ASTRO-JET

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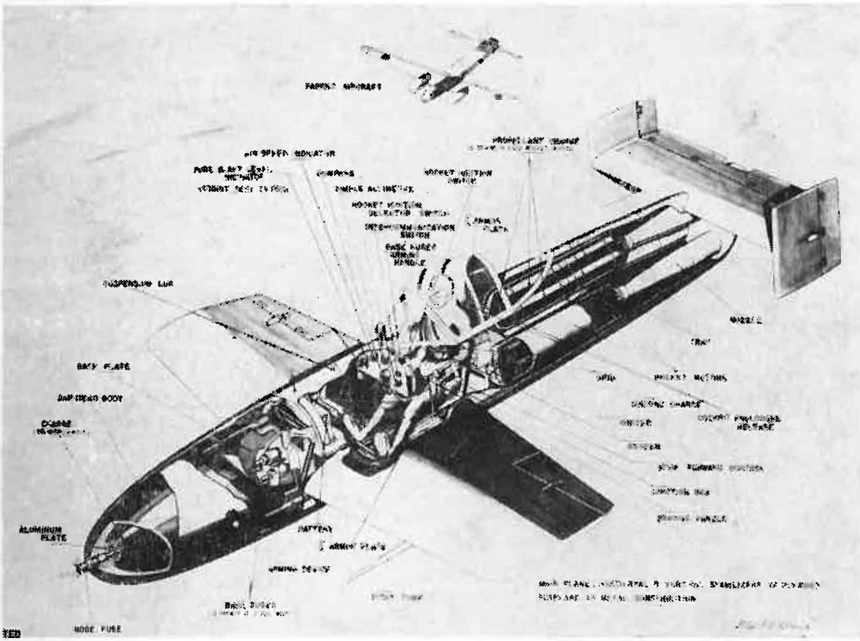

A.P. Photo

JAPANESE "BAKA" BOMB

This guided missile, propelled by solid fuel rocket engines, was the only type to see action. Other experimental "Baka" missles were equipped with jet engines.

TABLE OF CONTENTS

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Society Plans for 1946

During the coming year we are going to greatly increase our present experimental program.

Our research program this year will be divided into three main classifications; solid fuel rocket engine research, model jet engine research, and liquid fuel rocket engine research. The items for development in each group will be as follows:

1. Solid Fuel Rocket Engine Research
   - A. Construct Powder Mill.
   - B. Construct hydraulic press.
   - C. Construct test stand (this stand will be the protype of our liquid fuel stand).
   - D. Obtain definite information on black powder (so as to be able to sosign engines for thrust).
   - E. Begin research into other solid fuels.
   - F. Obtain data on nozzles, thrust augmentors, and auto-rotation.
   - G. Work on flight stabilization, two-stop models, and pre-set directional control.
2. Model Jet Engine Research
   - A. Continue development of model jet engines.
   - B. B uild whirling stand for model ram jets.
3. Liquid fuel rocket engine research
   - A. Obtain desert testing ground.
   - B . Construct test stand, modeled after protype solid fuel test stand.
   - C. Test old California Rocket Society solid-liquid fuel engines.
   - D. Test engines using liquid oxygen.
   - E. Test engines using oxydizers other than liquid oxygen.

Because of the large amount of research (not including liquid fuel) capable active members will be allowed to independently conduct society sponsored research. Accurate records will be kept and reported in Astro-Jet.

(Continued on page 14)

Solid Fuel Resbach

Now that we have begun research into many types of solid fuels our method of naming the various fuels has had to change. In the past since all our fuels contained a greater percentage of potassium nitrate than any other ingredient it was alright to merely have numbers for the fuels. Now that fuels containing many types of ingredients are being tested it is necessary to classify them according to the ingredients contained. It was decided to classify them according to their main ingredient. Large letters (ex. A) would be used to classify the powders into main groups according to their principle ingredient. The groups would be further divided according to the other ingredients in the fuel by small letters (ex. a). The specific fuels in each group would be listed by number.

The groups that have been started up to the present are as follows:

Group	Main Ingredient	Other ingredients
A	Potassium Nitrate	
Aa	"	Charcoal sulfur
Ab	"	Lampblack sulfur
Ac	"	Sugar sulfur
Ad	"	Ammonium nitrate charcoal
B	Zinc Dust	
Ba	"	sulfur
C	Potassium Chlorate	
Ca	"	charcoal sulfur
Cb	"	starch sulfur
Cc	"	starch
Cd	"	charcoal
D	Ammonium Nitrate	
Da	"	Potassium nitrate charcoal
Db	"	charcoal
Dc	"	lead nitrate charcoal
Ea	Charcoal	Ammonium Nitrate Potassium Nitrat

According to this new system all of the society's solid fuels described in Astro-Jet's No. 10 and No. 11 would be classified under the Aa group.

