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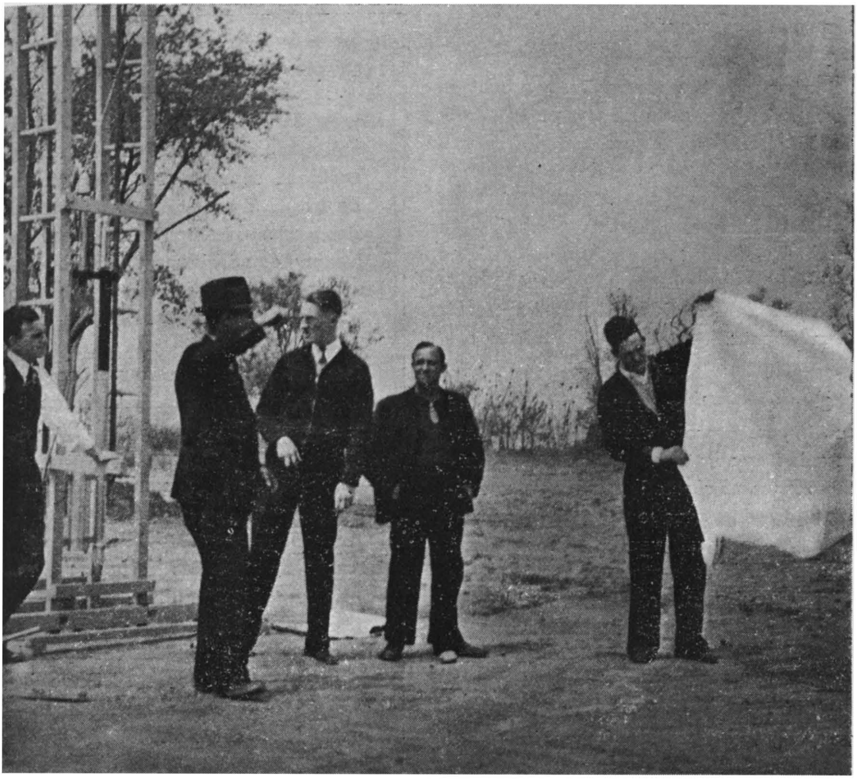

The Problem of Landing Gear—Mr. Shesta makes a preliminary study. **Rocket Trips Into Space**—Can a rocket be shot to the moon? **The Motor Takes The Spotlight**—Better motors on the way. **"House-broken" Rocket** — How to shoot them indoors. **New Proving Stand.**

Notes and News

THE BOARD OF DIRECTORS is the governing body of the Society: its members elect the officers, manage the organization's affairs, deal with the countless details that keep a society alive and operative. The seven members of the Board, elected by the active membership of the Society, are therefore charged with a peculiar and important responsibility.

The Society is fortunate this year in bringing two new members into the Board. At the annual meeting, April 29, Messrs. H. F. Pierce and James L. Wyld, both known widely for their important experimental work, were elected Directors. Members of the Board re-elected were Messrs. Alfred Africano, Max Krauss, Dr. Samuel Lichtenstein, G. Edward Pendray and John Shesta.

New Officers Elected

Officers and committeemen for the coming year were elected by the new Board immediately. Mr. Alfred Africano was re-elected President, a tribute to his excellent administration during the past year. Mr. Africano was one of the early members of the Society, a joint recipient, with the Society, of the Rep-Hirsch Award in Astronautics in 1936. He is a graduate of Stevens Institute of Technology with the degree of M. E. and is an engineer of the Interborough Rapid Transit Company in New York.

Mr. H. F. Pierce was elected Vice-President. Mr. Pierce also was one of the early members of the Society, was co-designer of the Society's first rocket, and has been closely identified with experimental work. His name and work are well known to readers of Astronautics.

Mr. Max Krauss, who served as Secretary last year, was re-elected to this important post. Dr. Samuel Lich-

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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, 420 Lexington Avenue, New York City. Subscriptions with Associate Membership, $3 per year. **Editor, G. Edward Pendray; Associate Editor, Laurence Manning.**

LANDING GEAR RELEASES

Road-map for An Excursion into Unexplored Territory

By JOHN SHESTA

SO far as the writer knows, a really successful and foolproof parachute or other landing gear release for use on liquid fuel rockets has not yet been built, perhaps because enough attention has not been devoted to this phase of rocket development. The importance of such a device is self evident, and hardly needs to be enlarged upon. This article is written in the hope that interest will be stimulated in the subject, and more independent experimental work will be done on parachute releases this summer. Such work does not require any elaborate equipment, and the tests can be made with powder rockets.

Requirements

A satisfactory parachute release has to fulfill certain basic requirements, as outlined below:

1. A premature ejection of the parachute must not take place.

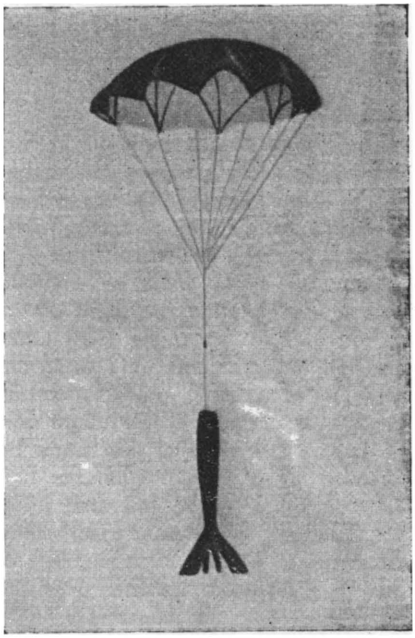
2. The release should positively function when the rocket begins to lose altitude, and be independent of any other factors whatsoever, such as the orientation or any lateral motion of the rocket.

3. It must not be thrown out of adjustment, or affected by vibration, shocks, or forces of acceleration.

4. The weight and size should be kept down to a minimum consistent with reliable operation.

Ejecting the Parachute

In practice the parachute is carried in the rocket in a special compartment, from which it is ejected at the right moment. Should the main parachute itself be forcefully ejected, there is some danger of fouling the shroud lines, so it is more desirable to make the release eject merely the pilot parachute, which will in turn unfurl the large one.



Oberth planned to have his rockets land by parachute, in this manner.

