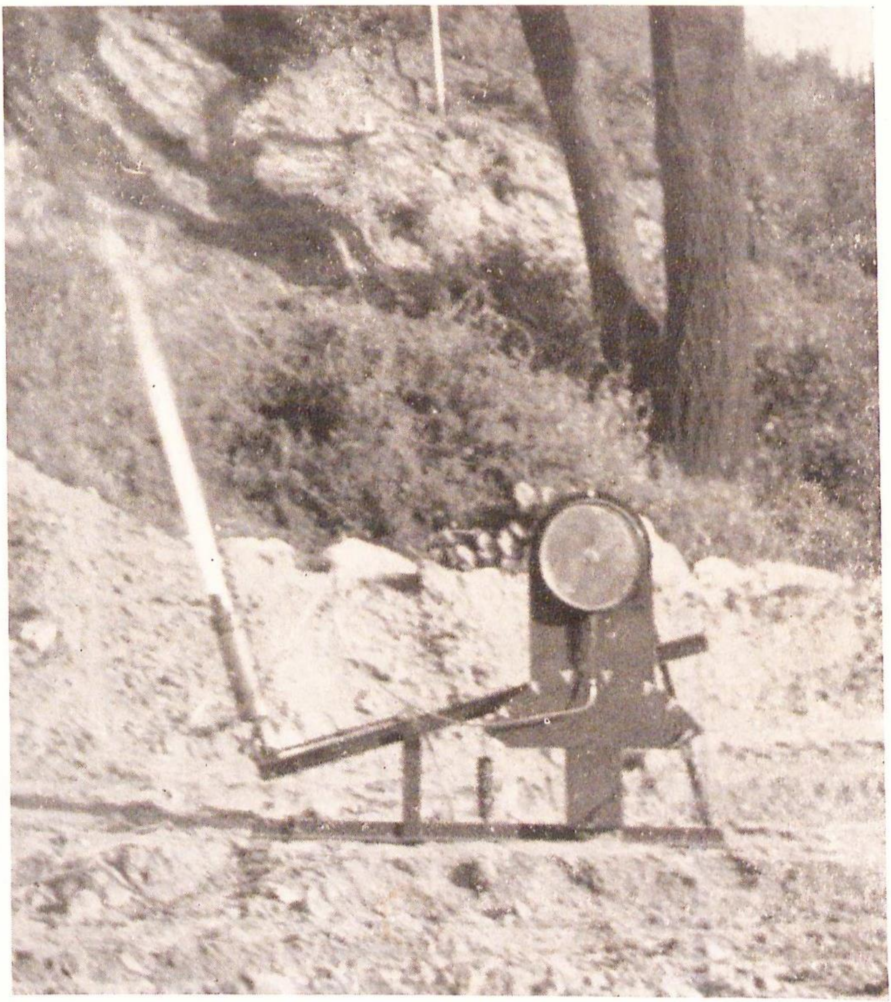
ASTRO-JET

JOURNAL OF THE REACTION RESEARCH SOCIETY

NUMBER 16 MARCH, 1947



Reaction Research Society Solid Liquid Engine No.1 in operation. Engine was making over 25 pounds thrust when photograph was taken.

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ELECTION OF DECEMBER 29, 1946

At the December general meeting the annual election of officers for the coming year was held.

By a vote of the active members the office of Director of Research was dissolved, for during the past year it was found that this co-ordinating job is too large a task for one member. During 1947 society research will be directed by the RRS Board of Directors.

By a unaminous vote of the active members it was decided to retain in office all of the present officers with the exception of Director of Research, until the end of 1947. These officers are:

President - - - - - George James
Vice-President - - James Hummel
Secretary-Treasurer-Carroll Evans

In addition to the above officers, Richard Schenz and Sherwood Mayall were elected members of the Board of Directors.

SOCIETY PLANS FOR 1947

During the coming year the Reaction Research Society will continue development along the lines of the research reports started during 1946.

Landing mechanism work will be greatly intensified due to the possibility of a liquid propellant flight before the end of the year.