Ash Tests on New Fuels

About a year ago, John Cipperly, in addition to performing most of the tests on the society's black powders conducted ash tests on many other types of combustable powder mixtures. At the time it was thought that there was no need to classify the mixtures as society solid fuels. However, since we are now investigating all forms of solid fuels, these formulas and ash percentages are presented. Many of the fuels, in particular the potassium chlorate group, are to unstable to be used as rocket fuels at the present. Until some way is found to make these powders more stable it is hoped that no one will be so foolish as to build metal rockets with them as the powders are very powerful and could scatter shrapnel quite a distance. Several of the very low ash chlorate powders can be detonated with a good hammer blow. For some reason Analytical Reagent (very pure) zinc dust does not work as well for the zinc and sulfur powders as the regular commercial variety. When using AR zinc dust the powders burn very slowly instead of exploding. The standard ash test procedure does not work too well with an explosive powder such as zinc powder for the violenceof combustion scatters a great amount of the ash off the weighing pan. When a zinc powder rocket is fired all that is left behind is white smoke, however, when ash tests of zinc powder are made many flakes of zinc sulfide and zinc oxide are scattered around. Possibly a more accurate way of determining the ash percentage would be to fire the powder in a length of metal tubing closed at one end, for then the results would be the same as those existing in an actual zinc rocket. The society zinc rockets are merely tubes of the above type with fins. To obtain the best results the powder is poured in loosely, the fuse inserted, and a paper plug is put over the end. Then the rocket is shaken well and fired. It has been found that if the zinc powders are packed, even slightly, they will just burn.

Another improvement to our powder testing procedure would be to make several tests of different batches of the same powder for it has been found that no two batches of the same formula give exactly the same ash percentage.

Below are the results of John Cipperly's solid fuel tests. All parts are by weight.

GROUP Ac

Number	KNO_3	$C_{12}H_{22}O_{11}$	S	%Ash
Ac-1	40	40	20	23.6

GROUP Ad

Number	KNO_3	NH_4NO_3	C	%Ash
Ad-1	50	30	20	20.8
Ad-2	40	35	14	34
Ad-3	50	38	22	22.4

GROUP Ba

Number	Zn	Zn (AR)	S	%Ash
Ba-1	78		22	17.6
Ba-2	71		20	18.8
Ba-3	90		10	10.8
Ba-4		75	25	25.2
Ba-5	75		25	6
Ba-6		87.5	12.5	12.4
Ba-7	87.5		12.5	8.4

GROUP Ca

Number	$KClO_3$	C	S	%Ash
Ca-1	50	30	20	2.5
Ca-2	50	27.5	22.5	2.2
Ca-3	52.5	27.5	20	2.1
Ca-4	50	25	25	2.1
Ca-5	50	20	25	1.9
Ca-6	60	20	20	1.4
Ca-7	75	15	10	.6
Ca-8	62.5	14.25	23.25	2.2
Ca-9	85	10	5	1
Ca-10	80	12	8	.7
Ca-11	70	20	10	.6
Ca-12	65	22.5	12.5	1

GROUP Ca (Continued)

Number	$KClO_3$	C	S	%Ash
Ca-13	70	25	5	1.2
Ca-14	80	10	10	1.6
Ca-15	75	10	15	.4
Ca-16	70	15	15	.4

GROUP Cb

Number	$KClO_3$	$C_6H_{10}O_5$	S	%Ash
Cb-1	70	20	10	2
Cb-2	70	15	15	3
Cb-3	70	25	5	1.6
Cb-4	75	20	5	4
Cb-5	75	15	10	4.8
Cb-6	65	30	5	2.8
Cb-7	65	25	10	3.2
Cb-8	72.5	25	2.5	3.2
Cb-9	67.5	30	2.5	3.2

GROUP Cc

Number	$KClO_3$	$C_{12}H_{22}O_{11}$	S	%Ash
Cc-1	70	20	10	3.2
Cc-2	70	15	15	7
Cc-3	70	25	5	3.6

GROUP Cd

Number	$KClO_3$	$C_6H_{10}O_5$		%Ash
Cd-1	72.5	27.5		3.2
Cd-2	75	25		4.8

GROUP Ce

Number	KClO	C		%Ash
Ce-1	75	25		2
Ce-2	72.5	27.5		3.2

GROUP Db

Number	NH_4NO_3		C	%Ash
Db-1	85		15	2

(Continued on Page 13)

The Testing and Development of Model Jet Engines

-Carroll Evans-

There are several types of jet engines, not all of them suitable for model work. The major types of jet engines are: (1) Ram Jet, (2)Resonance Jet, and (3) Turbo-Jet. Of these the resonance type is the most practical for model work, the ram jet is next in line and the turbo-jet is probably too complex for a model.

There are many problems which arise during the testing and development of model jet engines. Among the problems that concern any type of jet engine is the one of air flow, both inside and outside the engine, this requires careful design of the internal and external surfaces. Another problem is the method of providing the external air supply that is required for some types. Another general problem is that of fuel feed. It has to be decided which will be used, gravity or suction feed, and where the fuel should be mixed with the air stream.

