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Shooting Star

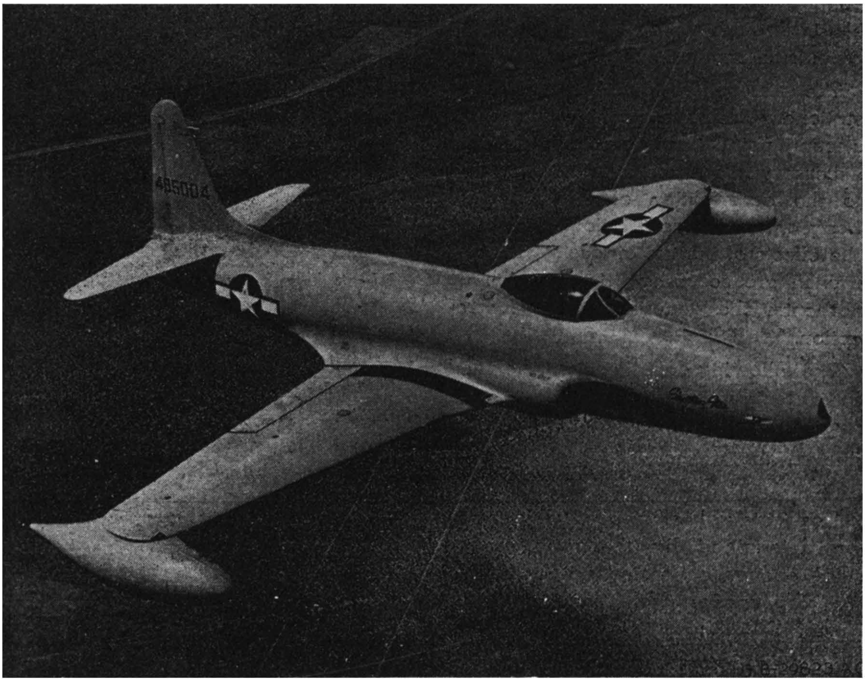
Further Details On The P-80

In conjunction with the recent public demonstration of the jet-propelled P-80 Shooting Star additional details were released by the Army Air Forces. The first prototype of the Lockheed Shooting Star was test flown on January 9, 1944. Numerous prototypes powered by a new General Electric high-thrust turbo-jet engine were tested before the design was placed in production.

The wing span of the P-80 is 38 ft. 10½ in., overall length, 34 ft. 6 in., and height, 11 ft. 4 in. Total weight with maximum fuel load is calculated at 14,000 lbs. and total weight empty approximately 8,000 lbs. Capable of speeds in excess of 550 m.p.h. and a ceiling well above 45,000 ft., the plane carries droppable fuel tanks on the extreme tips of the wings for increasing its range.

The GE turbo-superjet I-40 unit, mounted behind the cockpit, has a rotation of over 10,000 r.p.m. Air from the forward twin intakes is forced by the centrifugal flow compressor into fourteen combustion chambers arranged radially. Injected fuel (kerosene) burns and the expanded gases drives the turbine, which is coupled to the compressor, and exhausts through the tail nozzle producing thrust.

Absence of propellers permits the use of a low tricycle landing gear with small wheels. The small armor plated cockpit has good visibility and is pressurized and air-cooled. The throttle is the only engine control needed while the instrument panel is greatly simplified.



—U. S. Army Air Forces

Jet Fighter—AAF Lockheed P-80 Shooting Star in flight with auxiliary fuel tanks.

General Theory Of Reaction Propulsion

Formulae That Applies To Rockets And Jet Motors

By ZYGMUNT FONBERG

The general formulae for reaction derive from Newton's Laws of Motion.

These three fundamental laws define every movement of any body and obviously include the movements of rockets and jet propelled craft. The third law of motion is difficult for some people to apply to jet propulsion motors because they cannot fix the reference point between the acting force and the motion of reaction motors. That is why some believe that for rockets or jet motors to produce force, the force must act on some matter as the air. This is not true because the reaction force is strictly an internal force of the body created by loss of energy by the body. For practical purposes of calculation, the reference point will be considered as a particle of air through which the rocket or jet propulsion motor is moving.

The atmosphere can be considered stationary relative to the earth or starting point, but this concept is only necessary when the inertia force due to the acceleration of the propelled body enters the calculation. However, the effects of inertia, air resistance and friction are secondary items which do not enter the general formula for reaction.

The following definitions will be used in the text below:

The thrust force is the reaction effect due to the gases escaping from the nozzle.

The external efficiency, which will be determined by the ratio of the total energy generated in the nozzle and the energy useful for propulsion.

The external or useful power will determine the power used for the motion of the propelled body.

The external efficiency and external power of the jet motor or rocket is equal to zero when it is at a standstill, and all the energy generated in the nozzle is wasted, but its thrust is then at a maximum.

The internal efficiency will be the ratio of the total energy of the fuel burned in the motor and the energy generated in the nozzle.

Definitions:

E—kinetic energy generated in the nozzle

E_1—wasted energy

E_2—useful energy

u_1—speed of propelled body

v—speed of gases relative to the nozzle

u_2—speed of gases relative to the air

P—useful power

m—mass

T—time assumed as 1 sec.

F—reactive force or thrust

Total kinetic energy generated in the nozzle is:

$$F = \frac{mv^2}{2}$$

Wasted energy due to the differences in the speed of the propelled body and speed of gases lost through wasteful agitation of the air through which it is moving:

$$E_1 = \frac{mu_2^{\,2}}{2}$$

Total useful energy is:

$$E_2 = E - E_1$$

$$E_2 = \frac{mv^2}{2} - \frac{mu_2^{\,2}}{2}$$

since

$$u_2 = v - u_1$$

$$E_2 = \frac{(2v - u_1)u_1}{2} m$$

$$F = \frac{E_2}{u_1 T} = \frac{2v - u_1}{2} \frac{m}{T} \qquad (1)$$

$$\eta = \frac{E_2}{E} = \frac{2vu_1 - u_1^2}{v^2} \qquad (2)$$

$$P = \frac{(2v - u_1)u_1}{2} \frac{m}{T} \qquad (3)$$

These are the three general formulae which apply equally to any reaction motor, and also to rockets and jet propulsion motors.

Thermal Jet Motors

In special cases of jet propulsion motors we can assume the approximation that the quantities of air taken and exhausted are equal (the weight of fuel being only about 1/15 of the weight of the air).

