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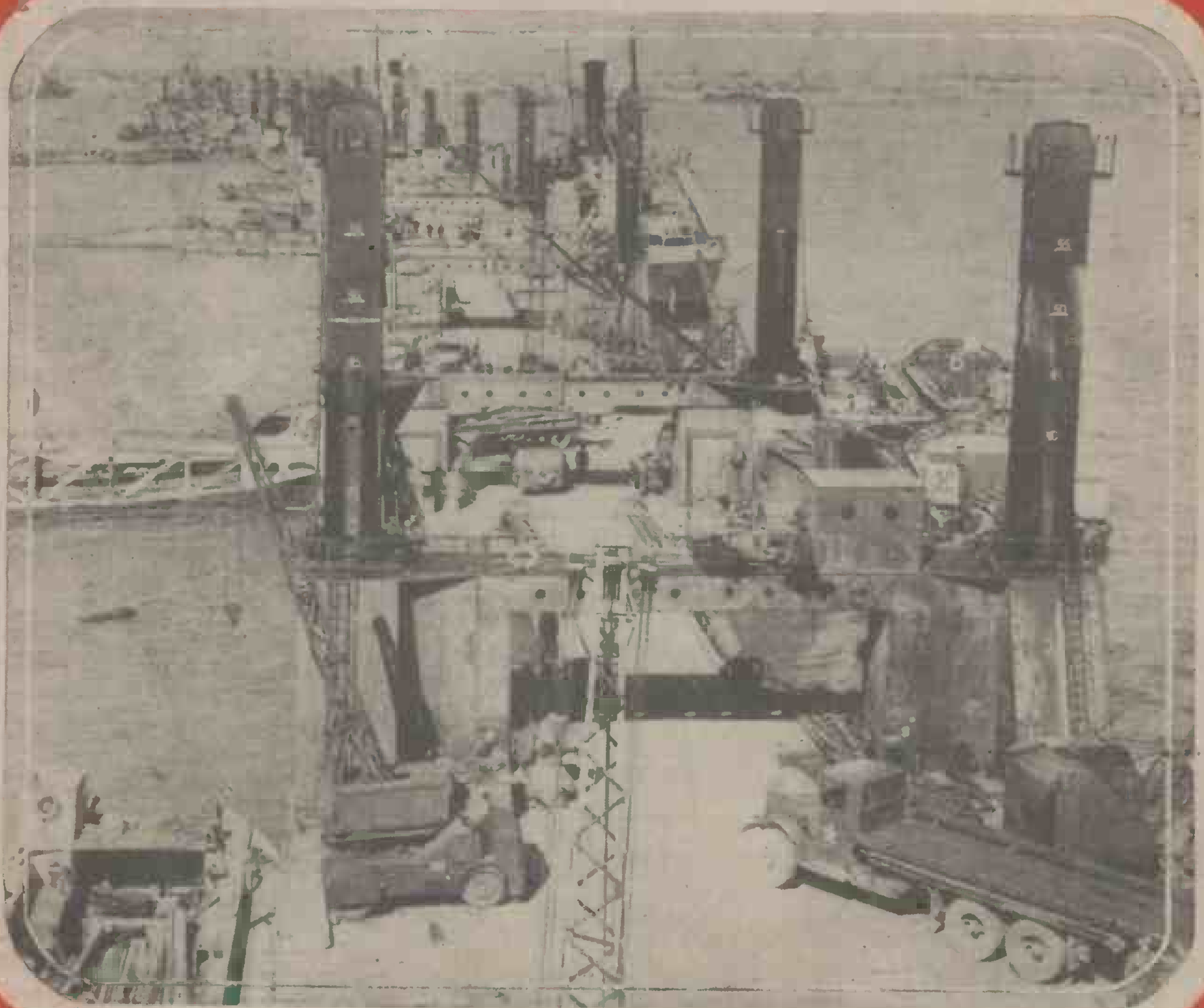

Rocket Propulsion

Further Details of American Research : The First British Rocket Society

By K. W. GATLAND

(*Continued from page 50, November issue*)

SINCE its formation in 1930, the American Interplanetary Society published a monthly *Bulletin*, but in May, 1932, the title of this was changed to *Astronautics* —a journal to-day heralded as the finest of its kind. From that time until January, 1933, the Society's official publication continued to appear each month, but in order to reduce expenditure, issue has since been made at quarterly intervals. Economy thus achieved financially, a more elaborate research programme was drawn up, and in September, 1933, the construction of three more rockets was begun.