Turbo-jets are probably too complex for model work because of several reasons. Among these are the high temperature at which the unit operates, requiring special alloy metals, and the high rate of speed at which the turbine and compressor have to operate.

The main difficulty with ram jets for model work is the problem of external air supply. As ram jets cannot operate efficiently without air being supplied to them at a high rate of speed, 100 MPH being the minimum for efficiency, and 300 still being too slow for maximum efficiency, they need a source of rapidly moving air.

Because the minimum speed at which a resonance jet will work is much lower and because they can be constructed with a minimum of machining, this type appears to be the most practical for model work.

Of course, there are many problems connected with the development of resonance type jet engines. Some of these occur because of the principle of resonance and others probably would also appear in other types of model jet engines.

When designing a resonance jet several things have to be considered. The first is to determine the size of engine to be built. The next is to choose the frequency of vibration. The thrid is to locate the fuel inlet. Another important detail is to use the proper heat resistant alloys because the rear portion of the engine becomes red hot during operation.

The first step in testing a resonance jet engine on the test stand is to adjust the length of the tail pipe to synchronize with the frequency of the blades in the valve. The next step is to determine the fuel mixture and the proper fuel to use.

In resonance and ram jets air has to be supplied at a velocity of at least 50 MPH. The most readily available source of air flow is an ordinary vacuum cleaner fitted with a hose attachment. However, this has barely enough velocity to operate a resonance jet and not enough to properly operate a ram jet.

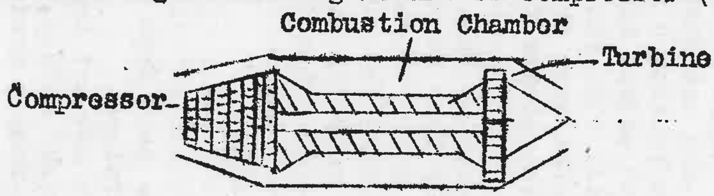
The ideal test stand for model jet engine research would be a thrust indication wind tunnel with velocities up to 300 MPH.

Even after a person has perfected an efficient model jet unit the problem remains of how to mount it in such a way that the heat from the tailpipe will not burn the model airplane.

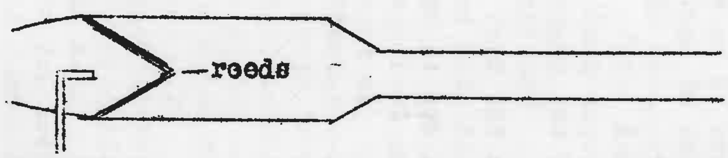
The problems of model jet engine research are numerous, but not insurmountable, and by considerable research the Glendale Rocket Society hopes to develop a successful model jet unit.

MAIN TYPES OF AIRCRAFT REACTION PROPULSION ENGINES

1. Compression-Expansion type--Efficient speed range-500-1500 M.P.H.
   A-Turbine drives compressor (Turbo-Jet, most common type)
   B-Standard gasoline engine drives compressor (Campini-1940)

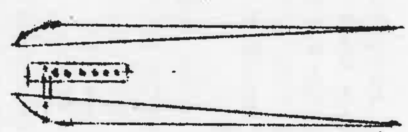


2. Intermittent Duct Engine--Efficient speed range-0-1500 M.P.H. (Resonance)
   A-Resonance Jet (Most common type).
   B-Poppet valve, shutter door, or rotary valve.



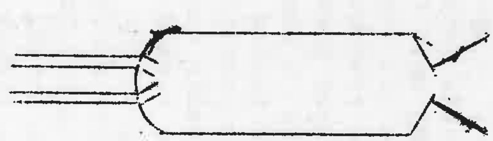
Reeds have same vibrating frequency as open tube frequency of entire engine. Sound wave generated by first explosion causes reeds to vibrate, opening or closing air and fuel intakes. Number of explosions per second depends on the frequency of the tube-like engine. Example-2 foot long engine-250 explosions per second.

3. Aerothermodynamic-Duct (Athodyd or Ram Jet) Efficient speed range-750-1500 M.P.H.



Air entering front of engine expands and slows down. This slow air is compressed by the fast moving air which has not yet entered the engine.

4. Rocket Engine-Efficient speed range-1500--+ M.P.H.
   Because the temperature rise due to skin friction becomes too great above speeds of 1500 M.P.H., all faster craft will have to travel at an altitute where none or very little air exists. The rocket, carrying its own oxydizer is the only means of propelling an aircraft at this altitude.



A Liquid Fuel Test Stand
-David Passel-

Up to the present the Glendale Rocket Society has been conducting research on solid fuel rocket engines with the exception of a few model jet engines. Liquid fuel research has been desired, however, due to the war and the scarctiy and cost of fuel and materials, liquid fuel research was impossible. Now that the war is over, it probably will be possible to begin liquid fuel research if we can obtain a testing ground in the desert.

