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Reaction Propulsion Research In Poland

Investigation Of Rocket Power As Applied To Aviation

By Z. L. KRZYWOBLOCKI

Rocket and jet propulsion investigation as applied to aviation carried out by the author was divided into two parts: theoretical and experimental. The first was started early in 1933 and proceeded in three directions.

(a) Investigation referring to rocket and jet propulsion of the whole aeroplane.

(b) Investigation referring to auxiliary rocket and jet propulsion during takeoff and landing.

(c) Investigation referring to rocket projectiles launched from the ground or from the aeroplane in the air.

As the result of these theoretical considerations, referring to group (a), two papers appeared (ref. 1, 2). The purpose of those investigations was to find out the optimum height of flight of a rocket propulsion aeroplane for the given kind of propulsive material, and the possibility of applying reaction propulsion to various types of aeroplanes. The conclusions drawn were as follows:

(1) The optimum density of air for the flight is inversely proportional to the square of velocity of exhaust gases.

(2) Taking into account the development of aviation technics of today it does not look probable that reaction propulsion might be applied to transportation aeroplanes and bombers.

(3) It is quite possible that in the near future this type of propulsion will find an application to fighter and pursuit types of aeroplanes.

The purpose of the investigations of group (b) was to calculate the distance of takeoff and landing with the application of powder rockets to land gliders, water gliders towed by hydroplanes or boats, landplanes and hydroplanes. The results of these calculations were published in Poland and in France (ref. 3, 4, 5), and in the last year in the United States (ref. 6) These were the first calculations of assisted takeoff and landing to be published. From the calculations the following conclusions were drawn:

Gliders With Skids

(1) About 24 lbs. of black powder (or 1.5 lbs. of gasoline) are needed to assist the takeoff of a 600 lb. motoglider from a level hilltop.

(2) About 19.5 lbs. of black powder (or 1.25 lbs. of gasoline) are needed to assist the takeoff of a 400 lb. glider from a level hilltop.

(3) For the takeoff of a 440 lb. glider on an inclined hilltop, about 9 lbs. of black powder (or 0.56 lbs. of gasoline) are needed.

(4) After takeoff, for a gain of altitude of 1,650 ft. for the 440 lb. glider, 160 lbs. of black powder (or 10 lbs. of gasoline) are needed.

(5) For horizontal flight from thermal to thermal, a 440 lb. glider will travel a distance of 3,270 ft. with a charge of 10½ lbs. of black powder (or 0.66 lbs. of gasoline).

(6) To cut the sinking speed in half while in free flight, a 440 lb. glider will require 6 lbs. of black powder (or 0.39 lbs. of gasoline).

(7) The use of rocket or jet propulsion blends in very well with the streamline shape of a glider and will not spoil its aerodynamic characteristics.

Water Gliders

(1) About 32 lbs. of black powder are needed to cut the distance of takeoff of a water glider towed by a seaplane to 30% of the distance of takeoff of the same water glider towed by a seaplane without use of rockets (rockets in seaplane or sea glider).

(2) About 14.6 lbs. of black powder are needed to cut the distance of takeoff of a 750 lb. two place sea glider towed by a 300 h.p. motorboat to 45% of the distance of takeoff of the same combination without rockets (rockets in sea glider).

Landplanes

(1) By use of powder rockets it is possible to shorten takeoff by 30 to 50%, the landing run by about 37%. The calculations showed that powder rockets are not large.

(2) It is characteristic that at greater overloading of an aeroplane the powder rockets are more effective; i.e., the percentage in shortening takeoff is greater when the aeroplane is heavier.

(3) It is very doubtful whether powder rockets may be used in case of takeoff when clearing obstacle since the volume of powder is too great.

Seaplanes

(1) The use of powder rockets permits shortening the length and time of takeoff by 40 to 50%. The weight of rockets is not great.

(2) In some cases, e.g., takeoff of an overloaded seaplane, the length of takeoff may be so great as to be feasible only with rocket or jet propulsion or some such device.

The purpose of investigations carried out in group (c) was twofold:

(1) General considerations of the possibility of using rocket or jet projectiles launched from the ground or from an aeroplane in the air, possible development of winged rocket bombs, rocket torpedoes, etc. The results of these investigations were published in Poland and later in the United States and Canada (ref. 7, 8, 9).

(2) The calculation of the range of a wing-bomb and rocket torpedo, the influence of the kind of propulsive material and the height of flight of an aeroplane launching the wing-bomb on the range. These calculations were performed in 1936 and were deposited with the Polish Air Forces authorities. Military secrecy did not permit their publication and the manuscript probably was destroyed in September, 1939 at the Institute of Technical Research for Aeronautics in Warsaw. In 1940, in London, the author reproduced from memory these calculations in much condensed form. They were held for sometime because of censorship and were published in 1944 (ref. 10), eight years after they were performed. The conclusions drawn are as follows:

Rocket Wing-Bomb Launched From An Aeroplane

(1) The influence of rocket propulsion in increasing the range of a wing-bomb, as compared with a similar bomb without propulsion, is greater at low altitudes than at higher ones.

(2) From a general point of view, height has more influence than rocket propulsion on the range of a wing-bomb.

(3) Following from (2), the influence of optimum lift/drag ratio and aspect ratio on the range of a wing-bomb is very considerable.

(4) The type of propulsive material of rockets has greater influence at low altitudes, where it is better to use stronger materials. At greater heights, the type of material is less important.

(5) The use of rocket propulsion for wing-bombs may be very advantageous in releasing bombs at low alti-

tudes, for it gives great accuracy of aim. In this case, stronger materials should be used.

Winged Rocket Torpedo Launched From The Ground.

(1) The influence of type of working material is very important. Strong materials should be used.

(2) The distance traversed by the rocket torpedo on the glide is much greater than that of the upward flight.

(3) Following from (2), very high lift/drag ratios and aspect ratios should be used.

(4) The ranges of rocket torpedoes, as given by approximate calculations are considerate and may reach the distance of about 230 miles.

Experiments

The experiments were begun early in the spring of 1935 and were performed by the author with Captain H. Stankiewicz on the military airfield at Lwow (South Poland). The propulsive material used was black powder. The rockets were produced in small quantities by a military pyrotechnist-specialist. The first part of the tests dealt with the value of the force which can be obtained from a powder rocket. The rockets were mounted on a horizontal table and the force was measured by the aid of a spring-scale. The rockets were ignited by a fuse. Those tests showed that from well manufactured black powder rockets, a pressure of 0.5 kg/cm^2 or 7.0912 lbs. per sq. in. may be obtained (ref. 3).

The second part of the tests dealt with flight experiments. The low wing models were made from laminated wood. The wings and fuselage were made separately and later glued together. The wingspan was about 2½ to 3 ft. The airfoil sections used were Gottingen profiles. The wing had a rectangular planform, the fuselage a square cross-section. Along the axis, the fuselage possessed a long circular hole inside, into which a powder rocket of circular shape was put. At the rear part of the fuselage, tail control surfaces were located of symmetrical airfoil. A series of these models were made. The factors which were subject to change were as follows:

(1) The location of the wing with respect to the center of gravity of the whole model.