The formulae can be transformed as follows:

$$E = \frac{mv^2}{2} + \frac{mu_1^2}{2}$$

$$E_2 = \frac{(2v - u_1)u_1}{2} m + \frac{mu_1^2}{2} = \frac{2vu_1}{2} m$$

The formulae (4) (5) (6) are logically and mathematically correct, and physically true within certain limits, but they should not be used in practice. It is much simpler to include the ram of the air into the compression in the compression-expansion type of jet motor. For the resonance type motors these formulas will give completely false results.

$$F = \frac{mv}{T} \qquad (4)$$

$$\eta = \frac{2vu_1}{v^2 + u_2^2} \qquad (5)$$

$$P = vu_1 \frac{m}{T} \qquad (6)$$

The general formulae for reaction should be simplified for the so-called Athodyd (aero-thermodynamical-duct), when the speed of the propelled body is always equal to the speed of the air going through the duct.

$$v = u_1$$

$$F = \frac{u_1}{2} \frac{m_1}{T} \qquad (7)$$

$$\eta = \frac{u_1}{v} = 1 \qquad (8)$$

$$P = u_1^2 \frac{m_1}{2T} \qquad (9)$$

The mass "m_1" is a part of the total mass "m" of air going through the duct, and is defined by the ratio of difference between the exhaust area "A" and intake area "a" of the duct divided by exhaust area "A".

$$m_1 = m \frac{A - a}{A}$$

The air or gas, in order to fulfill this condition, should expand in the duct at the ratio of the areas of intake and exhaust $\frac{A}{a}$;

Misleading Formulae

In current publications several other formulae can be found, greatly differing from the formulae given above. We wish to discuss them separately.

The most commonly cited formulae for the external efficiency of jet motors by other authors are:

$$\eta = \frac{u_1}{v} \tag{10}$$

$$\eta = \frac{2u_1}{v} \tag{11}$$

$$\eta = \frac{2u_1}{v + u_1} \tag{12}$$

The general formula (2) for efficiency will be represented as a parabola in function of speed of the propelled body u_1; with the external efficiency equal to zero when $u_1 = 0$ and $u_1 = 2v$; and equal to 100% when $u_1 = v$.

The formula (10) will show a straight line in function of u_1, and the efficiency will be more than 100% for any value of u_1 bigger than v_1, which is against all the laws of physics. This represents a jet propulsion motor or a wonder which can generate more power than it was supplied with.

This is also true for the formulae (11) and (12).

It should be noted that the formula (10) gives the correct value for efficiency when $v = u_1$ and when $u = 0$, but this check is not sufficient and can lead to rather serious mistakes in calculation.

The application of this formula for efficiency will give the value of 50% when it should be 75%, and so on.

The formulae (11) and (12) will give even greater inaccuracies and will not conform as a mathematical expression, and cannot form the basis for any of the current experiments.

In many cases the general formulae for repulsion have been adopted to rockets and jet propulsion.

$$\eta = \frac{2vu_1 - 2u^2}{v^2} \tag{13}$$

$$F = (v - u)\frac{m}{T}$$

$$P = (v - u)u\,\frac{m}{T}$$

It is easy to see that they relate altogether to another type of motors, i.e. to repulsion motors, and will lead to serious mistakes when used in calculating reaction.

$$\eta = \frac{v^2 - 2u}{v^2 - u^2}$$

There the author starts from the formula for repulsion (13) and assumes that the air taken by the jet motor, which is at the speed of the propelled body u_1, is a total loss for the external efficiency of the jet propulsion motor. Besides, starting from the wrong formula, the second assumption does not seem to be logical (Compare with formula (5)).

Atomic Powered Rockets

Energy From Atoms For Propulsive Purposes

By CEDRIC GILES

Government reports* have partially lifted the veil of secrecy on the $2,000-000,000 research enterprise, the Manhattan Project which on July 16 conducted a successful atomic bomb test in New Mexico followed by the parachute dropping of single bombs on the Japanese cities of Hiroshima August 6, and Nagasaki three days later. The scientific achievement of splitting the atom ushers in an era where nuclear power may supplant the powder and liquid fuels now employed to propel rockets.

Atomic energy for rocket application may logically be divided into two general divisions: (1) the possibility of increasing the destructive power of the warhead; (2) the consideration of improving the propulsive energy of the fuel.

Atomic Warhead

Probably very few alterations would be necessary for adaption of the present atomic bomb to the warhead of the V-2 rocket or similar missiles. Instead of dropping the atomic bomb by parachute thereby enabling the bomb carrier to vacate the vicinity before the explosion, an atomic warhead rocket could continue on to the target. Employing the principles of radar, a radio-operated trigger could set off the explosion at a predetermined height above the ground. Exploding the remaining fuel with the bomb load, or the fuel and bomb load consisting of the same substance, are very possible.

*Atomic Energy for Military Purposes, by H. D. Smyth.

Statements relating to the Atomic Bomb, His Majesty's Stationery Office, London.

Practical Application

Atomic energy for industrial purposes will most likely be derived from safer atoms than in either the uranium or thorium series.

For conventional uses slow neutrons, traveling a few miles a second with several volts of energy, would release low-power controllable explosions. Further elimination of the danger of high-power explosions with their tremendous temperatures might be accomplished by using capsule size quantities of uranium 235, plutonium or more abundant elements. Moderators, such as paraffin, graphite, cadmium or heavy water, now used to reduce the energy of the neutron by slowing it, are applicable for shielding off the deadly radioactive rays.

Atomic Drive

Utilization of the vast energy locked in the atom as the ultimate fuel for propelling the rocket has long been considered by rocket technicians. Propulsion of the rocket will still depend on the outward expulsion of a stream of gases or minute electronic particles with the future propulsive jet very likely having greatly increased velocities and exceptionally small mass.

Atomic power may be used alone or in combination with other present fuels in the same plant. The high heat released from exploding atoms might be employed to heat liquids or gases for driving turbine units or for the expansion of the regular efflux gases. In one thermal jet propulsion system the disintegrating of a thin wire of atomic fuel fed at a controlled rate from a rotating drum would heat induced air.

(Continued on Page 20)

Motor or Engine?

On The Proper Usage Of Terms

By MARSHALL NAUL

As language is a flexible tool, and its usefulness stems in part from that property, its inexactness is at times a hindrance to the proper expression of certain things; things which naturally fall into more precise categories than the usual definitions attached to them. In such a case, a state of chaos exists until such time as definitions of the exact degree of differentiation commensurate with the prevailing usage of those terms are agreed upon. Such is the present status of the two terms, **motor** and **engine**, particularly in connection with rocketry.

Since rocketry was first seriously studied, these two words have been used interchangeably in referring to the mechanical part of the rocket which does the driving, sometimes called the **propulsor.** Of these words, **engine** is the more ancient, and until less than a century ago, it was a very general term. As extant examples of its varied uses, we have **fire-engine, dividing-engine,** and **cotton-gin** which is a corruption of **cotton-engine.** In the years preceding 1900, many mechanical contrivances hardly more complex than a buggy were given the elegant term **engine.** The comparatively modern word **motor** has been in vogue for the past century, but has also fallen into general misusage.