In order to conduct liquid fuel experiments it will be necessary to have a self-recording test stand which may be operated from a point approximately fifty yards away. This stand should have an automatic recording unit for thrust, temperature, chamber pressure and fuel and oxydizer consumption.

The recording device could consist of a roll of graph paper drawn past hydraulic bellows operated stylii by a small electric motor. All readings would be traced on the same paper one above the other. If it is possible it would be desireable to have an electrically controlled motion picture camera which could be turned on during the test in order to get a close up of the engine in operation. The recording instrument could probably be mounted near the stand in a heavy metal box so it the engine exploded the records would be saved.

The thrust could be measured through a hydraulic system in which the thrust would be exerted against a hydraulic bellows which would connect, through a pipe line, to the recording unit where the hydraulic pressure would move a bellows to which a recording stylus was attached. If visual observations were also wanted the thrust bellows could also move a large hydraulic guage capable of being observed from a distance.

The chamber pressure and fuel and oxydizer consumption recordings could also be made in the same manner as the thrust recording.

The temperature might be measured by a thermocouple device which would operate an electrically driven stylus in the recording mechanism. This method has the disadvantage, however, for since thermocouples do not generate much current it would be necessary to use sensitive relyas if not electronic control amplifiers to operate the equipment which would be necessary for recording. Another solution to the problem might be to utilize the coeficient of expansion of a gas which would be contained in a small bulb of some material suspended over the jet opening. As the temperature increased the gas would expand and operate a bellows which would be connected to the recording unit in the same manner as the thrust indicator.

The control panel would contain all the controls needed for starting and stopping the recording unit, start the engine and operate the fuel and oxydizer valves. The fuel valves could be operated very well by small actuator motors of the aircraft type.

In order to operate this stand it will be necessary to have a power supply. Since all the motors used in this system can be of the 24 volt D.C. type the power supply will have to be capable of delivering 24 volts D.C. at approximately 10 amperes. For this purpose four six volt auto batteries could be connected in series. The ideal situation, however, would be to have a 24 volt gasoline driven generator.

If such a stand can be built it will greatly aid our research in liquid fuel work.

Society Model Jet Engine Research, June-September, 1945
-George James-

Although we had been planning a model jet engine research program for wuite some time we were not able to start it until June, 1945 because of our lack of machining facilities. During June two very fortunate things occured.

Previous to this and unknown to us, Carroll Evans, then not a member, had suceeded in constructing a model jet engine similar to the Sigmon engine illustrated in the March, 1944 Air Trails magazine.

During June, Carrol learned of our organization and we, independently, learned of his jet engine. Because he had no efficient way to test it, he decided to let the society modify and test the small engine.

When we obtained the engine we found that it needed a closer fitting valve-to reduce leakage and a more positive breaker point system. It was also found that considerable weight could be removed.

The second fortunate occurance was when Mr. Robert Wise, a friend of mine, stated that he would be glad to do any small machining jobs we needed.

G.R.S.J.-1 (Figure 2)

After being modified, Carrol's engine was renamed G.R.S.J.-1. Great difficulties arose with its attempted testing. The propellor was very hard to turn because of the duct behind it. Even with holes cut in the duct the air flow would be ruined to such an extent that the propellor would seldom turn. A conventional model airplane needle valve would not function because the pressure drop in the intake tube was not great enough. Gravity feed did not work very will because we did not have enough control over the amount of fuel entering the engine and the excess would cause the valve to stick. The intake tube was too small to allow enough air to enter the combustion chamber. Since it was apparent that we needed to know more about fuel injection it was decided to construct another engine.

G.R.S.J.-2 (Figure 3)

This engine consisted solely of the combustion chamber of G.R.S.J.-1. The main thing learned from this engine was that model airplane needle valves will not work on an engine with a large air intake and a small nozzle throat because of the back pressure that develops. Pressure feed did not work very well since we did not have any valves with which to control the amount of fuel accurately. The best of the three methods tried was gravity feed. It was almost impossible to start combustion with the spark plug. The usual procedure was to pour some alcohol in the bottom of the chamber, open the gravity feed valve, light the fuel in the chamber and gradually bring the air from our vacuum cleaner blower toward the engine. If we were fortunate we could keep combustion going in the chamber but usually it would go out and the cycle would have to be restarted.

G.R.S.J.-3 (Figure 4)

This engine was the first to use a fuel injection system. The fuel line extended through the rear of the engine, became vaporized and was injected into the chamber through six #80 holes in the fuel line. It was planned to have the shutter doors in the front operate a valve which would allow fuel flow only at the correct time. The development of a low friction leakproof valve proved too much of a stumpling block and after several tests using continous fuel injection the system was abandoned. Several needle valve systems were tried without success. The fuel would flow down the needle valve stem and flow into the combustion chamber where it would form a pool of burning gasoline.