(2) The angle of set of the wing with respect to the longitudinal axis of the fuselage.

(3) The angle of set of horizontal tail surface with respect to the longitudinal axis of the fuselage.

(4) The change of center of gravity of the whole model by the addition inside of small pieces of lead.

(5) The angle of inclination of launching device.

The rockets were ignited by a fuse and models were launched at first from the ground from an inclined wooden launching device specially designed with variable angle of inclination. Later, models were launched from the roof of a building. The difficulties met during the tests and results were as follows:

(1) Because of lack of flight control devices and the change of center of gravity in flight, the first models after a short distance of flight assumed a steep glide path towards the ground long before the rocket was burned out.

(2) Many tests were performed in which the wings were transferred towards the front and towards the rear of the fuselage, sections of the wing were changed, the position of center of gravity was changed by the addition of pieces of lead in various places of the fuselage, and the angle of set of the horizontal tail surface was changed.

(3) It was very difficult to find a

position of center of gravity, location of wing, angle of set of tail surface such as to give a steady horizontal flight path of such a heavy model.

(4) The longest distances of flight were obtained using such a position of c.g., and such a location of wing that the flight path was a slightly inclined climb, with a glide or steep dive after the whole rocket was burned out.

The longest distance of flight obtained during those tests was over 200 yds. Projects were started for the designing of a larger model with control devices, but the tests were stopped

References

1. Krzywoblocki, Z. L., "Reaction Propulsion," Zycie Techniczne, Lwow Institute of Technology, December 1934.

2. Krzywoblocki, Z. L., "Possibilites de l'application de la propulsion a fusee dans l'aviation," Lwowskie Czasopismo Lotnicze, Appendix to Czasopismo Techniczne, Lwow, Vol. III, X, pp. 72-81, 1935.

3. Krzywoblocki, Z. L., "Les possibilites de l'emploi des fusees a poudre dans l'aviation," Lwowskie Czasopismo Lotnicze, Appendix to Czasopismo Techniczne, Lwow, Vol. IV, X, pp. 61-122, 1936.

4. Krzywoblocki, Z. L., "Les possibilites de l'emploi des fusees a poudre dans l'aviation amerissant," lwowskie Czasopismo Lotnicze, Appendix to Czasopismo Techniczne, Lwow, Vol. VII, V, pp. 1-15, 1939.

5. Krzywoblocki, Z. L., "La reaction comme la mode de propulsion auxiliars," L'Aeronautique, Paris, Vol. 21, No. 242, pp. 276-281, July 1939.

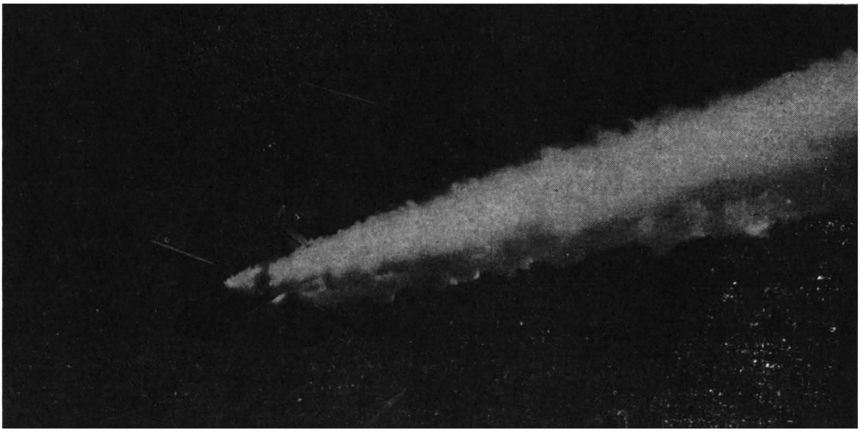
6. Krzywoblocki, Z. L., "Applying Jet Propulsion to Gliders," Soaring, Vol. VIII, Nos. 7-8, pp. 7-9, July-August, 1944

7. Krzywoblocki, Z. L., "Rocket Winged Bombs and Torpedoes," Przeglad Lotniczy (Monthly of the Headquarters of the Polish Air Forces), Warsaw, 1938.

8. Krzywoblocki, Z. L., "Winged Rocket Bombs," Astronautics, No. 51, pp. 7-9, December 1941.

9. Krzywoblocki, Z. L., "The Rocket Wing-Bomb and Rocket Torpedo," The Engineering Journal, Montreal, Vol. 25, No. 3, p. 192, March 1942.

10. Krzywoblocki, Z. L., "Rocket Wing Bomb and Rocket Torpedo," The Journal of the Royal Aeronautical Society, Vol. XLVIII, No. 399, pp. 58-67, March 1944.



—U. S. Navy

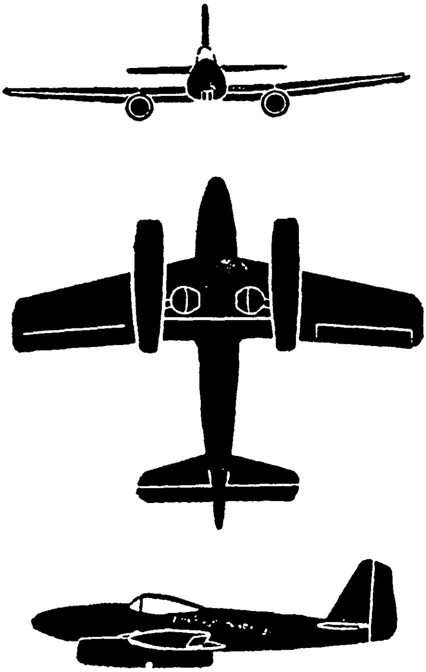
Jet Assisted Takeoff—A massive bi-motored Martin Mariner (PBM) in a jet-assisted takeoff from the water.

Notes On Turbo-Jet Aircraft

Other than Italy's Caproni-Campini jet-propelled plane of the much publicized Milan-Rome flight, England, United States and Germany have each developed a number of designs employing the turbo-jet type of engine. The British line of evolution apparently runs from the Gloster to the Meteor to the new Vampire. Produced by De Havilland, this new fighter plane is powered by a simplified jet engine and has a speed in excess of 500 m.p.h. Developed just before the European war ended, the plane is scheduled for service in the Pacific in the near future. Stemming from the British Gloster jet units, the U. S. has brought forth the Bell Airacomet and the Lockheed Shooting Star with considerable development on later models.

Numerous designs of jet-driven aircraft have been produced in Germany. The often mentioned Messerschmitt Me 163 is rocket powered and does not have turbo-jet units as used in the Me 262, the Heinkel He 280 and the Arado Ar 234. Reports are current of a small single-seater plane with two cannon propelled by an impulse duct engine, and a long-range bomber, said to be the Messerschmitt Me 264, which uses mixed power units of orthodox reciprocating engines and propulsion jets.