The ejecting device may be variously constructed, and may depend upon the action of a spring, a blast of compressed gas, or an explosion of gunpowder. The latter method is simplest and has been most often used, as the charge of powder can be ignited electrically by means of a fine resistance wire and a miniature battery. One disadvantage of the method, however, is the danger of burning the parachute.

The ejection of a parachute by compressed gas involves some slight additional complication of mechanism. The writer has not heard of the method being used, yet it appears that because of its freedom from the danger of burning the parachute, it merits further attention.

Gas Ejection

The charge of gas might be held in a very small tank, connected to one of the main rocket tanks by means of a fine tube, with a check valve, such as a tire valve, in the line.

Thus the tank could be charged automatically during the flight of the rocket, and yet when the main tanks are empty the small tank will still hold its compressed gas. A carbon dioxide "Sparklet" capsule might also be used. The blast of gas might be released by a special valve, or better still, by a spring operated firing pin, arranged to perforate a soft metal diaphram in the tank. The blast of gas thus released, instantly fills the parachute container, and ejects either

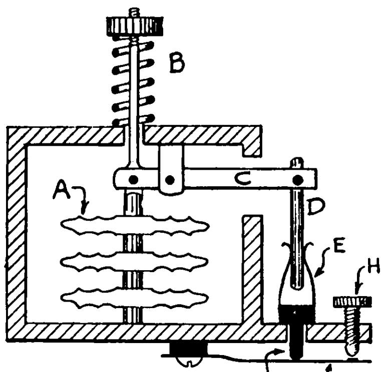


Fig. 1

Mr. Shesta's proposed barometric parachute release. (See Page 7).

the pilot or the main parachute, as the case may be. The trigger releasing the firing pin may be operated mechanically or electrically by a small solenoid.

There are numerous methods of actuating the landing gear simply by the release of a spring. Reinhold Tiling, among others, has used this scheme in connection with his powder rockets. (See Page 6—also **Astronautics** No. 39, page 7). The springs were released at the moment the powder was used up, and pulled a number of rather large guide fins out of line, which fins then acted as wings to effect a safe descent of the rocket. Tiling was the first experimenter to achieve a considerable degree of success with this method. In some of his models the wings made the rocket act as a glider, while in others, the whole rocket was made to spin rapidly about its axis, the fins acting as autogyro wings.

Advantages of Wings

This method offers some definite advantages over the parachute, as there is always a chance of the parachute not opening properly, of the shroud lines getting tangled up, and various other mishaps. It requires, however, a more careful design of the rocket. The wing area must be adequate to sustain the weight of the rocket, and yet, the wings must fold in such a way as not to offer undue air resistance during the ascent. The wings must be lightly built, and still be rigid enough to withstand the air impact and cantilever beam loading.

In large liquid fuel rockets, particularly those of long and thin cross section, the wings must needs be mounted on a bearing so as to spin freely without rotating the rocket itself, for such rapid rotation might prove detrimental to the rocket should any out of balance condition exist.

Trigger Mechanisms

Whatever the type of landing gear or arrangement in the rocket, the trigger mechanism which sets off the release is really the most vital part of the whole assembly. The operation of the trigger is made to depend upon some phenomenon connected with the behaviour of a rocket in flight. The devices so far used or proposed can be roughly divided into four types according to the phenomenon utilized, to wit:

1. A predetermined lapse of time.
2. Gravitational effects.
3. Air pressure on the nose of the rocket due to forward motion.
4. Barometric effects.

One of the earliest devices used by the Germans consisted simply of a photographic timer, or even a length of slow burning fuse, so contrived as to explode the powder charge after a lapse of time that the designer thought was "about right". The tank pressure method of release is an elaboration of the same scheme. When the tank pressure falls to zero, presumably at the end of the flight, a special catch releases the parachute, either at once, or after a suitable delay to allow for free flight. The time method is open to criticism from the standpoint that it is well nigh impossible to determine in advance the duration of flight. Besides it gives no protection at all in case a nozzle burns out or the motor misses fire in the air, or any other one of the many things that may happen.

Utilizing Gravity

The utilization of forces of gravity and acceleration offers many possibilities. When a rocket ceases firing it becomes a freely falling body. The

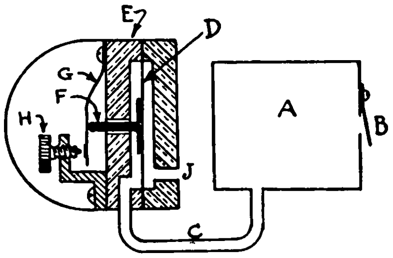


Fig. 2

Another type of barometric release mechanism. (See Page 7).

gravity acts upon the rocket as a whole, but any mass within the rocket experiences no downward pull with respect to it. At the end of the firing the rocket will generally have a high forward speed, and the air friction will produce rapid deceleration. This effect will cause any free body in the rocket to develop a force upward. These phenomena have been suggested to operate pendulous devices, mercury switches, escapement mechanisms, etc.

No. 4 Rocket Release

One of the simplest applications of the above principle was used by the writer on the A. R. S. No. 4 Rocket. The head of the rocket had a fairly heavy, loosely fitting cap with a delicate spring underneath, designed to throw it off and release the parachute at the peak of the flight. During the upward coasting period the air resistance held the cap in place. However, the one time the rocket made its flight the device failed to function.

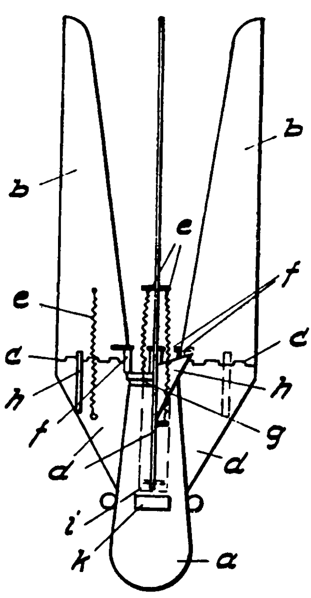
Later Messrs. Alfred Africano and Peter Van Dresser worked with powder rockets using substantially the same system with varying degree of success.

The air resistance type of release depends upon the increased pressure on the head of the rocket when it is traveling forward at high speed. A Pitot tube on the head of the rocket oporates a diaphram coupled to a switch through the medium of an escapement mechanism in order to prevent a premature discharge.

