quently entertain the others, while, it is to be hoped, benefiting themselves.

No mention has been made of the suppers and other entertainments of classes and societies; one of which, however, perhaps deserves mention as being a feature of a woman's college which distinguishes it from men's colleges. The freshman class is greeted soon after its advent by the sophomores with a supper and some pleasant entertainment, which we are inclined to think is preferable to hazing. This may be prejudice, though.

Does this seem a very extensive list of "sports" for a place whose ostensible purpose is work? But are we not hearing from every part of society the cry for more play? And if a college aims at something more than the imparting of a certain, or uncertain, amount of knowledge, or a definite number of facts, is it not right that it should attempt to give its students some conception of the proper relative proportions of work and recreation? We believe in the old saw, "Work while you work, play while you play," and that rest from work should be *play*, not *doing nothing;* and we think that it is worth while to make even considerable effort, if necessary, to deliver ourselves from the evil of idly "sitting around" in our hours of recreation, doing nothing, or talking gossip, rather worse than nothing. The true end of a college, as of any other mode of education, will be attained only when we shall have learned the due proportions in which to mingle work and play, in order that healthy minds in sound bodies may carry on with all the energies of which they are capable the work of making the world, or that little corner in which each of us may be placed, the better for her having lived in it.

A. A. Wood.

A NEW FLYING-MACHINE.

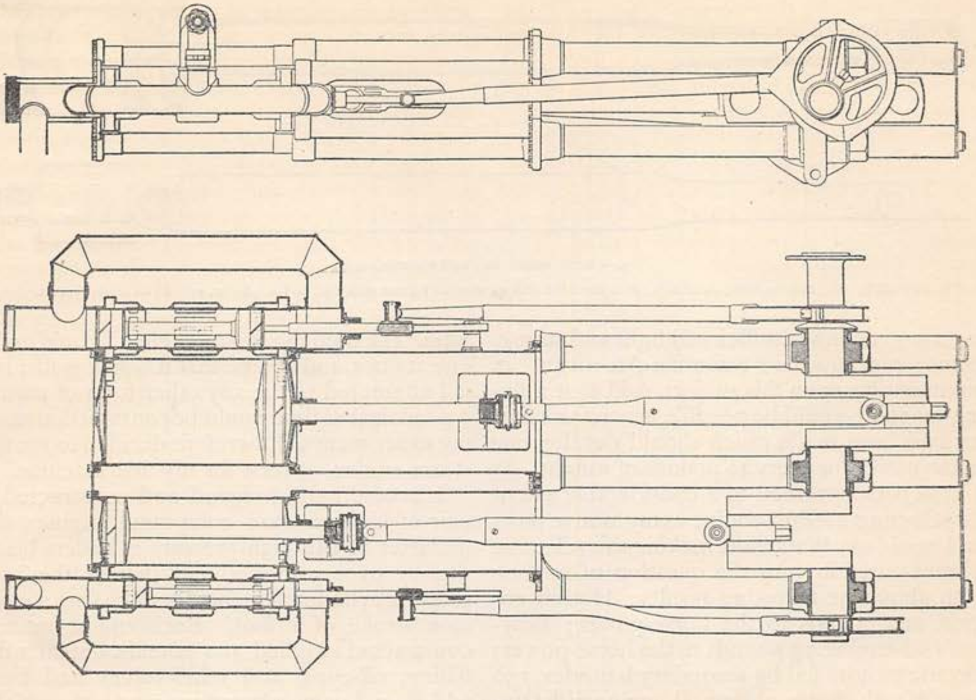
MAXIM'S EXPERIMENTS IN AËRIAL NAVIGATION.

BY THE INVENTOR.

IN 1889 I decided on conducting a series of experiments in order to ascertain if it were possible to construct a practical flying-machine; but before beginning these experiments I took every means of learning what had already been done by others, purchasing all the books on the subject obtainable in the English and French languages. A careful study of the subject at that time seemed to point to the following state of the art: The only apparatus which had ever been made to ascend with one or more men on board was the balloon. Many attempts had been made to steer or navigate balloons, but without success. They had been made in every possible shape, and had been provided with various kinds of motors, but in every case the power developed was not sufficient to enable them to make headway against the lightest kind of breeze. With machines heavier than air no progress had been made. It seemed to me to be quite impossible so to construct a balloon that it would not be completely at the mercy of the wind, and that success could be obtained only with a machine heavier than the air, something that should depend wholly on mechanical energy both for sustension and propulsion. It is true that a great many experiments in this line had been conducted by others, but generally on an exceedingly small scale, with very imperfect apparatus, and the results had always been most unsatisfactory. I therefore determined to make my experiments on a scale sufficiently large to render them of some value, and in order to do this it was necessary to obtain large premises where both gas and water were available. Baldwyn's Park, in Kent, situated about a mile from one of the principal gun-factories, was obtained for this purpose.