It is also interesting to note that at least four models of jet-propelled helicopters were under development in Germany. The aircraft, which were designed to take off and land on small surface craft or submarines by jet power, employed standard engines and rotors for traveling. The single and double-seater models were built at Wiener Neustadt and at St. Poelten, Austria, and were equipped with 60 to 135 h.p. engines. Fuel consumption for one model was estimated at 35 gallons per hovering hour and 10 gallons when traveling.



Me 262 is powered with two Junkers jet units mounted in the wings.

Fuel Selection

The high fuel consumption, a fact disregarded in wartime but most essential in peacetime use, will be largely offset by light weight power plants and low cost fuel. Jet units may be adapted to operate on low grade oil, kerosene, high octane gasoline, powdered coal or even a compressed wood fuel. High octane gasolines with anti-knock properties are not required; B.T.U. content expressing the quantity of heat determines the efficiency of the fuel. The type and mixture ratio of fuel is important due to high combustion temperature limitations of available alloys. The ideal turbo-jet fuel is probably midway between kerosene and gasoline, with careful refining required as at high altitudes the low temperatures have a tendency to solidify the wax content in kerosene.

The Repulsor Rocket

Description Of A British Experimental Design

By A. E. CRAWFORD

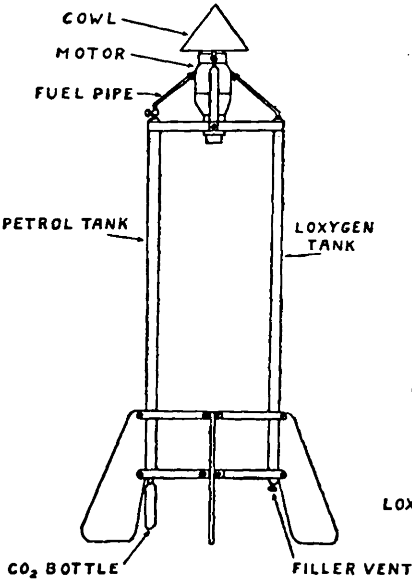
The repulsor rocket, although capable of flight, can be used most conveniently as a test bed for motors. It is of very simple construction and is adaptable for modifications to motors, fuel, etc. As is well known, it was the logical development of the German 'Mirak' rocket and credit must be given to Herr Klaus Riedel for its simplicity of design. It was, of course, the first really satisfactory liquid fuel rocket to be produced and has some fine flight records. It is proposed to describe a modification of this rocket based on practical design and using the minimum of materials and facilities. Although dimensions are quoted in some cases, the description is intended to be of the most general nature as modifications can be made to suit available material and requirements. As described, the rocket was constructed for motor testing and has proved highly satisfactory.

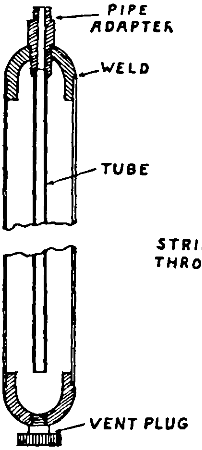
General Description

The general layout consists of two cylindrical fuel and liquid oxygen tanks combined by a framework to form a rigid structure. At the lower end are fitted stabilizing fins. The motor is suspended centrally over the top end and fuel is led to it via pipes from the top of the tanks. A cowling is placed over the top of the motor to provide some attempt at streamlining and to make a space for fitting recording instruments.

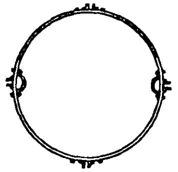
Fuel Tanks

The oxygen tank as shown is constructed from a piece of high grade drawn steel tubing 3 ft. long, 1⅛ in. outside diameter and 14 gauge thick. The tubing should be carefully selected for freedom from cracks, dents, and flaws of any kind; if the specification is deviated from it should be stressed out to give a safety factor of at least

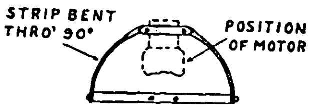




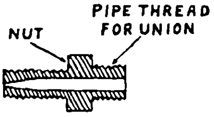
LOXYGEN TANK



FIN FRAMEWORK



MOTOR FRAMEWORK



JET SECTION

X3 over the operating pressure that it is planned to use in the fuel tanks. Ends are turned as shown and carefully welded into position, preferably using oxy-acetylene equipment. The lower end has a 3/8 inch B.S.F. tapped hole provided in it for filling purposes; this is normally closed with a shouldered bolt. A fibre washer is provided to make the joint gas and liquid tight. Fibre has been founded to stand up best under the temperature condition imposed on it. The top cap has a hole into which a piece of copper of similar tubing is brazed. This tube is just long enough to reach the bottom of the casing, and is to ensure that liquid oxygen reaches the combustion chamber by being forced under the pressure of gaseous oxygen at the top of the tank. Into the outer side of the end cap is screwed a double ended bush provided with a gas thread to take a standard union nut. The diameter of hole through the copper tube and bush should be sufficient to take the maximum rate of flow that the motor is designed for.

The petrol tank, about 10 inches distance from the oxygen tank is of similar construction with the exception of two items. The filler bolt is replaced with a fitment to take a 'Sparklet' soda syphon recharger or similar small tube of compressed gas, for forcing the petrol into the combustion chamber. The compressed gas most generally used is carbon dioxide but it may be possible to use a combustible gas, thereby providing a little extra fuel. Instead of the double ended bush, a small tap such as a standard gas cock is used. This provides a control of the fuel flow for combustion mixture adjustment and ease of handling.

Framework Construction

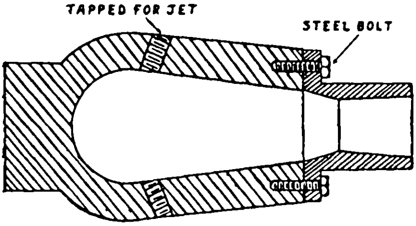
The supporting framework is made entirely from 1 inch by 16 gauge mild steel strip. Three hoops 11 inches in diameter are made up by lapping the ends over an inch or so and riveting or welding in position. Pipe clips are made up to suit the diameter of the fuel tanks and are positioned and clamped by two B.A. cheese head screws and nuts. The two lower hoops are provided with four lugs each, welded or riveted on. The lugs have a clearance hole through them to fix the fins in position. The top hoop has a diametrically placed semicircle of strip secured to it; the strip is twisted through 90 degrees at its midpoint and shaped to fit round the top of the motor. A loose clip is provided for clamping the motor in position.

For the sake of compactness when packing for transportation, nuts and bolts were used on the original model, but in most cases rivets and welding could replace them.

The fins are made from 18 gauge sheet duralumin and are cut to a suitable shape. A size suitable for the suggested framework would be 12 inches by 6 inches.

Motor And Jets

The motor and fuel jets will be described briefly but it is, of course the major part of the rocket, and can be made to any form desired by the constructor—concentric feed, fuel whirls, thrust augmentors, etc. can be constructed to suit personal needs.



