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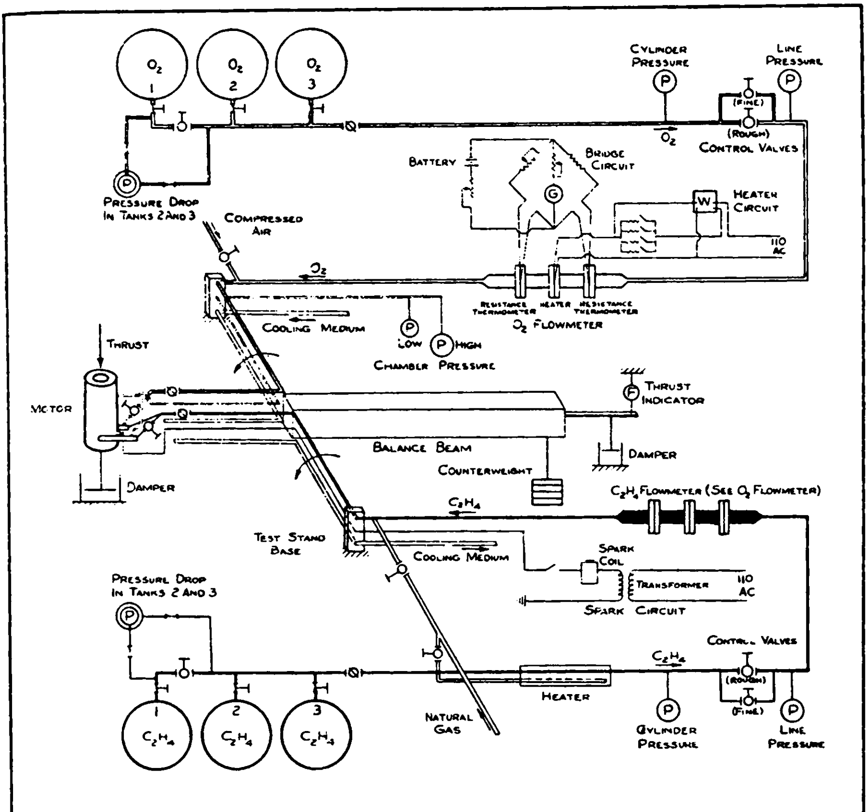

Schematic Diagram Of The GALCIT Rocket Motor Test Stand

The GALCIT Rocket Research Project — Plans and Program for Research at Cal. Tech. **Dry Fuel Experiences**—What can be done with powder rockets? **The Rocketor's Workshop**—Parachutes, valves.

Notes and News

ASTRONAUTICS takes pleasure in presenting so careful and complete a program as that outlined by the GALCIT research group; Mr. Malina is to be complimented not only on his leadership but also on his clear presentation of its methods and aims. Incidentally, Mr. Malina does not explain the origin of "GALCIT." With his usual penetration, your editor imagines these are the initials of "Guggenheim Aeronautical Laboratory, California Institute of Technology".

THE ENGLISH are much interested these days in protection against raiding aircraft. Of interest to rocketors is the suggestion of Mr. Grindell Matthews, British inventor, that rockets may be developed to serve in anti-aircraft defense, by planting a series of parachute-borne snare-wires or aerial bombs high in the air ahead of hostile aircraft. As Mr. Matthews pictures them, these rockets would be 12 to 15 feet long and two and a half feet in diameter, with gyroscopic control and stabilizing fins, capable of 1,200 miles per hour speed, and altitudes of 10,000 to 30,000 feet. Each rocket would eject, at the top of its flight, fifteen to thirty parachutes, each trailing 500 to 1,000 feet of wire. He hopes to receive aid from the British Government for experiments on aerial defense of this type.

DR. GODDARD'S RESULTS: A recent Associated Press story, confirmed to **Astronautics** by letter from the experimenter himself, revealed two interesting new steps in Dr. Robert H Goddard's conquest of rocket difficulties: (1) he has added a potential 30 per cent to the range of his rockets since his last announcement two years ago; (2) he has devised a successful method of controlling the

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ASTRONAUTICS, official publication of the American Rocket Society, is devoted to the scientific and engineering development of the rocket and its application to problems of research and technology. Published quarterly (January, April July, October) by the American Rocket Society, 50 Church Street, New York City. Subscriptions with Associate Membership, $3 per year. **Editor, G. Edward Pendray; Associate Editor, Laurence Manning.**

GALCIT proving stand now being completed.

ROCKETRY IN CALIFORNIA

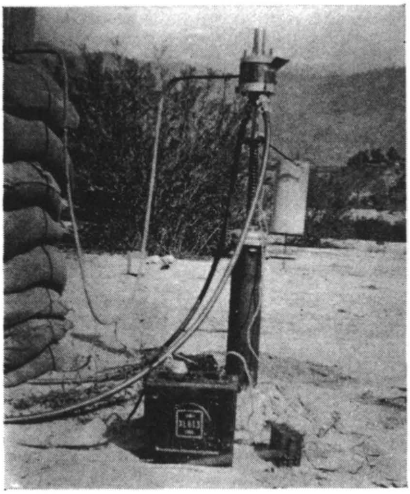
Plans And Progress Of The GALCIT Rocket Research Group

By FRANK J. MALINA
Pasadena, California

FOR the past two years a rocket research program has been under way at the Guggenheim Aeronautical Laboratory of the California Institute of Technology, supported primarily by a fund donated by Mr. Weld Arnold. The group taking part in the research consists of Frank J. Malina, Hsue-Shen Tsien, A. M. O. Smith, J. Parsons, Weld Arnold, and Edward Forman.