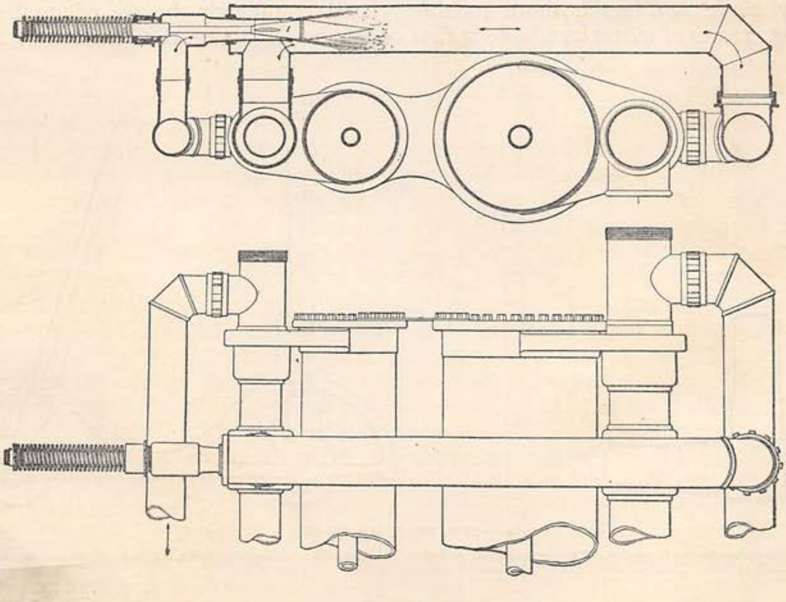
After taking possession, the first thing was to erect a very large wooden building, one end of which was composed of four immense doors. In this building experiments were begun. Before attempting to construct a large machine, I made a series of experiments with a view to ascertaining how much power would be required to perform artificial flight, using aëroplanes for sustension, and screw propellers for propulsion. These experiments I fully described in THE CENTURY MAGAZINE for October, 1891. The results seemed to show that unless there should be some unfavorable factor relating wholly to size, it would be possible to make a practical flying-machine.

Engineers and scientists have long admitted that a flying-machine would be possible provided that some one should succeed in produc-



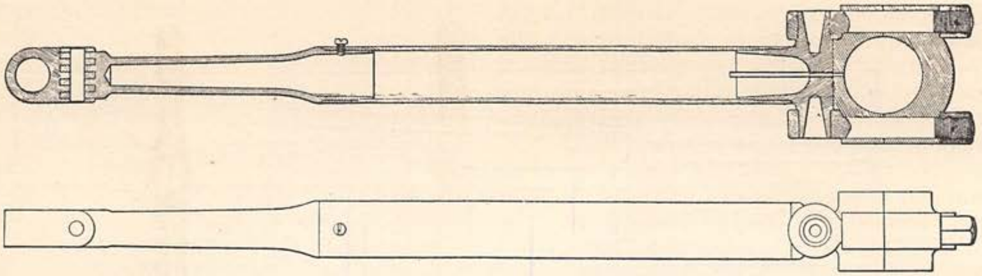
I.— HORIZONTAL SECTION AND SIDE ELEVATION OF THE ENGINE.

Nearly every part of these engines is constructed of tubular steel. Piston-valves are employed, and all the moving parts are of tempered steel and exceedingly light.



2.— PLAN OF TRANSVERSE SECTION OF THE ENGINE.

Showing the by-pass, which consists of a species of injector, and which allows steam to pass directly from the high-pressure supply to the low-pressure cylinder, producing more direct pressure on the low-pressure piston than back pressure in the high-pressure cylinder. This valve may be adjusted so that if the pressure should rise above a certain point, instead of blowing off at the safety-valve, it blows past the high-pressure cylinder in the manner shown.