In the Spring of the year following, however, the Society changed its name, the term "Interplanetary" being discarded in favour of the more conservative American *Rocket* Society, a change made in the belief that many prospective members considered the Society's space-crossing ideal unattractive at that early stage of technical development; nevertheless, it was emphasised that the alteration by no means meant to infer a general abandonment of the interplanetary idea.

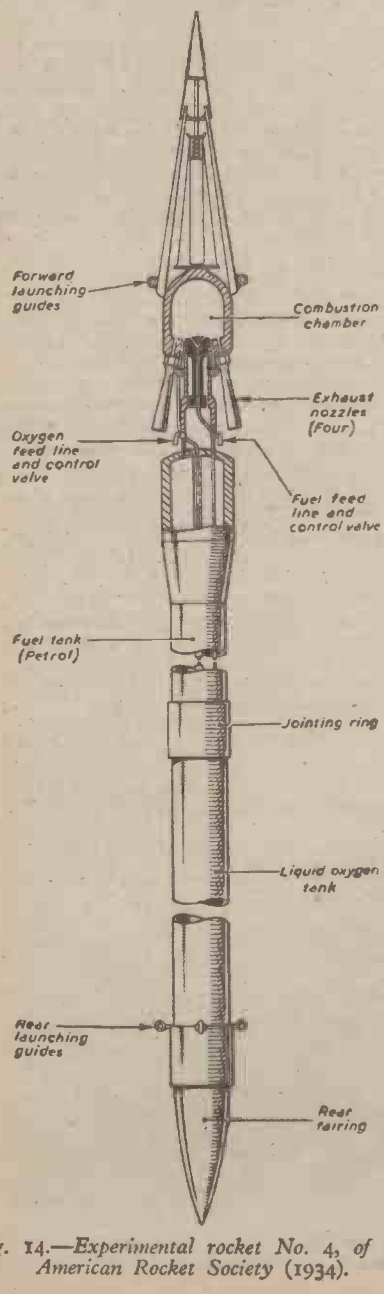

Fig. 14.—Experimental rocket No. 4, of the American Rocket Society (1934).

A.R.S. Revised Research Programme

For the prosecution of the new development programme, the A.R.S. Experimental Committee was divided into three sections, and certain research engineers made responsible for the individual design and construction of the three projected rockets, the following, many now well known among rocket authorities, being prominently featured: Experimental Rocket No. 3, G. E. Pendray (at that time President of the Society), A. Africano and B. Smith; Experimental Rocket No. 4, L. Manning, C. Ahrens, A. Best and J. Shesta; and Experimental Rocket No. 5, N. Carver, H. F. Pierce, and N. Schachner.

A.R.S. Experimental Rocket No. 3—Design

The general layout of the Society's third rocket (Fig. 13) was, to say the very least, original.

The combustion chamber was located at the rocket "head," the top of which formed externally a conical nosing. The motor was built in two halves for easy replacement should any damage be sustained during testing runs.

A nozzle of high expansion ratio extended the entire length of the rocket, and for almost half its depth the nozzle was jacketed by the petrol tank, which served as coolant for the nozzle throat, the heat dissipation acting conversely to vaporise the fuel, and facilitate the feed problem.

The liquid oxygen tank was positioned concentrically within the outer rocket shell, and by this arrangement the volatile "supporting" element was adequately insulated from combustion heat. The space between the two tanks was employed for storage of compressed nitrogen, employed for feeding the fuel.

Supported about the lower portion of the rocket, a venturi duct, or "thrust augmenter,"—a device designed to increase thrust and provide stability during flight—was fitted.

A.R.S. Experimental Rocket No. 4—Design

Rocket No. 4 (Fig. 14) differed considerably from the former design; the motor, located at the rocket "head," incorporated four nozzles inclined laterally to eject the exhaust away from the narrow section tanks. The fuel tank was supported directly beneath the motor, and the liquid oxygen tank below this.

The complete rocket, fitted with nose and tail fairings, measured 7ft. 6in., the maximum cross-sectional diameter being only 3ft.

