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ROCKET GUN — Firing high explosive rocket shells this light, simple weapon is well suited to the new high-speed methods of war. Mr. Edward Chandler, ordnance engineer associated with the development of this gun, describes its advantages in "Rockets For Defense"—See Page 3.

NOTES AND NEWS

Our nation has now become involved in the most titanic conflict this blood-soaked planet has ever witnessed. No war of boundary lines or tariffs, this, but a death struggle for world domination. It is either we or they, the loser will be "split asunder".

It is a startling war, a war still based on getting there first with the most fire power, but accelerated to an incredible tempo. A war of machines; tanks, planes, warships, engines, explosives, troops from the sky and torpedoes from the ocean's depths. It may well be won behind the front lines, in factories and laboratories. Production and invention will probably determine the outcome of this world upheaval.

Speed and fire power are the essentials, we must produce not only more but swifter and more heavily armed vehicles of battle. New weapons must be developed, old ones improved. It is now necessary to concentrate all our efforts on the military uses for rocket power. Successful rocket shells would have tremendous destructive ability, they must be developed. Rocket booster motors for bombers and fighters must be built. Aerological rockets for long range weather forecasting would be of great military value. We must have them now, not a year from now. We are ready to do our part.

ASTRONAUTICS now takes on a grimmer and more military note. Mr. Edward Chandler, who writes on "Rockets for Defense" in this issue, is a Consulting Research Engineer; Director, Chandler Research Laborator-

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Rockets For Defense

Jet Propelled Shells Offer Advantages

By Edward F. Chandler

A recent German dispatch complains of a "fiendish" rocket gun in use by the Russians. Believed to be of British design this gun is said to project a hundred or more rockets 20,000 feet into the air against enemy aircraft. Each rocket shell release a parachute from which is suspended a long cable. One salvo, it is said, will confront on-coming enemy airplanes with an aerial obstructive maze 1200 feet long, 300 feet wide and 300 feet deep.

Another report tells of a Swiss engineer's plans for greatly extending the effective range of artillery fire. He proposes to convert the forward part of a projectile into a rocket shell which, when the projectile has reached a predetermined point in its flight, becomes active to increase the velocity and trajectory of the projectile by the effect of reaction.

The possibilities of rockets in warfare have kept the subject alive for more than a hundred and fifty years and they have played their part in defensive and offensive operations.

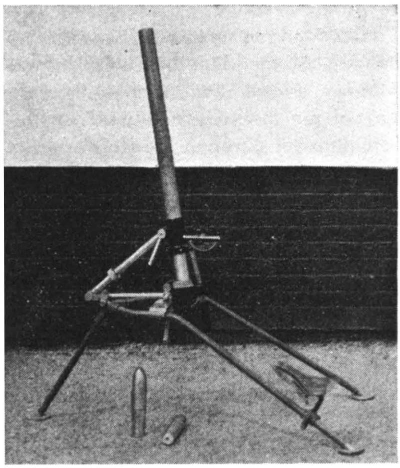
In the early part of the 19th Century they were rather widely used by the European armies. Against massed troops, within easy range, the war rocket was considered an efficient weapon, but for longer ranges they were deficient in accuracy. The stick-guided design of Congreve was eventually superceded by the Hale design, in which the gases impinged against a screw-like tail to impart rotational stability to the rocket in flight. These rockets were fired from a trough, the most effective range of the 9-pounder being about 1200 yards.

War rockets became obsolete about the time of our Civil War, although attempts were made to re-introduce them in World War I.

Neglected Possibilities

Progress in the development of the military rocket seemingly has, in the past, been retarded by the rapid improvements made in regular cannon artillery. Also the changing methods of waging defensive and offensive warfare have influenced official attitude toward the use of rockets.

The rocket battery was light and easily handled during an advance. Artillery, until recently, has been ponderous and difficult to move; often it could not keep up with the troops.



High-angle fire is possible. Dismantled gun will fit in golf bag.

The rocket batteries could go into action until the guns were brought up. However, with the development of quick-firing pieces, increased fire-power per unit and greater mobility less attention was paid to the rocket as an essential weapon. Nevertheless it has long been held by army ordnance engineers that there is a definite and important place for this type of equipment. They believe the subject deserves the same systematic research and engineering development that has brought modern ordnance pieces up to their present remarkable degree of perfection.

