J. J. Stevenson, while the chairman of the local executive committee of the affiliated societies is Prof. H. F. Osborn and its secretary is Prof. Bashford Dean.

FLYING MACHINES AND ORDNANCE.*

BY HIRAM MAXIM.

FLYING MACHINES.

In 1889 I determined to make a series of experiments with a view of ascertaining how much power was required to perform artificial flight on a large scale. All the apparatus made before this time had been so diminutive in size, so imperfect in construction, that the experiments were of little value. There were practically no data obtainable that would apply to the apparatus when constructed on a sufficiently large scale to be considered as a practical flying machine.

At that time it appeared to me that the most practical system of making flying machines would be what is known as the aeroplane system, that is, a machine made in the form of a kite.

Every boy knows that, when a kite is held up against a strong wind by a cord, it will ascend. The wind, blowing against the underneath surface of the kite, lifts it with a considerable degree of force ; conversely, if the kite should be driven forward through stationary air at the same velocity, the lifting effect would be identical.

My first apparatus consisted of a long arm revolving on a vertical pivot, the arm being of sufficient length so that the circumference around which it traveled was exactly 200 feet. This arm was provided with a screw propeller and it was possible to attach aeroplanes of any size or shape at any required angle, and to drive them around the circle at any velocity from 20 to 90 miles an hour. The apparatus was provided with tachometers, dynamometers, and various apparatus not only for determining the lifting effect of the aeroplanes, but also the actual amount of power required to propel the plane through the air ; to measure the thrust and slip of the screw ; also the amount of power required for driving the screw, and to determine exactly the velocity at which the apparatus was traveling.

The aeroplanes employed in this apparatus were for the most part about 18 inches wide and 4 feet long. Wooden aeroplanes with lightly curved surfaces were found to be best. These experiments demonstrated that 133 pounds could be lifted and propelled at the rate of 45 miles an hour with the expenditure of 1 H. P. I then constructed a very large apparatus, which was, of course, too large to attach to the rotating arm, the apparatus, in fact, being over 100 feet wide. I determined to try this machine by running it along a railway track ; that is, instead of running the machine in a circle or holding it up against the wind after the manner of a kite, I decided to run it at a high velocity along a railway track, and to provide it with apparatus to determine the amount of power consumed and the lifting effect of the aeroplanes. First, I had a steel track 9 feet gage, and outside of this and above it a wooden track 35 feet gage, made of 3 inch by 9 inch Georgia pine. The machine was provided with ordinary wheels for running on the lower steel track, and with special wheels for running on the underneath side of the outer or upper track. The wheels were adjusted in such a manner that when the machine was lifted 1 inch clear of the lower track, the special wheels engaged the outer or upper track, thus preventing the machine from rising in the air.

In these experiments the power consumed was altogether out of proportion to what I had anticipated. Had my large machine been as economical as the small apparatus, it would only have required 100 H. P. to lift it, but 100 H. P. was found to be completely inadequate, and it was not until I had increased the power to over 360 H. P. that I succeeded in getting a machine actually to lift from the ground.

These experiments demonstrated that large machines are nothing like so economical in power as small ones, and that aeroplanes, in order to be effective at a moderate velocity, should be long and narrow, rather than in the form of a kite.

Prof. Langley has constructed an apparatus similar to mine, but very much smaller, and he found that, with his apparatus, the power required per pound lifted was very much less than with my large machine, approximating closely to the original experiments made by myself with the small apparatus.

I understand that the government is spending $25,000 with a view of evolving a practical flying machine. I do not think they will succeed on the aeroplane system. I believe that, when we come to large apparatus, it will be necessary to construct a machine on a totally different plan. Moreover, the $25,000 will be found completely inadequate for the purpose, as my own experiments cost fully $100,000.

My experiments have been fully explained in various articles which I have written, which knowledge is now common property.

FIREARMS AND ORDNANCE.