This landing mechanism research will be greatly aided by the construction of the Miler and Submiler rockets. These micrograin rockets will carry three pound landing mechanisms to altitudes of 1500 and 6000 feet respectively.

Other definitely planned portions of the micrograin research program are a new, more sensitive test stand, and research with two-step micrograin rockets.

Semi-restricted and restricted solid propellant research will be continued because of the need for these units in body design testing of liquid propellant rockets.

Solid-Liquid rocket system research will definitely be undertaken during 1947, and if our research funds allow it, monopropellant rocket engine research will also be undertaken.

During 1947 the Reaction Research Society will publish four issues of Astro-Jet, March, June, Septmeber, and December. Special publications will include the Progress Report, Reaction Propulsion hints to Beginners, and RRS Notes.

With Present plans, it appears that 1947 will be the Society's most Active year.

DESERT TESTING OF JANUARY 5, 1947

This first testing of 1947 is probably the most comprehensive RRS testing held to date. An excellent spot was located by the site group in the Mojave desert near Palmdale.

The following items were tested:

1. RRS Solid-Liquid Engine No. 1
2. Detonation test on monopropellant
3. Two eight pound skyrocket charges
4. Slim Jim landing mechanism test rocket
5. Silver Streak landing mechanism test rocket
6. Fourteen foot aluminum lauchching tower.
7. AERO-SMOKE flares
8. New rocket ignition system

This was the best organized testing in society history. One factor which contributed greatly to the smooth operation of the event was the eight page booklet sent to all members. This booklet told all participating members exactly what to do and eliminated much confusion.

Five still cameras and two movie cameras made this the most photographed testing in RRS history. The 8mm color movies taken by Mr. Carroll Evans Sr. turned out exceptionally well; recording the complete flights of all the rockets tested.

The site locating group left society headquarters at 9:30 AM arriving at the site shortly after 10:30. This group assembled the solid-liquid test equipment, erected the launching tower, and loaded the micrograin rockets.

Because of the fragile nature of micrograin capsules it was not thought advisable to load the two micrograin rockets at society headquarters.

The remaining members and all the spectators arrived at the site shortly after 12:00. After lunch was eaten the testing started.

LAUNCHING TOWER

Our new fourteen foot launching tower is made from three pieces of aluminum "T" stock joined by aluminum cross members. The rocket slides up the outside of one of the rails. Although this tower weighs but 18 pounds, it is very rigid and is held erect by four 25 foot guy wires. This tower was designed and built with the hope that it will be possible to launch all future society rockets, including liquid propellant rockets from it.

AERO-SMOKE FLARES

Although these yellow smoke flares were originally designed for control line model airplane flying, they have found many society uses. Their dense yellow smoke (so excellently shown in the color movies) was found to make an ideal "two minutes before firing" signal. The desert is so heavily covered with brush that if it hadn't been for the AERO-SMOKE flares given each tracking station, the operators would not have been able to take bearings on the other station, even though the stations were only a thousand feet apart.

Recently there has been some controversy as to whether AERO-SMOKE was dense enough to be used on "100 mph plus" control line planes. This was given a conclusive test by using a standard AERO-SMOKE charge as the tracking flare for Silver Streak. Fortunately this rocket is large enough to accommodate the three ounce, 1" by 4" smoke unit below the landing mechanism. The color movies definitely show that at the maximum velocity of the rocket (over 250 mph) AERO-SMOKE is still very dense and easy to see. The task of taking pictures and tracking the rockets would have been very difficult if it were not for the tracking flares each rocket carried. At the present we appear to be the only group using this easy method of making flights of rockets more visible.

IGNITION SYSTEM

The placing of the rockets on the tower and the ignition of the tracking flare and rocket was taken care of by the two ignitors, Dick Schenz and Lee Rosenthal. After placing the rocket on the tower and making electrical connection the ignitors would retire to the ignition pit 175 feet from the lauchching site. Three wires connected the pit with the rocket. A small plastic box containing two switches, one for propellant and the other for the tracking flare, and two standard flash-light batteries were used to fire the rockets. Both micrograin rockets required breakaway contacts because of the tracking flares in the heads of the rockets. For this purpose the flare and propellant wires were immersed into small mercury cups.