A.R.S. Experimental Rocket No. 5

In the fifth rocket project a feeding system was evolved which dispensed entirely with the compressed gas "charger"; instead,

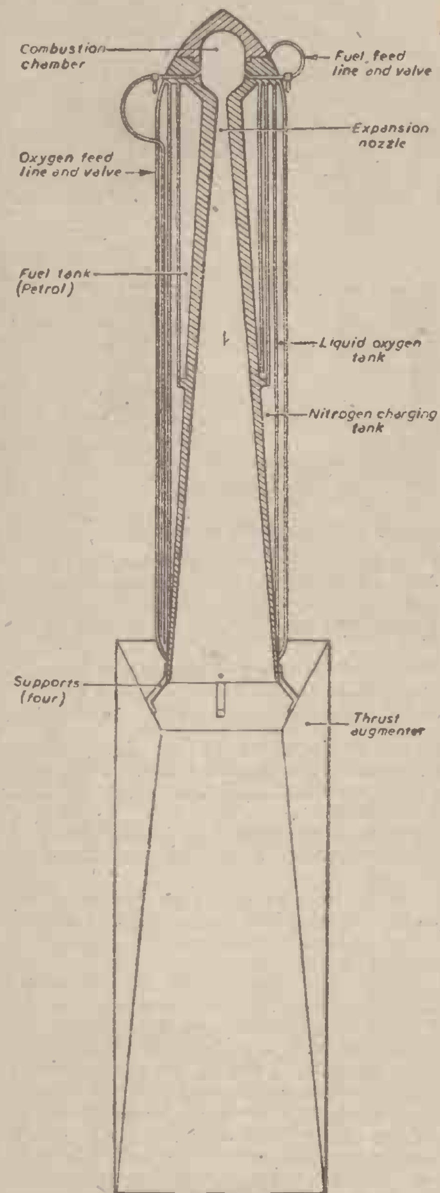

Fig. 13.—Experimental rocket No. 3, of the American Rocket Society (1934).

the expansion of the *liquid oxygen* being employed as the fuel pressure medium. This was arranged by the simple procedure of housing both liquids within a common cylindrical tank, the two fluids being separated by a movable piston. Pressure due to expansion of the liquid oxygen caused the piston to rise in the cylinder, so applying the pressure to the fuel, the pressure within the oxygen compartment at the same time remaining adequately sufficient to provide self-feed of the "supporting" element. The reaction motor was fitted, as in Rocket No. 3, at the "head" of the projectile, serving the dual purpose of combustion chamber and nosing.

A.R.S. Experimental Rocket No. 4—Trials

The first rocket to be completed, Experimental Rocket No. 4, was put to preliminary stand test on June 10th, 1934, the trial taking place at the Society's proving ground, Staten Island, New York. As a result, a fault was found to be that the inlet ports to the combustion chamber did not allow for an adequate supply of fuel, which resulted in oxydation and "burn out" of the motor.

Another motor was constructed, and the

Professor Hermann Oberth and others of the Verin für Raumschiffahrt E.V. In the foreground is one of the early "Mirak" type rockets. The other is an altitude rocket developed by Oberth (1931).

necessary alterations to the feed system carried out, but it was not until September 9th that the rocket was finally launched in free-flight.

The test was reported in the October issue of *Astronautics*, describing the flight as follows:

"Directly the valves were opened, the rocket leaped from the launching rack. Almost vertical flight was maintained for nearly 300 feet, at which point the rocket turned rather sharply out to sea. It was at this point, observers assume, that the burned out nozzle failed, shifting the direction of the propulsive forces acting on the rocket. The rocket rapidly sloped over until it was headed directly towards the water. Shortly after the change of direction, it began to 'hunt.' It struck the ocean with a terrific splash, the force of the impact bending the upper part."

During test, the rocket rose to a maximum height of 382 feet, and attained a speed well in excess of 600 m.p.h.

The projectile was recovered and examination of the motor revealed that one of the four nozzles had suffered severe burning rear of the "throat" with the result that the reactive balance had become upset, thus affecting the rocket's stability. Due to this defect, the parachute release mechanism did not function.

The term "hunt" referred to in the official test report may require elaboration. This is merely an expression meant to convey the manner in which a projectile may be observed to deviate from side to side as the result of compressibility, built up at the nose, when its forward speed is in the sonic region. The swerving is a natural inclination to dodge this local compression area.

This problem has since been overcome, to some extent, by the employment of automatic stabilising devices, such as the highly successful gyro/vane system tested during the Goddard rocket trials of 1935.

In the light of experience gained from the tests of Experimental Rocket No. 4, the A.R.S. Experimental Committee concluded that a great deal more routine ground test work was necessary before any practical gain could result from the firing of Rockets Nos. 3 and 5.

As the rocket motor had been the chief fault in every experiment hitherto conducted, the main effort was directed toward the general improvement of the propulsion unit.

Reaction Motor Tests

At the Society's proving grounds at Creswood, on April 21st, 1935, the first series of individual motor tests was made, and a number of motor forms embodying both long and short nozzles were put through their paces on the proving stand. The results of various tests were, however, by no means conclusive. It was found, for instance, that the length of the nozzle did not have material effect on the developed thrust of a given combustion chamber. Some measure of improvement was found when varying feed pressures were tried; it was discovered, for instance, that efficiency was greatest if the fuel was introduced into the chamber at a *high* presssure.