The terms **engine** and **motor** cover a definite sector in the field of machines and the prevailing method for specifying the type of engine or motor is to prefix the word most descriptive of the type. Thus we are able to recognize the essential difference between an **electric-motor** and a **tidal-motor,** and between a **diesel-engine** and a **gasoline-engine.**

The generic term for **motor** and **engine** is **prime-mover.** Now we come to the somewhat neglected question of 'when is a **prime-mover** a **motor,** and when is it an **engine?**' A purist might consult the New English Dictionary with these results:

Engine: 'Modern usage has limited the word to the steam-engine, and to some analogous machines . . .'

Motor: 'A prime-mover, as a steam-engine . . .'

Despite the lexicographers' confusion, modern engineering usage has clearly separated the two.

The function of both **engines** and **motors** is to effect a conversion of energy from one form to another, from potential to kinetic energy. The main point of difference is that an **engine** is an energy transformer, complete in itself and requiring no independent source of potential energy to function, aside from a fuel reservoir. An engine effects in one unit the combined functions of a generator and a convertor.

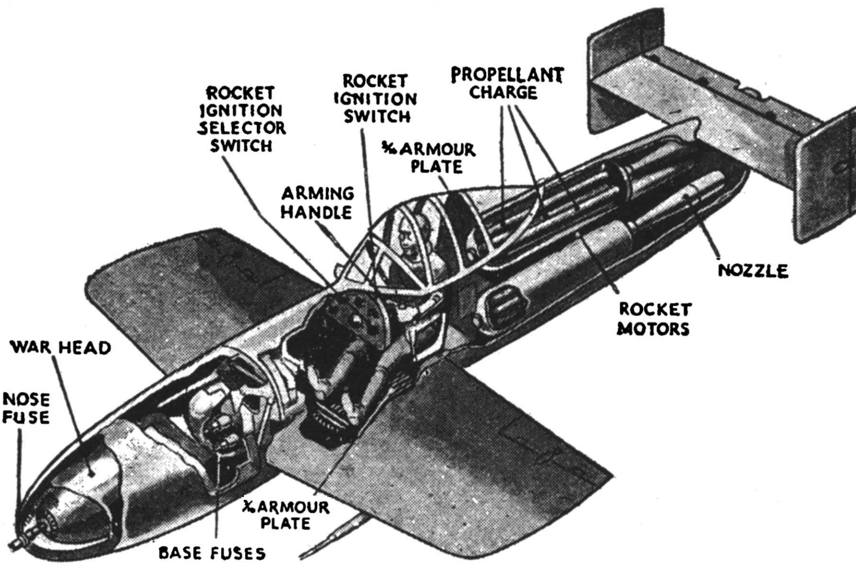
Distinctly different from this is the **motor** which is dependent upon an outside source of energy and is in the role of being complementary to, and dependent upon some sort of energy generator. Thus, in the case of an **electric-motor,** the outside source of potential energy is a generator in the form of a **dynamo** or a **storage-battery.** In the category of motors so defined are **tidal-motors, compressed-air-motors,** and so-called **solar-engines.**

This would limit the term **engine** to prime-movers of the internal-combustion type (as propulsors may be classed as internal-combustion engines), until such time as an atomic-engine is developed. In this connection, it may be mentioned that the **steam-engine** is a misnomer, and this prime-mover is in reality a **steam-motor**, as it must be supplied with steam from a steam-generator in order to operate. As shown before, the meaning of the word **engine** has changed since the invention by Watts of this prime-mover.

In the field of rocket-science, which is really, as yet in an embryonic state, a certain amount of disagreement is to be expected in the nomenclature, but it would be in the interest of coherency in this field to standardize on the terminology of the rocket in a logical manner and in agreement with the terms common to other sciences. It is the purpose of the foregoing to show that the generally used term **rocket-motor** is incorrect; rather, as it falls into the category of the internal-combustion engines as an independent energy transformer, it should be **rocket-engine**. This is not merely a matter of being precise, but rather one of correct usage. It (the rocket-engine) is not, like a **motor**, an accessory to a primary generator, but is in itself a complete power unit.

Some disagreement is also evident in referring to the prime-mover for jet-propelled machines. The prime-mover is also in this case, an engine, a **jet-engine**.

It is of interest to note that the rocket-engine shares with the athodyd the unique position of being the only prime-movers with no moving parts.



—Flight

The Japanese suicide jet-propelled bomb, the Baka, is 19 ft. 10 in long, 3 ft. 10½ in. high, and has a 16 ft. 5 in. wing span. The high explosive war-head weighs 2,645 lbs., including 1,135 lbs. of trinitroanisole, generally used as a booster charge.

Three tail rocket motors, able to fire together or alternately, gives the Baka a horizontal flight speed of 535 m.p.h. and about 650 m.p.h. when diving. Launched from beneath a large bomber, the Baka bomb is steered by the pilot to the target.

The Station In Space

Sun Power Stations Planned By Germans

Disclosure of German war secrets found buried in mines and in the beds of rivers and lakes reveal that the Germans were contemplating the construction of solar space stations in the next 50 years. The stations, floating some 5,000 miles above the earth, were to function as an observatory, to possess a mirror, two miles in diameter, for focusing the sun's rays on earth steam-producing plants or for reflecting concentrated sunlight against hostile forces, and finally to act as a base for launching spaceships into outer regions.

The reported plans coincide so closely to proposals made on the subject in the late 20's and early 30's by Noordung, Pirquet, Orberth and others that apparently the Germans based their projects on these early theories. The terminal in space idea, which may at present appear visionary, generally takes the form of an elaborate rocket-powered plant of several sections circling the earth like a satellite at an altitude depending on its duties.

Noordung's Design

Captain Hermann Noordung, pen name of the Austrian Captain Potocnik, proposed a space station consisting of three separate units—living quarters, observatory and powerplant — connected by flexible air cables and pipelines to each other and moving in the same orbit. Placed some 22,300 miles above sea level the station was to revolve around the earth each 24 hours.

A large wheel-like structure about 100 feet in diameter, creating artificial gravity by rotating once every eight seconds, would house scientists and crew. This rotary house had rooms for every purpose located around the rim of the wheel and connected to the central airlock by elevators and stairs. All the necessities of life—light, heat, oxygen, water and food—were provided for, with energy from the sun supplying the power requirements of the station.

Captain Noordung intended that the cylindrical spatial observatory would observe weather conditions and other happenings on the earth's surface and report all observations in detail to ground stations. Due to the absence of air and dust and the lack of weight powerful telescopes of any size could be constructed and maintained. Study of the motions, distances, magnitudes and physical constitutions of the heavenly bodies would be undertaken by learned astronomers.

The sun power plant, consisting of a parabolic mirror and engine house, was to function in a manner similar to an ordinary steam turbine system. Liquid nitrogen vaporized by the sun's rays would drive a turbine coupled to an electric dynamo for providing direct current to the different buildings. The fluid on leaving the turbine would circulate to a dark-surfaced cooling unit and be pumped back for reuse.