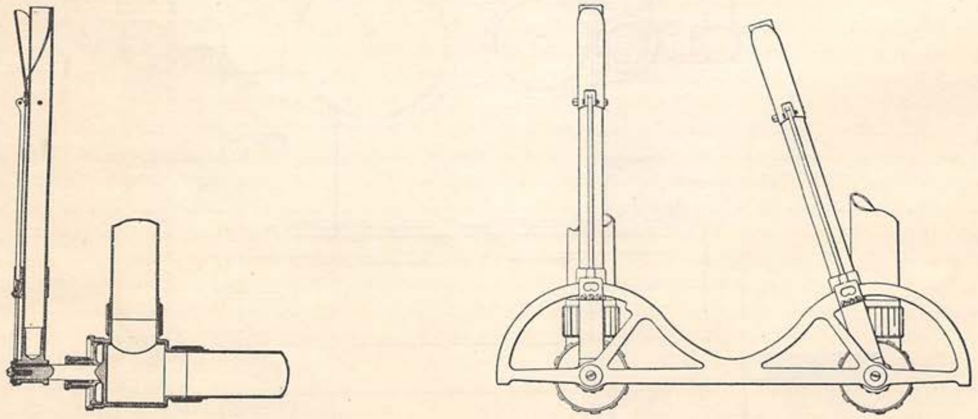


3.—NEW FORM OF CONNECTING-ROD.

Especially designed for flying-machines. It is provided with a universal joint at each end, and is tubular, with an oil supply inside.

ing a motive power sufficiently light and strong. Some years ago the "Scientific American," in commenting upon this subject, said that a flying-machine would be possible whenever a motor had been made which should develop one horse-power for every 40 pounds of weight. As I have been criticized to a considerable extent for selecting a steam-engine as my motive power, I would say that before making this selection I went carefully into the question of motors, with about the following results: Hot-air engine, 200 pounds to the horse-power; Brayton's oil-engine, 75 pounds to the horse-power; electric motors fed by secondary batteries, 130 pounds to the horse-power; oil-engine with Otto system, 50 pounds to the horse-power; steam-engines with condenser, pumps, and everything complete, such as were then used in boats, from 25 to 50 pounds per horse-power.[1] Moreover, the steam-engine appeared to me to be more easily made and much more reliable than any other form of motor available at that time. If I used the steam-engine, I could make one at once, and be sure that it would work; but if I attempted to use any other form of motor, a good deal of time would be consumed in making experiments. I therefore decided to use the steam-engine, at least for my first machine.

I accordingly designed and constructed a pair of high-pressure compound engines, the diameter of the high-pressure cylinders being slightly over 5 inches, and that of the low-pressure cylinders 8 inches, both having a common stroke of 1 foot. Each engine as first constructed weighed 300 pounds, but after the felting, oil-cups, and relief-valves had been added, and some alterations made, the weight was brought up to 320 pounds each. These engines are constructed almost entirely of a high grade of steel, many of the parts being tempered. In order to prevent vibration, the cranks were placed 180 degrees apart. This obviated completely the use of any balance- or counter-weights on the crank-shaft, and at the

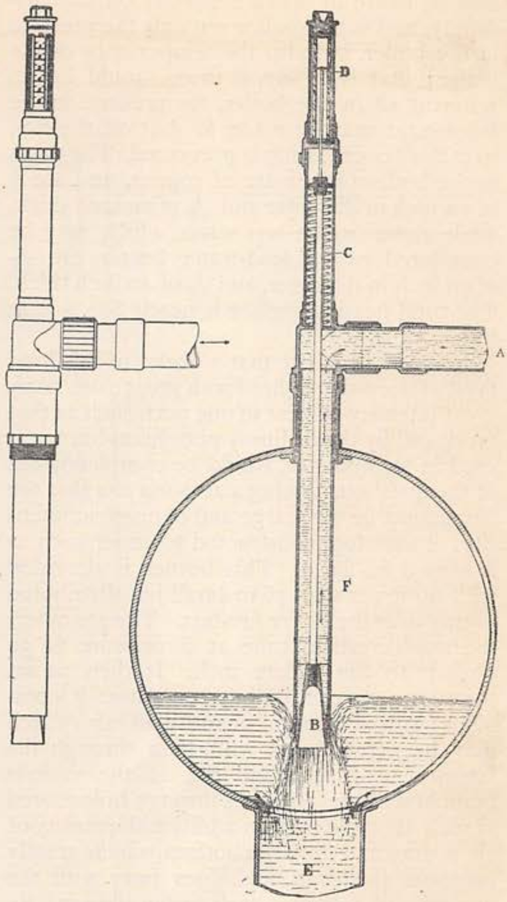


4.—THE THROTTLE-VALVES.