G.R.S.J.-4 (Figure 5)

This engine was designed and built by Lee Auslander, who at the time was stationed in a V-12 unit at Caltech. The combustion chamber was similar to the Sigmon engine. However, this engine contained many improvements. These included two spark plugs, a removable nozzle, and a poppet valve. This was the only engine in which we could easily get continous combustion. This was probably due to the two spark plugs. At times we could notice that combustion was occuring only on one side of the chamber. Because we were unable to obtain a fine enough control over the fuel we could not produce explosions in the chamber of sufficient power to close the poppet valve.

When we began our model jet engine program we were not aware of any material being available on the subject. Since then we have obtained a copy of the "Theory and Testing of Jet Propulsion Motors and Rockets' by Zygmunt Fonberg. This book tells how to design jet engines of the three main types-Turbo-Jet, Resonance jet and Ram jet. The accompanying plans show how to construct two types of small resonance jet engines and one model ram jet. These will probably be the next engines constructed by the society.

Mr. Fonberg points out that any intermittant combustion jet engines should not have the diverging type of nozzle. They should use instead a straight or converging nozzle.

At the present it appears that the reason why our early engines did not work was because of several mistakes of design. The main one of these was having two small a constriction for the exhaust gases to emerge through. Also our fuel control was very poor. If these factors are remedied we will probably get much better results from future engines.

Probably a successful engine of the intermittant combustion type using rotary valves, poppet valves, shutter doors or similar devides could be constructed if some way is found to regulate the fuel mixture accurately and constantly. One method might be to build a fuel jacket around the engine so that vaporized fuel could be forced in under pressure. A needle valve from a small blow torch would be an excellent way to control the ammount of fuel entering the engine. A safety valve would probably be needed to prevent the fuel jacket from exploding.

From the information available at the present it appears that the resonance jet engine is the most practical for small applications because of its ease of construction and light weight. The Giannini Laboratories located in Pasadena have had considerable success with this type of engine. An experimental model, which we saw in a model shop last summer, was about 27 " long and 2" in diameter. According to the owner of the shop it weighed 5 ounces and developed two pounds thrust standing still. The fuel consumption was one ounce per minute. He claimed to have flown a control line plane at 150 MPH with the engine. The balsa wood tube body of the plane was badly charred from the heat of the engine.

(Continued from page 5)

GROUP Dc

Number	$Pb(NO_3)_2$	NH_4NO_3	C	%Ash
Dc-1	15	70	15	8

GROUP Ea

NUMBER	C	NH_4NO_3	KNO_3	%Ash
Ea-1	49	37	14	10.4

(Continued from page 1)

Our main objective this year, besides our research program will be to make ourselves and our work know to the general public. This will be done for two reasons, first to publicize reaction propulsion and second to increase our membership.

In order to aid our experimental fund, we hope to establish a manufacturing company by the name of Reaction Research Inc. Some of the first things to be sold will be reaction propulsion devices for model U-control airplanes.

Because of our extensive research program we have been considering the possibility of a new non-regional name employing the term "reaction research" since our present name is very limited in scope and does not include jet propulsion.

In the way of publicizing our group we are planning to hold a nation-wide model rocket plane contest this coming summer. More information on this contest will appear in Astro-Jet No. 13. Also we are planning to publish a book called "Practical Hints to Reaction Propulsion Experimentors", telling how to safely build and test small solid fuel rocket engines and jet engines for model airplanes, boats etc. We are also still considering the idea, which is almost as old as the society, of sponsoring some mail rocket flights.

The prospects of carrying out our proposed program appear to be very good since with the ending of the war much information and material needed for our research efforts has been released.

Glendale Rocket Society Jet Engine No. 1 Tested June, 1945 (Actual Size)