The Triple Station

Count Guido von Pirquet, a co-founder of an Austrian rocket society, elaborating on the plans of Noordung suggested a three-unit arrangement consisting of an inner station for observations, an outer station for landing and refueling spaceships, and a transit station for contact purposes. The first two stations would travel in circular orbits around the earth while the transit station circling in an elliptical orbit would approach within a mile of their orbits.

The approximate altitudes from the earth, length of orbits and time required for the stations to revolve around the earth are shown in the table. Speed of the transit station was

	Altitude above sea level (miles)	Length of orbits (miles)	Revolution around earth (minutes)
Inner Station	470	27000	100
Transit Station	470-3100	34000	150
Outer Station	3100	44600	200

to be three-quarters of a mile faster than the inner station as it neared the latter's orbit.

Oberth Sun Mirror

Professor Hermann Oberth was much in favor of a station for observations which every four hours circled the earth at a height of 600 miles. He also conceived of a concave sun mirror constructed of small movable facets of metallic sodium mounted on a wire network in a circular frame. Sodium, a silver-white alkaline metallic element having high reflective properties, was considered most favorable for use in the non-corrosive airless regions of space. Adjustment of the facets by electro-magnets or other means would reflect the sun's rays over a large area or concentrate the heat energy into a single beam. Construction details were minutely worked out whereby free wires attached to a rotating spaceship could be made to spread out to form a huge network upon which strips of metallic sodium would be fastened.

Suggestions for shooting the sky station to its destination, towing or propelling it by rocket power were discarded in favor of the accepted idea of transporting the space plant piece by piece by rocket ship and assembling it in space. In the weightlessness of space workmen in space suits were conceded to have no difficulty in assembling heavy sections of the station.

The proposed sun mirror was to be employed beneficially or as a devastating force. Solar energy on being directed to ground turbine stations was to be utilized to generate steam for creating electrical power. Reflected heat would control weather, evaporate useless water and melt ice fields or illuminate large areas of the earth's surface at night.

Means for launching exploring spaceships to other planets and beyond into inter-stellar space was foreseen. Especially favorable was the suggestion of using the station as a refueling depot for spaceships ascending from the earth. The required fuel load from earth to space would be greatly reduced, as only enough fuel would need to be carried to overcome gravity from earth to the starting point for space travel.

History relates that in the seige of Syracuse, 212 B.C., Archimedes, Greek philosopher and inventor, set fire to the sails of the Roman ships by focusing the rays of the sun through newly invented burning glasses. As a weapon the Oberth reflector would also act much like a burning glass. Concentrated rays on earthly targets would turn bodies of water into steam while ships, cities and the implements of war would be burnt and destroyed.

Suggested References

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Oberth, Hermann, Wege zur Raumschiffahrt, 1929.

Ley, Willy, Rockets: The Future of Travel Beyond the Stratosphere, 1944.

The Flying-Submersible

Its Relation To Rocket And Thermal Jet Power

By ROBERT D. WOLCOTT, Sr.

Designers have produced on paper and in blueprint form several attacks upon the problems involved in designing a flying-submersible.. Whether the experiments were a success or not, a certain amount of purely scientific knowledge has been gained.

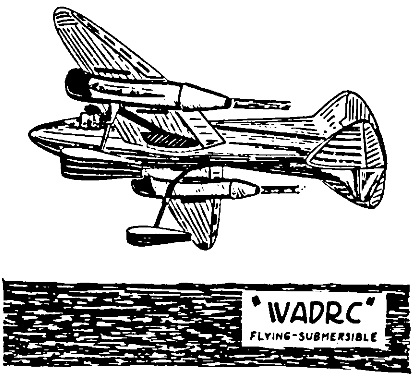
Rather than a submarine, a flying-submersible can best be visualized as an aircraft capable of withstanding the stresses and chemical reactions encountered while operating at a limited depth in water. The factor determining the operating depth is of necessity that point at which all members of the craft's structure are considered to be operative with little or no harmful reaction.

Let us consider the term "Flying-Submersible" which means only that a craft is capable of flying in air and submersion in water; no more. It would be highly unlikely that a craft embodying the proportions of a somewhat radical aircraft could travel for any great distance while submerged without prematurely exhausting its fuel supply. Therefore, let us dispense with that conception and concentrate on a craft which can maneuver for short distances under water with little applied power, retaining its fuel for airborne operation.

In the light of what has been said it should be easy to grasp the following description of a prototype flying-submersible which is briefly presented in order that the application of thermal jet and rocket power to this type of craft may be visualized.

Wadru Design

The Wadru flying-submersible was introduced to the Navy Bureau of Aeronautics in 1943 and later in a revised form to the Army Air Forces Materiel Command; however, at the time it was designed, thermal jet had not been considered as a formidable power-plant. It was, instead, designed with two 24-cylinder Allison or two 24-cylinder Rolls-Royce internal combustion engines. Each of these engines developed approximately 2,000 h.p.



The main feature in the entire design at that time was the combined use of several known but little tested principles, one of which was a modified system of hydrofoils as originally designed by Sr. Giovanni Pegna in his PC-7, an Italian seaplane racer, which was notably different from other seaplanes of that time in that it used hydrofoils instead of pontoons.

The second notable feature of the Wadru design was the use of the air-foil fuselage designed by Vincent J. Burnelli. This design lends itself beautifully to the task of storage of fuel and cargo.

Doubtless skeptics will ask how it is possible to make a craft light enough to fly and yet strong enough to withstand the extreme contrast of pressure while submerged. The problems encountered while submerged have been solved by a method which cannot be disclosed at this time but which are similar in some respects to the method used on the PC-7 which was capable of resting partly submerged on the water's surface. However, the PC-7 never was completely water-tight.

Since it is possible to submerge a flying-submersible, the next item of interest pertains to the welfare of the crew. A method was developed and introduced into the Wadru design whereby free air from the atmosphere was forced into the craft by means of a pump connected to an air shaft located within the periscope housing in back of the optical tube. This system was similar in many respects to the Schnorkel-Spirall system in use in German U-boats. To supplement the free air an emergency oxygen supply is provided for the sole use of the crew.

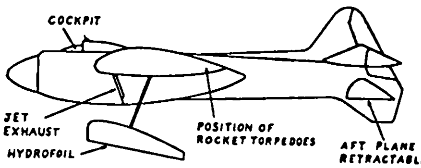
Ballast is used in much the same manner as in a submarine; by adding water to the total weight until it has reached the proper point of bouyancy.

Armaments

Since the design was very much like any other twin-engine aircraft with these chief differences, it should be easy to follow the principal differences in operation. The only evident practical use for the flying-submersible is as an instrument of warfare, primarily for the launching of torpedoes.