Parachute releases of the gravity, accelerated and air resistance types, albeit quite sound theoretically, have one fault in common. If the rocket does not come to a stop at the peak of its trajectory, but describes some sort of parabola, traveling at high speed, the release will not work. This, for instance, is what hapened to the No. 4 Rocket.

Reinhold Tiling's Patented Design

Fig. 1



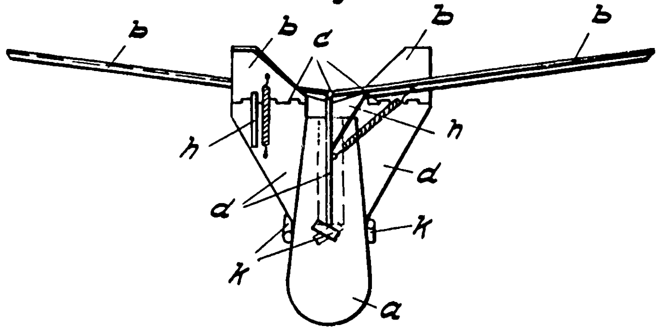
"The flying rocket, after the ignition of the charge, rises like a projectile with the fins in folded position shown in Fig. 1. When the rocket charge has finished its action or the flying rocket has reached the desired height and position, a recoil charge indicated by i in Fig. 1 is ignited either automatically or by the pilot, so that the rocket case accommodating the charge and the ring g are thrust out towards the rear.

"This ring g bearing against the slidable locking plates shifts the same over the point of articulation of the fins b, and the springs e then pull automatically the fins into the approximately horizontal spread position shown in Fig. 2. The flying rocket then commences its free fall, the fins b retarding the flight like a parachute . . .

"In order to completely or entirely stop the drop shortly before the rocket comes into contact with the ground, rocket aggregates k are also connected to the flying rocket and may be arranged . . . so that they discharge tangentially outwards, namely in opposite direction to the direction of the flying body. These aggregates become operative shortly before the rocket reaches the ground so that a lifting force acting in opposition to the free fall is produced owing to the increased torsion of the flying rocket."

—Quoted from U. S. Patent 1,880,586, issued to Reinhold Tiling, of Osnabruck, Germany, Oct. 4, 1932.

Fig. 2



Barometric devices seem most likely to be the key to the ultimate solution of the problem and are deemed worthy of more detailed discussion. Their chief advantage is that they depend solely upon the ascent of the rocket, irrespective of other disturbing factors. Barometric devices were first proposed by Mr. James Wyld, who is at present conducting research along these lines.

Barometric Methods

One type of barometric release is shown in Fig. 1, (Page 4). The delicate parts are drawn somewhat out of proportion for the sake of clarity. A number of aneroid cells, such as are used in barometers (A) are held distended by an adjustable spring (B). A lever, or a system of levers, as at (C) causes the rod (D) to move up or down. As the rocket ascends, and the barometric pressure drops, the evacuated cells (A) expand and the rod (D) moves down. It slides between two delicate spring blades (E). These blades are attached to the hard rubber button (F), which has a shoulder and cannot move down. When the rocket begins to fall, air pressure will increase and contract the aneroid cells. Rod (D) will move up and lift the rubber button (F), thus allowing the insulated switch blade (G) to rise and contact the screw (H). A variant of the straight barometric principle employs a system similar to the one used in aviation in the rate of climb indicator. It is shown in Fig. 2 (Page 5).

A hard rubber box (E) is provided with a delicate diaphram (D), made from a thin rubber membrane. One side of the box connects to an air reservoir (A) by tube (C). While the rocket ascends the air in the reservoir expands and escapes through a rubber check valve (B). When the rocket begins to fall, the air pressure will increase, and close the valve (B). The denser air will enter the diaphram box through orifice (J). This slight increase of pressure will deflect the rubber membrane to the left, push on the rod (F), and cause the switch blade (G) to contact screw (H).

Notes on Design

The barometric pressure scale becomes very small at extreme altitudes, but we need not worry about that at present. At moderate heights one inch of mercury corresponds to about 1000 feet of altitude. The barometric device must therefore be quite sensitive. A reasonable assumption would be a free fall of about one hundred feet before the parachute is released. Too sluggish an instrument would cause the rocket to develop too great a downward velocity, and besides, in case of an impotent rocket, the release might function too near the ground to do any good. The barometric device, therefore, should be able to operate with a pressure differential equal roughly to one inch of water.

In designing the instrument shown in Fig. 2 for the same pressure differential we should really allow one half inch for diaphram displacement, in which case the volume of the air reservoir (A) will be about 760 times the volumetric displacement of the diaphram.

Release by Gyro

This discussion of release mechanisms would be incomplete without mention of an entirely different principle suggested some time ago by Mr. Street of Providence, and later, independently, by H. F. Pierce.

The proposed rocket carries a gyro with its axis of rotation parallel to

(Continued on Page 12)

THE MOTOR TAKES THE SPOTLIGHT

The Road Ahead—A Significant Experiment—Tests to Come

So many interesting and important communications on rocket motors have come to hand recently that they seem unusually significant. Are we on the verge of solving the motor problem? Something like that is suggested by this impromptu symposium.—Ed.

PROGRESS? — Yes, Says Mr. Manning

Talk about rockets has been passing through a series of stages for the past fifty years that almost seem as though the deeper the study, the less the progress and the more modest the claims. From old, enthusiastic schemes for rounding the moon, it dropped to ideas for crossing the ocean. Then came a further fall to plans for meterological study by rockets and a series of experiments to shoot a liquid fuel rocket even a mile or two into the air. Nor was this the final stage, at least in the experiments of members of the American Rocket Society. There followed for the past two or three years a series of tests to devise such a humble beginning as a liquid fuel motor that would work on a stationary test stand!

No Discouragement

Out of this retrogression it is possible that some experimenters may derive discouragement. I, on the contrary, discussing the subject and watching experiments closely, derive a swelling satisfaction that the problem has been reduced to the point where it will in all probability be solved by a few more months of work.

The circumstances which lead to this conclusion are roughly as follows: All ambitious schemes in rockets that have been put forth in the past have depended on one basic assumption—a motor that uses liquid fuels efficiently. Now this assumption still holds: grant the motor and the wildest dreams are just as good as ever. So what has seemed to be a retrogression in rocketry has really been a business of searching for the basic problem and narrowing down the field to the one point—the pivot on which the whole must turn.

