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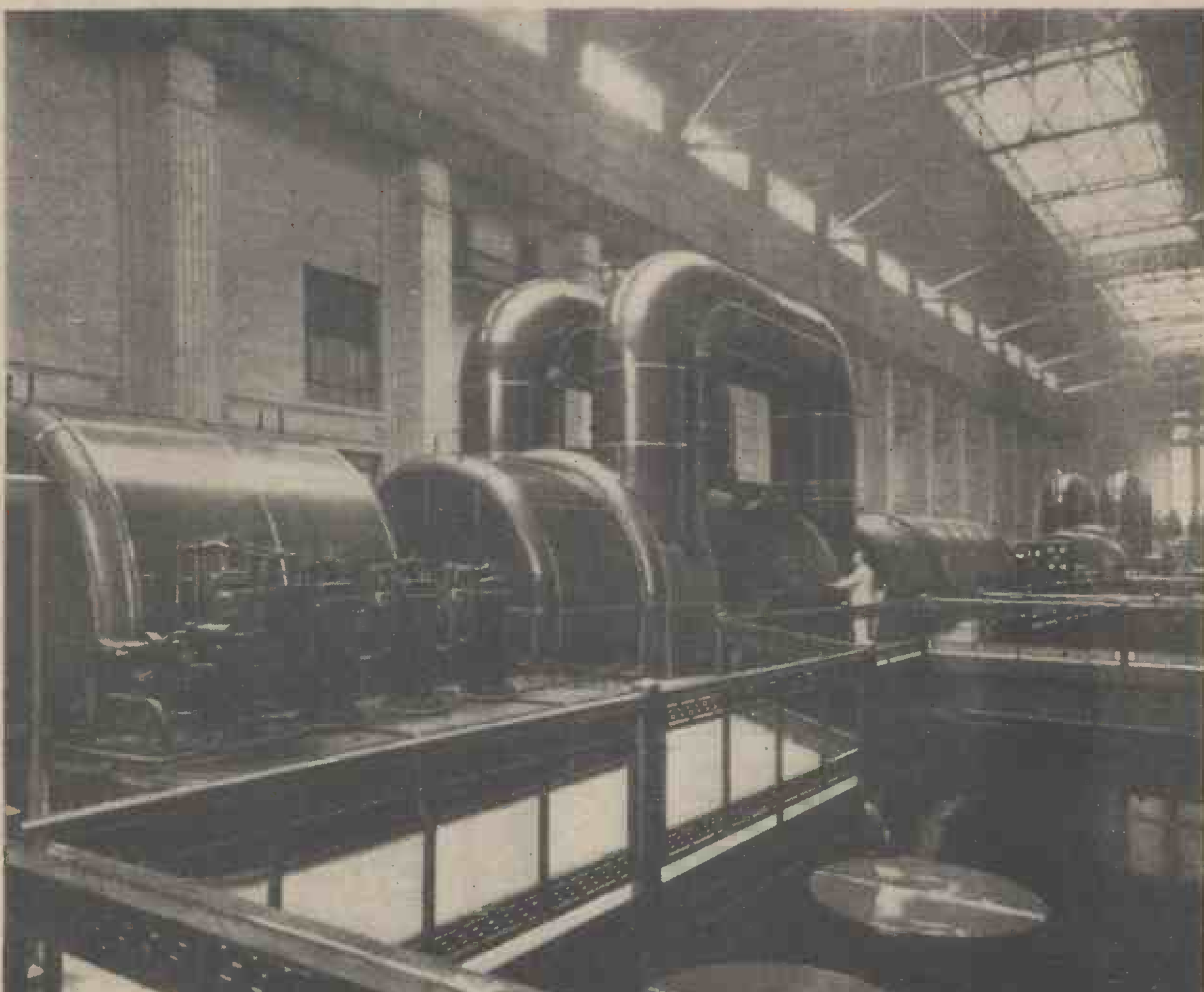
OUR ELECTRICITY SUPPLY

NEWNES

PRACTICAL MECHANICS

9D.