Torpedoes are released from their internal stowage by means of retractable launching racks which are entirely enclosed in the airfoil portion of the fuselage. They may be released in salvos of equal numbers or separate and individual rounds, the latter requiring more skill to launch because of the imminent tendency of the craft to porpoise during that type of launching.

The Wadru design has been refitted to accommodate rocket-torpedoes



which would increase the effectiveness of the craft far more than normal torpedoes.

All cannon and/or machine guns are provided with muzzle caps which prevent damage to the interior of the barrels by salt water or spray.

A radar firing mechanism was proposed for the aiming and release of the rocket torpedoes. By this means the craft could attack an enemy vessel while completely submerged and with the crew using the emergency oxygen supply.

The exact benefits and reasons for using a flying-submersible in place of a torpedo-carrying aircraft are obviously retained for military purposes.

Jet Propulsion

With the increased interest in and development of practical rocket and thermal jet units, the problem of power plants for such a craft becomes less difficult. Since rocket propulsion can undoubtedly be made to operate under water as well as in air the solution should be near at hand. When considering a form of rocket or thermal jet power one should examine the advantages of the two forms to ascertain which will be best suited to the design requirements.

The rocket form of operation involves two main factors. The first is fuel supply, the second oxygen supply. To be true rocket propulsion both must be contained within the design. The weight and space required will be great considering that there will be no means of replenishing the supply while in flight.

Thermal jet operation, however, requires only that fuel be combined with an oxygen supply derived from the atmosphere by means of a ram type intake or an impeller type compressor. Thermal jet requires less space for similar operation, as only fuel is carried, therefore an increase in the range of the craft could be effected by increasing the fuel supply as long as the increased weight is not allowed to impair the flying characteristics.

Takeoff

In applying these principles to the design of a flying-submersible one must also consider the takeoff from the subsurface or surface of the water, which will necessitate the use of rocket propulsion. A thermal jet system may be so constructed as to utilize rocket propulsion for the length of time necessary for launching the craft from the water. When sufficient altitude has been gained, thermal jet principles may be employed.

When surfaced the flying-submersible needs approximately 15 to 30 seconds to reach full power for the takeoff. With jet power almost instantaneous the rocket unit would perform the first stage of the takeoff; and when airborne enough to clear the spray and wave crests, the combined efforts of the thermal jet and rocket arrangement may be well coordinated until the thermal jet system is performing smoothly, and rocket propulsion can then be dispensed with entirely.

Concluding the presentation: one has only to look at the benefits that rocket and thermal jet propulsion provide for this application and it is easy to visualize much of the research ahead that will undoubtedly bring even better application in particular reference to the flying-submersible.

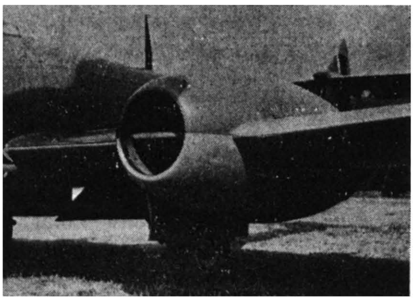
GLOSTER METEOR

The RAF Gloster Meteor, first flown experimentally in March 1943, was the first Allied jet fighter to see combat making its debut against V-1 flying bombs on August 4, 1944. The single-seat, low-wing, all metal monoplane has elliptical shaped wings with tapered edges and a high split tail plan of similar design.

Dimensions of the plane are: wing span, 43 ft., length, 41 ft., height, 13 ft., and wing area, 374 sq. ft. Powered by two Rolls-Royce Welland or Derwent jet engines, development of the Whittle basic design, the Meteor does over 450 m.p.h. The centrifugal-compressor turbo-jet units are placed on either side of the fuselage.

Servicing of the plane is made most convenient by the specially designed retractable low tricycle undercarriage. With the main wheels installed between engines and fuselage and a nose wheel the tail is raised high. Armament consists of a camera gun which may be used separately or linked with the four 20 mm. Hispano nose guns.

The Meteor is reported to have a high maneuverability, with an absence of vibration and noise in flight and a not too high landing speed.



—British Official Photograph

Close-up of the nacelle of the port power unit of the Meteor jet fighter.

ROCKETRY NEWS

American-British Penetration Bomb

U. S. 8th Air Force Flying Fortresses employed jet-propelled bombs on February 10 and again on March 14 of this year against E-boat pens at Ijmuiden, Holland. The British-American newly developed bomb, after being dropped in the usual manner, travels downward at speeds greater than sound (1,100 f.p.s. at sea level). Fused to explode after deep penetration, the rocket-propelled bomb creates a minor earthquake in the vicinity.

3,000-Mile Rocket Bomb

German records disclose that the V-2 long range rocket, which was first successfully tested on October 3, 1942, was a product of the drawing boards of 1940. One winged version of the V-2 was reported to have a range of 300 miles, with a later model to reach 1,800 miles.

At the end of the war specifications for production of accurate 3,000-mile range V-2 rockets were being drawn up, with German scientists contemplating in two years time the development of rockets extending the horizontal distance to 15,000 miles. Also under consideration was the application of these rockets for commercial use in carrying mail and passengers.

Underwater Rockets

Experiments on rockets fired at airplanes or coastal cities from submerged submarines of advance design were underway in the Toeplitz Sea, an Austrian Alps lake, at the war's end by German experts under the direction of a Dr. Heinrich Determann. Apparatus and methods had been successfully developed enabling the firing of rockets from 300 feet underwater.

V-2 For Cosmic Ray Study

Plans have been perfected by Alexander Dauvilliers, French professor of physics, for employing the V-2 rocket for the study of cosmic rays and other radiations. Taking off from an especially constructed launching ramp at the Observatoire du Pic du Midi, the rocket would carry instruments for recording cosmic ray data in its ascent at 2,000 m.p.h. through the stratosphere and return to the earth.

Jet-Driven Unicycle

A jet-propelled one-wheel vehicle, developed by Lt. Robert Morgan, British naval pilot, is expected to attain speeds of 520 m.p.h. Powered by a liquid gas, the Bomb, as the car is called, is slated for attacks on present land speed records.

The 12-foot single wheel, within which the driver sits, will be covered by a glass and steel streamlined, pear-shaped body 15 feet high and 25 feet long. Rear stabilizing fins come into action after two small wheels for holding the machine upright at the start are discarded.

Jet Plane Races

One of the attractions in next year's national air races will be a race for jet-propelled planes. The Weatherhead Company at Cleveland has donated a trophy for the event to foster continued development in the field of jet propulsion.

Atomic Bomb Metal

Carboloy cemented carbide, the hardest metal created by science, was used in the atomic bomb. Made of powdered tungsten carbide and cobalt placed under high pressures and temperatures, the metal weighs 50 per cent more than lead.

Ryan Fireball

The Navy's new fighter plane, the Ryan Fr (Fireball), is both propeller and jet driven. The front Wright Cyclone engine gives a speed of 320 m.p.h. to the Fireball while the rear General Electric thermal jet engine drives the plane at 300 miles an hour. Top speed of the highly maneuverable, fast-climbing plane is withheld.