Necessity and Advantage

Progress in motor design has been marked. The big news, so treated in conversations between rocket men this winter, for instance, was the (1) necessity and (2) immense advantage of a form of cooled motor in which the fuel prior to burning runs through a jacket around the motor. This does two things: first it cools the actual motor, or combustion chamber, to temperatures which enable the builder of it to use simple metals in its construction, and second it pre-warms the fuel so that it burns more quickly and completely inside the chamber. The first is my "necessity" and the second is my "immense advantage".

As to the necessity part, consider that of all our testing-stand motors not one burned 30 seconds with pure gasoline and oxygen. In nearly every case the metal gave way either to the temperature or to the combined temperature and erosion. Since the nozzles of many were made of Nichrome (about as high a working temperature of any practical material) their failure marked the end of the road except for substances like tungsten carbide which cannot be worked on a lathe.

The end of the road—but why did we take the road? Why, when early rockets of the German Society were water-cooled in many cases, did we not continue with cooled motors? Because water weighs pounds and reduces efficiency. Why did we not load our fuel with carbons, or frankly water it, as did some experimenters? Because again efficiency must suffer —and efficiency is necessary if rockets are to be in any practical sense useful means of transportation. Why not have cooled with fuel? I presume no one ever got around to it.

So now I, for one, am an outright optimist. It seems to me probable that rocket research is in the position of an explorer in a strange country. He sees a mountain ahead, and trying to reach it has taken several paths all of which ended in impassible quagmires. Now there remains only one path and in starting along it he finds it ascends above the lowlands and directly to his objective. There may be impassable chasms or cliffs ahead, but so far it would appear that by mere walking he can reach his goal at last.

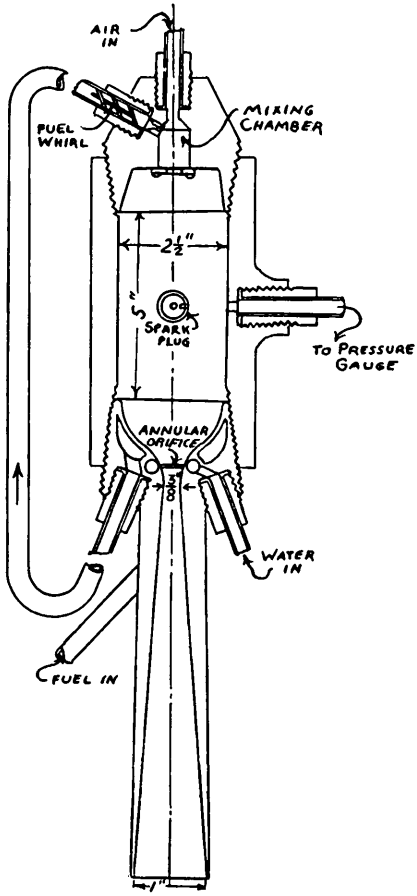
And as I have hinted, a number of experimenters are taking the walk right now.

—**Laurence Manning**

GAS, AIR, WATER—An Unusual Experiment Reported by Mr. Truax

During the latter part of December (1937) a test was conducted by the author at Annapolis, Md. on a motor of conventional design using compressed air and gasoline as fuels.

The chief design features of the motor were as follows: fuel injected under high pressure differential and atomized by a centrifugal whirl, nozzle cooled from entrance to throat by gasoline circulation in a double-walled portion, and from throat to mouth by water injected through an annular orifice. Combustion chamber and nozzle were of nickel steel.



Design of Mr. Truax's motor.

Supply air under 700 pounds per square inch forced the water and gasoline into the chamber. This pressure at full operation was throttled to 200 pounds per square inch for the fuel, and 160 pounds per square inch for the water. The air pressure differential was negligible. To measure the

Mr. Truax's experiment in progress.

thrust, the only scale available was a beam balance. (See photo).

As the operator was necessarily within 15 feet of the combustion pot, to insure safety, the entire setup was given a hydrostatic test up to 1,000 pounds per square inch and a quarter inch steel shield interposed between the motor and tanks.

The air compressor was started and as soon as the supply pressure reached 700 pounds per square inch the ignition coil was started and the water and gasoline valves cracked. Then the air was slowly cut in. At first there were no results.

The motor and fuel lines were heated red hot and another attempt made. This time the motor ran—like a motorcycle engine. With extremely careful adjustment of valves, there came a short, smooth roar, and then again an infernal popping.

Thinking that the momentary pressure built up during the explosions might have prevented the fuel coming in, we changed the constriction in the mixing chamber to a smaller one, giving a greater pressure in that chamber. The motor then would not even pop. We removed the constriction entirely and observed the vapor spray without the nozzle. It whirled out in a finely-divided mist. We replaced the nozzle, heated the chamber, and opened gas and air valves slightly. With careful regulation the popping reappeared and then, at a certain delicate adjustment, the motor emitted the loud, smooth roar which indicates continuous combustion. Almost immediately the nozzle became red hot and the water injection had to be cut in. This cooled the nozzle instantly. Subsequently the water valve was left slightly open. As soon as proper operation had commenced, the chamber pressure rose to fifty pounds, and by slowly opening up, keeping the proper mixture, a final pressure of 150 pounds per square inch was reached. With the motor wide open the roar was deafening.

Since the motor had been designed for gas oxygen, the ports were too small to admit sufficient air to build up the designed 300 pounds in the combustion pot. At about 100 pounds, the beam balance, which had been set to ten pounds above the weight of the apparatus, kicked up.

Several runs were made, improving the steadiness of burning and control by replacing the valves with less sensitive ones.

Valuable Observations

Since no provisions were made for measuring the amount of fuel used or for obtaining a constant thrust reading, the experiments were quanitatively inconclusive. However the rocket experimenter may find these several observations of value: The matter of determining the proper fuel mixture caused no concern; the motor would not run an improper mixture. While the rocket motor was in full operation, without water, there was neither smoke nor flame issuing from the nozzle mouth. This probably indicates excellent combustion and complete expansion. In fact, with the jet at full power an observer put his hand into the blast about a foot and a half from the nozzle, and so little heat remained unconverted that he was able to hold it there (though with considerable effort) without injury.

The water injection cooled the nozzle very effectively, the amount used in the tests equalled about one-half the quantity of gasoline, but a smaller volume would undoubtedly prove sufficient with an increase in the maximum allowable temperatures.