JULY 1945



of it, in very much the same way as they are happening at that time.

We instruct the rocket pilot to "step on it." He does so. Very soon we are travelling at the speed of light, which is approximately 186,000 miles a second. Just before attaining this rocket velocity we glance at our telescopic screen, and, to our horror, we chance to witness a tragedy being enacted on earth. A man is murdering his wife. We see him, knife in hand, about to plunge it into her body. But, strangely enough, as we fly away from the earth at exactly light's velocity the cruel murderer never seems to complete his wicked task. Our telescopic picture is "held" like a "still" in a cinema drama. We travel outwards for days, for weeks and even for months and years still keeping very precisely in step with the speed of light, yet the picture still persists. The man is still murdering his wife. He never finishes the job so far as our telescopic screen is concerned.

Record of a Tragedy

Why is this? Well, obviously when any action takes place on the earth's surface the light rays which proceed from it travel outwards into space with an absolutely constant velocity of 186,000 miles per second, and if, by means of our imaginary space rocket, we travel abreast with those light rays and keep up with them in velocity, then we shall continually witness the scene or record which those light rays carry with them. Thus we may travel for years at the speed of light in our space rocket, and have continually on our telescopic screen the spectacle of the man murdering his wife because we are ourselves actually keeping in step with those light rays, whereas, far away from us on the earth, the man may have been hanged for his crime years ago.

Suppose, however, that instead of travelling with the speed of light we bring additional power into operation in our space rocket, and so increase its rate of travel that our rate of progress through space becomes actually greater than the velocity of light?

Inverting Time

In these circumstances, an extraordinary state of affairs would take place. We should, in a way, be able to invert time and to witness the past, or, at least, a moving record of it, for, by travelling out into space faster than light we should be able to overtake light rays which had left our earth before we had embarked from it. And, consequently, the faster we travelled in excess of the speed of light the more long-departed light rays from the earth would we overtake. Hence, on our automatic telescopic screen we would witness a sort of cavalcade of past history taking place on the earth, or, on our selected area of the earth. By suddenly decreasing our rocket speed to that of light we should be able to "hold" any required screen picture for as long as we required. Thus, we should, given these fantastic means, be able to examine at leisure any stage of the earth's historical record in which we were particularly interested. We could, for example, witness any selected moment of the Battle of Waterloo for hours together if we so had the mind.

Similarly, by decreasing the speed of our space rocket below that of the speed of light, past events would recede from our screen view and the apparent future would gradually build itself up, for, under those circumstances the light rays projected from earthly scenes would gradually overtake our travelling rocket.

Thus, whilst travelling freely in our space ship, past and future would have apparently little meaning, for, by altering our speed we should be able to mix them up to our hearts' content. We should literally be "playing with time."

Time, therefore, although its real positive nature eludes us, is a relative sort of thing. It cannot exist by itself. It depends on the existence of matter, and, very likely, on the presence of space. Certainly, also, its manifestations are greatly modified by motion through space.

It looks, therefore, as if Time, Matter, Space and Motion are all intimately associated, for we are never able to experience any one of these entities separately and independently of the others.

Time, apparently, began. So, also, does it seem likely to end. But, seemingly, it will be the last of all material attributes to end.

"*Tempus edax rerum*" (time consumes all things) said the old Latins. They were right. It is only the unchangeable entities which can withstand Time's continual corrosion.

Rocket Propulsion

Power Rockets : Stability Trials and Details of Alighting Methods : Range Sighting

By K. W. GATLAND

(*Continued from page 316, June issue*)

FURTHER to the development of liquid fueled rocket units, the American Rocket Society has carried out numerous exacting tests of powder charge rockets; principally in order to gain practical experience of stabilising methods and the function of alighting mechanisms.

Powder Rocket Trials in 1935

The experiments which P. van Dresser and A. Africano conducted near Danburg, Connecticut, in 1935, have thrown much light on the relative effects on stability by varying the location of the centre of thrust.