Dr. Robert H. Goddard

A Biographical Note

Robert Hutchings Goddard was born in Worcester, Mass., on October 5, 1882. His early schooling was obtained at Boston, where he lived with his family until he was sixteen, and his college work at Worcester, where he was graduated from the Worcester Polytechnic Institute in 1908.

Upon graduation, he obtained a position at Worcester Polytechnic Institute as an instructor in physics. He continued to be connected with the academic world until 1934, part of the time on leaves of absence. His teaching career was convention, rising in the usual steps from instructor to assistant professor and finally to full professor at Clark University. During a small part of this period, in the 1912-1913 season, he served as research fellow at Princeton University. The rest of his academic career was passed in Worcester.

In his school days Goddard enjoyed mathematics, and was fond of studying better ways to do things. In his freshman year at college one of his professors assigned the topic "Traveling in 1950" as a theme subject. Goddard produced a bold paper in which he described in detail a railway line between Boston and New York, in which the cars were run in an evacuated tube and were prevented from metal-to-metal contact with the guide rails by electromagnets. With such a "vacuum railroad" he calculated it would be possible to make the run from New York to Boston in ten minutes.

As a young professor of physics, Goddard made contributions of importance on the conduction of electricity from powders, the development of crystal rectifiers, the balancing of airplanes, and the production of gases by electrical discharges in vacuum tubes. During his fellowship in Princeton, he produced the first laboratory demonstration of mechanical force from a "displacement current" in a magnetic field; this current being the fundamental concept in Maxwell's theory of electromagnetic waves (radio).

These achievements, however, were merely tune-ups for the real accomplishments of his life, which were soon to begin. There is no record of the first experiments he made with rockets, though it is known that this work began as part of a search for practical means of sending meteorological instruments into the stratosphere. To friends, Dr. Goddard once described with amusement some static tests he made as early as 1908 with small rockets in the basement of Worcester Polytechnic Institute. His experiments filled the basement of the building with acrid smoke, and so disturbed the equanimity of the institution he was asked to desist, at least until better equipment could be provided.

It was during his brief period at Princeton in 1912 that he made the initial computations which later were to form the basis of the Smithsonian paper of 1919. In this period, when he was about thirty, the great excitement of discovery first began to come upon him, for his calculations clearly indicated that only a little fuel, relatively, would be required to lift a payload to really great heights by rocket power, provided the rocket was so constructed as to make use of the fuel effectively.

Upon returning to Clark, in 1914, he began to experiment in earnest, beginning with ship rockets, and continuing with rockets of various types manufactured by himself. By 1916 he had reached the limit of what he could do on his own resources. Inexperienced though he was in the ways of money-raising for scientific research, his earnestness and enthusiasm won respect and attention. When he presented his idea on paper to the Smithsonian Institution that year he promptly received a letter from Dr. Charles D. Walcott, then secretary of the Institution, commending him on the report and inquiring how much money would be needed.

Goddard guessed it would require $10,000, but cautiously asked for $5,000. Between that day in 1916 and the appearance of his first paper in 1919, the experimental work required a total of $11,000, the whole sum of which was made available by the Smithsonian. This was the investment that launched modern rocketry and jet propulsion.

The rest of Goddard's achievements are told, factually, in his two reports. What is not disclosed—what can never adequately be told—is the labor and persistence and thought and heartbreak that went into these accomplishments, through which Goddard fathered all the research and development which led to the great expansion of jet propulsion in World War II; which continues to grow and unfold today in the jet propulsion research achievements of peace.

In 1924 Goddard married Esther Christine Kisk, who had been associated with him in his work, and who continued after their marriage to play a large part in the continuance of his research. He frequently ascribed to her the courage and faith which made his continuing efforts possible. Among other things, she was the official photographer of his tests. It was her camera that produced the pictures which illustrate his two reports.

After the entry of the United States into the first World War in 1917, Goddard volunteered his services, and was set to the task of exploring the military possibilities of rockets. He succeeded in developing a trajectory rocket which fired intermittently, the charges being injected into the combustion chamber by a method similar to that of the repeating rifle. He also developed several types of projectile rockets intended to be fired at tanks or other military objectives, from a launching tube held in the hands and steadied by two short legs, a device similar in many respects to the "bazooka" of World War II.

These weapons were demonstrated at the Aberdeen Proving Grounds on November 10, 1918, before representatives of the Signal Corps, the Air Corps, the Army Ordnance and others. The demonstrations went off quite successfully, but the Armistice next day put an end to the war and also to the experiments.

In the Second World War Goddard likewise volunteered his services, and was engaged in work on liquid fuel rocket research for the Navy at Annapolis throughout the conflict.

Goddard concluded his last report, in 1936, with these words: "The next step in the development of the liquid-propellant rocket is the reduction of weight to a minimum. Some progress along this line has already been made."

Part of this progress consisted of the development of ingenious, light-weight, simple fuel pumps for injecting the propellants rapidly into the liquid-fuel rocket motor. The physicist had expected to return to New Mexico as soon as possible after the War, to continue his work on high altitude rockets, and planned to set some altitude records which would have been spectacular indeed. His death, at the age of 62, brought this program to an untimely end. Nevertheless, Goddard lived to see the dream of his youth become reality. Jet propulsion, for the uses of war at least, matured in his lifetime from a fantastic notion into a billion-dollar industry. It gave promise,

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Society Notes

An Appreciation

Dr. Robert H. Goddard, who was for many years a member of the American Rocket Society and at his death was a member of its Board of Directors, was the first scientist to apply modern technical methods to the investigation of rockets and jet propulsion, and literally was the father of all the research and development which has led to the great expansion of jet propulsion in all its forms.

He was universally beloved and respected, and especially so by his associates in research on rockets and jet propulsion. The Board of Directors recently paid tribute to him in these words:

"With the death on August 10, 1945, of Dr. Robert H. Goddard, American science has lost one of its greatest pioneers—the creator of the modern science of rocketry.

"His investigations covered almost every essential principle involved in both the theory and practice of high-power rockets, and were mainly responsible for the immense progress of the subject in the last three decades, which has exceeded in importance the results previously attained in several centuries of early development.

"His inventions included the first liquid fuel rocket, the first smokeless powder rocket, the first practical automatic steering device for rockets, and innumerable other devices. He was one of the first to develop a general theory of rocket action, including the important "optimum velocity" principle, and to prove experimentally the efficiency of rocket propulsion in a vacuum.

"Even more impressive than Dr. Goddard's technical skill and ingenuity was his extraordinary perseverance, patience and courage in carrying on his investigations in the teeth of public skepticism and indifference, with limited financial resources, and in spite of heartbreaking technical difficulties —a combination of obstacles which might have baffled and disheartened a less stout-hearted pioneer. Almost single-handed, Dr. Goddard developed rocketry from a vague dream to one of the most significant branches of modern engineering.