A Blitzkrieg Weapon

Experimental research work on rocket motors, both here and abroad, has done much to awaken public interest in the possibilities of jet propulsion. The practical aspects of the reaction principal, based on data already established, intensify its obvious advantages when applied to a new and highly modernized type of ordnance.

Today's engagements between fully mechanized, fast moving, hard hitting armored hordes has made obsolete many of the methods and much of the equipment of "trench warfare" days. Present tactics afford remarkable opportunities for light weight, relatively noiseless and smokeless, easily handled guns of high fire power. A rocket gun could fill this bill, being as handy as the automatic rifle or machine gun and having the blasting force of field artillery.

Anti-tank Rockets

The airplane has so thoroughly revolutionized modern warfare that surprise operations on a large scale and with heavy equipment can generally be discounted by the enemy. Successful attack has become largely a question of speed, hitting power and ability to maintain the forward drive until the objective has been won.

The dive-bomber and armored tank have become the spearheads of the attacking force and it is against these formidable weapons that effective defensive means must be found. The stopping of either — and particularly the tank—will do much to slow the present battle tempo. The powerful anti-tank guns, capable of stopping a tank in its tracks, are not sufficiently mobile and quick acting in a high speed tank assault.

Armor-piercing projectiles may be the answer but a well placed high explosive shell, or a number of them fired in quick succession, from an extremely light, easily manipulated gun will probably prove more efficient. A gun of this type is well within the scope of reaction ordnance.

Heavy Fire Power

A study of the possibilities of rocket-propelled shells and specially designed guns for their firing shows that their application applies to modern warfare in any tactical situation where the elements of surprise, demorilization and destruction are of especial value and importance in an operation. A handfull of men, equipped with small, light arms suddenly releasing a salvo, from an unexpected vantage point, equal in intensity of fire-power to a battery of field artillery might well cause surprise and demorilization in the ranks of an enemy. Destruction would follow the ability to sustain the assault.

Theoretically there is probably no limit to the size and weight of a shell that may be fired or to the distance over which it may be projected by the rocket system. Interest, however, is directed more particularly to arms and reaction ammunition of calibers ranging from 1" to 5", to meet present military needs. Obviously much that has resulted from recent research applies as well to equipment of larger caliber.

In this research one objective has been to produce a shell capable of accurately holding its course over a sufficiently long range to meet exacting military requirements. A system of dynamic stabilization of the shell in flight has stepped up its average velocity, resulting in a flatter trajectory.

Rotational Stability

The scientifically developed aerodynamic form of the modern reaction projectile becomes an important factor when dealing with high velocities. From the standpoint of fire-control it has been shown that the directing influence of the gun can be so impressed upon the projectile, during the instant of launching, that its course will be retained by the gyroscopic effect of the projectile after leaving the gun barrel.

A rocket propelling unit may be designed to operate on liquid or solid fuels. The liquid fuel burning rocket motor has many advantages but a simpler system is more desirable for general military use, so accordingly much of the important work in this field is being done with solid fuels. Its use makes possible the production of pre-loaded shells which may be stored and handled in the field like ordinary fixed ammunition.

No complicated mechanism is required for automatically governing the thermo-gas generating action of the solid propellant as the desired operating characteristics are established by the design of the reaction jet system, the form and size of the combustion chamber and the chemical composition of the propelling charge. Such shells are of simple and inexpensive construction and well adapted for mass production.

The rocket shell, carrying its own propellant, develops only enough energy while within the gun barrel to effectively launch it on its course. As it leaves the barrel and approaches its target the shell's velocity is accelerated whereas the velocity of a shell fired in the ordinary manner, by an explosion in the gun, gradually decreases. Accordingly a rocket shell that is designed to strike its objective with a force comparable to that of an ordinary shell may be fired from a light, tube-like gun mounted on a light, easily maneuverable carriage.

Many Uses Possible

The extremely light weight of the complete rocket gun, coupled with the low recoil of reaction ammunition, makes it an ideal weapon for dispatching shells loaded with sensitive high explosives. It makes possible the arming of airplanes, small boats and mobile light troops with easily manipulated, long-range, accurately shooting guns of unusual fire-power.

