber, it doesn't mind being mounted right side up, upside down, or sideways. Additional installation flexability is available by positioning the throttle arm as well as the fuel inlet fitting on either side of the body.

The system's insensitivity to orientation makes it suitable for aerobatic operation, given, of course, the availability of an inverted fuel and oil system.

SIMPLICITY:

A picture is worth a thousand words. Figures 7 through 9 show the Throttle Body Injector, and two conventional fuel metering units disassembled.

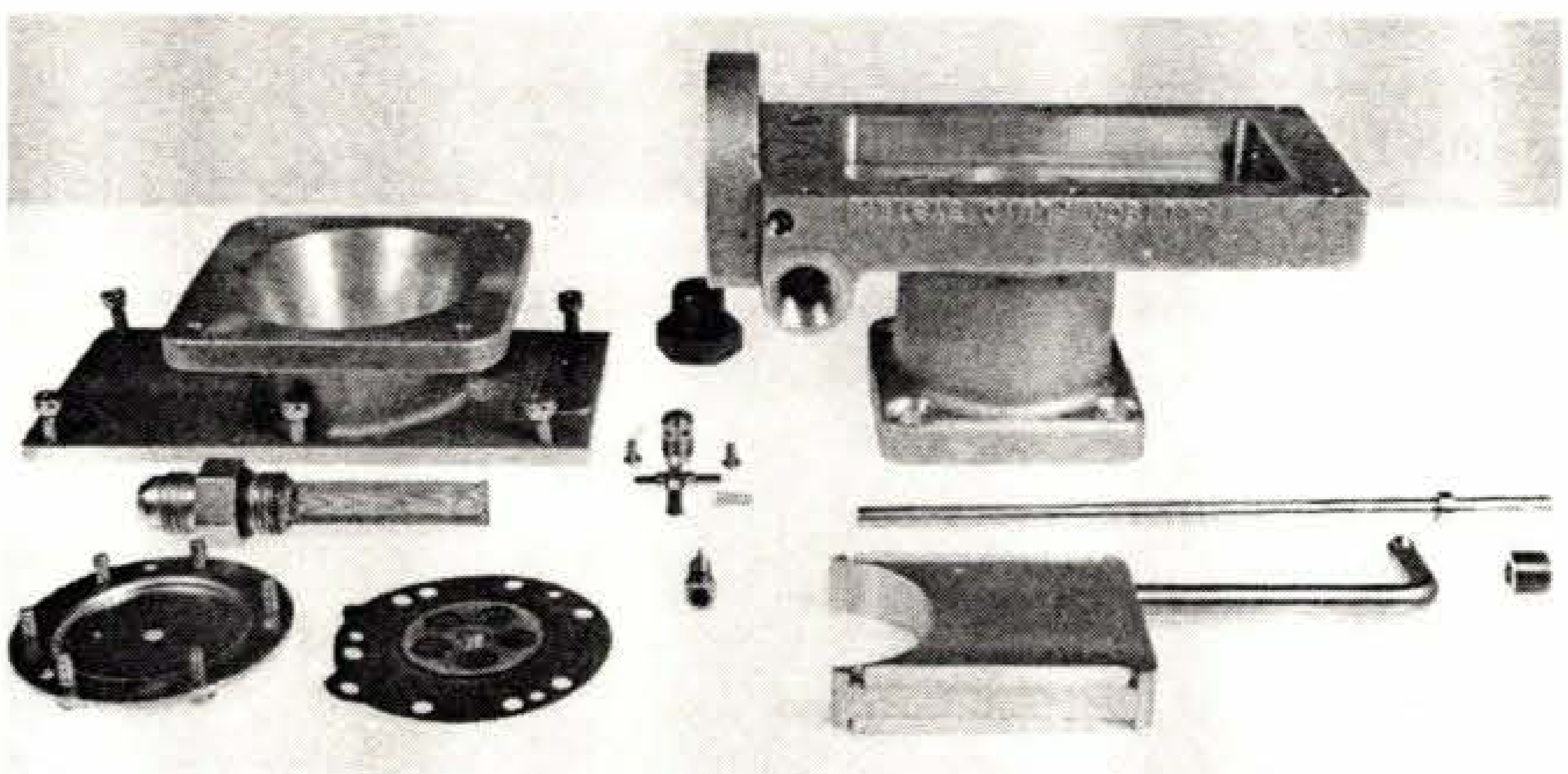


Fig. 7