There is a throttle-valve for each engine. They are opened and shut by means of a self-locking lever. The machine may be steered either to the right or to the left by these throttle-valves, simply by running one engine faster than the other.

[1] My complete steam-motor as it now exists weighs 2040 pounds, which includes the boiler, engines, gas-generator, pumps, and 200 pounds of water in the boiler; but this does not include the supply of fuel, the water in the tank, or the condenser. The highest power developed is 363 horse-power, which gives 5.6 pounds to the horse-power. An atmospheric condenser can be made weighing no more than 1 pound to the horse-power.

same time enabled the engines to be held in position by light steel tubes and wire stays. The connecting-rods, being on universal joints at each end, permitted a certain degree of springing, or distortion, of the parts without causing any friction. The first steam-generator which I attempted was composed of a large number of thin and very small tubes. In order to insure great lightness, I wished to do away with any considerable weight of water in the boiler. I believed that if a series of fine tubes should be properly heated by a large gas-flame, water passing in at one end of the series would be converted into steam, and might be drawn out at the other end. The heating surface of this boiler weighed 300 pounds, but it required such a nicety of adjustment in regard to the quantity of water pumped in, and the quantity of gas consumed, that it was found to be impracticable, and had to be abandoned. Whereas the first boiler was intended to evaporate *all* or *nearly all* the water passing through it, the second one was designed so as to evaporate only about 20 per cent., the remaining 80 per cent. being separated from the steam, and driven again through the boiler by a species of injector, shown in fig. 5. This second boiler, as will be seen (fig. 10), is composed of a great number of small tubes. The cold water from the pump first passes through the very fine tubes at the top; this brings it up to a temperature of about 250 degrees. It then passes down through a spring valve (shown in fig. 5), the spring being of a tension sufficient to maintain 30 pounds more pressure in the feed-water heater than in the boiler. The water, in passing, say, from 330 pounds pressure to the square inch to 300 pounds pressure to the square inch, does work on the surrounding water, and forces it down through the large tubes which are outside the boiler. It will therefore be seen that not only is the feed-water driven through the series of small tubes which form the heating surface of the boiler, but it also takes along with it whatever water has accumulated in the drum or steam-separator of the boiler, the steam being drawn off through a suitable perforated pipe in the top of the drum, and led to the engines. This boiler, with its casing, smoke-stack, feed-water heater, seating, etc., weighs 909 pounds without its water, while the burner which takes the place of the grate in other boilers weighs about 100 pounds. A peculiar feature of this boiler is the thermostat regulator, consisting of a closed steel tube partly filled with water and hermetically sealed, and made in the form of two loops, one of which is in the lower part of the steam-drum, while the other is in the furnace. In ordinary firing, with the right quantity of water in the boiler, there is a rapid circulation in this tube. Steam at a high pressure is generated in the lower loop, rises, and is condensed by the water which surrounds the upper loop in the steam-drum. Ordinarily the pressure is about 10 pounds more in the loops of the thermostat than in the boiler; but if the supply of water should be insufficient, there would be little or no water in the drum, and the temperature would rapidly rise until the pressure in the thermostat would greatly exceed that in the boiler. A common pressure-gage attached to this thermostat enables the engineer to know exactly what is taking place inside the boiler. If the water is too high, the pressure will be only slightly in excess of the boiler-pressure; while if the supply is insufficient, the pressure mounts rapidly, which also indicates the exact degree to which the steam is superheated. The pressure in the thermostat may



5.—THE FORCED CIRCULATION.

A forced circulation is maintained in the boiler by utilizing the force of the incoming feed-water, the pressure of which considerably exceeds the boiler pressure. The water enters at A, descends through the pipe F, and escapes through the valve B. The spring C automatically adjusts the valve to suit the quantity of water entering. As the water descends through the pipe E at a high velocity, it takes whatever water has accumulated in the steam-drum along with it. The pipe E is connected with the bottom tubes of the boiler from which all the small tubes branch that form the heating surface of the boiler. The quantity of water entering is indicated by the little button D, which may be seen through the glass tube in which it moves.