During the last three hundred years the cleverest mechanicians of all countries have been engaged in making improvements in firearms, always with a view of greater accuracy and rapidity of fire, but it was not until metallic cartridges came into use that it was possible to construct breechloading firearms which could be fired with any degree of rapidity.

It is, however, true that long before metallic cartridges were invented, several attempts were made to construct rapid-fire machine guns. It was, I think, in about 1840 when the great Peter Cooper made what was perhaps the first machine gun ever thought of in this country. In 1854 my own father conceived the idea of making a machine gun. He proposed to make it something after the manner of a revolver, but instead of having loaded chambers, a sprocket wheel took the place of the cylinder, and this was supposed to feed up loaded links of a chain, bring them in line with the barrel and discharge them by the working of a lever by hand. He believed it would be possible to make a gun of this kind that would fire one hundred rounds in a minute. Curiously enough, the gun which was experimented on by Peter Cooper, and the one conceived by my father, of which I made a wooden model, were almost exactly alike.

The first machine gun that ever went into practical use was the Gatling. The Gatling gun had a series of from six to ten barrels arranged in the form of a cylinder, and so constructed that when one turns a crank by hand the barrels are brought successively into action. Then we had the French mitrailleuse, which had thirty stationary barrels arranged in the form of a cylinder. All of these were loaded and fired simultaneously, and the recoil was so great that the gun had to be provided with a mounting quite as strong as would be employed with light pieces of artillery. Later on we had the Gardner, the Lowell, the Pratt & Whitney, and the Nordenfeldt, all being provided with a considerable number of barrels arranged in groups, with hopper feeds, and in all cases being worked by hand by means of a crank or lever. The Nordenfeldt gun, on account of greater simplicity and lightness, met with greater success than the other types of hand-operated guns, but none of these guns were used to any extent by the great military nations of Europe, and it was not until after the automatic gun was invented that such nations as Germany, France, and Austria would even consider the use of machine guns in the service.

Many years ago, while firing at a target with a military musket, I was much surprised at the force of the recoil. It appeared to me on that occasion that this waste of energy might be profitably employed in loading and firing the arm, but it was not until I went to Europe, and, finding myself in Paris, with insufficient work to keep me fully employed, that I actually took up the question of automatic guns. I first made a drawing which I afterward took to London, and having obtained and equipped a small factory there, I commenced experiments with a view of evolving a gun which would load and fire itself. There was not a particle of data to go by. No one before had ever spent a single cent in experimenting with automatic guns. I first thought of applying the recoil to working existing forms of mechanism, but found that impractical. I then designed and constructed a totally new mechanism and a totally new system of feeding.

In the spring of 1884 I constructed the first apparatus ever made in the world in which the recoil of one cartridge would load another cartridge into the barrel and fire it. This apparatus is now in the South Kensington Museum, in London, and labeled "This apparatus loads and fires itself by force of its own recoil, and is the first apparatus ever made in the world in which energy from the burning powder is employed for loading and firing the arm."

When it was first reported in London that an American electrician had succeeded in making a gun which had loaded and fired itself, everyone was incredulous ; they looked upon it as Yankee brag or boast. Many people came to my place and wished to see the gun with their own eyes.

I had fitted up a place in the basement where a gun could be fired with loaded cartridges, and my visitors increased daily. Everybody, from the Prince of Wales down, came to see what was then considered a nine days' wonder, and it required a very considerable portion of my time to receive visitors and show the arm ; in fact, so much of my time was consumed that it became necessary to work nights in order to carry on the work and take out the patents in the various countries of the world.

I used fully 200,000 rounds of cartridges showing my first gun to visitors. The British government was the first to give me an order. They asked me to make a gun which would not weigh more than 100 pounds, and which should fire 400 rounds in a minute. I presented a gun which weighed only 40 pounds and fired 2,000 rounds in three minutes. At these trials I showed three different forms of automatic guns, and all were purchased by the government and are now in their museum.