In the first phase of the project theoretical studies were made of the thermodynamical and hydrodynamical problems of the reaction principle as found in available literature, and extensions were made based on new knowledge of the phenomena encountered. Analyses were also made of flight performance of the sounding rocket propelled by constant thrust, as supplied by the constant pressure motor (c. f. "Flight Analyses of a Sounding Rocket" by F. J. Malina and A. M. O. Smith in the Journal of the Aeronautical Sciences, March, 1938) and by successive impulses, i. e., the constant volume motor (powder motor).

The second phase was devoted to elementary experiments of the two types of reaction propulsion in order to determine the problems to be met in making static tests of the motors. Tests were made on the test stand shown in Page 4, using methyl alcohol and gaseous oxygen in a motor of similar design to that developed by the American Rocket Society. Also



Preliminary proving stand.

a 50-foot ballistic pendulum was constructed and used for tests with methyl alcohol and liquid nitrogen dioxide (NO2) which were injected into a small steel motor. The apparatus as a whole was mounted on the pendulum bob.

Two Minutes Enough

From the theoretical studies and the elementary tests several conclusions were drawn as a basis for further experimental research. The analyses of flight performance showed that the constant pressure motor lining and exhaust nozzle would only be required to have a life of the order of two minutes. This fact is of a very favorable nature as it may offer the possibility of solution of the problem of withstanding the very high temperatures to be encountered in the motor (temperatures around 6000°F) without resorting to the use of motor cooling.

From the thermodynamical studies of the constant pressure motor it became apparent that a series of more or less exhaustive experiments of the effects of different factors, such as chamber pressure, exhaust nozzle shape, etc., on the thermal efficiency are needed to form a basis for reliable prediction of rocket motor performance. In this country no data have been published for chamber pressures above 400 lbs./sq. in., as reported by the American Rocket Society. Although E. Sanger made tests at higher chamber pressures, as reported in his paper "Nuere Ergebnisse der Raketen Flugtechnik" in Flug, December, 1934, the effect of chamber pressure on the thermal efficiency is not explicitly shown.

Use Gaseous Combustibles

The tests made with the constant pressure motors led the group to believe that for laboratory purposes it would be sensible to use gaseous combustibles. At first thought, there might be some question as to the usefulness of such a procedure since liquid propellants must be used in actual sounding rocket motors. However, further considerations lead one to expect that the results obtained with gaseous propellants should approach the optimum that can be expected from any constant pressure motor as more complete combustion should be possible, due to the simple method of controlling the chamber mixture by manually operated regulating valves. E. Sanger in the paper mentioned states that the completeness of combustion in the main determines the rocket motor's thermal efficiency. Furthermore, recently, A. Bartocci presented in an excellent report (La Forza Di Reazione Nell'efflusso Di Gas, L'Aerotecnica, March, 1938) the results of experiments on the reaction force using cold oxygen gas, and his results verify the theoretical analysis made by this group, at least for this more simple case of a cold exhaust gas.

On Page 3 is shown the test stand now being completed for the study of the constant pressure motor using gaseous combustibles. Many of the details of experimental technique remain to be worked out. However, preliminary tests have already been made. The apparatus in its present form has several design details which may be of use to other experimenters. For this reason some of the apparatus will be discussed in detail.

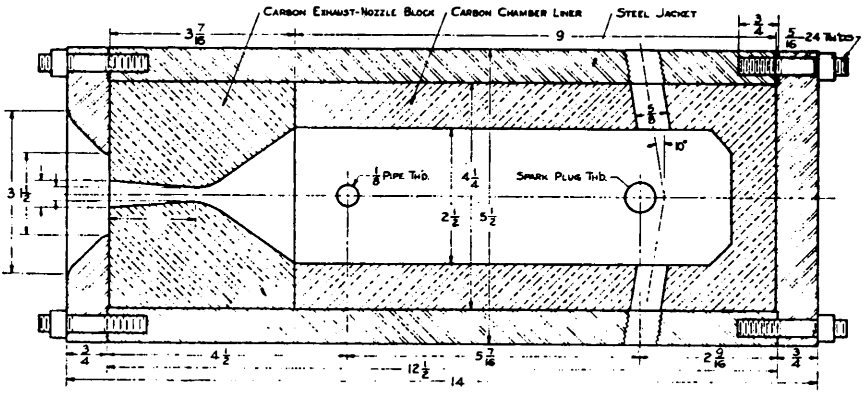
Pressures from 100 to 1000 lbs.