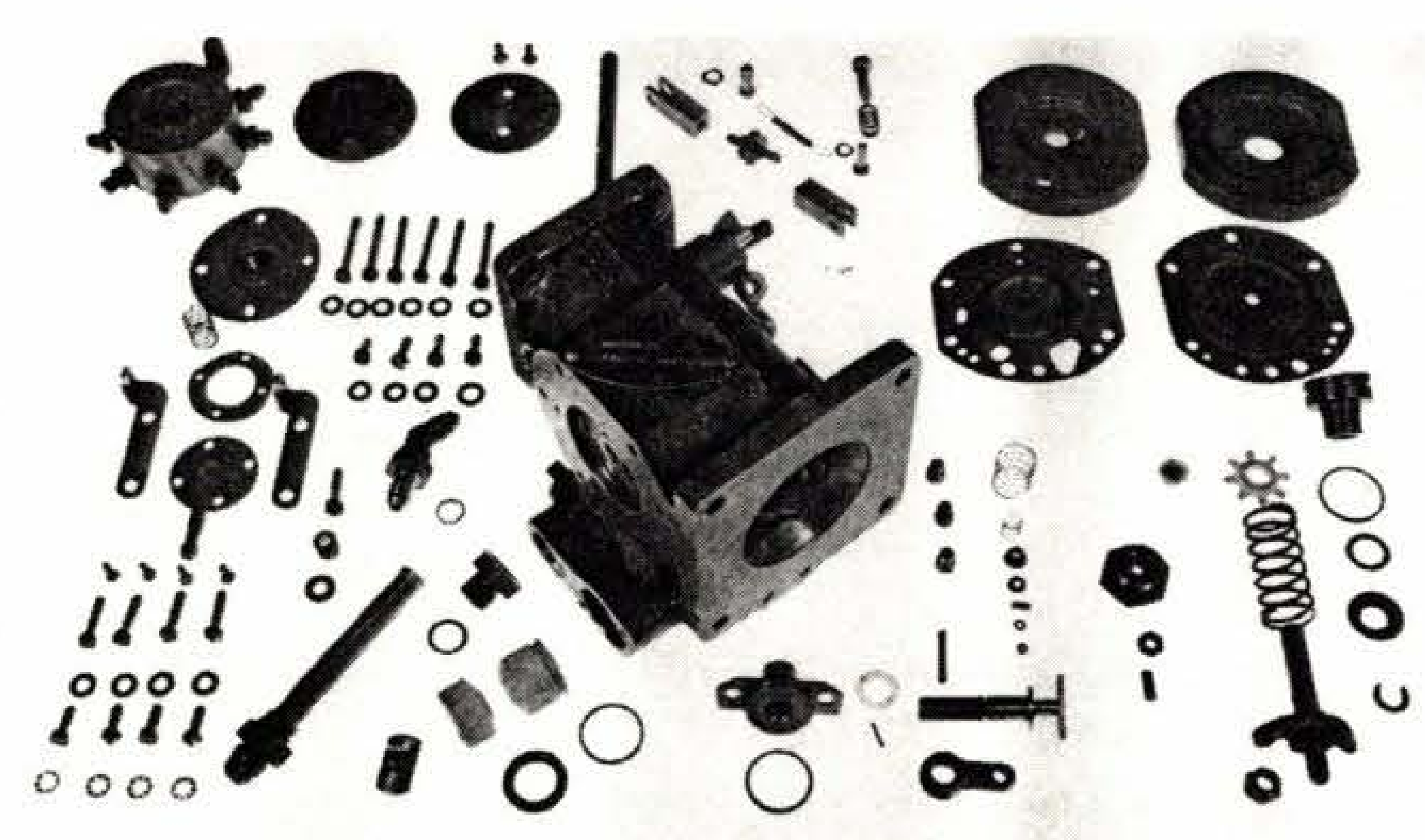


Fig. 8

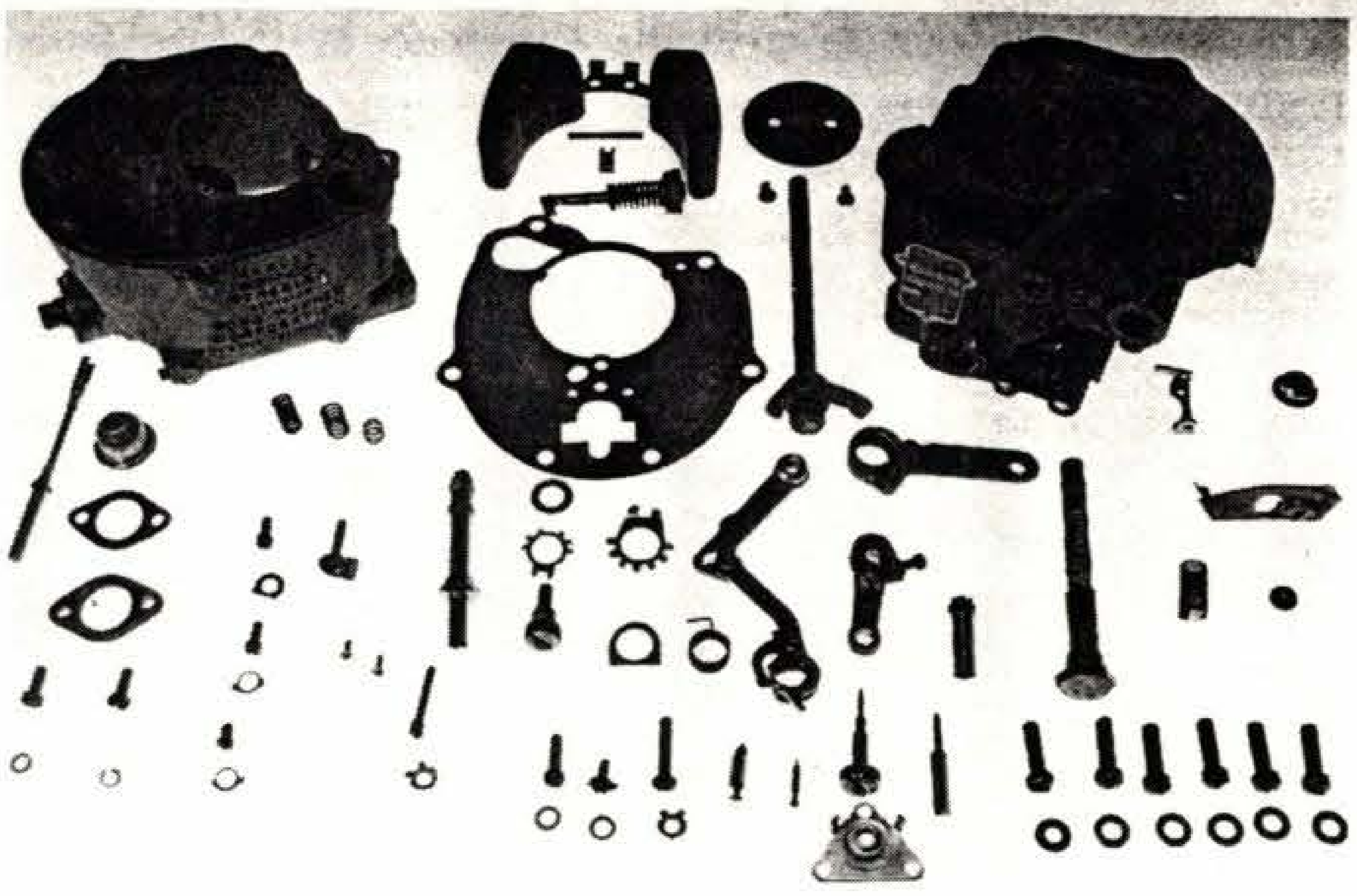


Fig. 9

WEIGHT:

The weights of the three TBI models along with other popular fuel metering systems are listed below.

MANUFACTURER	WEIGHT MODEL	WEIGHT (lbs.)
Marvel-Schebler	MA-3SPA	3.0
	MA-4SPA	3.1
	MA-4-5/	5.25
Bendix	PS-5	6.85
	RSA-5	7.64
Ellison	EFS-3	2.25
	EFS-4	2.8
	EFS-4-5	3.0

FUEL FILTRATION:

A 150 mesh removable finger screen is built into the Throttle Body Injector and serves as a "last chance" filter. In accordance with good design practice, an airframe mounted filter of equivalent or finer mesh is usually installed elsewhere in the aircraft's fuel system.

AVAILABILITY:

The Throttle Body Injector models EFS-3, EFS-4, and EFS-4-5, are currently in production and are available for outright purchase or purchase on an exchange basis. All Brand X units received in exchange will be tagged with the exchangers name, and stored at the EFS facility for one year. This will allow any unhappy purchaser to get his original carburetor and money back.

Sales brochures and pricing information are available from any of the three sources below, however, orders should be addressed to the two dealers.