TRACKING MECHANISMS

The two standard RRS tracking mechanisms were used at this testing, each being placed 500 feet from the launching site and 1000 feet apart. The operators were Rodney Skager and John James. It was found that an accurate means of measuring the base line must be developed, for the method used, a 50 foot cloth tape, was not too satisfactory.

SOLID-LIQUID ENGINE

The test stand used for this test consisted of a steel beam pivoted two-thirds of the way from one end and connected to a lever which worked a thrust dial. The engine with nozzle up was placed at one end and springs were attached to the other end. The chamber pressure guage was placed above the thrust dial. The actual attempted testing of the engine was a failure. Two car storage batteries failed in producing enough amperage to cause the carbon rod in the engine to heat sufficiently to burn in the injected oxygen. Before this engine is again tested a pyrotechnic method will be found for igniting the carbon rod.

MONOPROPELLANT DETONATION TEST

This test consisted of detonating a test vessel made of $1\frac{1}{4}$" pipe, suitable fittings, and an electric blasting cap. The container was filled with 150 ml of the monopropellant. When the ignition switch was thrown, a very loud, pipe-fragmentating blast resulted. The fact that the society developed monopropellant detonates is not too serious for all monopropellants developed so far demonstrate this charcteristic. A far more important test, to be conducted in the near future, will be a detonation propagation test. This test will determine if, when the rocket engine explodes, the propellant line will propagate the explosion back to the propellant tank.

EIGHT POUND SKYROCKETS

In 1944 Bernard Smith gave the society five 8 lb skyrocket charges. Before this testing, two had been tested. The two charges fired on the 5th were for the purpose of determining the effect of storage on skyrocket charges. These had been purchased in 1940, making them at least six years old. For this test the charges were fitted with paper cones, tracking flares, and aluminum fins strapped to the bodies. Due to a shortage of AERO-SMOKE flare, the first of these was fired without a two minute warning, taking the tracking mechanism operators by surprise. This resulted in not obtaining any readings from one station, making the height of the first rocket undeterminable. The rocket, fired from the 5 foot launching rod used at the press show, took off with a hissing roar; rising about 200 feet before an unexpected thing occurred. The rocket began spinning about very rapidly and when it stopped firing twirled down to earth like a helicopter. It was found that the fins had slid back, due to acceleration, bringing one set of straps into the jet blast. For some reason when the straps melted, the fins sprung outward, forming an almost perfect set of twirling blades, thus gently lowering the rocket. This unintended landing device was the only one that worked at the testing.

The second rocket rose 245 feet, blowing its front plug in the process. The fins acted in exactly the same manner as the first rocket.

Because of the long time lag between ignition and the start of smoke on the small tracking flares, (not AERO-SMOKE), bothe skyrockets were fired before the smoke had started.

This skyrocket test definitely proves the RRS conviction that old skyrockets are not dependable, i.e., one worked, and the other blew its front plug.

SLIM JIM

The landing mechanism test rocket, Slim Jim (details of construction etc., given in ASTRO-JET No. 15), was fired for the THIRD TIME at this testing. The parachute mechanism was similar to the device tested at the press show. When launching was first attempted only the tracking flare ignited, ejecting the parachute seven seconds later. Too much blowing charge had been used, for the parachute was ejected to a height of twenty feet, tearing away from the cord that secured it to the rocket. The nose was replaced on the parachute case, an unburned smoke flare (from one of the skyrockets) was attached, and the rocket rose 818 feet, trailing the smoke from its tracking flare.

The difference between this and the 1200 feet attained at the press show is probably due to the heavier landing mechanism. Slim Jim buried itself nose firs, about 18 inches in the sand and was not damaged in the least. With not more than 15 minutes work, the rocket could have again been fired.

SILVER STREAK

This shiny stainless steel and aluminum landing mechanism test rocket, built by Sherwood Mayall, tested a free falling weight landing mechanism and an AERO-SMOKE flare. From its four fins to its long tapering nose it was just short of six feet in length. It was 1-1/2 inches in diameter and and used 1-1/2 pounds of micrograin propellant.