MOTOR

The simple motor made for initial experiments was constructed from 3 inch diameter duralumin, the chamber was bored out on a lathe to proportions decided by the size of jets and desired thrust, the nozzle piece being similarly bored and smoothed to a venturi outline. A parallel shank is turned at the tuyere end to enable a thrust augmentor to be fitted if desired. Holes are drilled for four ¼ inch B.S.F. bolts, and counterbored to provide a seating for the boltheads.

A simple set of jets can be made as pictured. They are machined from steel and are screwed to fit into the motor; a pipe thread is cut at the inlet end to suit a pipe union. The body is provided with a hexagon shaped collar to enable a spanner to be used for tightening purposes. The dimensions of the jets are of course decided by the theoretical design of the rocket while the bores should be polished to a mirror finish to reduce friction to a minimum.

A cowling is provided to increase motor cooling and to provide a space for a small recording accelerometer or other instruments. It is bent up from 24 gauge sheet duralumin and is held in position by small wing nuts and bolts. If desired, the whole cowling including the instruments can be released after the rocket reaches its maximum height and a small parachute arranged to return the record safely.

It is hoped that this brief description is sufficient to encourage enthusiasts to construct their own rockets. No attempt has been made to discuss the theoretical design of rocket motors but a great deal of data has been published in the past by the Manchester Astronautical Association, the Astronautical Development Society, and the British Interplanetary Society.

JAPANESE SUICIDE ROCKET BOMBS

Airplane-launched glider-type rocket bombs have been used by the Japanese Kamikaze, or special suicide corps, since April 12 in attacks on Pacific Fleet surface units in the battle for Okinawa. The human-piloted, twin-tailed Japanese version of the German glider bomb has been named by the Americans "Baka" bomb, a derisive Japanese term meaning stupid or foolish.

Constructed of wood and light metal, the one place jet-propelled bomb has a wingspan of 16 ft., is almost 20 ft. long and has an 8 ft. tailplane. Launched from the underside of a Betty or other large bomber generally at a 3 mile altitude, the projectile may attain speeds of 500 m.p.h. the first minute of flight from the impulse of the tail rocket motor.

The pilot rides astride the projectile under a streamline transparent canopy and exercises moderate control by sideslipping and other maneuvers to guide the bomb to the target. Due to the high speeds involved, the Baka bombs are difficult to steer allowing a surface craft to dodge by evasive action, though a number of hits has been scored. As no landing gear is attached, the pilot is doomed if the bomb hits its objective thereupon exploding the half-ton warhead of explosives or misses it completely. When released from a 6 mile altitude, the rocket bomb due to its initial jet power and gliding possibilities is reported to reach ranges of over 100 miles.

The C.B.A.S.

Correspondence with the Combined British Astronautical Societies reveals that the British groups are holding a number of special meetings for the purpose of discussing the future policy of the organization. The main issues to be debated concern the single society idea, future name, types of membership, publications, formation of committees and line of development in the postwar era.

Mr. A. E. Crawford, who has an article in this issue, was recently elected to Fellowship from membership.

Fifteen Years Of Organized Rocketry

The American Rocket Society Notes Its Anniversary

On the evening of March 21, 1930, a dozen men gathered in an apartment at 450 West 42nd Street, in New York City, to form an ambitious society for the "promotion of interest in, and experimentation toward interplanetary expeditions and travel . . . the stimulation by expenditure of funds and otherwise of American scientists toward a solution of the problems which at present bar the way toward travel among the planets, and the raising of funds for research and experimentation."

It was the first meeting of a group which then called itself "The American Interplanetary Society" and which subsequently became the American Rocket Society. The year 1945, consequently, marks the fifteenth anniversary of the Society, and of organized rocketry in this country; a decade and a half which has seen the rise of rocketry and jet propulsion from an obscure and somewhat fantastic hobby to the status of a major engineering field and wartime industry, employing hundreds of thousands of people and producing jet propulsion engines, thrustors, jatos, jet planes and rockets valued at more than $1,000,000 annually.

The leader of the original organizing group was David Lasser, a graduate of the Massachusetts Institute of Technology, and then editor of a popular science-fiction magazine called Wonder Stories. Mr. Lasser, now a government official in Washington, D. C., became the first president of the Society.

Other founders included C. P. Mason, a writer and editor, who was the first secretary; Fletcher Pratt, the noted writer and authority on naval and military matters; Clyde J. Fitch, an engineer now connected with the International Business Machines Company; C. W. Van Devander, a newspaperman; Laurence Manning, a writer and businessman, who is at present a member of the Society's Board of Directors; Nathan Schachner, a lawyer and noted writer; and Dr. William Lemkin, chemist, teacher and writer of textbooks in technical fields.

Mr. Van Devander, who is now a newspaperman in Washington, D. C., became the editor of the Society's first publication, known as the BULLETIN. G. Edward Pendray, in whose apartment the organization meeting was held, was elected vice-president, and given the assignment of organizing a research program.

First Activities

The Society's first public activity was to arrange a ceremony in which Captain Sir Hubert Wilkins, the explorer, presented to its library an old copy of one of the earliest books on interplanetary travel, The Discovery of a New World, by John Wilkins, Bishop of Chester, written in 1640. Bishop Wilkins was a distant ancestor of Sir Hubert's. In the same ceremony, the explorer became a member of the Society.

The second public activity of the organization was to provide for an address at the American Museum of Natural History in New York by Robert Esnault-Pelterie, the famous French engineer, airplane builder and rocket enthusiast. The auditorium at the Museum holds 1,500 persons, but so great was the crowd attracted to this address, that enough people came to fill the seats twice over. An overflow crowd of more than 1,000 persons remained outside throughout the first performance, and nearly filled the auditorium again at ten o'clock, when the entire program was repeated.

The Society was thus well launched. The membership climbed. Among the well-known American scientists and engineers who joined were Dr. H. H. Sheldon, professor of physics at New York University; Dr. Alexander Klemin, head of the Guggenheim School for Aeronautics at New York University; Dr. George V. Slottman of the Air Reduction Company; Mr. John O. Chesley of the Aluminum Company of America; Dr. James H. Kimball, of the United States Weather Bureau, and Dr. Robert H. Goddard, the founder of modern rocket research and the foremost figure in our time in rocketry and jet propulsion.

Early Research

The experimental program of the Society got under way, in general, in 1931. Early in that year, Mr. and Mrs. Pendray had an opportunity to go abroad. They planned their trip in such a way as to enable them to study what the European experimenters were doing. The Society named them its official representatives, and they had excellent opportunity to learn what was going on in rocketry in Italy, France and Germany.

They found to their dismay, that most of the European "rocket experiments" which had so much excited the American public at the time were mostly publicity stunts, of little or no scientific value. At Berlin, however, they met Willy Ley, with whom Mr. Pendray had previously had much correspondence. Ley introduced them to the interesting and suggestive experiments then being carried on, with what are now called "solid" liquid fuel motors, by the Verein fur Raumschiffahrt (German Rocket Society) near Berlin.

Mr. Pendray's report on the German experiments was given before the Society on the evening of May 1, 1931, and appeared in a somewhat condensed version in the May issue of the BULLETIN. It marked the beginning of liquid fuel experiments in this country, other than the work of Dr. Goddard, who had, of course, been using liquid fuels in his motors since about 1920.