The initial flight tests concerned a projectile of elementary form having the motor at the extreme rear, and this model also served to test a simple parachute release gear, the 'chute compartment being placed at the rocket "head" and joined to the charge casing by a length of dowel. Four small guide fins were fitted at the rear.

A second rocket was somewhat more elaborate, the power charge being contained within an aluminium body shell. It had a fully loaded weight of 3½ lb., of which 1¼ lb. constituted the rocket charge. There was provision for modifying the centre of thrust from the nose to the centre of mass and the tail, and under the changed conditions the weight distribution was kept constant by the simple procedure of moving a pair of ring weights along the outer shell. The idea of altering the position of the power element was to gain comparative data on the flight stability under these varying conditions.

On test, however, the rocket proved a complete failure. It was found that the effective thrust was almost halved when firing took place through the shell, and with the motor mounted in any position other than at the tail the efflux melted the aluminium of the body tube.

Tests of the simple tail-drive rocket gave far more conclusive results, and about 12 free-flights were made in conjunction with a 10ft. catapult apparatus.

It was unfortunate that, through bad co-ordination of timing in the release of the catapult and the ignition of the powder charge, the rocket was often fired from the rack not under the most optimum conditions, with the result that the performance was appreciably less than the calculated figure (as derived from the available thrust impulse and mass). In the majority of tests the altitudes reached varied between 200 and 250ft., but in one particular flight, when the timing was exactly right, a height of over 400ft. was attained. The rocket showed itself quite stable, and ascended on a trajectory which, in the majority of flights, did not deviate more than 20 or 30ft. from the vertical.

Parachute Release

The most useful result achieved, however, was from the tests of the alighting gear. The parachute in this particular model was of silk, 32in. in diameter, with a 2in. vent hole in the centre. There was also a small pilot 'chute of 10in. square, and this was attached to the top of the main supporting canopy by four shrouds secured equally around the vent.

When packed ready for use, the main shroud line was coiled beneath the 'chute pack and fastened to a bolt in the bottom of a tubular container situated at the "head" of the rocket. The pilot parachute was loosely packed at the top, and a ballistic shaped aluminium nosing was then fitted, not too tightly, over the compartment.

The device was so designed that the parachute would not release when the rocket was accelerating or travelling in a vertical ascent. When the projectile reached the apex of its trajectory, however, and turned over under the slowing influence of gravity, the lateral air resistance developed during its fall served to blow off the light nosing and thereby expose the pilot 'chute. This was readily caught by the air flow, so pulling out the main parachute from its container.

In order that the device should be sensitive in operation, two small vanes were fitted externally—at the rocket "head"—and these served to increase the lateral resistance.

This method of release is, of course, suitable only for light rockets, and in the tests reviewed the device functioned perfectly in practically every instance.

While on this subject of alighting mechanisms, it is as well to trace briefly their development. The parachute has, of course, long been used for display purposes; the idea was probably first conceived by the Chinese pioneers of pyrotechnics early in the Christian era. The rocket star-shell, for instance, uses a number of small parachutes from which are suspended coloured display "fires" and this principle was adapted in the 1914-18 war, when the "flaming onion," or magnesium flare, first came to be used extensively.

Professor Goddard is credited with the initial application of the parachute in liquid fueled rockets, and his first successful experiment took place on July 17th, 1929, when a rocket, complete with a camera and barometer, was safely wafted to the ground. In more recent work, he is said to have perfected a parachute release gear of faultless operation.

The German experimenters employed parachutes in their early powder rockets—particularly the mail-carrying versions—and the Verein für Raumschiffahrt E.V. fitted them to the "Repulsor" liquid-fueled types, as also did Johannes Winkler in his liquid fuel rocket of 1932.

Some of these earlier rockets simply had a slow burning fuse to function the release gear while others incorporated a clockwork "photographic" timer. The pressure within the propellant tanks has, too, been employed as the release medium, effecting operation through a spring-loaded plunger when the fuel is consumed and the feed pressure has dropped to zero.