The launching of this rocket was perfect. As soon as the tracking flare ignited, the rocket was fired and with a bright yellow flash it left the tower leaving a 60 foot column of propellant smoke. The AERO-SMOKE flare made picture taking easy because it was visible during the entire flight. The shape of the flight path was a very narrow parabola, since the rocket landed only 33 feet from the launching tower. The hightes point reached by the rocket was 1178 feet. As usual, the parachute mechanism did not function. With minor straiganing of the propellant tube, this rocket will again be ready to test another landing mechanism.

Because of the fact that the nozzle of Silver Streak was not of standard configuration, it will not be possible to calculate the thrust of the rocket until the new micrograin stand is finished.

Because of the reorganization of the researdh projects for the PROGRESS REPORT none of the rockets tested on January 5, 1947 have yet received their experimental number designations. However, this information will be in the progress report.

One of the most remarkable features of the micrograin test rockets is the low cost of firing. The cost of propellant for Slim Jim and Silver Streak was $.40 and $.60 respectively. Since the rockets were recovered intact this was the largest cost of firing. About $.25 can be added for the cost of the tracking flards and electric ignitors.

RRS SOLID-LIQUID ROCKET ENGINE PROGRESS
Research Project No. 11

Up to the present, eight solid-liquid experiments have been held. The first of these has been reported elsewhere in this issue.

EXPERIMENT NO. 2

For this test, held on January 26, 1947, the space under the carbon rod was packed with black powder. After the powder had been ignited electrically, the oxygen was turned on. The powder did not supply enough heat to ignite the carbon rod.

EXPERIMENT NO. 3

This experiment, conducted on January 29, 1947, consisted of packing an ignition powder made of potassium perchlorate and aluminum in the space beneath the carbon rod. This was ignited outside the engine to see exactly how the powder would act. After being ignited, the powder burned violently for about 10 seconds. The carbon had become extremely hot, and the four holes in the rod were covered with aluminum oxide.

EXPERIMENT NO. 4

On February 2, 1947, a solid-liquid wood fuel ignition test was held (see cover). For this test, a piece of wood the diameter and length of the combustion chamber was drilled with forty-eight 1/8" holes running the length of the rod, and placed in the combustion chamber with some ignition powder and an electric fuse. The oxygen was opened to about 300 pounds infection pressure (a guess) and the wood ignited. Immediately a large bright orange flame leaped from the nozzle and the thrust indicator jumped the stop set at 25 pounds. This spectacular run lasted 3.4 seconds. It was not possible to get chamber pressure readings for the guage broke at the start of the run.