Shortly after the May 1931 meeting, H. F. Pierce, who later became president of the Society, proposed that experimental work begin at once. An experimental committee was formed. Mr. Pierce and Mr. Pendray designed, more or less by rule of thumb and what guidance they had from the German data, the Society's first liquid fuel motor and rocket.

Publications

The rest of the story of the American Rocket Society to date is told in the early issues of the BULLETIN, and subsequently in ASTRONAUTICS, now the JOURNAL. Before the war, the Society was the largest and most active organization of rocket experimenters in the world. It had an elaborate experimental program of its own, and in addition, many of its more than 300 members were also carrying on research in rocketry and the various phases of jet propulsion.

It had by that time produced, in the issues of the BULLETIN and ASTRONAUTICS, one of the largest accumulations of data, information, theory and conjecture about rockets and jet propulsion available in any language, and by far the largest in English.

Experiments

It had performed literally hundreds of tests of motor designs, fuel combinations, rocket designs, aerodynamic experiments, studies of dry fuel and liquid fuel problems, parachutes, catapults and the like. The data obtained from these tests were all duly reported in the Society's publications for the use and guidance of other engineers and experimenters.

It had, through a long series of tests covering a period of more than five years, encouraged and made possible one of the first practical regenerative liquid fuel motors—the so-called Wyld regenerative motor — named for its originator, James H. Wyld, who later became president of the Society. The Wyld regenerative motor was the progenitor of liquid fuel motors which played a major part in the liquid fuel jet propulsion apparatus developed for military use during the war.

It had made and shot many rockets, including a notable series of liquid fuel rockets culminating in the shot of Rocket No. 4, designed by John Shesta, later chairman of the Society's Experimental Committee and now a member of the Board of Directors. Mr. Shesta's rocket was shot on September 9, 1934, at Marine Park, Staten Island, New York. Its observed velocity at one point exceeded 1,000 feet per second—about 700 miles an hour.

Prewar Accomplishments

It had done much to establish the whole field of rocketry and jet propulsion—which up to then had been too much the realm of fantasy writers, publicity stunts and unsound theorists—on a reliable and wholesome engineering basis, with technical reports of its work, an analysis of the engineering problems to be solved, and an orderly approach to their solution. With its publications and experimental work, as well as the educational work it carried on with the public, it laid the groundwork for a great deal of the thinking and development in jet propulsion that came with such suddenness during the war.

Finally, perhaps the most important of the Society's prewar accomplishments was the subtle one of training a number of young engineers and technical men in the thinking and "know-how" of rocketry. Many of these men—Alfred Africano, John Shesta, Roy Healy, H. F. Pierce, Lovell Lawrence and James Wyld, to name just a few—are now in key positions in the war effort. Though the nature of their work is necessarily undisclosable at present, it is proper to note that they have all made extremely important contributions to rocketry and jet propulsion in the war.

Present Aims

The Society is now changing from an essentially amateur group of experimenters (there were no professional rocket and jet propulsion engineers before the war) to a professional engineering society, devoted to the furtherance of rocket and jet propulsion engineering, and the general advancement of this new and growing field. The membership has enlarged rapidly during the war; likewise the demand for the Society's publications. It is hoped that regular monthly meetings can be resumed by next autumn—meetings which were discontinued at the request of the military authorities for security reasons soon after Pearl Harbor.

The Society has affiliate groups, some of which have commenced to consider postwar research programs of their own. Other affiliates are being encouraged on a regional basis, offering the Society a means of becoming truly national in character.

So ends the American Rocket Society's first fifteen years. It looks forward to the coming fifteen years with expectation and enthusiasm.

—G. E. P.

ERRATUM

In the article, "Frictionless Flow In A Rocket Motor, the factor

$$\frac{2}{n+1}$$

appearing under the radicals in Equations (2) and (5), as well as in that giving values for Am, should read

$$\frac{2}{n-1}$$

The New York Rocket Battalion

Experiences Of A Civil War Rocket Unit

Shortly after the start of the War of Secession a public meeting was held at the town of Perry, Wyoming County, New York State, to interest the citizens in forming a light artillery company. Some twenty volunteers to the cause journeyed to Fort Porter, Buffalo where they joined a similar group from Monroe County. Proceeding to Albany the men on December 6, 1861 were mustered into the service of the United States to serve three years.

Major Thomas W. Lion, a British officer who claimed improvements on the Congreve war rocket, organized the Wyoming-Monroe group together with several other squads into a rocket battalion. The 160 men in the battalion were divided into two companies, A and B, led by Captain Alfred Ransom and Captain Jay E. Lee, respectively. The battalion went by steamer to Washington, D. C. to receive the necessary training and equipment. At the capital the enthusiastic unit changed the name of their encampment to Camp Congreve, in honor of the rocket inventor, but were obliged to wait four long months before receiving the much vaunted "rocket guns."

Rocket Artillery

The standard rocket of the time had an overall length of 12 to 20 inches with a diameter of 2 to 3 inches. Surmounted by a conical solid iron head, the hollow rocket body contained the fuse-ignited propellent powder. These rockets were accredited with a range of three miles. The sheet-iron launchers either consisted of a 3 inch hollow tube or three ¾ inch rocket-guiding rods bound in an open framework by sturdy bands. Advantages claimed for the rocket were: limitless size, negligible recoil, speed of firing, easiness of transportation, lightness and simplicity of launching equipment, and resultant confusion created among mounted troops.

An improved design of rockets were to be used by the battalion. The hollow warhead was designed to carry seventy-four musket balls with powder to be exploded in grapnel fashion at a predetermined point by a time fuse. Ignited by a fuse the inflammable compound in the rocket body created large gas masses which on expelling through tangentially placed outlets gave a forward spiral motion to the rocket. The imparted spin and heavier head were considered to aid the stability of the rocket giving a straighter flight and greater range.

The wrought iron rocket projectors were 8 feet long with 2¼ inch bores. Inch in diameter holes for the rocket's exhaust gases perforated the tubes throughout. Four rocket-launching tubes were mounted on each of the four lighter than usual carriages enabling the gunners to discharge 16 rockets at one volley.

In April 1862 the battalion tested the rockets by discharging them at an army blanket hung as a target a mile away. A number of faults appeared, the most common the failure of the projectile to hold a true course reverting in some cases in a retrograde movement. Due to the urgent need for light artillery replacements the rocket equipment was exchanged for rifled cannon, and shortly afterwards the battalion left Washington. On February 11 of the next year the rocket battalion was officially changed to the Twenty-third and Twenty-fourth Independent Batteries New York Artillery.

Reference

Merrill, J. W., Records of the 24th Independent Battery, N. Y. Light Artillery, 1870.

A Vocabulary For Jet Propulsion

Part II — An Astronautical Nomenclature

By G. EDWARD PENDRAY

This part completes the list of words and phrases used in the field of jet propulsion. The first section of the glossary was published in JOURNAL No. 61.

Chamber pressure—Pressure shown by a gage connected to the combustion chamber during firing.