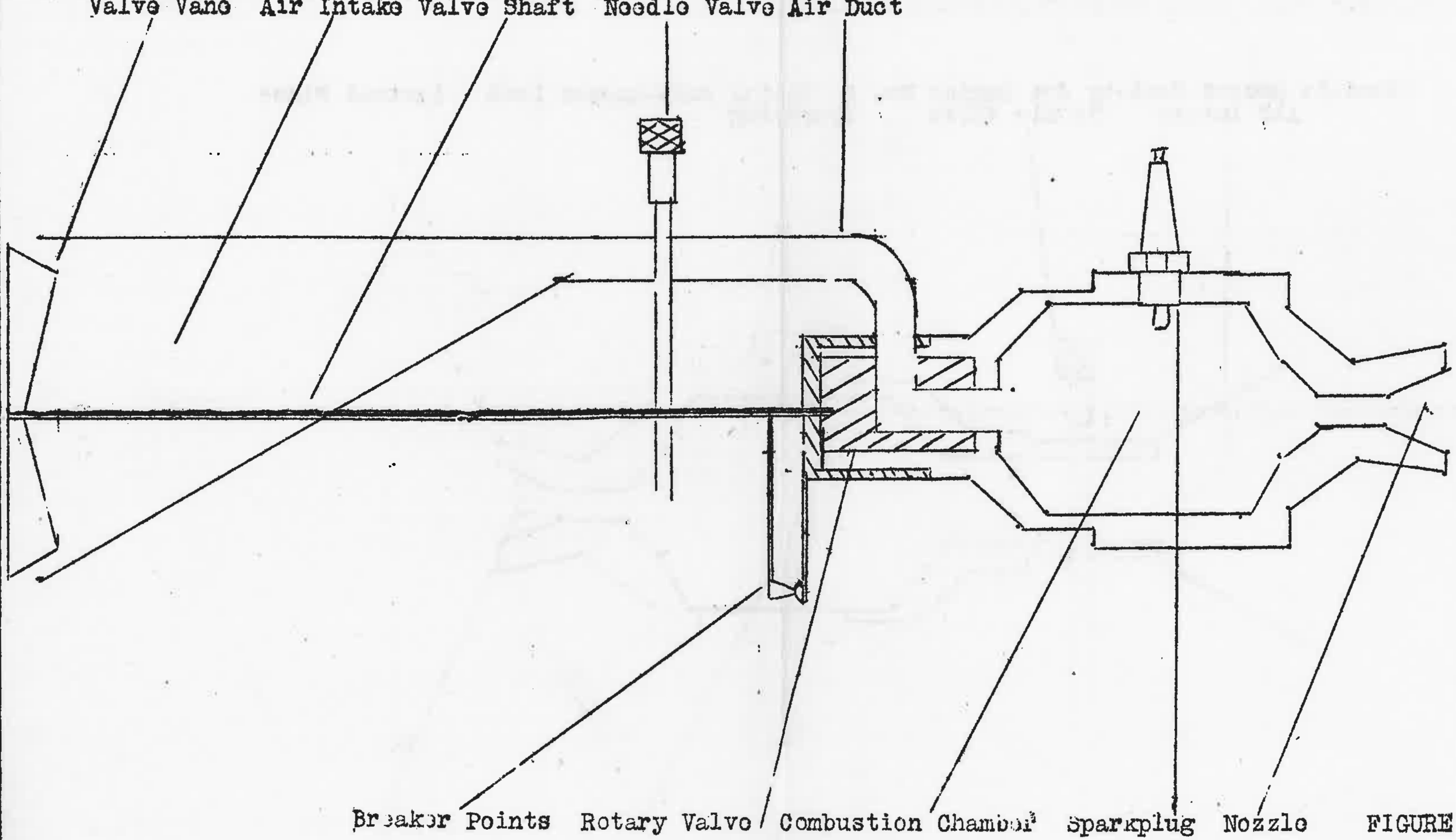


FIGURE 2

Glendale Rocket Society Jet Engine No. 2 Tested July-August 1945 (Actual Size)