On Page 5 is shown a cross-section of the combustion chamber. The chamber pressure is to be varied from 100 lbs./sq. in. to 1000 lbs./sq. in. and with the rates of flow of combustibles planned a maximum thrust of 20 pounds is expected. The motor is not provided with cooling, although the test stand is designed to allow cooling medium to be supplied.

Tests of various types of refractories with an acetylene torch (temperatures around 5000°F) showed that no commercial refractories, except carborundum, offered useful possibilities. As carbon is highest in melting point in the table of elements it was also tested (carbon in the form used as electrodes in refractory furnaces). The resistance of the carbon to temperatures of the acetylene torch justified an attempt of its use. The carbon electrode is easily machined into forms needed in the rocket motor. As its strength properties are not of sufficient amount, the liner and nozzle block are tightly fitted inside a steel jacket which carries all the loads produced by the chamber pressure. A test of the motor at 300 lb./sq. in. chamber pressure for a period of one minute showed that the carbon liner had withstood the temperatures and the exhaust nozzle throat which was of 0.136" diameter suffered only an enlargement of 0.015" due to the erosive action of the exhaust gases.

Ethylene as Fuel

In the diagram (See cover) is shown the arrangement used to supply the combustibles to the motor and the method of obtaining necessary data. At present ethylene (C_2H_4) is being used as a fuel from cylinders under 1200 lbs./sq. in. pressure. The gas flows from the cylinders through a flowmeter; its rate of flow being controlled by hand valves, through a burner into the combustion chamber

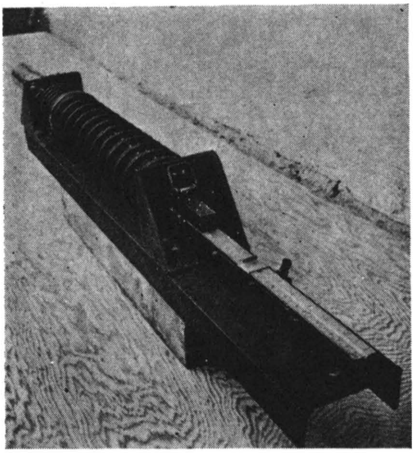


Proposed experimental carbon-lined motor.

where it mixes with gaseous oxygen, which is supplied in a similar manner from cylinders under 2000 lbs./sq. in. pressure. At first "wire drawing" of the ethylene through the control valve caused freezing. This difficulty has been eliminated by adding sufficient heat to the gas before it passes through the valve.

Measuring the Thrust

The measurement of the thrust developed by the rocket motor has in the past been troublesome due to the fact that heavy tubes had to convey the combustibles under high pressure to the combustion chamber. In this stand A. M. O. Smith has applied the method of the torsion balance for measuring the thrust, utilizing the tubes themselves as the torsion member. The motor is supported on a lever made up of the tubes which are extended ahead of the torsion member and is balanced by a beam and counterweight. An extension of the balance beam actuates a dial gauge when the motor thrust causes rotation about the torsion member. This method of measuring the thrust has been found to be very accurate and sensitive.



Dry fuel test set-up.

The instrument panel shown on Page 3 will be photographed during the tests and will give the motor thrust, chamber pressure, propellant line and cylinder pressures, rate of flow of combustibles, and time elapsed.

Studies of the powder motor showed that many of the possibilities mentioned by R. H. Goddard in his paper "Method of Reaching Extreme Altitudes", Smithsonian Institute, 1919, were indeed worth striving for. Although the most difficult problem of the powder rocket appears to be the reloading mechanism, it was felt that additional and supporting data of the powder motor efficiency was desirable before design of a rocket propelled by successive impulses was attempted.

Dry Fuel Experiments

At present J. Parsons and E. Forman are conducting experiments with powder in a motor of similar design to that used by R. H. Goddard, and it is planned to study the effect of the weight of the powder change, i. e., the chamber pressure, on the thermal efficiency and also the characteristics of different types of powder. The tests are being made in the setup shown on this page.

In all the various phases of the project, the research group has depended greatly on the valuable advice of Drs. Th. von Karman, C. B. Millikan, and E. E. Sechler. The group especially wishes to express its appreciation of their scientific fortitude.

The Society is cooperating with authorities of the New York World's Fair, with a view to incorporating a rocket exhibit at the Fair. Details will be announced later.

WEATHER INSTRUMENTS

Mr. Carver Suggests Some Ingenious Radio Operated Types

BY NATHAN CARVER
New York City

CONVENTIONAL instruments for measuring air and the condition of the air depend for the most part on the conditioning of some mass of matter to move a pointer or to expand or contract metal or liquid.

This action, unfortunately for the weather rocket, involves time lag and delays the sampling of different strata. These problems have been frequently discussed at meetings of the Society, and various solutions proposed. Here are some suggestions which may overcome the difficulty:

1. Since weight is a very important limiting factor in rocket flight, any system which saves flight weight is worthy of careful consideration. I suggest that we can save weight by recording meteorological data on the ground, near the flight base, by radio. Radio instruments in the rocket can transmit readings either simultaneously on as many wavelengths as there are instruments, or by means of a rotary switch with a timer, as in the radiometeororgraph.