"The lifework of Dr. Goddard, as both a scientist and a man, will always remain a brilliant inspiration to all of those who are privileged to carry on his endeavors, and to every other bold explorer on the new frontiers of science. In time to come, his name will be set among the foremost of American technical pioneers."

SOCIETY'S OFFICERS

James H. Wyld, research engineer for Reaction Motors and designer of the Wyld regenerative motor, one of the first practical liquid fuel motors, has been re-elected President of the American Rocket Society. A pioneer experimenter, Mr. Wyld is a long-time member of the Society's Experimental Committee.

John Shesta, chief engineer of Reaction Motors, Inc., long-time member of the Society's Experimental Committee and formerly its Chairman, a pioneer experimenter and designer of one of the first liquid fuel rockets to reach the speed of sound, was elected Vice-President of the Society.

G. Edward Pendray, private counselor in management, public relations and education, formerly President of the Society, and at one time Editor of Astronautics, was re-elected Secretary. Pioneer experimenter and co-designer with H. F. Pierce of the Society's first liquid fuel motor and first liquid fuel rocket, Mr. Pendray is author of "The Coming Age of Rocket Power."

Dr. Samuel Lichtenstein, a member of the Society almost since its founding and long a member of the Board of Directors, was re-elected Treasurer of the Society.

Cedric Giles, former President of the Society, and a member of the Board of Directors, was re-elected Editor of the Journal of the American Rocket Society. Mr. Giles, long interested in rocket experimentation and long-time member of the Society, is employed by the New York Telephone Company

Lovell Lawrence, Jr., former Secretary of the Society, a pioneer experimenter in rockets in this country, specialist in electronics, and now President of Reaction Motors, Inc., was named Chairman of the Program Committee.

H. F. Pierce, former President of the Society and pioneer experimenter, co-designer of the Society's first liquid fuel rocket and motor, former member of the Society's Experimental Committee, now a member of the staff of Reaction Motors, Inc., was elected Chairman of the Nominations Committee.

MEMBERS

The following alphabetical list of members are enrolled in the Active grade of membership of the Society. From time to time the JOURNAL will list the names of members in this and other grades of membership.

Alfred Africano, Cumberland, Md.
Col. A. A. Albahr, Los Angeles, Calif.
Russell T. Anderson, Denver, Colo.
Roy Price Barker, New York, N. Y.
David D. Beach, Ft. Lauderdale, Fla.
Murray C. Beebe, Jr., Glastonbury, Conn.
Martin R. Benjamin, Kew Gardens, N. Y.
Capt. Fred Bertino, New York, N. Y.
Alfred H. Best, Irvington, N. J.
Karl Leo Braun, Jr., Springfield, Ohio.
Robert J. Bremner, Southampton, Hants, England.
Louis Bruchiss, New York, N. Y.
Eric Burgess, Denton, Manchester, Eng.
Frank R. Canning, East Orange, N. J.
W. Hodge Caraway, Berkeley, Calif.
J. O. Chesley, Pittsburg, Pa.
Joseph Karel Chmel, Toronto, Canada.
Alexander P. de Seversky, New York, N. Y.
Ens. Herbert F. Duquette, Jr., New York, N. Y.
Zygmunt Fonberg, New York, N. Y.
Edward M. Foote, Jr., New Rochelle, N. Y.
Edward E. Francisco, Jr., Little Falls, N. J.
Fred M. Garland, Pittsburg, Pa.
Cedric Giles, Brooklyn, N. Y.
L. Michael Grieco, Baltimore, Md.
Leonard A. Guaraldi, Somerville, Mass.
Joseph Haaga, Astoria, N. Y.
Wm. S. H. Hamilton, Larchmont, N. Y.
Charles Marshall Hayes, Terre Haute, Ind.
Roy Healy, Dover, Del.
Edmund J. Henke, Chicago, Ill.
William S. Holloway, Honolulu, T. H.
Robert H. Hunter, Cleveland, Ohio.
Nicholas Ivanovic, Philadelphia, Pa.
Hugh D. Ivey, Atlanta, Ga.
Ens. E. P. Killian, Little Creek, Va.
Dr. Alexander Klemin, Greenwich, Conn.
Richard E. Knight, Bridgeport, Conn.
Max Krauss, New York, N. Y.
Dr. M. Z. Krzywoblocki, Providence, R. I.
Joseph E. Kucher, Lyndhurst, N. J.
Lovell Lawrence, Jr., Pompton Lakes, N. J.
Constantin P. Lent, New York, N. Y.
Sgt. John F. Lewis, New York, N. Y.
Dr. Samuel Lichtenstein, New York, N. Y.
Charles C. Littell, Jr., Piqua, Ohio.
Prof. Arthur A. Locke, Detroit, Mich.
Laurence E. Manning, New York, N. Y.
Jacques Martial, New York, N. Y.
Mrs. Jean Mater, Summit, N. J.
Capt. Milton H. Mater, New York, N. Y.
T. Melville-Ross, Sussex, England.
Robert Earl Meyer, Parris Island, S. C.
Lee V. Mincemoyer, Philadelphia, Pa.

Lt. C. B. Moore, Jr., Spring Lake, N. J.
A. L. Murphy, St. Petersburg, Fla.
Mrs. Clayton C. McCauley, San Francisco, Calif.
John F. McLeod, Jacksonville, Fla.
David E. Pearsall, Avon, Conn.
G. Edward Pendray, Crestwood, N. Y.
J. J. Pesqueira, New York, N. Y.
H. Franklin Pierce, Fairlawn, N. J.
William C. Rohrer, Redlands, Calif.
Nathan Schachner, Bronx, N. Y.
W. A. Semion, Los Angeles, Calif.
John Shesta, North Arlington, N. J.
George V. Slottman, New York, N. Y.
Donald Smith, Farmingdale, N. Y.
Leo E. Supina, Stafford Springs, Conn.
Leslie Velossy, New York, N. Y.
William A. Villevock, Cleveland, Ohio.
Michael T. Vincek, Clifton, N. J.
Herbert James Webb, Pittsburg, Pa.
James N. Wheeler, Sea Cliff, N. Y.
Malcolm J. White, Berkeley, Calif.
Cpl. R. D. Wolcott, New York, N. Y.
Albert V. Works, Jr., Dallas, Texas.
James H. Wyld, Pompton Lakes, N. J.

ROCKET SOCIETIES

Georgia School of Technology Rocket Society

The Georgia School of Technology Rocket Society, Atlanta, Georgia, was formed on April 3, 1945 by Harold J. Mason, the present president and a member of the A.R.S. The Society which has a membership of fifty, is holding meetings and collecting reports on rocket subjects for future publication.