The spark plug proved sufficient to initiate the combustion, but with injection of fuel toward the nozzle, the speed of ignition was less than the velocity of the mixture, resulting in the constant blowing out of the flame. Preheating the combustion pot and fuel reduced this tendency considerably.

As to the quantity of gasoline used, only a rough estimate can be made. Ten gallons served to run the motor intermittently and at varying powers for six or seven hours, but it is probable that the equivalent full power consumption would correspond to that reported by the Society.

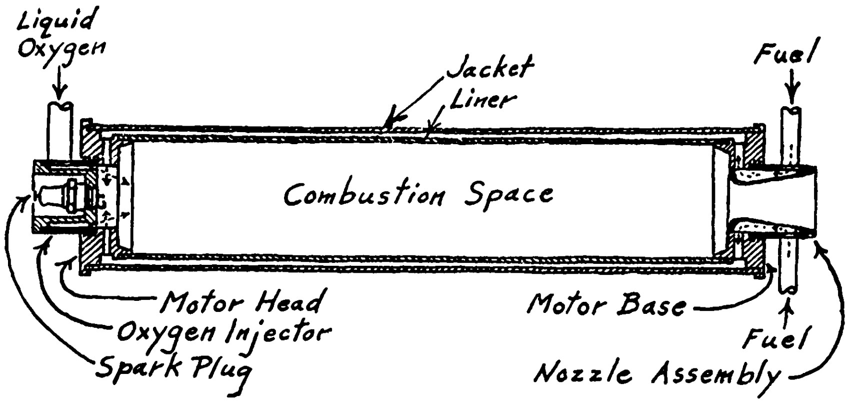
Since the tests last December, a new motor has been constructed embodying a fuel-cooled nozzle and chamber, and reverse fuel injection. Also aparatus has been assembled for accurate determination of fuel consumption, thrust, and consequently, thermal efficiency. The author hopes to be able to present the results of new experiments, using both oxygen gas and air, on both the new and old motors, by the end of September.

—**R. C. Truax.**

FUEL AS COOLANT—Mr. Wyld Describes His New Motor

Conventional types of rocket motors have proved exasperatingly difficult to cool when working at high efficiency and high temperature. Heavy-walled chambers and nozzles have been employed and water-jacketing has also been attempted, but the results have been unreliable and the weight excessive. Concentric feed seems to prevent burnouts, but fuel wastage is hard to avoid.

However, the rocket's own fuel provides several quarts of satisfactory coolant, and if this is passed through a suitable jacket surrounding the



Mr. Wyld's new self-cooled tubular regenerative motor.

motor and nozzle it should be possible both to cool the motor properly and to preheat the fuel and thus improve its combustion. A motor constructed along such lines is now nearing completion.

As shown in the sketch, the fuel enters a tubular jacket surrounding the nozzle. From the nozzle throat the fuel passes outward through radial holes to a channel in the rim of the motor base, and from there flows axially along the blast chamber between the jacket and liner; it then escapes through another set of radial holes into a cavity in the motor head, where it mixes with liquid oxygen injected through a ring of small pinholes surrounding a small ignition spark plug (used in starting.) The mixture burns in the main combustion space and is ejected through the nozzle.

Care has been taken to insure rapid flow along the heated surfaces, thus improving heat absorption and avoiding the formation of vapor films. The multiple fuel and oxygen ports are expected to improve mixing. The fuel will be largely, if not entirely, vaporized in the chamber jacket, which ought to materially improve the combustion efficiency.

Despite its rather complicated construction, the completed motor will weigh only two pounds, which compares very favorably with more conventional types.

This motor is thought to be the first of its type to be constructed in this country. In view of the remarkable results claimed for similar designs by Dr. Sanger of Austria, experimental tests should prove unusually interesting. Such tests will probably be run as soon as proving-stand facilities are available.

—J. H. Wyld.

DOUBLE CHAMBER—The Westchester Rocket Society Will Test New Motor

A "double chamber" liquid cooled motor will be tested by the Westchester Rocket Society (A. R. S. affiliate) this Summer.

The motor is of the one inch constriction class and will be, I am informed, one of the largest tested on the new A. R. S. proving stand. It is constructed of brass, duraluminum, and monel and features a special system by which various methods of loxygen feed nozzles may be tested.

Although double chamber motors are not new (being used for some time by Mr. Pierce) this particular one cannot be considered as a conventional type as it is constructed so as to first allow the fuels to expand in the mixing chamber and then compress in the blast chamber. The cooling agent is introduced into the blast chamber through a circular opening which allows it to form a protective wall of superheated steam around the inner wall of the chamber.

—Nick Limber

Landing Gear Releases

(Continued from Page 7)

the rocket axis. The rocket is provided with suitable fins and is so balanced as to turn upside down upon the termination of its ascent. When the rocket turns over, the freely suspended gyroscope will retain its original axis of rotation, and a suitable trigger attached to the gimbal rings can be made to operate the parachute release. It appears that this method could be made to function with entire satisfaction, granting a properly constructed gyroscope.

ROCKET TRIPS INTO SPACE

An Engineer Discusses What We Must Do to Reach the Moon*

By ALFRED AFRICANO

FROM astronomy we learn that an object falling to earth from an infinite distance in space would not attain an infinite velocity, as one might ordinarily expect. It would keep increasing its velocity from zero to a definite velocity of about 7 miles per second, called the "parabolic velocity." If we wished to reverse the process—say to shoot a projectile back to infinity or out of the earth's gravitational field—we would have to start it with the same velocity of 7 miles per second for it to succeed in escaping completely. Its trajectory would be a parabola, never returning to earth.

Accelerated Flight

Let me emphasize at once that this initial velocity is required only of the projectile—not of a rocket. A rocket could be designed to accelerate as slowly or as rapidly as desired. It could continue to accelerate far beyond the earth's atmosphere because it does not depend on the air for its lift or reaction. In fact, the rocket reaction—similar in principle to the force causing the recoil in a cannon — is actually more efficient in the vacuum of space than in air, since the air hinders the free escape of the rocket's exhaust gases.