2. The radiometeorograph, however, does not act quickly enough for use in the meteorological rocket. Perhaps radio could be made to read the condition of the air directly, instead of merely "reading" the more or less conventional type instruments of the radiometerograph. This could be done I believe, by utilizing the principle that air is a dielectric, the dielectric properties of which vary in proportion to pressure, humidity, temperature and other factors.

To measure temperature, for example, a radio frequency oscillator of a stable type, such as a dynatron or a Barkhausen Kurtz, might be used. Two identical coils and identical condensers would be required, one set to each oscillator. Both oscillators would be adjusted on the ground to exact resonance (zero beat). Both circuits would be identical except that the air tuning condenser of one would be exposed to the air passing the rocket, while that of the other would be enclosed in a constant temperature chamber with minimum air circulation. The difference in beat that would develop in flight, therefore, would be a measure of the difference between the temperature of the outside air and that of the constant temperature chamber.

Barometric pressure, humidity, or any other factor that might affect the dielectric properties of the air, could similarly be measured; the basic principle being that if all other factors are equal on both sides of the oscillator balance, a change of one of these factors on one side during flight will produce a beat note that can be calibrated experimentally and used to measure the amount of unbalance and therefore the quantity of the disturbing factor.

Power supply for such instruments could be had from light primary batteries of low voltage and high amperage. High voltage could best be obtained from a vibrator mounted on a step-up transformer; the reed of the vibrator being actuated by a slot in the flux gap of the transformer.

RECENT ROCKET PATENTS

Cooling Systems, Gyroscopic Control; Aircraft Deceleration

TO the many designs for cooled motors proposed by rocket experimenters Dr. Robert H. Goddard on July 5 added a new one, embodied in U. S. Patent 2,122,521, illustrations for which are reproduced on this page. It consists of tubing wound helically around the thin inner wall of the combustion chamber. Heat transfer is improved by properly-shaped "filler strips" wound around the chamber in such a manner as to fill the spaces between the windings of the tube.

Dr. Goddard proposes several kinds of filler strips and strip arrangements, as indicated in the seven different Figures. "It is the general object of my invention," he explains, "to provide an improved cooling jacket construction by which such (combustion) chambers or containers may be very effectively cooled by a jacket structure of minimum weight."

Other interesting patents not previously reported in **Astronautics** include the following:

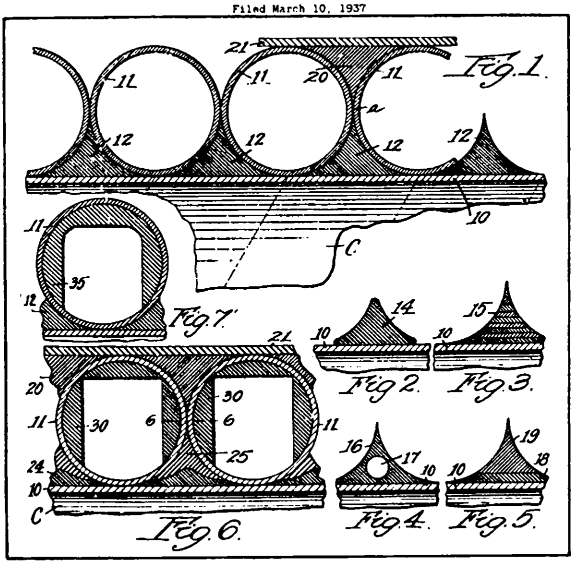
"Method of Producing Motive Forces on Aircraft, by the Explosion of Inflammable Mixtures of Substances", No. 1,983,405; granted to Paul Schmidt, of Munich, Germany.

"Means for Decelerating Aircraft", No. 1,834,149; granted to Dr. Robert H. Goddard, of Worcester, Mass. A method for slowing rockets or airplanes without adding materially to the weight or deflecting the flight.

July 5, 1938. R H GODDARD 2,122,521

COOLING JACKET CONSTRUCTION

Filed March 10, 1937



Dr. Goddard's cooling jacket construction.

"Apparatus for Charging Explosion Chambers", No. 1,982,666; granted to Hans Holzwarth, of Dusseldorf, Germany.

"Rocket", No. 1,879,579; granted to Herman Stolfa and Rudolf Zwerina, of Vienna (Austria). The inventors believe that by turning the jet back on itself they have increased the efficiency.