Chemical fuel motor—A true rocket motor, using propellants supplying their own oxygen (as opposed to the air-stream engines, which obtain their oxygen from the air).

Chugging—Irregular combustion due to incorrect mixture or poor chamber design.

Chute boot—The parachute container of a sounding rocket.

Combustion chamber — An alternative term for blast chamber.

Compressibility burble — An unsteady type of airflow around an airfoil operating close to the speed of sound, marked by reduced useful lift and increased drag, caused by shock waves on the airfoil surface.

Concentric tanks—Fuel or propellant tanks nested one within the other, with a common central axis.

Construction weight—The weight of tanks, motor, pumps, controls, landing gear, etc. of a rocket, exclusive of fuel. (Same as **structural weight**).

Controlled rocket—A rocket which has a guiding mechanism capable of controlling the direction of flight.

Coolant—Any material used to cool a rocket combustion chamber or nozzle.

D

Delayer—A substance mixed with the propellant of a dry-fuel rocket to slow down the rate of combustion.

Dipropellant—A combination of two substances used as a rocket fuel.

Dissociation — Decomposition of the burned gases in a combustion chamber at high temperature, producing a loss of heat energy.

Drag coefficient—A factor representing the relative air resistance of a particular shape of airfoil or hull, used in air-drag calculations.

Drop unit—A booster rocket which can be jettisoned after exhaustion of its propellants.

Dynamometer—A device for indicating and recording the thrust of a rocket motor during test, also called a **reaction balance.**

E

External efficiency—The ratio between the energy usefully employed in propulsion and the kinetic energy developed by the jet. (Same as **ballistic or mechanical efficiency**).

Escape velocity—The velocity at which an object would escape the gravitational attraction of a given astronomical body. The escape velocity of the earth is 6.664 miles per second.

F

Fill-hole — The orifice through which liquid fuels are loaded into a rocket's tanks.

Final mass—The mass of a rocket at the end of powered flight.

Fins—Fixed rudders on a rocket to help give it direction.

Fizz pot—An airplane booster rocket.

Flaps—Movable rudders, either attached to the fins or placed in the jet of a rocket, to direct the flight.

Flare—The bell-shaped inner curve of some types of rocket motor nozzles.

Free flight—The portion of a rocket's flight which follows the combustion of the fuel or the turning off of the rocket motor.

Free rocket—A rocket which has no guiding or flight control devices other than fixed tail or fin surfaces.

Ft/sec (or fps)—Feet per second, frequently used in connection with measurement of jet velocity.

Fuel—The combustible component of a rocket propellant; through this term is often used also to denote the oxidizer as well.

Fuel-weight ratio — The ratio of the weight of a rocket's fuel to that of the empty rocket without fuel. Also called the **fuel structure ratio.** It is equal to the **mass ratio** minus 1.

Fusee—A small pyrotechnic squib used for igniting a rocket motor.

G

g—Symbol for **gravity,** the unit of acceleration, equal to 32.2 feet per second per second.

Gyrocontrol—A gyroscopically operated device for guiding a rocket in flight.

H

Hull—The outer casing of a large rocket projectile

I

Ideal rocket—A rocket constructed to such a weight-fuel ratio that it will reach the velocity of its own jet. In a gravityless vacuum this ratio would be 1 to 1.72; the larger number referring to the fuel; in air the ratio is 1 to 2 or better.

Impulse—The total output of a jet motor in a given shot; equivalent to average reaction multiplied by time.

Impulse-weight ratio — The ratio between impulse (reaction multiplied by total firing time) of a jet motor and the total loaded weight, including auxiliaries.

Igniter—A device for igniting a rocket motor.

Initial mass—The mass of a rocket at the beginning of flight.

Initial velocity—Velocity of a rocket at the start of the firing period.

Injector—The inlet device which admits propellants to a rocket motor.

Inlet ports—The openings or nozzles through which propellants are injected into the rocket motor.

J

Jato—Apparatus for producting jet assisted takeoff, or an airplane so equipped.

Jet—The stream of gas ejected by a rocket motor.

Jet-assisted takeoff—An airplane takeoff accelerated by the use of a thrustor rocket or jato.

Jet engine—An airstream engine; a reaction motor equipped to use oxygen of the air as an oxidizer.

Jet propulsion—Rocket power: propulsion by thrust developed by ejecting a jet of rapidly moving gas or other substance through a nozzle.

L

Landing gear—Equipment, usually consisting of a parachute and release mechanism, for bringing a rocket gradually to earth after a shot.

Launcher—The aiming device from which a rocket is shot.

Launching angle—The angle, measured from a horizontal plane, at which a rocket is inclined at launching.

Launching rails—A rocket launching device, usually attached to an airplane.

L/d ratio—The ratio of length to diameter of a rocket motor combustion chamber.

Liquid-fuel rocket—A rocket driven by a motor burning liquid propellants.

Loaded weight—Weight of a rocket or jet motor apparatus loaded with propellant and ready to fire.

Lox, or **loxygen**—Liquid oxygen.

M

Mach number—The ratio of the velocity of a rocket or a jet to that of sound in the medium being considered.

Mach waves—Nodes or standing waves in a rocket motor jet, caused by reflection of the jet from the surrounding air.

Mass ratio—The ratio between the total initial mass of the rocket ready to shoot and the final mass of the empty rocket. Also called **weight ratio.**

Mechanical efficiency—The ratio between the energy usefully employed in propulsion and the kinetic energy developed by the jet. (Same as **ballistic or external efficiency).**

Metering orifice—A constriction in a liquid feed line for regulating the propellant flow rate.

Monopropellant—A propellant consisting of a single liquid, which contains both fuel and oxidizer, either combined chemically or in a mixture.

Motor head—The forward portion of a liquid-fuel rocket motor, usually containing the propellant injection ports and the igniter.

Mouth—The large end of the expansion nozzle of a rocket motor.

Mouth area—The cross-section area of the nozzle mouth.

Multinozzle motor—A rocket motor with more than one nozzle.

N

Nozzle—The orifice and expansion device through which the jet is ejected from a rocket motor.

Nozzle coefficient—The amount, experimentally determined, by which the shape of a specific nozzle increases the thrust of a motor.

O

Oxidizer—The oxidizing component of a rocket propellant, in general a substance containing or consisting of oxygen available for combustion.

P

PSF ratio—The payload-structure-fuel weight ratio.

Parachute release—An automatic device for ejecting a landing parachute from a rocket.

Payload—The useful load carried by the rocket, in addition to its necessary structural weight and fuel.

Payload-structure-fuel weight ratio — The ratio between the payload, the structural weight and the fuel weight; sometimes called the PSF ratio.

Powered flight—The portion of a rocket's flight during which the rocket motor is in operation.

Pressure gas—A gas, usually nitrogen, used to force the propellants of a liquid fuel rocket into the blast chamber during firing.

Pressure ratio — The ratio between chamber pressure and the pressure at the nozzle mouth (or other reference point).

Propellant—The materials used in a rocket motor to produce the driving jet.