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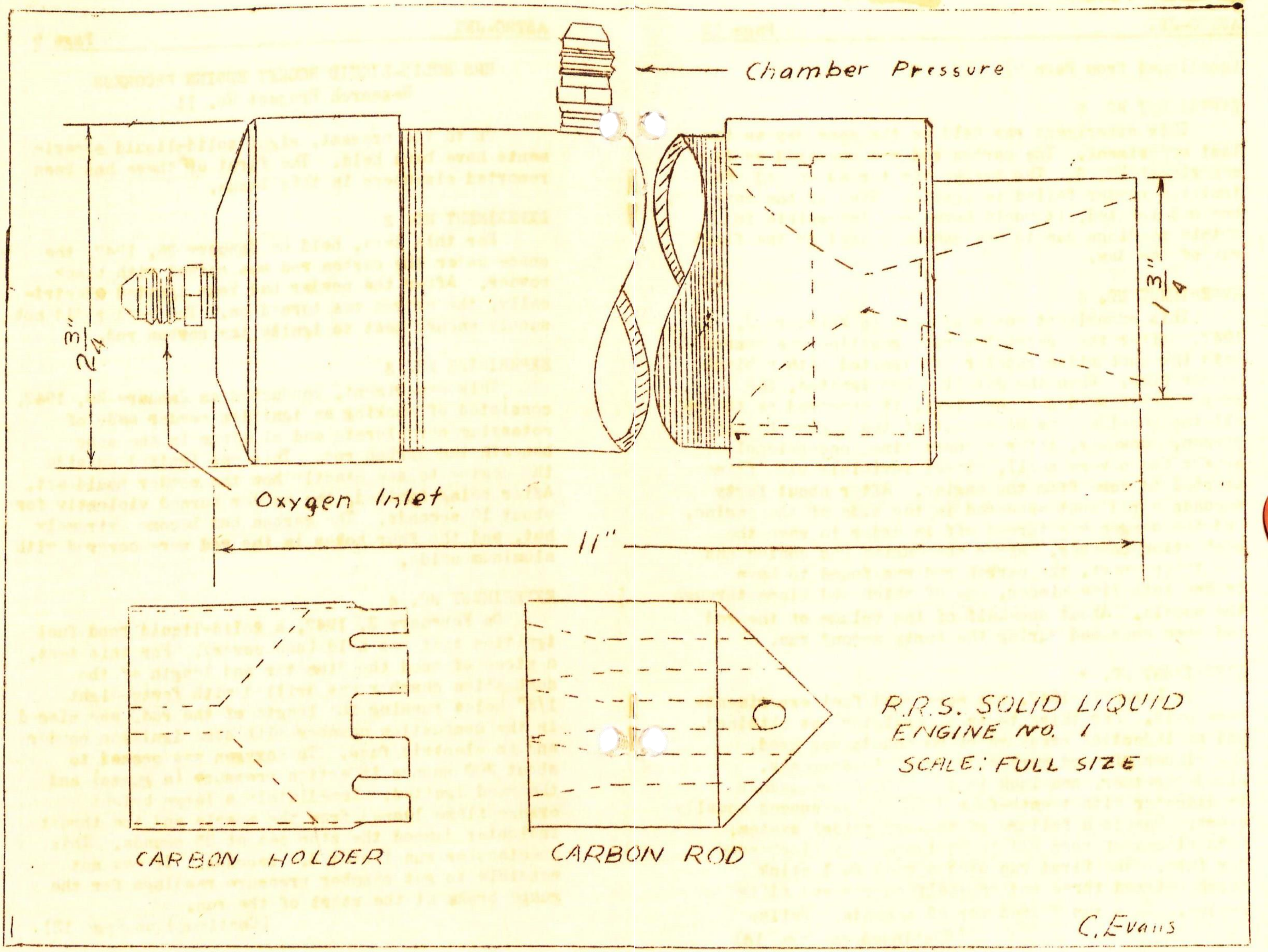

Chamber Pressure
$1\frac{3}{4}$"
$2\frac{3}{4}$"
Oxygen Inlet
11"
CARBON HOLDER
CARBON ROD
R.R.S. SOLID LIQUID
ENGINE NO. 1
SCALE: FULL SIZE
C. Evans

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EXPERIMENT NO. 5

This experiment was held on the same day as the last experiment. The carbon rod was prepared as in experiment No. 3. The oxygen was turned on and the ignition powder failed to ignite. Even if the carbon had ignited, it would have been impossible to obtain readings due to the damage caused by the first run of the day.

EXPERIMENT NO. 6

This experiment was also held on February 2, 1947. After the preceeding run, gasoline was poured into the combustion chamber and ignited with a black powder fuse. When the gasoline had ignited, the oxygen was turned on. At first, it appeared as though all the gasoline was blown out of the engine by the oxygen. However, after a short time, occassional sparks and a very small, almost invisible blue flame started to come from the engine. After about forty seconds a red spot appeared in the side of the engine, and the oxygen was turned off in order to save the combustion chamber. After the engine had cooled and was taken apart, the carbon rod was found to have broken into five pieces, one of which had blown through the nozzle. About one-half of the volume of the rod had been consumed during the forty second run.