"Rocket Motor Airplane", No. 1,838,984; granted to Louis Berkowitz, of New York. Says the inventor: "The invention has for an object the construction of an aeroplane which is characterized by a plu-

(Continued on Page 15)

DRY FUEL EXPERIENCES

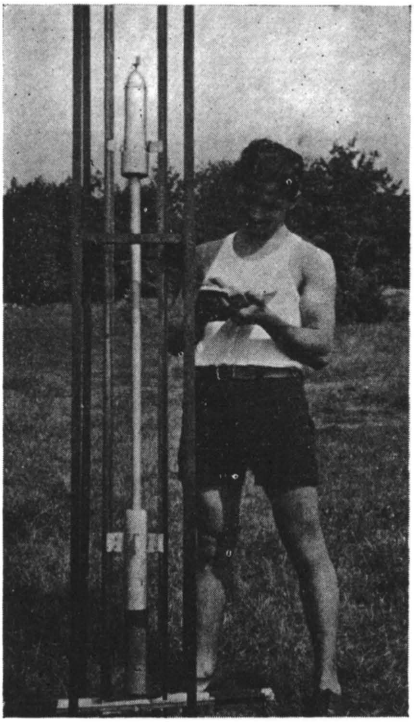
Mr. van Dresser Reports Some Interesting Parachute Trials

By PETER VAN DRESSER
Ft. Lauderdale, Florida

MR. John Shesta's recent suggestion as to the desirability of experimental work on parachute mechanisms, with the aid of gunpowder rockets, may make worth while a summary of some tests of this sort I carried on in the summer of 1935, near Danbury, Connecticut, with the help of Mr. Alfred Africano.

The tests were intended to throw some light on the question of the most suitable placing of the rocket motor —at the nose of the rocket, at the center of mass, or at the tail. The largest type of rocket manufactured by the Unexcelled Fireworks Company— the so-called "six-pound" size — was selected as the motive power for the models. The cartridges or carcasses of these rockets were obtained minus the tail, "garniture", wrapping and other accessories. They were about two inches in diameter and fourteen inches long, and weighed a pound and a half.

After some preliminary tests to reveal the thrust characteristics of these rockets, two types of models were designed and built, to be powered by the "six-pound" cartridges. The first was primarily to test a simple type of parachute release, to provide practise in launching and sighting technique, and to test the extreme "tail-drive" type of long, slim rocket. The second was more elaborate. It was a tubular aluminum rocket shell, made so that the driving cartridge was contained within the shell, discharging through the rear opening. The position of the cartridge could be varied from the nose to the center of mass and the tail. The over-all shape, weight and weight-distribution could be kept constant for the different positions by shifting a pair of ring-weights along outside of the shell. I planned to run a series of shots with this rocket using cartridges (which corresponded to the motor of a liquid-fuel rocket) in different positions. By noting the stability of flight under the varying condi-



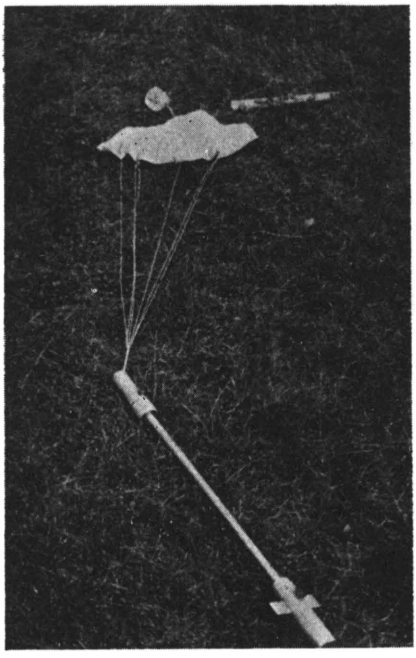
Preparing model for flight—launching catapult set.

tions, some idea could be got as to the relative merits of "nose-drive", tail-drive" and "center-of-mass drive" rockets. Each model weighed about three and one-half pounds.

Program Curtailed

It proved impossible to carry out the entire program. The tubular rocket, designed for flights under varying conditions of motor placement, was a complete failure. The rocket-cartridges when firing through the shell lost about half their thrust, and the heat of the jet melted the aluminum. It was therefore impossible to get any comparative results with this equipment.

About a dozen flights were made, however, with the simpler tail-drive model, launched from a ten-foot rack equipped with a catapult. Due apparently to slowness in getting under way, the altitudes reached were only about 200-250 feet, much less than that theoretically possible with the available impulse and mass. It was difficult to release the catapult (by a cord attached to a trigger) at precisely the right instant before the fuse touched off the charge. If the operator delayed an instant too long, the rocket accelerated away from the catapult, since the thrust of the exhaust was if anything greater than the force developed by the elastic shock-cords that actuated the catapult. However, in one flight when the timing was exactly right, an altitude of over 400 feet was reached.



Pilot 'chute, main 'chute and rocket after landing—untouched.

The long, thin tail-drive rocket was quite stable in flight; the peak of the trajectory generally did not deviate more than twenty or thirty feet from the true vertical. On one flight, however, the rocket flew in a marked curve, landing about a thousand feet away. There was no visible reason for this, other than a possible irregular combustion of the powder charge.

Parachute Release

Interesting results were obtained from the type of parachute and release employed. The parachute was of pongee-silk rinsed in borax-water and ironed for maximum smoothness. It was of conventional design, 32 inches in diameter, with a two-inch vent in the center, bound with cord. A square pilot parachute, ten inches on each side, had its four shrouds run down and sewed firmly into the edges of this vent-hole The main 'chute was packed by suspending it from the center and allowing it to fall in regular pleats like a folding umbrella. The long wedge-shaped fold of fabric was then rolled from the point, leaving the pilot 'chute dangling outside the cylindrical roll which was the final result. The shrouds of the pilot 'chute thus emerged from the center of this roll, while the main shrouds came from its outer surface.