Projected area—The maximum cross section of a rocket hull, when viewed head-on.

Proving stand—An equipment for testing or "proving" rocket motors. Also **test stand.**

Pyrotechnic fuel — A solid propellant which supplies its own oxidizer as part of the mixture, as in the case of gunpowder.

R

Reaction — The recoil or "kick" produced by the jet of a jet motor, which provides the propulsive force.

Reaction motor—The general term for all types of motors and engines that operate by jet propulsion.

Regenerative motor—A liquid fuel rocket motor equipped with a cooling jacket, through which the fuel flows on its way to the injector, thus carrying the waste heat back into the blast chamber.

Resojet—An intermittent duct engine, sometimes called the **buzz-bomb engine.**

Rocketor—A rocket engineer or rocket experimenter.

Rocketry—The field of rocket research, engineering and experimentation.

S

Sectional density — The weight of a rocket divided by its maximum cross section. Used in estimating air-resistance.

Self-contained motor—Same as **chemical-fuel motor or true rocket motor.**

Servomotor — A mechanism to make force act at a distance, proportional to the force impressed upon it, as in gyrocontrol mechanisms which guide rudders on steered rockets. In particular, pneumatic or hydraulic cylinders used for this purpose.

Shock waves—Sound waves set up by an object moving at supersonic speeds, causing increased energy losses.

Shot—A rocket flight.

Spinner—A winged device like the rotor of an autogyro, used instead of a parachute to bring a rocket gently to earth.

Solid-fuel rocket—A rocket propelled by a solid pyrotechnic propellant; a **dry-fuel rocket.**

Sounding rocket—A high-altitude rocket carrying air-sounding equipment.

Step rocket—A rocket consisting of several sections or "steps" fired successively, each step being jettisoned when its fuel is exhausted.

Subsonic velocity—A velocity less than that of sound.

Supersonic velocity—A velocity greater than that of sound.

T

Tandem-tank rocket—A rocket with cylindrical propellant and pressure tanks placed end to end; a **single-stick rocket.**

Taper—The angle at which some types of rocket nozzles open out from the throat.

Thermal jet engine — A type of air-stream engine containing a rotary air compressor to provide air under pressure to sustain combustion.

Thermal efficiency—The ratio of the kinetic energy developed by the rocket jet to the thermal energy content of the fuel.

Third Law of Motion—Sir Isaac Newton's statement of the principle upon which the reaction motor works: "To every action there is always an equal and contrary reaction; the mutual actions of any two bodies are always equal and oppositely directed."

Throat—The narrowest part of a rocket motor nozzle.

Throat area — Cross-sectional area of the smallest part of the nozzle.

Thrust—The push produced by a jet or rocket motor.

Thrust augmentor—A funnel-like device for guiding the surrounding air into a rocket motor jet, thus producing suction which increases the thrust.

Tracker—A mechanism for observing

ROCKETRY NEWS

V-3 Long Range Rockets

During the months of February and March experimental German V-3 long-range rockets were launched against England. The V-3 was described as a 120 lb. two-stage projectile, jet driven and carrying 40 lbs. of explosive in the warhead. Upon depletion of the fuel the propelling section fell off and the warhead continued on alone.

A battery of some fifty launching barrels at Marquise Mimoyecques, near Calais, which was first neutralized by bombing then captured by the Allied armies, was found to be provided with underground barracks, storerooms, etc., some 300 feet deep. Six-inch caliber projectiles were to be launched from the 400 foot smoothbore barrels, which lack of rifling made adequate for firing numberless rounds. When perfected, ten rockets per minute were to rain night and day on London, supplemented by V-1 robot bombs and V-2 long-range rockets.

Featherweight Bazooka

General Electric Company recently announced that the seventh basic bazooka design is 42 percent lighter but carries the usual heavyweight punch. Made of aluminum, the 10½ lb. weapon has greater wall thickness than used on the standard steel models. A new type of eyesight improves the accuracy over previous models. Representing several years of research the design is now in production.

British Rocket Projector

A new type rocket projector used for medium artillery barrage work by British troops is described as "one of the war's most devastating weapons." Each rocket projector has thirty-two barrels which discharge missiles of a smaller size but comparable with a 100 lb. shell of the orthodox 5.5 inch gun. The twelve projectors of each barrage group deliver 384 rockets comparable in firepower to 280 5.5 inch guns.

—North American

A B-25 showing four machine guns and three rocket tubes.

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or controlling a flying rocket from the ground, or the man operating such a device.

Trajectory—The curve which a body, as a missile, describes in moving through space under the influence of the force of gravity.

True rocket motor—A self-contained or chemical fuel motor.

Turbo-jet—A thermal jet engine in which the compressor is driven by a gas turbine.

V

Valve man—The operator who actually fires a liquid fuel rocket.

Vj—The jet velocity of a rocket motor.

W

Warhead—The explosive section of a military rocket.

Weight-fuel ratio—The ratio between the structural weight and the fuel weight.

Weight ratio—Same as **mass ratio.**

Wetted surface—The total external surface of a streamline hull exposed to air friction.

BRITISH PATENT SPECIFICATIONS

The following listed British patent specifications comprise the majority of war, lifesaving and pyrotechnic rocket patents employing powder as a fuel. A list of British airstream engine patents appeared in ASTRONAUTICS No. 60.

No. 4,853, Congreve, Sir William, Oct. 16, 1823.

No. 4,952, Perkins, Jacob, May 15, 1824.

No. 7,759, Dennett, John, Aug. 2, 1838.

No. 8,771, Golightly, Charles, Jan. 4, 1841.

No. 10,008, Hale, William, Jan. 11, 1844.

No. 195, Longridge, J. A., Jan. 24, 1856.

No. 382, Hewetson, Henry, Feb. 13, 1860.

No. 450, Walker, William, Feb. 22, 1861.

No. 550, Roys, Thomas Welcome, and Lilliendahl, Gustavus Adolphus, Feb. 27, 1865.

No. 940, Hale, William, April 18, 1853.

No. 965, Walker, William, April 16, 1859.

No. 1,029, Morgan, Henry John, April 24, 1860.

No. 1,103, Hale, William, April 20, 1865.

No. 1,220, Hale, William, April 25, 1862.

No. 1,517, Boxer, Edward Mounier, June 18, 1864.

No. 1,534, Crosley, Henry, July 9, 1855.

No. 1,578, Hale, William, June 29, 1860.

No. 1,955, Hewetson, Henry, Aug. 13, 1860.

No. 2,301, Roys, Thomas Welcome, Sept. 2, 1857.

No. 2,305, Haddan, John Coope, Oct. 30, 1854.

No. 2,400 Fitzmaurice, the Honourable William Edward, Nov. 13, 1854.

No. 2,489, Bessemer, Henry, Nov. 24, 1854.

No. 2,497, Hale, William, Nov. 8, 1858.

No. 2,629, Court, John, Jr., Dec. 13, 1854.

No. 3,008, Macintosh, John, Dec. 28, 1853.

No. 3,102, Fletcher, Thomas Hanmer, and Forrest, Robert, Dec. 9, 1863.