EXPERIMENT NO. 7

On March 9, 1947, two more wood fuel experiments were held. For thise tests a regulator was obtained, and an injection pressure of 50 pounds was used. The pieces of wood were made from six segments, glued together, one inch in length and two inches in diameter with twenty-four 3/16" holes spaced equally apart. Due to a failure of the electrical system, both pieces of wood had to be ignited by black powder fuse. The first run used a wood fuel stick which weighed three and one-half ounces and fifty grains. This run lasted for 25 seconds. Unlike

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DEFINITION OF REACTION PROPULSION TERMS

-George James-

In this article the Reaction Research Society presents its definition of the common terms used in the science of reaction propulsion. These terms, as stated here, will be used in all society publications and records. Because most RRS research has been with rocket propulsion, the terminology of this field is the most completely defined. As more research is conducted into the other fields of reaction propulsion, their terms, lidewise, will be defined in greater detail.

REACTION PROPULSION

The science that directly applies Newton's Third Law of Motion to the propulsion of devices.

I--Rocket Propulsion

The division of reaction propulsion in which the devices carry all the materials necessary for their propulsion.

Common Rocket Propulsion Terms

PROPELLANTS--The reacting materials necessary for the propulsion of a rocket device. These generally consist of a fuel and an oxidizer.

ROCKET ENGINE--The part of a rocket system which converts the propellants into propulsive energy. There are two main types of rocket engines: the COOLED or REGENERATIVE and the UNCOOLED. Cooled engines are constructed so as to allow one of the propellants to circulate around the combustion chamber and cool it. A liquid propellant rocket engine consists of three main parts: INJECTORS, COMBUSTION CHAMBERS, and NOZZLE. Solid propellant rocket engines usually only contain only a combustion chamber and nozzle.

INJECTORS--The orifices that allow the propellants to enter the combustion chamber.

(Continued on next page)

COMBUSTION CHAMBER--The part of the engine where the combustion or decomposition required to generate the propulsive energy takes place.
NOZZLE--The orifice through which the propulsive gases escape.
IGNITION SQUIB--A pyrotechnic device which shoots a flame into the combustion chamber.
INJECTING SYSTEM--The system for injecting the propellants into the rocket engine. There are two common systems: The pump system and the pressure system.

Common Types of Rocket Propulsion Systems:

(A) SOLID PROPELLANT SYSTEM
A rocket propulsion system that contains its propellants in one solid or semi-solid material; which, in the case of solid propellant rocket systems, is called the propellant.

(1) MICROGRAIN SOLID PROPELLANT SYSTEM
A solid propellant rocket system in which the propellant is in the form of very small grains, or more commly, dust.
(2) UNRESTRICTED SOLID PROPELLANT SYSTEM
A solid propellant system in which the propellant is in the form of a large grain or grains (compared to micrograin) and is free to burn on all surfaces.
(3) SEMI-RESTRICTED SOLID PROPELLANT SYSTEM
A solid propellant system in which the propellant is in the form of a large grain or grains and is inhibited so as to burn on more than one, but all surfaces.
(4) RESTRICTED SOLID PROPELLANT SYSTEM
A solid propellant system in which the propellant grain or grains are so inhibited as to allow combustion on only one surface.

(B) SOLID-LIQUID PROPELLANT SYSTEM
A rocket propulsion system that uses one solid and one liquid component for propellants.
(Continued on next page)

(C) LIQUID PROPELANT SYSTEM
A rocket propulsion system that uses liquid componnents for propellants.

(1) MONOPROPELLANT ROCKET SYSTEM
A liquid propellant rocket system in which the propellants are combined in one fluid.

(2) BI-PROPELLANT ROCKET SYSTEM
A liquid propellant system in which the two propellants are stored separately until injection into the combustion chamber.

(3) MULTI-PROPELLANT ROCKET SYSTEM
A liquid propellant rocket system in which the three or more propellants are stored seóparately until used.

II JET PROPULSION

The division of reaction propulsion in which the devices carry only part of the materials necessary for propulsion and therefore require atmospheric air for operation.

(A) MECHANICAL COMPRESSOR SYSTEM
A jet propulsion system where air for the combustion of fuel is obtained by means of a mechanical compressor.

(1) MOTOR-JET SYSTEM
A mechanical compressor system in which the compressor is driven by a reciprocating engine.