The most satisfactory results of the day's work were obtained during the second test conducted, when a maximum thrust of 59lb. was recorded, the chamber pressure being 300lb. For this particular experiment, a short nozzle was fitted. The maximum firing period was 17 seconds.

As the result of these and subsequent motor trials, a considerable amount of empirical data has been obtained for the research files of the Society. Such is the reliability of this data that most features of performance can now be predetermined during design, the test results being mere confirmation of the calculated figures. These methods of calculation will be discussed in a subsequent article.

British Rocket Development—Limitations

In Britain, the development of the rocket can hardly be said to have received encouragement—officially, the use of liquid oxygen for purposes of rocket experimentation is prohibited. The sole range of propellant available for research in this country must come within the bounds of the specified term "approved composition"; that is, certain fuels of the "solid" or powder variety. Yet the restrictions do not end here; under the obsolete Explosives Act, 1875, any experimental rocket, if the experimenter wishes to "keep within the law," though it employs as fuel "approved composition," may be put to test only if the following conditions are satisfied: (a) The firing range must be sanctioned by the local police authorities concerned. (b) The design of the rocket must be approved by the Secretary of State, through his advisers, and (c) The filling of the rocket must take place in premises licensed under the Explosives Act, 1875. It is stated that approval could not, under any circumstances, be given for the use of the liquid oxygen-hydrocarbon propellant; small wonder that to-day, apart from the developments of our American associates, we find the enemy alone using technically progressive rocket weapons.

The First British Rocket Society

Despite the fact that almost insurmountable difficulties lay in the path of the would-be British rocket experimenter, thanks to the determination of one, P. E. Cleator

Valier rocket car, powered by the Heylandt constant volume combustion motor, being charged with liquid oxygen prior to a test (1930).

(author of a foremost rocket literature in the English language, "Rockets Through Space," pp. 246, Allen and Unwin, 1936), the first and probably still the most renowned rocket organisation yet formed in this country, the British Interplanetary Society, was brought into being in 1933. As a beginning, important Press contacts were made, and thanks to resultant publicity, interest in the new science of astronautics was slowly but surely aroused all over the country.

The first official meeting of the Society took place on October 13th, 1933. The founder, P. E. Cleator, was unanimously acclaimed president, while C. H. L. Askham became vice-president, and L. J. Johnson, secretary. The number of persons in attendance at this intial assembly of the Society was six. By the end of the year the membership figure has risen to 15, and due to added publicity provided by the first issue of a Society *Journal*, which for some months was reflected in the National Press, the Spring of 1934 found the Society's numerical strength at 29.

The group's chief problem at that early stage was one of limited finance—publication of a *Journal* at regular intervals was hardly possible on the subscriptions of so few, leave alone to allow for practical research. Various avenues were exhaustively explored in the attempt to gain financial support, but with no success. Finally, in desperation, the Government was approached, and this is what P. E. Cleator has to say of the move in his book, "Rockets Through Space": ". . . The Air Ministry evinced not the slightest interest. The Under-Secretary of State, in refusing to discuss the matter, explained that although rocket experimentation abroad was watched with interest, scientific investigation into its possibilities have given no indication that jet-propulsion could be a serious competitor to the internal-combustion engine and the propeller of the aeroplane. In the circumstances, there could be no justification for spending either time or money on rocket experimentation. . . ."

Here is a classic example of the handicaps which oppose progressive thought in this country. To-day, we can judge for ourselves how wise was that official decision; the German Messerschmitt Me. 163 rocket-propelled fighter, and thermal-jet aircraft, bears adequate testimony.

Further Goddard Research

Soon after the Guggenheim grant made in 1929, Dr. R. H. Goddard set up an isolated laboratory near Roswell, New Mexico, and there continued with his experimental research.

Work at Roswell consisted largely of routine tests of rocket motors and feeding systems, and apart from a brief report, which appeared in the American Rocket Society Journal, *Astronautics*, September, 1934, little information of Goddard developments was forthcoming:

"The work consisted in the construction and flights of a number of models designed primarily to test operation rather than reach great heights. Flight speeds in excess of 400 m.p.h. were obtained. . . ."

In March, 1935, however, information was given of the free-flight trial of a large meteorological rocket, which incorporated a unique stabilising device.