No. 347, Jensen, Peter, Jan. 26, 1878.

No. 491, Rogers, John Banting, Feb. 10, 1873.

No. 600, Pain, James, Feb. 18, 1873.

No. 674, Johnson, John Henry, March 5, 1872.

No. 939, Heathorn, Thomas Bridges, March 8, 1878.

No. 949, Bland, James Fox, March 11, 1879.

No. 1,024, Meade, Herbert George Phillip, March 25, 1868.

No. 1,460, Taylor, Addington, May 20, 1870.

No. 1,734, MacDonald, John, April 24, 1876.

No. 1,824, Telescheff, N. de, April 10, 1883.

No. 2,540, Faure, Camille Alphonse, and Trench, George, June 25, 1878.

No. 2,744, Stephens, John, Aug. 7, 1874.

No. 3,113, Rogers, John Banting, Sept. 10, 1874.

No. 3,871, Hooper, James Humphrey Singleton, Oct. 6, 1876.

No. 3,873, Mackie, Samuel Joseph, Oct. 2, 1878.

No. 4,834, Jensen, P., Dec. 19, 1877.

No. 5,000, Hellhoff, Hermann Emil Albert, Dec. 27, 1876.

No. 5,099, Burridge, Joseph, Dec. 12, 1878.

No. 5,210, Giese, William, Dec. 19, 1878.

No. 8,189, Milnes, J., April 6, 1898.

No. 12,669, Edward, E., July 25, 1891

No. 13,799, Elsdale, H., July 29, 1892.

No. 14,000, Newtown, A. V., June 24, 1896.

(Continued on Page 20)

BOOK REVIEWS

The Coming Age of Rocket Power, by G. Edward Pendray. Harpers and Brothers, New York, 1945; 244 pages, $3.50.

The story of the rocket from its discovery in China centuries ago to modern wartime developments in the robot, the bazooka and the jet-propelled plane is comprehensively told by the present Secretary of the Society. The reaction principle, rocket fuels, types of rocket motors and airstream engines, design and construction details are fully explained. Descriptions are given of jet devices in peace and war, and the rocket weapons as employed today.

There is an informative treatment of rocket societies and methods of research and experimentation. Future potentialities of postwar transportation by rocket and the possibilities of interplanetary flight are presented by the author. Numerous drawings and photographs supplement the text, and also is included an appendix with a useful glossary of rocket terms and an index.

Spacewards, Official Organ of the Combined British Astronautical Societies. Vol. 6, No. 2, January 1945; 14 pages, 1s.

Concentrating on society news, the editorial comments focus attention on meetings of the society, while the major part of the periodical contains reports of a general meeting of the Northern Branch and a technical meeting of the Southern Branch. An article on the ideal astronautical society is presented, and a brief mention of a radio type of altimeter first reported in ASTRONAUTICS. A photograph of Gerhard Zucker's 1931 aerial torpedo is shown on the front cover.

The Modern Gas Turbine, by R. Tom Sawyer. Prentice-Hall, Inc., New York, 1945; 216 pages, $4.00.

This work covers the latest information on the application of the gas turbine as a supercharger and prime mover in all fields of service, including jet propulsion. Fundamentals, early inventions and history of the gas turbine, and its many uses with modern engines are discussed. A chapter considers applications of the exhaust turbosupercharger to aircraft engines.

The last chapter of the book includes material supplied by G. Geoffrey Smith, author of "Gas Turbines and Jet Propulsion for Aircraft," with the addition of theoretical calculations and performance characteristics on the operation of the jet-propelled plane and jet propulsion. The edition is profusely illustrated with photographs, drawings, graphs and tables.

Gas Turbines and Jet Propulsion for Aircraft, by G. Geoffrey Smith. Aerosphere, Inc., New York, 1944; 124 pages, $3.00.

This revised American edition contains additional material on thermal jet propulsion systems with rotary, reciprocating or combined units, and surveys steam and gas turbines driving airscrews. A description is given on the working cycle of a turbine-compressor unit, with new chapters on turbine-compressor units, jet versus airscrew, boundary layer control and broadcast talks on turbine-compressors. Also included is a new introduction, foreword, and biographic sketches of Group Capt. Frank Whittle and others who developed the jet planes. The volume dedicated to the Institute of the Aeronautical Sciences, is well illustrated and indexed.

Book Notes

A reprint of the article "The Day Dawns for Jet Propulsion" from the March 1945 issue of Westinghouse Engineer has been arranged in pamphlet form for distribution to members of the Society. Much useful information, in this discussion prepared by Westinghouse engineers, was obtained from G. Edward Pendray's "The Coming Age of Rocket Power."

The book "Aircraft Armament," by the noted armament expert, Louis Bruchiss, published by Aerosphere, contains all available material on offensive and defensive aircraft armament of the world. Chapters on rocket weapons and future war armament are also presented.

(Continued from Page 18)

No. 14,161, Bott, J. E., and Cammell, G. H., Sept. 9, 1890.

No. 14,188, Underwood, W. J., June 23, 1902.

No. 19,231, Unge, W. T., Sept. 6, 1904.

No. 19,556, Bott, J. E., Dec. 5, 1889.

No. 19,664, Lovegrove, T. J. and Huey, W. G., Dec. 2, 1890.

No. 25,327, Turpin, E., Dec. 31, 1894.

No. 25,945, Unge, W. T., Nov. 17, 1896.

No. 28,588, Unge, W. T., Dec. 29, 1903.

—C. G.

THE ROCKETOR'S LIBRARY

The Coming Age of Rocket Power, by G. Edward Pendray.	$3.50
Gas Turbines and Jet Propulsion for Aircraft, by G. Geoffrey Smith	$3.00
Rockets, The Future of Travel Beyond the Stratosphere, by Willy Ley	$3.50
Shells and Shooting, by Willy Ley	$2.00
Rocket Research, by Constantin Paul Lent.	$5.00
Rockets and Jets, by Herbert S. Zim	$3.00
Rockets, Dynamators, Jet Motors, by A. L. Murphy.	$2.50
The Modern Gas Turbine, by R. Tom Sawyer.	$4.00
Astronautics, Nos. 1 to 60	each $1.00
Journal of the American Rocket Society	each $1.00
Bibliography of Rockets and Jet Propulsion	$0.50
Miscellaneous Drawings (Set of 12)	$1.00
Index to Astronautics	Free

Rocket Projectile Explosive

Pentolite, a superexplosive having 20 percent more power than TNT, is being used for bazooka ammunition and other rocket projectiles. In one production method, 5-40 percent of PETN (pentaerythritol tetranitrate) is mixed with TNT forming a mixture nearly as powerful as PETN and which retains TNT insensitivity to shock. The Pentolite is heated to a pasty form and then poured into the projectiles, thereby eliminating the usual press loading method.

The JOURNAL OF THE AMERICAN ROCKET SOCIETY (formerly ASTRONAUTICS) is devoted to the purpose of disseminating information on the development of the rocket and jet propulsion and their application to problems of research and technology.

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