The roll was then slipped into a cylindrical space about four inches long provided for it in the nose of the rocket. The main shroudline was coiled beneath the roll and fastened to a bolt in the bottom of the 'chute chamber. The pilot chute was crumpled in a small wad and placed on top of the roll, above the edge of the rocket shell. A bullet-shaped aluminum cap was then set in place covering the pilot 'chute.

So long as the rocket was accelerating or travelling upward along the line of axis, air-resistance pressed this cap firmly in place. At the apex of its flight, however, the rocket would tend to lob over and fall sideways for a short distance. The lateral air-resistance developed in this process blew the light cap off sideways, the air caught the pilot chute and jerked it open, the head of the rocket was jerked back to the vertical again and the main chute pulled out of its case. Two pairs of small vanes were placed at the point of the cap to increase its lateral resistance and make it more sensitive in operation.

Pilot 'Chute a Success

This method of release of course would not do on a large rocket where positive action is essential, as during a curving trajectory the air-pressure would always press the cap in place and no lateral pressure would be generated. This actually happened during the one curving flight, which in fact duplicated in miniature the flight of ARS rocket number 4, in which Mr. Shesta's parachute release designed on similar principles also failed.

Rocket being placed in rack—catapult sprung, showing construction.

However, the interesting thing was that on every occasion when the pilot parachute was freed, it never failed to swing the rocket and release the main parachute. The mechanism worked on all flights except the ones mentioned, although once several shrouds tore loose. This would appear to be a useful principle for rocket designers to employ, since release and ejection mechanism for a pilot parachute can be so much smaller and lighter than for the main parachute. Besides this advantage, the pilot parachute serves to slow the fall of the rocket somewhat so that the full force of the deceleration is not thrown on the main parachute and its shrouds.

The chief difficulties in the way of making adequate tests with powder-rockets appear to be:

First, the extremely high acceleration rate and short firing period of this type of rocket make it more of a projectile than anything else, so that its behaviour is not comparable even to a small liquid-fuel rocket, which should accelerate comparatively slowly for a much longer period.

Second, the shape of a gunpowder rocket makes it difficult to adapt to the characteristic shapes of the liquid fuel rocket. Either it must be inserted in light dummy hulls whose weight-distribution apes a liquid-fuel rocket of the same proportions, or ballast must be used to correct the situation, in which case the total load is so heavy that the flight range is greatly reduced.

Third, irregularity of burning (for which even the most carefully made gunpowder rockets are notorious) makes uncertain many observations as to flight stability.

A nearer approach to the conditions of liquid-fuel shots could be obtained by using large powder rockets of the life-saving type. Some of these rockets, as tested by Louis Damblanc in France, developed peak thrusts up to 100 kilograms and burned for as long as 4 seconds. (**Astronautics** No. 33 contains a summary of these tests). Large models could be made, powered by such rockets, which would closely simulate liquid-fuel rockets as far as the masses and forces involved are concerned. But even so the time of actual acceleration in free air — which is the unique factor in rocket flight—would be so short that effective studies would be difficult.

Letters to the Editor

MR. C. P. MASON, whose gift for digging up odd and interesting items of information is well known, writes to say:

> A friend showed me an old book which contained a description of what is, I believe, the first scientific attempt (as distinguished from theory) to establish rocket or reaction propulsion by continuous combustion. I jotted down the essentials.

Mr. Mason's enclosure, copied from **Mechanic's Magazine, Museum Register, Journal and Gazette** (London) of Saturday, February 27, 1847, was the following:

> In our Journal of 25th October, 1845, we give a full account illustrated by engravings, of a new method of propelling vessels patented by Mr. Alex Gordon, to which he has given the name of "Fumific Propulsion". The inventor has since subjected his theoretical conceptions to the test of actual experiment, and has published the results in a pamphlet . . .
>
> "Having constructed a small model boat, with brass rocket case in the hull, I made a series of rocket experiments with different compositions. The model boat displaced 15 pounds weight of water and a common one-ounce rocket, inflamed under water, impelled this boat 30 feet in 4 seconds, or at a rate rather over 5 miles per hour . . .
>
> "Into a boat, 26 feet long and 4½ broad, I fitted a close furnace or retort, and a common forge bellows. Each stroke of the lower portion of the bellows passed air through the close fire for the hot products of combustion to rush out against the water. The products of combustion, almost altogether aeriform, but also occasionally mixed with smoke, dust and ashes, rushed out, at a temperature of 800 or 900 degrees, by the discharge pipe, which was 3 inches in diameter.
>
> "The first blast, by one man, always started the boat, weighing nearly two tons, from a state of rest, three feet in two seconds: and I believe that no two men, with oars or sculls, with all the advantage of their flexor and extensor muscles, could do more. And neither paddle wheels, nor the Archimedean screw can start the same weight into such motion in the same time."