Sport Flight Inc.
3500 So. Mendenhall Rd.
P.O. Box 18690
Memphis, TN 38118
901-365-7606

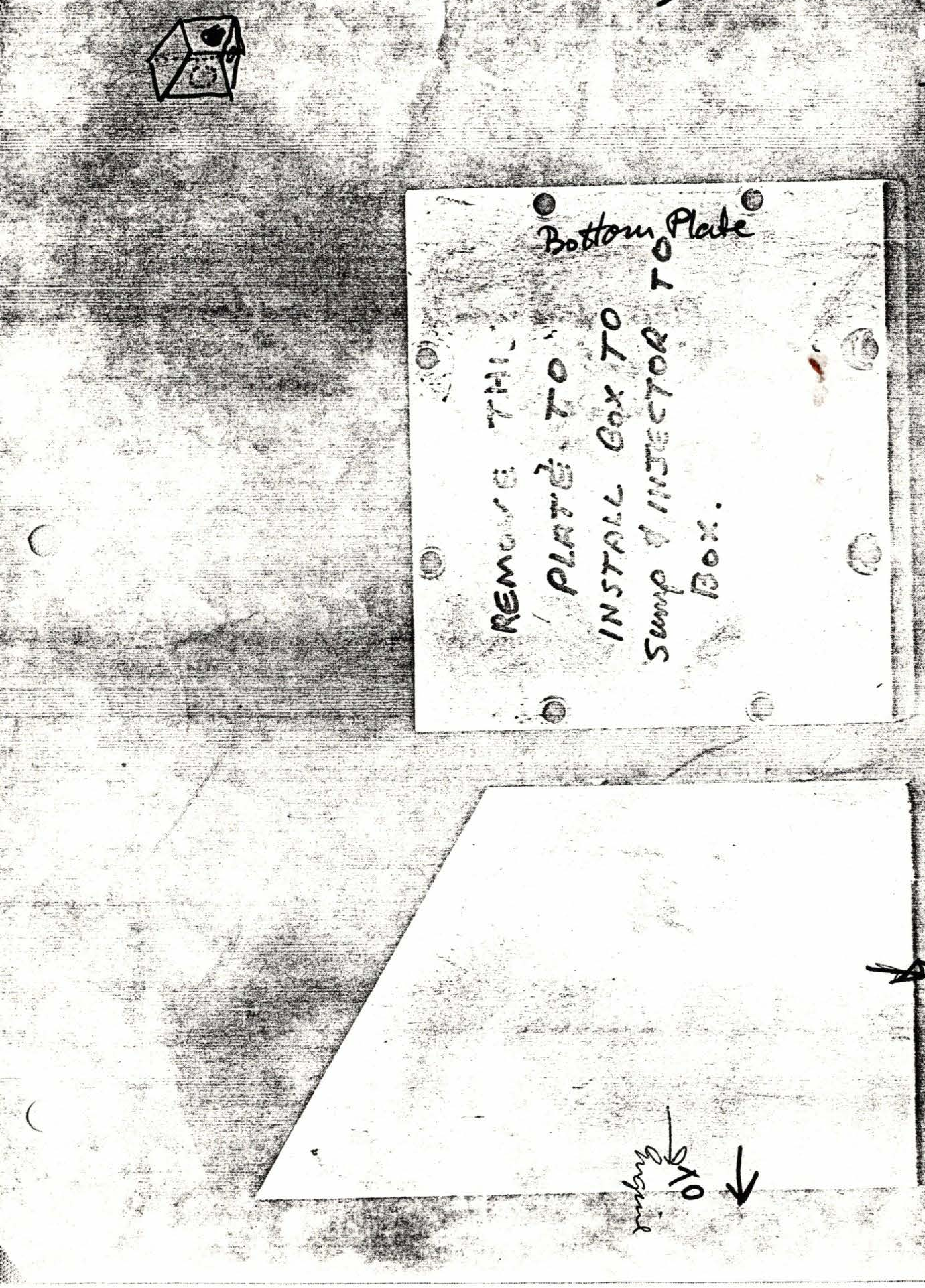
Henry Haigh Aviation
3540 W. Grand River
Howell, MI 48843
517-546-9501

Ellison Fluid Systems Inc.
350 Airport Way
Renton, WA 98055
206-271-3220

An installation manual applicable to all three Throttle Body Injector models may be obtained from Ellison Fluid Systems Inc. at the above address for $6.00.

#44B
($.10)

See Photo Reverse



This was Ellison's way of turning a Throttle body 90° toward Front of a <u>Tractor</u> engine. Untested is idea if Throttle body were mounted on 45° side to clear engine parts in <u>Pusher</u> directi