Light quick-firing and automatic arms using reaction ammunition specially designed for this service will be used for blasting machine gun nests out of protected positions; for protecting raiding parties; by landing parties and for many other operations where the regular artillery pieces of equal fire-power could not be used. In short research and modern engineering methods have taken the rocket shell out of the hit-or-miss mortar class of the Congreve and Hale period giving us instead a new, accurate and hard-hitting weapon of almost unlimited tactical possibilities.

Thrust of Powder Rocket Charges

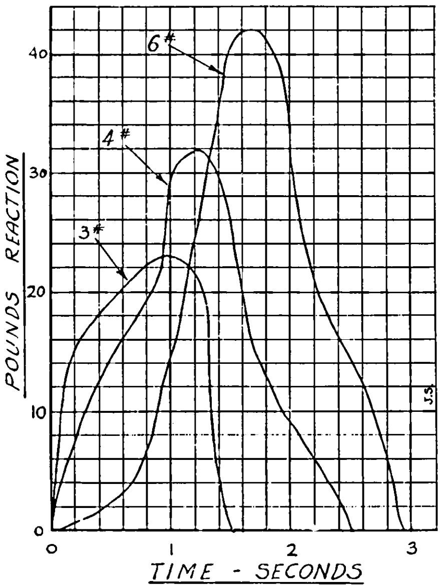
Commercial Types Tested

To obtain data on the reaction developed by standard powder rocket charges, of the type used in signal work, the Experimental Committee tested three of the more commonly used sizes on August 1st, 1941 at Midvale, N. J. Thrust curves, prepared from film records by John Shesta, are shown below.

Each cartridge consists of a charge of black gunpowder tightly packed into a rolled cylinder of heavy paper. In actual use these cartridges are fitted with a head of star shells set to burst at peak altitude. A long wooden stick is clipped to the side of the case. The lower fireclay plug is drilled to form a nozzle, this orifice continuing conically upward through the powder, forming a combustion chamber.

The three sizes tested were of the designation "3 lb", "4 lb" and "6 lb", the latter being the largest size obtainable. The weight designation is taken from Army shot of diameter equal to the charge. Thus the "3 lb" rocket charge actually weighs but 0.6875 lb. of which 0.250 lb is black gunpowder, as measured by the writer. The cylinder is 11" long by 1-11/16" diameter and the throat of the nozzle is 7/16". The "4 lb" type weighs 0.906 lb, contains 0.406 lb powder, is 12" by $1\frac{7}{8}$" and has a nozzle orifice of $\frac{5}{8}$". The "6 lb" type totals 1.5 lbs of which 0.656 lb is powder. It is 13" long by $2\frac{1}{8}$" diameter and has a throat of $\frac{3}{4}$". It must be noted that there is considerable variation between the products of different manufacturers, even when the designation is the same. Those tested and listed here are made by the Unexcelled Manufacturing Corp., through whose kindness these charges were obtained.

It can readily be concluded, from the short periods of effective thrust obtainable, that commercial powder charges of this type have very little value in serious rocket work.



Thrust Curves of Charges

Roy Healy

Winged Rocket Bombs

Destruction from a Distance

by Zbigniew Krzywoblocki, M.E., A.F.R.Ae.S.

In "L'Aviation de Bombardment", a brilliant but little-known work by the French aerial strategist Rougeron, mention is made of a possible weapon of the future: a winged bomb. Such a bomb, if given the added advantage of rocket power during its flight, could increase bombing potentialities many times. The rocket power need not be of high efficiency to be effective. The combination might well comprise the most formidable and effective weapon yet devised by man.

One of the aims of today's aerial powers is the development of a method of bombing from a distance. The reasons are obvious. Defense of an objective from aerial attack is today the task of anti-aircraft batteries and fighter planes. Objectives of attack, as cities and industrial centers, do not represent a very large area. Also the defense of a country during air raids introduces the problem of defending a large number of points throughout the country. However, were an enemy able to bomb from a distance of, say, 200 miles, then not only the objective would need be covered by guns and defensive planes but also an area equal to the area of a circle with a radius of 200 miles with the objective at its center.

Offensive Aid

If, then, we trace circles around every important objective in a highly industrialized country, it will be seen that it would be necessary to defend the entire country, not merely the objective. From the foregoing it is readily seen that the defensive problem would be multiplied many times. On the other hand attacking from a distance would be much easier and less dangerous for the bombers. Attacks from the sea would be particularly facilitated and bombing raids could be carried out on important objectives, previously invulnerable from attack because of heavy localized defense.