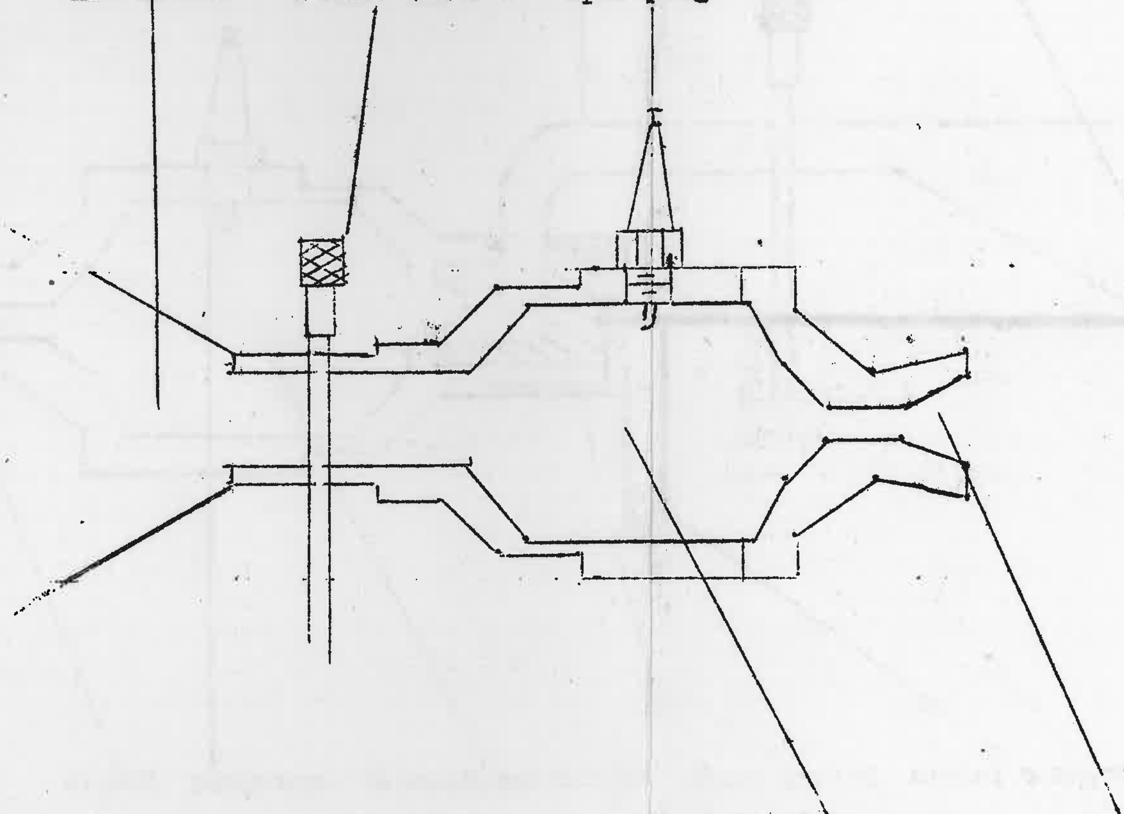


FIGURE 3

Glendale Rocket Society Jet Engine No. 3. Tested August-September 1945 (Actual Size)

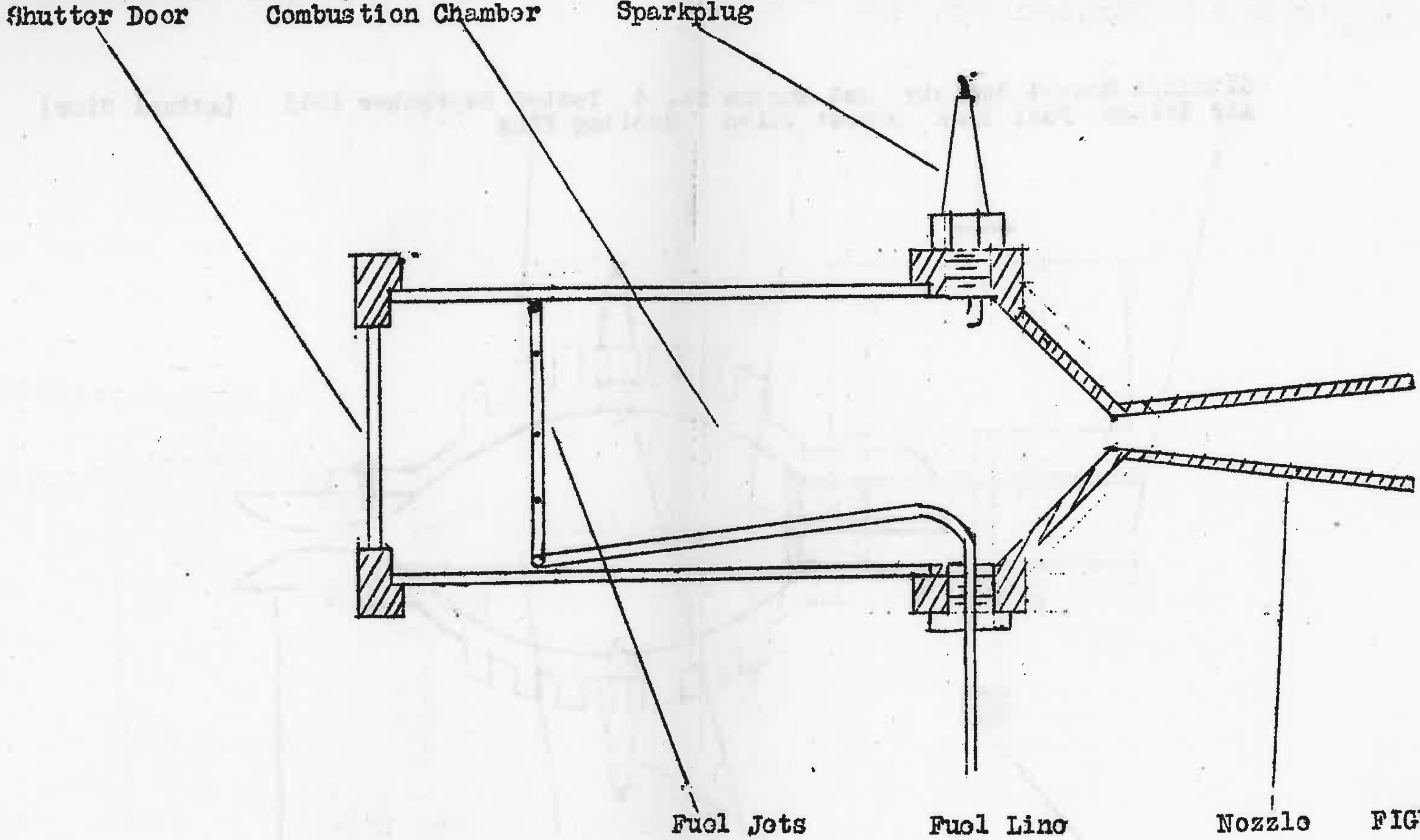


FIGURE [illegible]