In the more recent and larger type rockets, the parachute release is effected by the firing of a small powder charge, similar to the method employed by J. H. Wyld in his 1939 sounding rocket. (PRACTICAL MECHANICS, June, 1945, page 316.)

Other devices recently developed are functioned by air pressure, in the operation of a trip mechanism by a barometric pointer. Release is arranged to take place at a height previously determined from the performance calculations, the trip device either ejecting a pilot 'chute through the release of a compressed spring, or causing the explosion of a small charge.

Yet other release devices have been advocated which would work under rapid negative acceleration—at the time when a rocket which had just ceased firing was slowed up by atmospheric resistance. This factor, coupled with the rocket's curving trajectory at the flight apex, it has been suggested, would cause any free body in the rocket to be forced upwards, and so enable the function of a pendulous device, or some form of escapement mechanism, in conjunction with a spring or "shot" ejecting gear.

Tiling "Flying Rocket"

Finally, in this short summary of alightment apparatus, the patented design of Reinhold Tiling (U.S. Patent 1,880,586, Tiling, Osnabruck, Germany, 1932) cannot go without mention.

The method as fully outlined in Tiling's specification does not involve the parachute, but makes use of stabilising fins which, at the end of firing, hinge at a set angle of incidence, to form supporting blades. By this means, the rocket is brought to the ground as a gyro-plane.

The Tiling "flying rocket" (Fig. 25), as the device is termed, is of form simply a finned rocket with the propellant charge contained conventionally within the body shell, having provision for mail in the nose. Equally spaced around the shell are fitted four stabilising fins which project some distance from the rear, and each of these are so built to hinge outwards from a point just aft of the body.

Having served their initial purpose of maintaining the rocket in stabilised flight throughout the duration of combustion and propulsive momentum, the free part of the fins are automatically brought almost horizontal (relative to the vertical body axis), at the same time setting a slight positive incidence. The rocket is thus wafted to the ground by the reaction of air on the supporting "planes," which causes rotation about the body axis.

The Tiling specification suggests also the provision of four auxiliary rocket units fitted to discharge tangentially from the body. These are intended to become operative shortly before the rocket reaches the ground, and have the effect of creating a lifting force opposing the free fall due to the "powered" spinning of the rocket.

Whether or not Tiling ever put his "flying rocket" to actual tests is uncertain. Certainly he built, and demonstrated with no small success, several "winged rockets" of particularly unique design, but they differed greatly from the patented form. In the tested version there were four long fins; but these were rigid and did not fold. Instead, two other fins were fitted which pivoted from near the after part of the rocket body, and were folded back snugly beneath the horizontal stabilising surfaces during ascent. When firing and upward momentum had ceased, they automatically snapped open, thereby transforming the rocket into a glider.

Why Tiling should have employed this rather cumbersome and heavy arrangement in preference to the gyro type "flying rocket" is not clear. It is true, nevertheless, that the "winged" version had a creditable performance, often rising above 2,500ft.