Long distance bombing might be accomplished by winged bombs, rocket-powered winged bombs or rocket-powered aerial torpedoes. The use of such bombs and torpedoes would depend upon the solution of such constructional problems as instruments for flight stability; propulsion details and accuracy of aim. Concerning propulsion we can consider the present engine-propeller unit, or liquid and powder fuel rocket propulsion plants.

In connection with jet propulsion present day bombs might be made with greater penetrating properties.

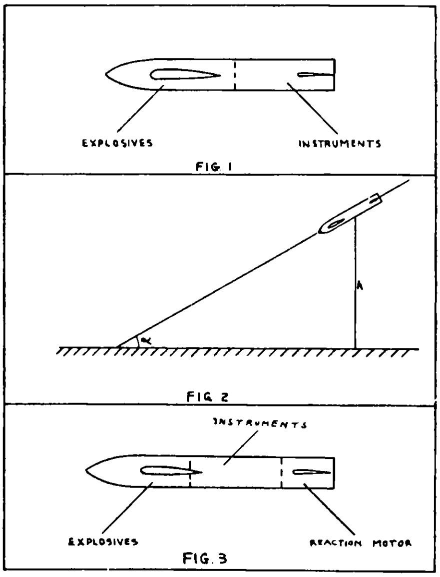
Winged Bombs

A typical wing-bomb might be similar to that shown in Fig. 1. Similar in outer appearance to an airplane, the bomb could carry a heavy explosive charge in the head, while the rear would contain instruments to guide the bomb to its target. Such a bomb could be carried under an airplane and launched some distance from the objective. Neglecting the energy imparted to the bomb by the airplane we can assume that its line of flight will be a straight line inclined at an angle as in Fig. 2. The gliding angle will depend upon the aerodynamic characteristics of the bomb, and on its lift/drag ratio. A wing-bomb of this type has already been patented in England.

Propulsion

To increase the range of this wing-bomb it could easily carry some method of propulsion, which would begin to function immediately the bomb was launched. During the period of powered flight the course of the bomb would be horizontal or even upward. After exhausting its fuel supply the bomb would come down at the angle as explained previously.

The engine-propeller mechanism seems too complicated; among existing methods of propulsion the rocket principle lends itself to such a scheme. Efficiency could be increased if the bomb were launched at a high speed.



Winged bomb and winged rocket bomb.

Rocket Power

In considering the question of liquid-fuel rocket motor or large powder rocket charge it is evident that the latter is the most simple and easily adapted for propelling a winged bomb. A typical bomb of this type is shown at Fig. 3, the front part the warhead, the center section containing the instruments and the rear part the reaction generating method. As far as the weight of such a bomb is concerned it it difficult to state any limitations for the future, but for today's bombers we may accept the weights of 1000, 2000 or even possibly 4000 pounds as within reason.

Rocket Torpedo

A further development of this winged bomb would be the aerial rocket torpedo, launched from the ground and carrying destruction to great distances. Catapult launched for high speed start the torpedo would climb upward under its own power to a great height and then glide down upon the enemy at a predetermined angle. As great speeds could be attained the rocket efficiency would be high. In order to develop an aerial projectile of this type the problems of aerodynamics, ballistics and jet propulsion would all have to be thoroughly studied.

The problem of flight stability would be made easier than first appears, by the further development of existing methods. A great deal of progress has been made in recent years; this could easily be directed to the problem of the rocket torpedo.

Accuracy, the maintaining the correct direction of flight, is perhaps the most difficult problem of winged bombs and torpedoes. Obviously it is necessary to consider the effect of winds and other movements of the atmosphere which might throw the projectiles off their course

Winged bombs might be either non-controlled or under radio guidance. In the first case the pilot releasing the bombs would have to compute the effects of air currents before releasing the bomb. This problem, although difficult, is not new. Long range artillery must also take air currents into consideration before aiming the shell. Radio controlled airplanes have been flown both here and abroad, although the distances have been small it is encouraging to know that a basis has been laid and only further development is necessary to increase the flight range to 200 miles or more.

The problem presents many difficulties; in the opinion of the writer the problem of accuracy will never be completely and satisfactorily solved. On this account the wing-rocket-bomb or torpedo will be suitable for the bombing of large objectives such as large cities, industrial centers, etc. This could be done as accurately as present day dive and horizontal bombers can do the job over a well protected target, and without the loss of large percentages of the bombing force.