(2) TURBO-JET SYSTEM
A mechanical compressor system in which the compressor is driven by a turbine wheel rotated by the combustion gases.

(B) INTERMITTANT JET PROPULSION SYSTEM
A jet propulsion system in which the operation is regulated by mechanical or other types of valves and gives intermittant thrust in frequencies regulated by the valve mechanism.

(1) Pulse-Jet System
An intermittant jet propulsion system in which

the cycle of operation is regulated by the length of the tube like engine. The valves are metal reeds placed at the front of the engine.

(2) MECHANICAL VALVE SYSTEM

In this intermittant jet propulsion system poppet valves, shutter doors, rotary valves, or other mechanical valves replace the vibrating reeds of the pulse jet.

(C) RAM JET SYSTEM

A jet propulsion system where the compressed air needed for operation is obtained by the forward speed of the engine, consequently neither valves nor compressors are used.

It is hoped that this definition of some of the basic terms of reaction propulsion will be helpful in correcting the vast confusion of terms that exist at the present.

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the wood test of February 2nd, only a small three inch flame accompanied by intermittant bursts of sparks emerged from the nozzle. The flame moved from side to side and even disappeared at times.

EXPERIMENT NO. 8

For this run a wood fuel stick weighing three and one half ounces and eighty grains was used.. The same poor type of combustion observed in the last run was also seen here. Combustion lasted 23.5 seconds. After both runs the nozzle was covered with a heavy layer of soot. The test stand had been repaired and calibrated to 25 pounds thrust, but no thrust was evident in either of the runs.

FUTURE PLANS

The main advantages of using wood as a fuel in the solid-liquid type of rocket engine is its easy igniyion. After some positive method is found for igniting carbon we will probably go back to using it because of the greater amount that can be placed in the combustion chamber.

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RRS RESEARCH PROJECTS

Below is a complete list of all society research projects started up to January 31, 1947. The PROGRESS REPORT, to be issued next summer, will contain the results of these projects.

1. Solid Propellants
2. Solid Propellant Manufacture
3. Solid Propellant Rocket Test Stands
4. Micrograin Solid Propellant Systems
5. Unrestricted Solid Propellant Systems
6. Semi-restricted Solid Propellant Systems
7. Restricted Solid Propellant Systems
8. Liquid Propellants
9. Liquid Propellant Manuffacture
10. Liquid Propellant Test Stands
11. Solid-Liquid Propellant Rocket Systems
12. Monopropellant Rocket Systems
13. Bi-Propellant Rocket Systems
14. Ignition Mechanisms
15. Smoke Mechanisms
16. Launching Mechanisms
17. Rocket Stabilization
18. Thrust Augmentation
19. Step Rockets
20. Rocket Tracking Mechanisms
21. Landing Mechanisms
22. Jet Engine Test Stands
23. Intermittant Jet Propulsion Systems
24. Ram Jet Systems
25. Model Free Flight Rocket Rocket Planes
26. Model Control Line Rocket Planes
27. Model Rocket Propelled Race Cars
28. Pyrotechnics
29. Paper Tube Manufacture

RENTON TO BE SCENE OF NEW NATIONAL SECURITY PROJECT:

BOEING WILL TEST EXPERIMENTAL RAM-JET ENGINES THERE

The city of Renton, Wash., where Superfortresses were produced during the war, is to be the scene of another important national security project, the Boeing Aircraft Company revealed.

Preliminary operations at the Renton location were scheduled to begin last February. The Boeing announcement said combustion tests of high-speed ram-jet engines will be conducted there for the AAF as part of the compan's broad program of research and experimentation with new types of power plants, including jet and turbo-jet.

Scene of the experiments will be a Boeing propulsion laboratory housed in two buildings on the shore of Lake Washington, 300 feet from a Steam Electric Power Plant.

A modified General Electric I-40 jet engine, driven by steam piped from the electric plant, will be used to compress air to supersonic speeds for testing of the Boeing engines in a "thermodynamic" wind tunnel.