The Rocketor's Workshop

PARACHUTES FOR ROCKETS— Roy Healy Tells How to Make, Fold and Use Them

The idea of slowing the descent of a falling body, by means of a cloth canopy, is centuries old. Strangely enough, one of the first uses to which it was put was in lowering empty rockets and suspending pyrotechnics in the air. Long before the first Montgolfier balloon rose from the earth, men skilled in the preparation of spectacular fireworks were using small 'chutes to hang blazing displays in the night skies. Old records tell of sending small animals aloft in rockets and their safe return by 'chute.

Parachute Patents

At the opening of the 20th Century, Maul of Germany and Antoonivich of Russia were granted patents on parachutes designed to lower empty rocket shells. During the World War the parachute really came into its own; for not only were many lives saved in the air, but millions of small 'chutes were used in conjunction with magnesium flames, "flaming onions", star shells and other devices, many of which were shot skyward by rockets.

Goddard may be credited with the first application of the device to a liquid fuel rocket. On his shot of July 17, 1929 a 'chute lowered the rocket, containing a barometer and camera, unharmed. Since then he is said to have perfected his method of ejection to the point where it functions "unfailingly". During 1927, 1928, 1929 several Germans demonstrated powder rockets equipped with 'chutes. The G. R. S. claim to have installed them in their later "Repulsors", and Winkler had one in his large liquid fuel rocket which exploded when shot during 1932.

Parachutes have reached their highest state of efficiency as lifesaving devices, hence a few characteristics of this type may be of interest to those seeking to apply them to rockets. The best 'chutes are made of the highest grade of Japanese "Habauti" silk, imported as yarn and woven here by special processes. Its weight is about 1.45 ounces per square yard. Recently pongee silk has appeared as a competitor as it is much less expensive and but slightly inferior in quality. Either silk must meet Department of Commerce specifications for 'chutes; filing 90 and warp 120, double threads, tensile strength of filing 50 pounds, of warp 40 pounds. Tear resistance 6 pounds across filing, 4 pounds across warp. (Warp is vertical, filing horizontal).

The silk is sewn together in triangular patches to form a large circular canopy, at the top of which a round vent is left open to prevent bursting of the 'chute when rapidly opened; also allowing the trapped air to escape, reducing swinging. The shroud lines, of silk cord, run up one side of the dome and down the other, usually being 12 in number, but giving the appearance of 24 lines from the skirt down. The number may be reduced for smaller 'chutes.

Rate of Descent

An average 'chute is 24 feet in diameter, giving a man weighing 175 pounds a rate of descent of 16 to 18 feet per second. Empirical figures which may be applied to rocket 'chutes are:

Sq. ft. of silk per lb. of load	Drop per second, in feet
3	14
4	10
5	8

It must be borne in mind that while slow descent is desirable, the slower the descent the greater the wind drift.

When a jumper jerks the ripcord, rubber strands pull back the flaps of the canvas pack, allowing the spring-loaded pilot 'chute, usually 30 inches in diameter, to pop out and drag the main 'chute after it. Complete opening is accomplished from 1½ to 3 seconds after the ripcord is pulled. The pilot 'chute is not being used in the latest models, but will undoubtedly be of use in rocket installations. Small 'chutes of the type used by the Navy to drop flares and messages are available for a few dollars each and would probably be suitable for present experimental work.

When not in use 'chutes should be loosely rolled and stored in a clean, dry place. Unrolling and airing once monthly will prevent molding and deterioration of the silk. If the silk becomes spotted with dirt or grease, do not wash, but clean with a non-injurious solvent.

When preparing for use stretch 'chute out on a clean table, separate lines into two groups and hold down at one end of table. Straighten out panels until 'chute lies in flat triangular shape. Fold both longitudinal edges in to the center, then from the skirt, fold endwise, fold on fold, until a small flat bundle is made. Fold up shroud lines, avoiding tangles. Do not roll up the 'chute, or wind the lines around it, as this will delay and may prevent opening.

—Roy Healy.

ROCKET VALVES — Mr. Pierce Suggests One That Doesn't Interfere With Streamlining

The success of any rocket experiment will depend largely upon the type of valves that are selected, and how they will perform under the difficult conditions of extreme low temperature and high pressure present in rockets. Too much attention cannot be given this subject of the valves.

It is not wise to trust that the valves used in industry will serve the purpose of the rocket. Industrial valves are designed to meet certain conditions, but whether in the low or high pressure field, these same conditions are seldom found in rocket experimentation.

In searching for valves for the rocket it is not really necessary to look for new principles as well as new designs, but to design anew around known principles. The ball type valve lends itself very readily for use in rocket or test stand work. In fact this valve has been used by experimenters with a great deal of success and is very much favored. When under pressure this valve will have a minimum of leakage and will not freeze when used with liquid oxygen.

Ball Valve and Clamp

The ball valve, as used with the pull-off clamp, should have features incorporated into the clamp to compensate for any distortion which may occur in the valve seat. The clamp, having a strong spring action due to the design at the top, will force the ball down as the seat increases in diameter.