If we decided to accelerate at 2g, or twice the acceleration of gravity, with a powerful enough fuel, we could attain the escape velocity in about ten minutes, shut off the rocket motor, and then coast along from that point exactly like the projectile. The rocket or projectile speed would not, of course, remain constant as it shot outward from the earth. If it did, and the moon were our objective, the time required for the flight would be only 9 hours. However, the velocity would decrease constantly and rapidly as the price exacted for working against the earth's pull. It would be almost zero at the neutral point of gravity between the earth and the moon, and would finally increase its speed to 1-½ miles per second if allowed to fall to the moon's surface unchecked.

The average velocity for the whole trip would be only about 10 per cent of the initial 7 miles per second so that the total time taken for such a trip would be from 85 to 100 hours.

Hitting the Target

Close calculations would have to be made to determine at just what point in the heavens to direct the rocket projectile. Allowance should be made for the effect of the earth's rotation, which gives all surface objects a velocity varying from 1000 miles an hour at the equator down to zero at the poles. The moon's motion in its orbit around the earth would have to be just enough to allow it and the projectile to coincide at the end of the flight.

This sounds very involved—and it is—but nevertheless the moon offers several advantages as the first objective of an interplanetary flight — the most important of course, being that it is the only other body in space

* Excerpts from an address by President Africano before a joint meeting of the American Rocket Society and the Amateur Astronomers Association, American Museum of Natural History, Nov. 17, 1937.

which travels at the same orbital speed as the earth around the sun—18-1/2 miles per second. The sun's attraction would cause some deviation, but it would be small, and of secondary importance.

The Meteor Problem

Much time could be spent discussing the many problems the daring astronauts would have to solve before completing such a trip. They should of course avoid making the trip during the times of active meteor showers, as for instance, during the month of November. Meteors travel from 7 to 40 miles a second and would go through a space ship like water through a sieve if they made direct hits. However, some mathematician has calculated that the probability of such a hit is less than one in a million—negligible compared to the traffic risks we take nearly every day.

The opposite extremes of the intense cold of space, and the burning heat from the sun have already been overcome to a certain extent in stratosphere balloon flights. A "space suit" was successfully used by Lieutenant Adam of the British Royal Air Force when he made his record altitude flight of 10 miles this year.

The deadly effect of the sun's ultraviolet rays, and the so-called electric heat belt about 50 miles up in the region of the Kennelly-Heaviside radio reflecting layer may quite possibly be overestimated. Even if it is not, a similar problem existing right here on earth has been solved satisfactorily, for physicians and technicians who work constantly with x-ray machines have learned to protect themselves from serious burns and sterilization by using lead-lined aprons and gloves. A similar protective lead lining could no doubt be incorporated in the space suit if it is found to be necessary.

Navigation in space will be a difficult matter, but it can be solved by means of a ring of auxiliary motors placed at right angles to the main motor, for turning the ship about its center of gravity in any plane. You can get an idea of this problem by imagining an airplane being turned without being properly banked. The plane would continue to slip along sideways in its original direction. We experience the same sort of trouble with automobiles skidding on icy pavements when we try to make a turn too suddenly. You can't turn a corner in space at all, but must proceed along some definite curve to get from one point to another.

Physiological reactions of the human body and organs due to loss of gravity at the neutral point, and in fact along most of the journey when the rocket is not accelerating or decelerating, is an interesting point for speculation but is certainly no more a reason than the other problems I have cited to explain why a rocket trip to the moon has never been made.

Fuel—Chief Obstacle

These problems are all relatively insignificant compared to the single real problem, that of finding a fuel with enough power to do the job.

From a practical engineering point of view, even the liquid fuel efficiencies are too low to accelerate a rocket to the escape velocity of 7 miles per second. However, I should mention here that Professor Oberth of Germany found a theoretical solution in spite of these low efficiencies in what is called the "3 or 4 step rocket": If a ratio of fuel to dead load of 4/1 is the maximum that practical construction will allow, the final result to raise a few tons of payload might be a fantastic ship the size of one of our largest dreadnoughts.

ARS No. 2 PROVING STAND

This Equipment Will Be Ready for Use Early in June

THE Society's new proving stand is rapidly nearing completion and is expected to be ready for operation early in June.

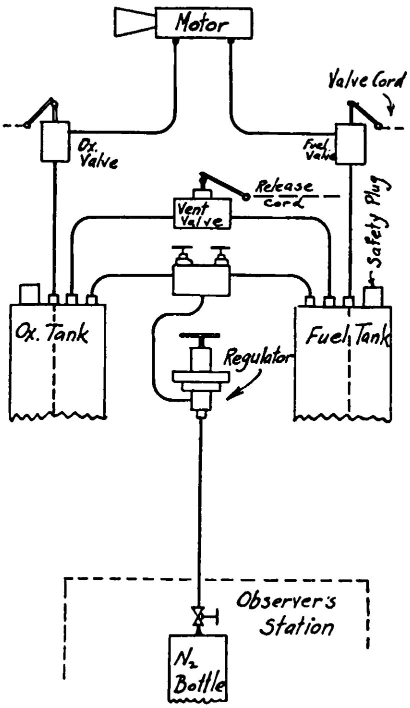
The stand will embody several new features, developed as a result of previous experience with the No. 1 Stand. Effort was made to increase the scope and accuracy of work, and to provide for increased safety and convenience of operation, as far as consistent with a workable design.

For the following details **Astronautics** is indebted to Mr. John Shesta, Chairman of the Experimental Committee:

Feed System

The fuel will be fed into the motor under constant pressure from both tanks, the source of pressure being a standard nitrogen bottle feeding the tanks through an adjustable reducing valve. Provision will be made to use the old system of feed, by the expansion of gas in the tanks, as in the No. 1 Stand, for special tests. Another provision will be for a tank of cooling water under pressure, where the design of motor to be tested requires such cooling. The lines will be protected by check valves whereever necessary, in order to prevent any possibility of mixing the fuels in the lines or tanks. In the interest of safety the whole arrangement is such that there should never be any need for anyone to approach the stand when the tanks carry pressure. The fuel valves and the vent release valve are operated remotely from the observers' station, by a cord. The diagram shows schematically the arrangement of piping.