"Ram-jet theoretically is the simplest medium of propulsion," Col. Harley S. Jones, AAF resident representative at Boeing, stated, "and as far as we know today is one of the most efficient means of achieving supersonic flight. Howefer, much remains to be learned on this and other phases of high-speed power plants to translate the theories into practical application. To achieve this, a large national defense research program is now being conducted throughout the nation under government sponsorship. We are happy that Boeing is one of the import‸nt participants in this program."

"The tests will prodice sounds somewhat similar to the rumble of distant thunder," said a Boeing Engineer. "However, we will not operate at night, and only for a total of approximately eight discontinous hours a month."

PUBLICATION REVIEWS

Recent Publications of the
British Interplanetary Society

(A) The Bulletin of the British Interplanetary Society; Vol. 1 No. 9, November, 1946; and Vol. 2 No. 1, January, 1947.

These printed bulletins very closely resemble the BIS Journal. Among the articles in Bulletin No. 9 are: Air Conditioning Problems of Rocket Travel; and the Problem of Interplanetary Propulsion. Several of the interesting articles in Bulletin No. 1 are: The Physical Condition of Jupiter, Green Plants as Atmosphere Regenerators, A Suggested New Unit of Time, Planetary Photography in the Ultra-Violet and Infra-Red, and a most interesting commentary on Mr. Farnsworth and the United States Rocket Society by P. E. Cleator.

(B) The Journal of the British Interplanetary Society: Vol. 6 No. 3, December, 1946

This issue contains three papers including a thought provoking paper entitled "The Challenge of the Spaceship" written by A. C. Clark. The other papers are : Thermodynamics of the Rocket Motor by E. Burgess and High Speed Flight by Terence R. F. Nonweiler.

Note:

With this issue of ASTRO-JET all society members will receive the November issue of the BIS Bulletin. In the near future all RRS members will receive the other BIS publications reviewed in this issue. Because of the long time it takes bulk mail to cross the Atlantic, about three months elapse between the time the BIS issues a publication and we send it to our members.

Publication Reviews Continued

Journal of the American Rocket Society
Number 68, December, 1946

Several of the more interesting articles in this 48 page issue are: Liquid Propellant Rocket Developments, Some Possibilities for Rocket Propellants, Elevators and Levitators, and the Variable Nozzle for Engine Efficiency When Throttling.

By an interesting coincidence, the ARS issue contains M. Z. Krzybolocki's article "Elemmentary Formula of Rocket and Jet Propulsion," which appeared in the March 1946 issue of ASTRO-JET.

Pacific Rockets, Journal of the Pacific Rocket Society, Volume 1, Number 3, December 1946.

This issue contains articles on Recent Progress Our Exploratory Frontier of Tommorrow, Amethod for Injecting Liquid Propellant into a Rocket Engine from Low Pressure Reservoirs, Aerodynamics in Rocket Design, and Mojave Notes.

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Before any more runs are made, the chamber pressure guage will be repaired and the test stand calibrated for higher readings.

Because of the high pressure oxygen regulator made availible to the society by Bob Seth, all future experiments will be run at much higher oxidizer pressures.

REACTION RESEARCH SOCIETY

PURPOSE

The REACTION RESEARCH SOCIETY is a non-profit organization whose purpose is to aid in the development of reaction propulsion, its applications, and to promote interest in this new science. This purpose is carried out by maintaining an active research program, encouraging other experimenters, and promoting interest in reaction propulsion by the publication of ASTRO-JET, Journal of the Reaction Research Society.

MEMBERSHIP

At the present time there are two forms of membership in the REACTION RESEARCH 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 are able to vote and hold office in the society. This form of membership is $5.00 per year. All applicants for active membership must also submit an article for ASTRO-JET or by some other means show a genuine interest in reaction propulsion. Associate membership is for those who find it inconvenient to become active members. They have all the privileges of active membership with the exception of holding office and voting. This form of membership is $3.00 per year. If you are interested in joining the society, please write to:

SECRETARY, REACTION RESEARCH SOCIETY
3262 Castera Ave., Glendale 8, California

OFFICERS

President and Editor .... George James
Associate Editor .... Sherwood Mayall
Vice-President .... James Hummel
Secretary-Treasurer .... Carroll Evans

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