Combined British Astronautical Society

The June-August issue of the Official Bulletin of the Combined British Astronautical Society states that on August 25 a London Branch of the C.B.A.S. was formed at Birkbeck College, London. The two other divisions of the C.B.A.S. are the Astronautical Development Society (Southern Counties) and the Manchester Astronautical Association (Northern Counties).

British Interplanetary Society

An informal meeting of the non-active British Interplanetary Society was held last June to consider the possibility of restoring the Society to full activity. An emergency committee, consisting of Prof. A. M. Low, P. E. Cleator and others, was appointed to reorganize and incorporate the Society.

Melbourne University Interplanetary Society

Formation of the Melbourne University Interplanetary Society, Melbourne, Australia, took place the beginning of this year. The present president is Dr. H. C. Corben, author of papers on theoretical quantum mechanics, and the secretary is S. N. Milford.

Glendale Rocket Society

Discussion on the experimental program constitutes the greater part of the meetings of the Glendale Rocket Society, Glendale, Calif. The Society's officers are: President, George James; Vice-President, Richard Reiss; Secretary-Treasurer, Robert Stucker; Director of Research, Lee Rosenthal.

Springfield Society for Rocket Experimentation

After a period of inactivity due to the war, the Springfield Society for Rocket Experimentation, Springfield, Ohio, is again contemplating an active program. Officers of the Society are: President, Karl Braun; Vice-President, Francis Ruzsa; Secretary, Richard Snodgrass.

Australian Rocket Society

The former president of the Australian Rocket Society, J. A. Georges, is reorganizing the Society, which became disjoined during the war, and has a postwar program in preparation. A change of name is contemplated with the replacing of the word "Rocket" with "Astronauts".

BOOK REVIEWS

Raketenflugtechnik (Rocket Flight Technique), by Eugen Sanger. Verlag von R. Oldenbourg, Berlin, 1933. Published and distributed in the public interest by authority of the Alien Property Custodian by Edwards Brothers, Inc., Ann Arbor, Mich., 1945; 222 pages, $5.00.

A reprint of the German technical work on the many experiments conducted by a teacher of aerodynamics at the Technical High School of Vienna. The first part considers rocket propulsion in relation to properties of various fuels, the second discusses aerodynamic problems and the third section deals with trajectories of rockets and rocket planes flying at supersonic speeds. Valuable information is given on rocket motors with extra long exhaust nozzles and in numerous tables on combinations of fuels and oxygen-carriers. The book is well illustrated with drawings and is indexed.

Wege zur Raumschiffahrt (Way to Space Travel), by Hermann Oberth. Verlag von R. Oldenbourg, Berlin, 1929. Published and distributed in the public interest by authority of the Alien Property Custodian by Edwards Brothers, Inc., Ann Arbor, Mich., 1945; 431 pages, $8.00.

Reprint of the greatly enlarged third edition of the original 1923 German booklet "Die Rakete zu den Planetenraumen" (The Rocket into Interplanetary Space) which helped to inspire the German authoress Thea von Harbou to write a manuscript for the film "Frau im Mond" (The Girl in the Moon). The third edition was awarded the 1928 REP-Hirsch Interplanetary Prize of 500 francs which was doubled in value.

Starting with the four assertions—the building of space machines, the ability to attain escape velocity, the carrying of personnel and the possibilities of future development — the author mathematically treats each in turn. The theoretical classic also contains advanced mathematical calculations on the problem of fuels, types of rocket motors, step-rockets, and a solar space mirror to reflect the sun's rays to the earth. Numerous drawings, graphs, tables, four plates and an index supplement the text.

Rockets, Official Publication of the United States Rocket Society, Inc. Vol. 1, No. 1, May 1945; 32 pages, $4.00 yearly.

This first quarterly issue, of a Society mainly concerned with interplanetary travel, emphasizes the earth to moon proposition. Feature articles deal with the V-1 robot bomb, conditions on the moon, and an excerpt of a talk on moon rockets. Other items refer to an analysis of rocket control, rocket stamps, planet reference tables, book reviews and society notes. A number of illustrations are included to clarify the text.

Astro-Jet, Journal of the Glendale Rocket Society. No. 10, July 1945; 10 pages. $1.00 per year.

Appearing in printed form the publication shows a marked improvement over previous issues. An account of the 1936 rocket mail flight from McAllen, Texas to Reynosa, Mexico is given, followed by articles on determining the combustion efficiency of black powder charges by weighing and computing the percent of ash, and calculations on a rocket flight test of a sighting device system. A number of society ground tests and flights are also recorded.

BOOK REVIEWS

Theory and Testing of Jet Propulsion Motors and Rockets, by Zygmunt Fonberg. Aircraft Jet and Rocket Corporation, New York, 1945; 82 pages, $2.00.

A booklet developed from a paper on the theory of reaction propulsion and methods of testing jet propulsion motors. Theory and thermodynamics of reaction motors are discussed with illustrative examples showing the practical application of formulas and definitions to the solution of problems. Various types of jet motors are considered with chapters on the rocket motor, the compression-expansion type, the resonance type, the athodyd, and thrust amplifiers.

The static thrust, rotational, wind tunnel, and pendulum types of test stands are described and test examples are mathematically computed. Velocity and efficiency tables and graphs, and drawings of reaction motors and test stands are included.

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too, of achieving also the objectives of peacetime research for which he had spent a lifetime of thought and effort.

Dr. Goddard had been a member of the American Rocket Society for many years, and a few months before his death on August 10, 1945 at Baltimore, Md., was elected to the Society's Board of Directors. In a public statement the Board of Directors pointed out that "American science has lost one of its greatest pioneers — the creator of the modern science of rocketry,"

—G. E. P.

(Continued from Page 5)

Concentrating a beam of electrons on drops of water would immediately split them into oxygen and hydrogen atoms which on uniting would form steam to drive turbines. Ships could use sea water, while the necessary large tank of water carried by land vehicles and aircraft under favorable conditions might be augmented by condensing moisture from the atmosphere.

Electronic Control

Attaching light compact atomic jet producers to cross-arms on a revolving shaft will provide a source of power. A number of adjustable disintegrator projectors would permit directional control of the rocket by varying the intensity of the propulsive energy of the bombarded material.

An electronic rocket steered by electrostatic or magnetic fields produced as a by-product of the atomic energy, or electrical or mechanical units operated by atomic power within the rocket have been suggested.

In the atomic age is the reality of atomic-propelled spaceships carrying a negligible fuel load and having the necessary power output for limitless range and high velocities. With atomic drive passenger travel in the stratosphere, stations in space, and interplanetary communications become a fact.

Recommended References

Pendray, G. Edward, "Rocket Power From Atoms?" Astronautics, No. 45, April 1940.

Sternberg, Robert L., "Electronic Spacial Rocket," Astronautics, No. 57, March 1944.

Cleaver, A. V., "Bombers or Rockets?" Flight, September 6, 1945.