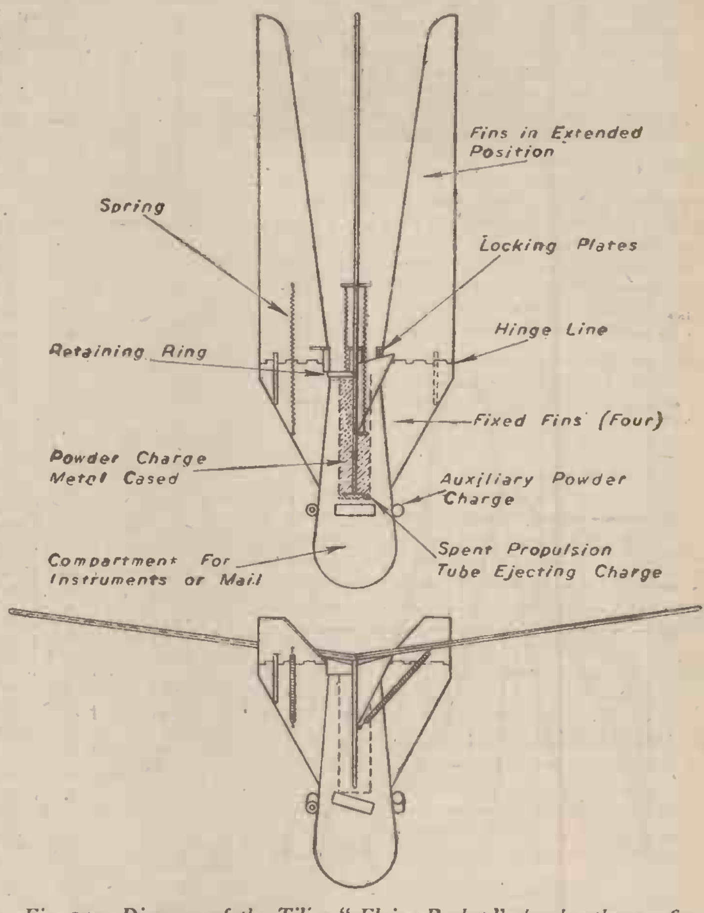


Fig. 25. Diagram of the Tiling "Flying Rocket," showing the two fin positions. Firing of the ejecting device forces out the propellant charge with retaining ring. This action deflects the locking plates, and the stabiliser fins automatically collapse to form "supporting planes."

Further Stability Trials

A further series of powder rocket trials took place at Pawling, N.Y., in October, 1937, under the auspices of the American Rocket Society Experimental Committee. Again, stability formed the subject of the experiments, which were centred toward searching out flight phenonema both during propulsion under power and momentum, for various conditions of the centre of thrust, the centre of gravity and the centre of lateral area.

The rocket bodies were constructed by H. F. Pierce, simply of balsa wood and cardboard tubing; being designed from various suggestions put forward by members of the Society. Commercially obtained charges of 12oz. loaded weight (comprising 6oz. powder), served as the propelling element, each rocket having a single charge which fitted into a central tube in the body.

Firing took place from a special launching rack, the rocket under test being attached to a small trolley which ascended the apparatus under thrust along a single guide rail. Ignition was either performed electrically or through a touch fuse. Each flight was ciné photographed in order that a subsequent study of trajectories could be made at leisure.

Of the seven rockets tested, two were outstanding both in respect to the altitude reached and their flight stability, as the accompanying table (Fig. 26) shows. It will be noticed that both types were the lightest in weight, thereby making more effective the impulse of the charge and so producing increased rate of acceleration. Another point of significance is that the centre of propulsion was forward to the centre of gravity and the centre of lateral area.

Experiments at Mountainville, N.J.

Following up the stability question, the Experimental Committee of the American Rocket Society carried out further trials of small-scale powder rockets in September, 1939, from a prepared test site at Mountainville, N.J.

The models tested were based on the results of the earlier Society experimentation at Pawling, and, as then, balsa and cardboard were used in construction. The launching apparatus bore much resemblance to the single-rail type which had proved itself in the former trials.

It is of interest to point out that, in this, and the majority of free-flight experiments previously discussed, the altitude figure was derived from the use of special sighting instruments developed on the principle of the surveyor's theodolite. The system requires two remote sighting locations spaced at a known distance. In the trials under review, this length was 1,100ft. on a straight line 50ft. west of the launching point. The location "A" was 800ft. to the south, and location "B" 300ft. to the north. The altitude is calculated in accordance with the simple formula:

$$H = \frac{b}{\cot A \quad \cot B}$$

where H is the altitude in feet, b is the base line of the two sighting locations in feet, cot A is the observed angle from location "A," and cot B is the observed angle from location "B."