On the basis of the foregoing general discussion, we can maintain that the problem of the winged bomb and the rocket torpedo, although difficult, is not insoluble. A similar problem, already solved, is that of the familiar sea torpedo which presented many difficulties in its development. The purpose of these aerial projectiles is the same as that of today's bombers, but the many advantages of bombing from a distance are obvious.

THE ROCKETOR'S LIBRARY

The library of the Society, which probably few members know the existence of, it having been located at various points about the city in the past, was recently moved to the present location of the Society's headquarters. As soon as the library is in more "shipshape" condition, members visiting headquarters will be given opportunity to read the available books on the many phases of rocket development.

Copies of rocket pamphlets or old science books on subjects pertaining to rocketry which members wish to donate will be greatly appreciated. The library would also like to receive information referring to recent articles on rockets published in the magazines or newspapers.

Recent Rocket Articles

Motoring To The Moon, Armchair Science, London, May 1941..

"Them As Has, Gits", The Technology Review, May.

Rockets vs. Propellers, Flying and Popular Aviation, July.

Rocketors, The New Yorker, Aug. 23.

Rocket Propulsion, Flight, London, Aug. 7, Sept. 4.

Jet Propulsion Of Aircraft, Flight, London, Aug. 28, Sept. 11, 25, Oct. 9.

Military Uses Of Rockets, The Military Engineer, Nov.

(Ed. note — Mr. Krzywoblocki has prepared detailed mathematical studies of the possible range of winged bombs and rocket torpedoes. If enough readers express their desire to see these they will be published in a future issue of ASTRONAUTICS.)

Powder Rocket Tests of the C.R.S.

Initial Experiments of the California Group

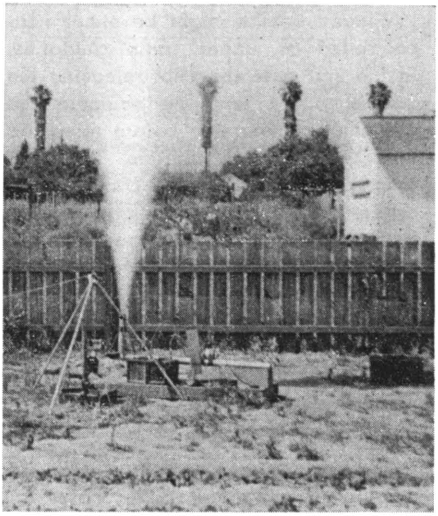
The initial experiments of the California Racket Society, in which an attempt was made to determine the characteristics of commercial powder rockets, was held on May 18, 1941. It was later planned to use charges of this type to test various gyroscopic stabilizing devices. Before the afternoon was over the experimenters had confirmed the findings of other rocketors — that powder rocket charges, and especially powder rockets, are of very little practical use.

The thrust indicator, which consisted of a steel bar mounted rigidly at one end but free to move at the opposite end, was calibrated by applying various known forces to the free end and observing the displacements with a very sensitive measuring instrument. A stop watch was placed next to the thrust indicator and a motion picture camera was focused on the two instruments.

Powder Charges Tested

A standard "8 lb." charge was fastened to the stand. The equipment was again checked and the ignition switch thrown. In the excitement of this first test the camera operator, quite naturally over-excited, failed to notice that he had overshot his target with the shutter release. As a result no data was available, except for a total firing period of 1.5 seconds as caught by another stop-watch.

Test No. 2 was made with a rocket charge to which was attached a steel nozzle 2½" long, 9/16" throat with a 10° flare. The normal fireclay nozzle of the charge was 11/16", the steel nozzle of smaller throat was used to determine if thrust could be increased. The charge exploded after 0.1 second burning, throwing the nozzle 75 feet into the air.



Powder Charge Firing

Test No. 3 was with a charge having a fireclay nozzle 2" long, ½" throat and a 10° flare. After a very short burning time the nozzle burned out.