During an initial trial on May 31st, the rocket rose to an altitude of 7,500 feet, attaining a velocity in excess of 700 m.p.h., the time taken in reaching the peak of trajectory being 14.5 seconds. The gyro-stabilising system embodied was designed to operate when the rocket axis deviated more than 10 degrees from the vertical, and at this angle the controlling mechanism brought into play vanes which acted to deflect the rocket exhaust, and so momentarily offset the thrust reaction, to return the projectile to its true flight path.

A motion film taken of the ascent shows the rocket shooting upwards, the action of the stabliser being clearly marked by the undulation of the projectile as it is constantly corrected to the vertical. Further tests of the gyro-controlled projectile took place in October of the same year. The height reached on this occasion was 4,000 feet.

The rockets tested in 1935 weighed from 58 to 85lb. No particular attention was given to obtaining lightness of construction.

Goddard Motor Trial Results

During the test of a certain liquid oxygen/petrol fuelled reaction motor, weighing 5lb., the combustion chamber being 5.75in. internal diameter, a maximum thrust of 289lb., and an efflux velocity of 5,000 feet per second, were recorded. The motor developed 1,030 h.p.

A report of Dr. Goddard's research progress, principally concerning the Roswell experiments, was published in 1936 under the title *Liquid Propellant Rocket Development*, 10pp., Smithsonian Misc. Collections 3381.

(To be continued.)

Letters from Readers

Engineer-built Houses

SIR,—I have read with great interest your series of articles on engineer-built houses, and I am very glad to know that engineers are at last going to interest themselves in the building of houses.

After the last war the engineers tackled the motor-car and not only greatly reduced the cost of cars but also improved both their performance and looks, and I hope they will do the same for houses.

I have noticed that when unloading bricks for house building they are taken five at a time and thrown from hand to hand, and have often wondered why bricks are not made five times as large as they are now. If they were it would surely save cost in building.

Also, why take, say, a door in plain wood and hang it and then paint it with a brush under the worst possible conditions. Surely it would be better to spray-paint it in a factory and take it to the site ready for hanging.

The bombings we have endured have, I feel sure, sickened a lot of people of the very thought of plaster ceilings, and also of plaster on walls, and I hope we shall see plastic boards in place of plaster.

There are many things in the houses we have had to live in that can be improved and money saved by alternatives, and I, for one, am very glad to see that at long last some brains and new ideas are to be introduced into the building trades.

A. H. BENTLEY (Horsham).

Power for Traction

SIR,—I would like to point out an error made in reply to a reader's query, which appeared in your issue of PRACTICAL MECHANICS dated November, 1944.

Your correspondent states that the resistance to the motion of a pneumatic-tyred vehicle on normal road surfaces is the sum of:

(a) Total weight (lb.) divided by 20.

(b) Total weight (lb.) divided by the gradient factor.

(c) Frontal area (sq. ft.) multiplied by

$$\left[\frac{\text{speed (ft. per sec.)}^2}{25}\right]$$

(d) Total weight (lb.) multiplied by acceleration in ft. per sec. and divided by 32.2.

The force required to accelerate the car, however, is not given correctly by (d), as no allowance is made for the acceleration of the engine parts, road wheels, and the whole of the transmission system.

The force required to accelerate the above mentioned masses is given by:

$$F=\frac{\frac{1}{r^2}\left\{I_A+G^2I_B\right\}\times f}{g}$$

where F=Force (lb.), r=effective radius of road wheels (ft.), f=acceleration, g=32.2, I_A=moment of inertia of road wheels and transmission system (lb.—ft.^{2}), G=gear ratio $=\frac{\text{Speed of engine (r.p.m.)}}{\text{Speed of wheels (r.p.m.)}}$, I_B=moment of inertia of engine parts (lb.—ft.^{2}).

This force F should be added to (a), (b), (c) and (d) when calculating the required tractive effort.

—F. L. ELLIS, G.I.Mech.E. (Oxford).

"Catalin"

SIR,—We have noticed in your November issue of PRACTICAL MECHANICS that a correspondent has inquired about information concerning the material "Catalin," and that you have stated that "Catalin" is a proprietary product manufactured and marketed by the Catalin Corporation of America.

We would advise you that "Catalin" has been manufactured and marketed in Great Britain by this Company since 1937. It is a proprietary product and, as you say, is manufactured by the controlled chemical interaction of Phenol (carbolic acid) and Formaldehyde (formalin). The material is then cast into sheets, rods, tubes, etc., for special castings of particular designs. "Catalin," as distinct from mouldings (i.e., Bakelite), is produced with or without a filler to make transparent, translucent or opaque objects by a casting process.—CATALIN LIMITED (Waltham Abbey).