The tanks are of 5 inch O. D. copper tubing, 1/8 inch wall, spherical bottom, and 1/2 inch brass flat plate top, silver soldered construction. Capacity 2 gallons each. These tanks were designed to work at 500 pounds pressure, and have been hydraulically tested to 750 pounds per square inch. The connections are screwed directly into threaded holes in the top plates. Instead of the troublesome pipe threads, which have been a source of annoyance in the past, straight machine threads are used with a shouldered plug and a lead gasket. The filling plugs are provided with thin silver diaphrams, designed to



Piping scheme of the proving stand.

rupture at a predetermined limiting pressure, thus serving as a safety blow off. The oxygen tank has an outside brass jacket with the inner space evacuated, thus acting virtually as a Dewar flask.

Fuel Measurement

Considerable difficulty was experienced in calculating motor efficiency in the old stand tests because the amount of fuel used could not be exactly determined. In the first place, while the alcohol poured into the tank before a test run could be measured volumetrically; only the roughest kind of a guess could be made for liquid oxygen, due to its unstable nature. In the second place, the motor did not necessarily use all the fuels in the tanks, and the kind and amount of residue, if any, could not be ascertained.

In the new stand, the tanks will be elastically supported by pantograph springs, and all connections will be brought out by means of flexible metal hose. During transportation a clamp locks the tanks securely in place. The tank bottoms are supported by rubber diaphrams over water in special containers. The weight of the tank is balanced against a water column. The height of the water column, colored for visibility, is observed in glass tubes mounted on the instrument board. The design is such that a readable indication on the record film will be given by 1/4 pint of fuel, while the total travel of the tank will not exceed 1/8 of an inch. This method was decided upon in preference to mechanical scales or pressure gages, as being simpler and more reliable, and at the same time less expensive.

Thrust Measurement

The motor undergoing test will be mounted horizontally on a carriage with a certain freedom of motion over a track, with flexible metal hose fuel connections. The motor thrust will be transmitted to a Sylphon bellows, and indicated on a pressure gage.

Mr. H. F. Pierce, co-designer of the stand with Mr. John Shesta, is working on a design of an instrument that will trace the reaction curve during the test, thus giving a rough check on performance right in the field.

Capacity of Stand

Since different fuels require different proportions of oxygen for complete combustion, the fuel capacity of the tanks will vary with the particular fuel being used. In the case of alcohol the total capacity of the stand is about 27 pints of combined fuel and oxygen. What this quantity of fuels can be expected to do, is shown in the accompanying tables. These tables were computed by means of Africano's Empirical Equations, based on previous experimental work with reaction motors. Of course it is impossible to say that new and different types of motors will perform in exactly the same way, yet these figures represent the best available data, and are sufficiently accurate for design purposes.

The design of various valves, connections, and reaction measuring equipment, was based on these figures. The figures in light face type are beyond the design limits, and represent conditions under which the stand is not normally expected to operate.

Scope of Work

It is planned to run tests at regular intervals this summer. Several motors have recently been completed by members, while others are being built. Tests of these motors will be scheduled as soon as the stand is ready for operation. Members wishing to have their motors tested can make arrangements through the Experimental Committee.

The Committee, however, reserves the right to refuse to test any motor, particularly where the design appears to be unsafe, or construction has not been carried out in a workmanlike manner, or the basic principle involved does not appear to be a sufficiently important contribution to justify the expense of a test.

Performance Ranges of No. 2 Proving Stand. Figures in lightface type are beyond the design limits.

TABLE I FUEL FLOW—PINTS PER SECOND

Chamber Pressure lbs. per sq. in.	Nozzle Throat Diameter ½	⅝	¾	⅞	1
100	.26	.40	.57	.78	1.02
200	.51	.80	1.15	1.56	2.03
300	.76	1.16	1.70	2.28	3.04
400	1.02	1.55	2.30	3.04	4.05
500	1.27	1.94	2.86	3.80	5.06

TABLE II FIRING TIME—SECONDS

	½	⅝	¾	⅞	1
100	106	68	47	35	27
200	53	34	24	17	13
300	35	23	16	12	9
400	26	17	12	9	7
500	21	14	9	7	5

TABLE III REACTION—POUNDS

	½	⅝	¾	⅞	1
100	30	48	68	93	122
200	61	95	137	186	243
300	91	142	205	280	365
400	121	190	273	373	487
500	152	237	341	466	608

Letters to the Editor

OUR AFFILIATES ARE ACTIVE: word comes that the Yale Rocket Club is holding public meetings, and planning a series of experiments for the summer.

The Westchester Rocket Society also is busy. Nick Limber, of the Westchester Society, writes:

> Since its organization in 1936 some research work has been conducted by the Society but an extensive experimental program was launched after its affiliation with the A.R.S. Previous to this affiliation, a theoretical study of the landing gear problem had been made and a set of 10 foot rotor wings constructed to test the autogiro type of landing gear on rockets.
>
> The rotors are at present undergoing some changes and field tests will probably be held during the summer months.
>
> As available data on autogiro rotor design and theory has been found to be inadequate for rocket adaptation, the society will conduct a series of tests to determine the effect of dihedral and attack angle changes as well as wing loading of rotor wings during vertical descent.
>
> In considering efficiency and desirability the rotors as compared with the parachute, it becomes obvious that both weight and storage factors are in favor of the latter. In conducting the giro tests we hope to prove or disprove certain advantages the wings might offer. (Such as decrease in drift, dependability, etc.). We thus make it possible for the experimenter to select the type of landing gear best suited for his purpose by recording the results of the experiments.
>
> Keeping a 'weather eye' on future demands of the science of rocketry, the Society has been studying the possibilities of testing rocket hulls at high speeds to determine the effects of air, etc. Although this study has by no means been completed, we find that several complications will arise in conducting such tests. Therefore, our members will be pleased to hear from other experimenters who have suggestions as to how such tests could be conducted, and who can offer advice on this matter.

The Westchester Rocket Society has headquarters at 1462 Leland Avenue, the Bronx, New York.

THE ROCKETOR'S SHOP

A Department Devoted to Shop-talk, Ideas, Devices

"HOUSEBROKEN" — A Rocket that can be Shot Indoors

A small "indoor" rocket was recently constructed by the writer for lecture hall use.

The rocket is, in effect, nothing more than a compressed gas bottle with a special valve and an exhaust nozzle. It is guided by two wires stretched from floor to ceiling. Springs and rubber bumpers are used to reduce the impact. This rocket has made a number of successful flights, rising to a height of 28 feet with a charge of 1200 pounds per square inch of nitrogen. Greater altitude could easily be reached except for the limitation imposed by the height of the ceiling.