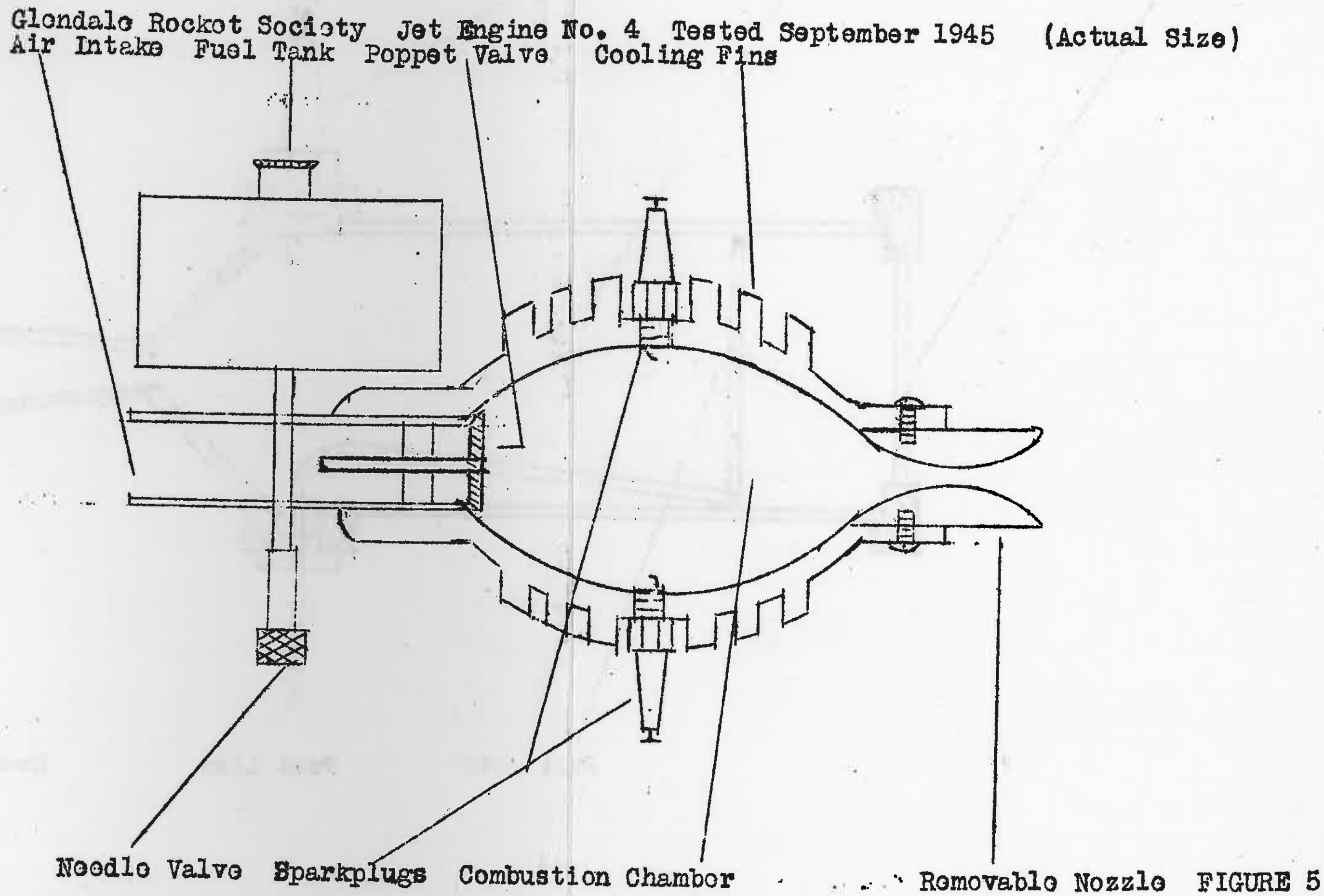

Glendale Rocket Society Jet Engine No. 4 Tested September 1945 (Actual Size)
Air Intake
Fuel Tank
Poppet Valve
Cooling Fins
Needle Valve
Sparkplugs
Combustion Chamber
Removable Nozzle

FIGURE 5

GLENDALE ROCKET SOCIETY

Purpose

The GLENDALE ROCKET SOCIETY is a non-profit organization whose purpose it is to aid in the development of jet propulsion and its applications, and to promote interest in this new science. This purpose is carried out by maintaining an active research program, encouraging other experimentors, and promoting interest in jet propulsion by the publication of ASTRO-JET, Journal of the Glendale Rocket Society.

Membership

At the present time there are two forms of membership in the GLENDALE ROCKET SOCIETY, Active and Associate. Active membership is for those who can engage in the activities of the society. They may come to all society meetings, all society testings, receive all society publications published during their membership, and will be able to vote and hold office in the society. This form of membershp is $3.00 per year. All applicants for active membership must also submit a rocket model or by some other means show a genuine interest. Associate membership is for those who find it inconvenient to become active members. They have all the privileges of active members with the exception of holding office and voting. This form of membership is $2.00 per year. If you are interested in joining the society, please write to

SECRETARY, GLENDALE ROCKET SOCIETY
3262 Castera Ave., Glendale 8, California

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