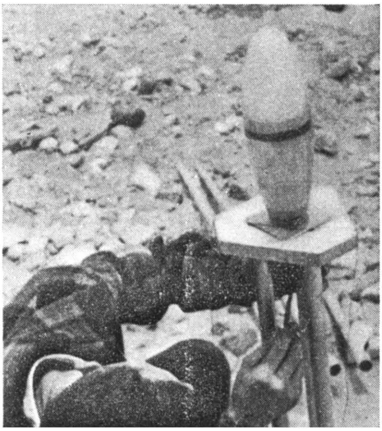
The final test was with an unmodified rocket weighing 25 oz. of which 12 oz. were black gunpowder. This rocket burned for 2.0 seconds and delivered a thrust of 27 lbs. during its period of maximum combustion. An additional 8 seconds of burning was evident but with little if any thrust.

Conclusions

From the limited duration of thrust available from these charges it is evident that a gyroscope would not have sufficient time to function. Since the cost of developing its own powder rockets is prohibitive the California Rocket Society has abandoned dry-fuel rockets for anything other than testing parachute releases, etc. Modifying commercial charges to build up pressure is inadvisable unless precautionary steps to strengthen the cartridge are taken.

Parachute Release Tests

A second group of experiments, in which parachute equipped powder rockets were used, took place on June 26, 1941. As part of our research on gyroscopic stability it was deemed necessary that a satisfactory landing method be developed. In these tests the parachute release was based on the spring action of the parachute's own compression when packed in the nose of the rocket. The nose was fitted to the rocket just tightly enough so that under no gravity differential, at the top of the flight, the parachute would throw off the cap.



"Lucite" Rocket

The first rocked fired was of the "8 lb." type with the parachute contained in the streamlined, hollow nose. After leaving the launching rack the rocket immediately deviated from the vertical some 10°, this angle increasing until, at an altitude of 137 feet the rocket went into an outside loop, rose again to 175 feet and ejected its parachute. The burned out charge drifted to earth. Total flight time was 10 seconds, the period of combustion 1.6 seconds.

Rocket No. 2's flight was similar to that of the first rocket, the parachute opening at 150 feet. The third test was with a rocket shell of plastic construction, developed by George Putnam. A small toy gyroscope was placed in the shell, as well as a powder cartridge. On firing the streamlined projectile left the launching rack at an angle of 15° from the vertical, and rose about 100 feet rotating rapidly about its longitudinal axis.

Test No. 4 was an attempt to lengthen the burning time of the commercial rocket charges by reaming out the nozzle from 11/16" of the manufacturer to 1". The time of the ground run was 2.5 seconds compared to 1.5 seconds with the original nozzle. No thrust measurement was taken.

The last flight was made with a booster rocket, being an additional charge used to give the rocket high inital velocity. The entire unit was ignited together, giving in effect a projectile with a high initial velocity. At an altitude of 200 feet the nose cap was blown off and the parachute torn loose. The projectile continued upward until an altitude of 1500 feet was reached.

It was concluded that the parachute release was reliable, that reaming out the nozzle of the powder rocket fails to be sufficiently effective, that powder rockets burn for too short a time to utilize gryoscopic stabilizing devices, although some action was observed in the third flight. Powder booster rockets are not effective, but the liquid fuel booster rocket offers interesting possibilities.

Robert Gordon

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ies; Vice-President, Oil Improvement Corporation, Member, A.S.M.E., American Association for the Advancement of Science and the American Rocket Society. He has done notable work on radio and gyroscopic control systems and developed new type, long range jet propelled torpedoes. Mr. Chandler has been associated with several government agencies in ordnance, chemical and building activities.

The Campini thermal jet propelled airplane has recently made successful flights of almost 300 miies, and has reached speeds of 250 m.p.h. in demonstrations. This Italian design was described in ASTRONAUTICS of November, 1939. It is understood that the plane, patent for which was obtained in the U. S. during 1932, was finally built in the Caproni plant under direct orders of Mussolini. It will be interesting to follow its course during this war.

Announcement has just been made of the award of the Collier aviation trophy to Dr. Sanford Moss. Given each year for the outstanding achievement in aviation engineering, the trophy for 1940 was presented to Dr. Moss for his development of the exhaust-driven turbo-supercharger, which he described at a recent A.R.S. meeting.

ASTRONAUTICS, official publication of the American Rocket Society, is devoted to the scientific and engineering development of the rocket and its application to problems of research and technology. Published by the American Rocket Society, 1 East 42nd Street, New York City. Subscriptions with Associate Membership, $3 per year.
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