In test stand work, where added weight is not important, the same valve can be equipped with a clamp permanently attached to the body of the valve. The valve can be opened or closed from a distance by the use of a can and lever action.

Valves will very often figure in the general design of a rocket, for some provision must be made for easy access to the valve and necessary clearance made for pulling off the clamp. Often as not this makes for difficulty with the streamlining of the shell. It is desirable then to have a valve that will be light, easily operated from a distance and one that can be used without breaking up the smooth lines of the shell.

An Electric Valve

One suggested to meet these conditions incorporates the principle of the rupture disc. Since it is to be used only to turn on the fuel and thereafter remain open, there is no reason why a true valve should be employed. This electrically operated valve is made up of a specially constructed pipe union. Between the parts of this union there is placed a rolled silver disc, which will act as a seal in the feed line when tightened. The lower part of the union is provided with a tubular fitting which houses a sharp-pointed plunger, the outer part of this housing being wound with several layers of copper wire.

In operation, the fuel under pressure will be released when the coil is energized, causing the pointed plunger, which is in an off balance position, to rise suddenly and puncture the thin silver disc. Once the disc is punctured, the pressure will complete the action of ripping open the clearance for the passage of fuel.

The current needed to operate this valve can be supplied by a storage battery of six or eight volts, depending upon the construction. To use this valve again it is only necessary to open the union and replace the disc.

This valve need not interfere with the streamlining because the two wires of the coil may be brought out through the shell by properly insulated terminals. To these terminals the leads for current supply are connected by simple clips. The storage battery should be placed on the ground as near to the rocket as possible. When the rocket begins its ascent the clips will simply be pulled off the terminals.

Valves of the type described have been constructed and have been found by experiment to be satisfactory.

—H. Franklin Pierce.

PATENTS (Continued from Page 8)

rality of rocket motors to aid in propelling. It is proposed to arrange these motors along the wings and body."

"Explosion Turbine", No. 1,982,665; granted to Hans Holzwarth, of Dusseldorf, Germany. Charges of fuel and air are fed periodically to one or more explosion chambers associated with the rotor of the turbine.

"Mechanism for Directing Flight", No. 1,879,187; granted to Dr. Robert H. Goddard, of Worcester, Mass. The noted experimenter's gyro control mechanism.

"Method of Producing Rockets, Especially for Aeronautic Purposes", No. 1,880,579; granted to Reinhold Tiling, of Osnabruck, Germany. The late German expermienter's method of making his powder rockets.

Copies of these patents may be obtained by writing to the United States Patent Office, Washington, D. C. Enclose ten cents in cash for each patent desired. —G. E. P.

Notes and News

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flight after his rockets have ceased firing. Details will be reported presently to the Daniel and Florence Guggenheim Foundation, which is financing the experiments.

CHANGE OF ADDRESS: Correspondents and members should note that the address of the Society's office has been changed. The new address is Room 382, 50 Church Street, New York; the telephone Cortlandt 7-2661. Visitors should ask for Mr. Laurence Manning.

ARS TECHNICAL COMMITTEE: To supplement the work of the Society's Experimental Committee, whose duties are concerned principally with the construction of rockets and auxiliary apparatus, the final launching and the recording of data, a new General Research Committee is now being formed which has been designated the "Technical Committee".

"Theoretical investigations and calculations covering rocket problems in all related fields of science," says President Alfred Africano's announcement, "will be referred to special sub-committees on Aeronautics, Chemistry, Physics, Meteorology, Astronomy, Mechanical Engineering, Electrical Engineering and Physiological Reactions of Rocket Flight, thus coordinating the entire technical and scientific resources of the Society's members. Both Associate and Active Members with suitable technical training are eligible for membership in these sub committees.

"Translations of articles in foreign language as well as reviews and reports will be part of the regular work of the Technical Committee. Technical questions will be referred to the proper sub committee as they arise. Frequent reports on the many theoretical problems should do much to advance our knowledge on the subject, and should help to make the regular meetings of the American Rocket Society a lively and interesting forum."

Dr. John Teeple has been appointed chairman. Qualified members who are interested in aiding in the theoretical investigations of the Technical Committee should communicate with Dr. Teeple at the Society's new address.

ROCKET EXHIBITS: During April and May this year an exhibit of historic rocket motors and rockets was viewed by visitors at the Hayden Planetarium, New Yoark. It included the shot-scarred motors of ARS rockets No. 2 and 4, and ARS rocket No. 3 complete. Also in the collection was Mr. James E. Wyld's promising new single-nozzle tubular regenerative motor.

THE AMERICAN ROCKET SOCIETY is open to membership for all persons interested in the development of rockets. Three types of membership are offered: Active, for experimenters and others with suitable technical training and experience; Associate, for those who wish to aid in rocket research and the publication of the results, and Junior, for High School students and others under 18. All members receive Astronautics, and are entitled to attend meetings. OFFICERS OF THE SOCIETY: Alfred Africano, president; H. Franklin Pierce, vice president; Max Krauss, secretary; Dr. Samuel Lichtenstein, treasurer. ADDRESS: American Rocket Society, Room 382, 50 Church Street, New York.