The "housebroken" rocket about to begin a trial demonstration flight.

The body of the rocket consists of a steel oxygen bottle 2 inches O. D. by 16 inches long, of 37.2 cubic inch capacity. It was obtained through the courtesy of Mr. Nathan Carver. this bottle, presumably of French make, bears the name "Mandet Paris" on its neck. The original plug had a particularly ill-fitting thread, made tight by the use of hemp and glue. The plug was cleaned, screwed back and carefully soldered in place. The hole was bored out to take a standard 1/8 inch pipe thread, which can be made tight without resorting to hemp.

Release Valve

The design of a suitable release valve presented a unique problem due to the necessity of keeping the nozzle coaxial with the rocket. The valve, as finally constructed, is shown in Fig. 1. This has given entire satisfaction, as the charge can be held in the bottle for a number of hours without appreciable loss. In appearance the valve somewhat resembles a boiler blow-off valve, being a 45° stem type. The rocket is charged from a standard nitrogen bottle by unscrewing the nozzle and attaching an S. A. E. fitting in its place. In use, the valve stem, which is smooth, is held down by a yoke (Fig. 2). This yoke has a trigger which can be pulled by a string. When the trigger is released the yoke drops off and allows the valve stem to snap into the open position. A cotter pin is used as a safety to prevent premature release. The rocket has two

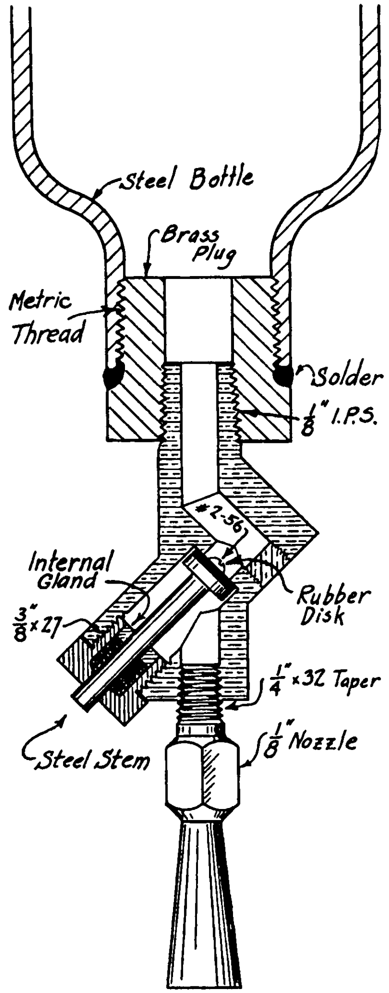
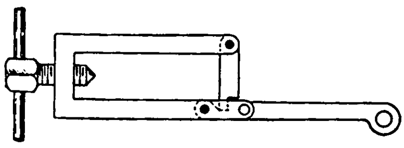


Fig. 1. Cross-section of the nozzle assembly of the "housebroken" rocket. Below—Fig. 2. The trigger release.



iron hoops holding the pieces which engage the guide wires. The total weight of the assembly is three pounds.

Preliminary calculations, on the basis of rocket weight 3 pounds, capacity 37 cubic inches, 1/8 inch nozzle throat, indicated rise with pressure as indicated by this table:

Charge pressure	Height of rise
400 lbs.	2.51 feet
500 lbs.	6. feet
600 lbs.	11.3 feet
700 lbs.	18. feet
800 lbs.	26. feet
1000 lbs.	50. feet

In preliminary tests these estimates, up to the limit height set by the prescenium arch of the main auditorium of the Engineering Societies Building, New York, proved reasonably close to the observed heights. In operation, somewhat more pressure was needed to overcome friction on the guide wires, etc. The "housebroken" rocket was first shot before an audience of about 800 members of the New York Railroad Club, on March 18, 1938.

—J. S.

SOME HELPFUL HINTS — Ideas Useful to Any Experimenter

To Mr. Louis Goodman we are indebted for the following:

A pair of loose gloves or mittens made of asbestos cloth will save time and trouble— to say nothing of blistered hands — for those who handle liquid oxygen.

A conventional tire check-valve will serve very well as an aid in charging a tank with pressure. In various experiments, they have stood up under pressures as high as 450 pounds (though not recommended at such pressures). They have been successfully used on rockets.

Notes and News

(Continued from Page 2)

tenstein, the Society's Treasurer for five years, will continue to serve in that capacity.

Mr. G. Edward Pendray will continue to edit **Astronautics**, and will have as Associate Editor Mr. Laurence Manning, one of the founders of the Society.

Elected chairman of the Membership Committee is Dr. John H. Teeple. Chairman of the Program Committee is Mr. James E. Wyld.

Of major importance among the Society's committees is the Experimental Committee, which serves to coordinate the research of members, stimulates experiment in new and promising fields, provides equipment and aid in experiments, and occasionally recommends to the Board expenditure of funds to purchase needed materials for experimenters. Mr. John Shesta, who has ably discharged the duties of Chairman of this committee in the last year, will continue in that capacity. Members who wish to serve on the Experimental Committee should communicate with Mr. Shesta at once, either personally or through the Society's headquarters at 420 Lexington Avenue, New York.

JUNIOR MEMBERSHIP: The question whether a new class of membership should be created, to be known as Junior Membership, was overwhelmingly carried at the Annual Meeting. Article 5 of the By-Laws is therefore amended as follows:

Section 4. There shall be an additional class of members enrolled in the Society, to be known as Junior Members. This class of membership shall be open only to High School students; or to others who have not yet attained the age of 18 years. The dues and othe rconditions of membership for this class shall be determined by the Board of Directors.

This is a move of major significance, opening membership to younger people and greatly widening the influence of the organization.

CONTEST FOR ROCKET AIRCRAFT London members of the British Interplanetary Society are planning for a model airplane contest throughout Great Britain this year, in which model airplane clubs can compete for a silver cup, to be presented by Professor A. M. Low, President of the BIS. These model planes are not to be driven by propellers, but by et propulsion.

The idea is to whip up interest in rockets and rocketry in England, where, since the BIS was moved to London, a push for members has been under way. "Despite the fact that there are a number of influential persons interested in the aims of the society," writes Edward J. Carness, of the BIS, "there is yet no adequate backing financially to warrant large scale experiments."