According to A. Africano, who participated in the test sighting, the Society instruments were operated as follows: When the rocket, seen through the eyepiece and cross hairs, was observed to reach its maximum altitude, a small indicator carried along in one direction by the upward motion remained in place at this point and the angle could then be read leisurely on a graduated quadrant, and noted. This method gives the altitude of a horizontal line formed by the intersection of two planes rotating about shafts set parallel to each other. While it does not locate the point definitely in space, as in the method used at Staten Island in 1934, where two vertical and two horizontal angles were measured, it is sufficient for present purposes. The instruments were later adapted for an automatic angle and time recorder with which it is possible to calculate the vertical acceleration and velocity in addition to the upward range.

To return to the rockets themselves, the propulsive charges were obtained commercially, and being the ordinary display rocket type their weight and thrust characteristics were known only approximately. In consequence, the results achieved in free flight were, in many ways, inconclusive.

The rocket charges used in these particular

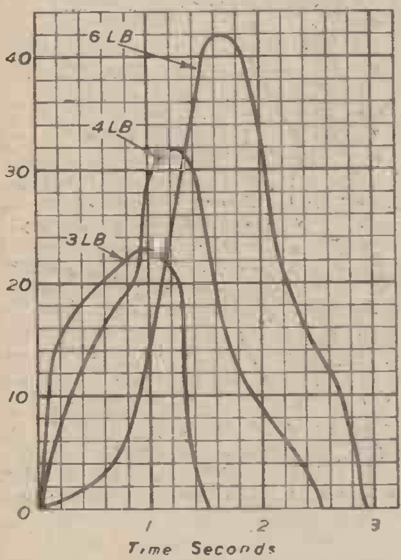


Fig. 27.—Thrust curves derived from proving stand tests of black powder rocket charges manufactured by the U.S. Unexcelled Manufacturing Corporation.

Model No.	1	2	3	4	5	6	7
After protype design of	Pierce	2 Step	Africano	Goodman	Wyld	Shesta	Repulsor
Distance from nose of rocket to centre of propulsion, inches..	15.9	28.0	8.0	14.0	39.0	59.0	14.0
Distance from nose of rocket to centre of gravity, inches ..	19.0	28.0	15.0	39.0	33.0	43.0	24.0
Distance from nose of rocket to centre of area, inches.. ..	22.0	28.0	19.0	50.0	25.0	35.0	22.0
Overall length of body, inches..	44.0	68.0	33.0	94.0	49.0	68.9	48.0
Initial weight of rocket, lbs. ..	1.19	2.27	1.19	2.16	1.85	1.72	2.28
Maximum altitude, feet (approximate)..	1,500	600	1,500	400	200	300	100
Time of ascent, seconds ..	7	5	5	5	4	4	3
Time of descent, seconds ..	3	4	3	4	4	3	2

Fig. 26.—Table of results of tests.

tests were designated by the manufacturer 2lb., 4lb. and 6lb., but their actual weight was considerably less. Writing in *Astronautics* (November, 1939), Mr. A. Africano, who conducted a private investigation of the values attainable from these size commercial charges, states that the 6lb. type shows an increase of thrust from 0 to about 40 lb. along a smooth curve in about one second, and he points out that the form of the reaction curve would, in all probability, prove to be similar for the other sizes. Mr. Africano reports the weight of powder in the 6lb. size as approximately 12 oz. The maximum thrust of the 4lb. charge which contains 4.8 oz. of powder, he gives as about 20lb., and the duration of reaction one second. The powder weight of the 2lb. charge is stated to be 2 oz., but no figure for thrust is available.