The next step was to take the gun on the Continent and put it in competition with guns working by hand. In every case I was successful over all competitors, and received large orders. On returning to England I had a field trial before Lord Wolseley. Every one admitted the superiority of the arm, both as regards accuracy, simplicity, and ease of manipulation, but his lordship said, on observing the enormous cloud of smoke given off by the gun, that the gun would be of little use in actual service unless it was provided with smokeless powder. At that time there was no smokeless powder in England, although the French were conducting experiments with the view of finding a smokeless powder.

Acting on his lordship's suggestions, I then commenced experiments with a view of making a suitable smokeless powder for my gun. The first powder which I made was pure tri-nitro-cellulose, made from high grade gun cotton. This not proving altogether satisfactory, I added by degrees small quantities of nitro-glycerine, commencing with about 5 per cent and increasing until I actually made a successful powder with as much as 60 per cent of nitro-glycerine ; but as there was great prejudice against the use of nitro-glycerine, I reduced the quantity to about 13 per cent and produced a thoroughly good smokeless powder. Both nitro-glycerine and high grade gun cotton are violent explosives; in fact, they detonate like a fulminating cap. Nobel, before my time, had attempted to tame or slow up nitro-glycerine by the addition of a sluggish explosive, like collodion cotton, but no one had attempted to make a slow-burning powder from two violent explosives.

Sir Richard Webster, in the celebrated case of Nobel v. Government, admitted that I was the first man in the world to make smokeless powder from nitro-glycerine and gun cotton. It was, I think, about nine years ago that I sent a quantity of this powder to this country. It was in competition with many other kinds of smokeless powder. It produced excellent results, and, according to the official report printed at that time, it was superior to any other powder submitted, and to-day it may be said that little or no improvement has been made in this original powder submitted by me at that time. The powder employed by the government to-day is practically of the same composition and the pressures and velocities are also practically the same.

A few years later the French, wishing to obtain a little higher velocity with an automatic gun than it was possible to obtain with the French powder, proposed to increase the length of the cartridge case, but I suggested that they might attain the desired velocities with the use of an improved form of powder. I accordingly made in England a quantity of smokeless powder with longitudinal perforations. I took it to France and produced results better than ever produced before. I attained the required velocities without increasing the size of the cartridge case, and the gun with the new form of powder was adopted into the French service.

[At the close of the lecture a fully automatic gun loaded with blank cartridges was fired in the lecture hall, at the rate of six hundred rounds a minute.

Mr. Maxim repeated this lecture before the American Society of Civil Engineers, at their club house, No. 220 West 57th Street, on the evening of December 14, and was enthusiastically received. It should be mentioned that he accompanied the lecture with numerous lantern slide illustrations of his aeroplane and ordnance factory.—ED.]

* Address delivered before the Engineering Society of Columbia University of the City of New York, December 8, 1898.

COST OF CLEANING BRICK PAVEMENTS.

The organ of the New York Reform Club Committee, Municipal Affairs, published quarterly, has, in its last issue, a very interesting and complete report upon the reforms effected in cleaning the streets of the city. By this it is shown that the ease with which certain types of pavement can be kept clean, as indicated by careful observations of the cost of doing the work, is as follows: Asphalt, 100; brick, 100; wood (smooth karri), 100; granite, 150; Belgian blocks, 160; cobble stones, 400.

All the pavements were in good condition and the accuracy of the table was checked by comparison with the number of sweepers actually employed in each subdivision in the city. For the entire city 1,623 sweepers were employed, each sweeper keeping clean an average of 5,746 square yards, at an average cost of $2.40 per 1,000 square yards a week; indicating, according to the estimate, that asphalt, brick, and smooth karri wood paving could be kept clean at 69 cents per 1,000 yards per week.

A brick pavement, when properly laid, is not a noisy pavement, it is a good and smooth road for traction purposes or for bicycling, while it affords a better foothold for horses than asphalt does, it is more than ten times as durable, it is lower in first cost, incomparably lower in cost of maintenance, and the New York report proves incontestably that, in the important matter of cleaning, the brick pavement is in no way inferior to asphalt; therefore, we cannot understand why the vitrified brick pavement is not universally adopted in all our cities.