Some two years later the Experimental

Model No.	Maximum Altitude, feet.	Time of Flight, seconds.	Total weight of Model, ounces.	Charge size, comml. "lb."	Body length, inches.	Maximum body diameter, inches.	Distance, nose to centre of gravity.	Distance, nose to centre of area.	No. of fins.	GENERAL REMARKS.
5	403	5 (up)	11.2	2	12.0	1.50	—	—	1 (Stick)	Lost in clouds.
6	—	—	5.6	2	12.0	1.75	7.625	11.125	4	Exploded over rack.
7	25	13	6.0	2	12.0	1.50 (Sq.)	7.75	10.50	4	Horizontal flight—400ft.
8	650	—	6.0	2	11.375	1.50	7.50	9.75	4	Better result expected.
9	56	—	9.0	2	14.75	1.25	9.625	11.50	4	Exploded over rack.
10	86	2.5	11.2	4	15.0	2.0 (Sq.)	9.50	10.50	4	Looped.
11	150	6	10.7	4	13.75	2.0	7.875	9.25	4	Horizontal, then looped.
12	620	12	18.7	4	17.875	1.875	12.125	15.50	2 (Sticks)	Cap ejected at flight apex.
13	235	8	25.0	4	28.125	1.75	18.125	19.125	4	Weighted model.
14	—	—	20.5	4	28.125	1.75	18.625	19.125	4	Caught in rack.
15	196	9	24.0	4	17.0	1.875	15.875	17.75	2	Excess frontal area (9 sq. ins.).
16	503	6 (up)	16.0	4	18.25	1.875	12.0	—	3	Lost in clouds.
17	725	19	34.0	6	23.625	2.375	16.25	16.0	4	Second best performance.
18	524	10	22.0	4	12.5	4.0	8.5	—	3	Over Observer "B's" zenith.
19	206	7	—	—	—	—	—	—	4	Exploded in flight.
20	75	6	37.0	6	30.5	4.0 (Sq.)	22.0	—	4	Excess frontal area (16 sq. ins.).
21	174	8.5	14.0	4	16.0	1.875	10.5	14.75	4	Fins broke off in flight.
22	145	10	12.0	4	13.5	1.875	8.25	11.50	3	Horizontal flight.
23	531	7 (up)	12.5	4	13.25	1.875	8.125	11.50	3	Swung into wind.
24	125	6	17.0	4	14.875	2.875	8.50	9.50	3	Launched late.
25	582	15	14.0	4	26.75	1.875	18.75	16.25	4	Fin area at extreme rear.
26	66	4	13.5	4	12.625	1.875	7.875	—	4	Looped (fin area at nose).
27	1930	24	39.0	6.2	25.25	2.375	18.50	21.50	8	{ Shows efficiency of two-step principle.
27	2nd step alone		9.0	2	12.75	2.375	7.75	8.0	4	

Fig. 28.—Table of results of 23 individual firings.

Committee carried out tests of similar commercial charges of the 3lb., 4lb. and 6lb. size, and their conclusions are set out graphically in Fig. 27.

The designations of these charges follow the usual practice of pyrotechnics in that a lead shot of diameter equal to the charge represents the weight. The *actual* weight of the 3lb. charge is 0.6875lb., of which 0.250lb. is black gunpowder, the containing cylinder being 11.0ins. long by $1\frac{11}{16}$ins. diameter, with a nozzle diameter of $\frac{7}{16}$in. Concerning the 4lb. type, the true weight is 0.906lb., of which 0.406lb. constitutes powder. This size has a case of 12.0ins. by $1\frac{7}{8}$ins., and a nozzle diameter of $\frac{3}{8}$in. The last size investigated, the 6lb. charge, has a weight of 1.5 lb., of which 0.656 lb. is powder. It is 13ins. long by $2\frac{1}{8}$ins. diameter and has a nozzle orifice of $\frac{3}{4}$in.

Firing Results

In the above table (Fig. 28) is shown, for easy comparison, the results of the 23 individual firings. Of these, rocket No. 27 is of particular interest, being of the two-step type. It consisted of two distinct sections, each a self-contained propulsion element—the main component having a 6lb. charge of commercial origin and the other a similar 2lb. charge. In this type the two sections are connected, and the larger fired first. Having consumed its fuel in raising the small component, a connecting fuse fires the latter, which automatically disengages and accelerates away from the expended "parent" rocket.

Another unusual type, rocket No. 26, had fins fitted forward of the centre of mass, but this model proved markedly unstable on test.

Other rockets, Nos. 6 to 11 and 21 to 27, were lightened by the removal of part of the charge casing, and to this is attributed the explosions of models 6 and 9.

(To be continued.)