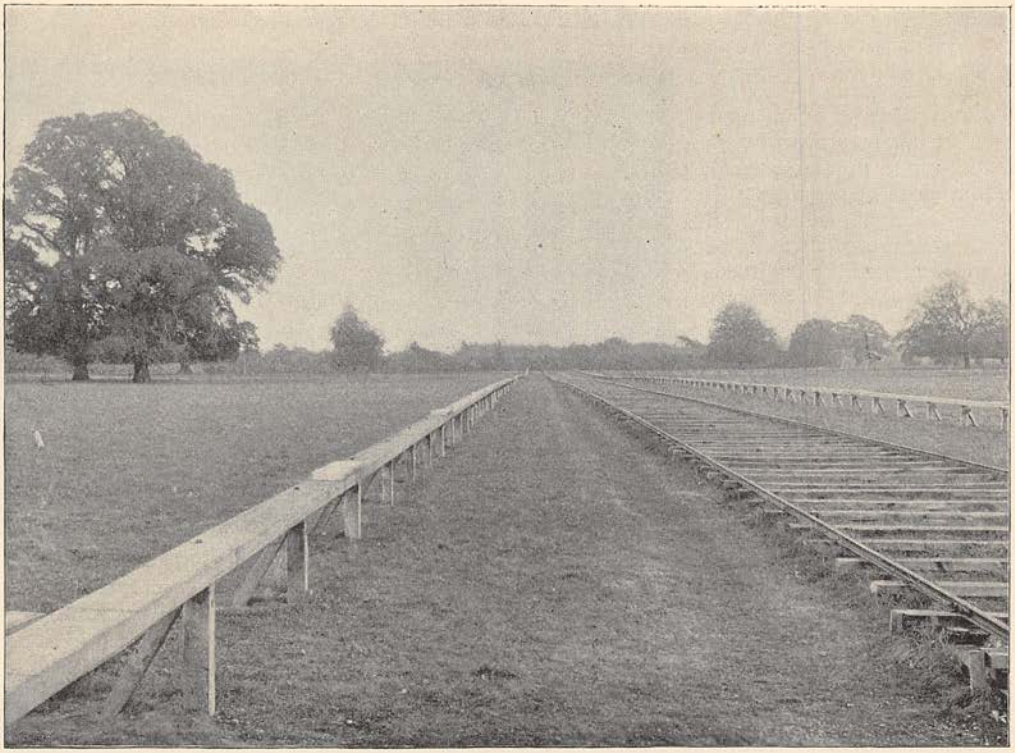
also be made to operate directly on the gas-supply, and so to regulate not only the pressure in the boiler, but also the temperature of the boiler; that is to say, if there should be no water at all in the boiler, the pressure in the thermostat may be made to shut off the fire, so that all overheating is prevented. The tubes in the boiler proper are of copper, and are $\frac{3}{8}$ of an inch in diameter and $\frac{1}{50}$ of an inch thick, while those in the top series, which may be considered as the feed-water heater, are $\frac{3}{16}$ of an inch in diameter, and $\frac{1}{60}$ of an inch thick. The total heating surface is nearly 800 square feet.

It is very evident that a boiler of this kind must of necessity be fired with great care. Any great intensity of heat in one part, such as that produced by the ordinary petroleum-burner as used in locomotives, would be completely out of the question, it being a *sine qua non* that the flame must be very large and of no great intensity. I therefore constructed a burner such as is shown in fig. 9. This burner is provided with no fewer than 7650 small jets distributed evenly over the entire fire-box. The gas enters the small vertical tube at a pressure of 50 pounds to the square inch. It then passes through a species of injector, where it combines with a certain quantity of air (which may be regulated at will), then through the large central tube and out at the various branches, where it escapes through holes bored at such an angle that an additional quantity of air is drawn in from the bottom, which greatly increases the draft, and does away with the necessity of a smoke-stack or fan-blower. By regulating the air-inlet of the injector, any sort of flame, from smoky-red to one perfectly blue, may be obtained; but it is found best to use one of a purplish-white color, and about 22 inches in height.

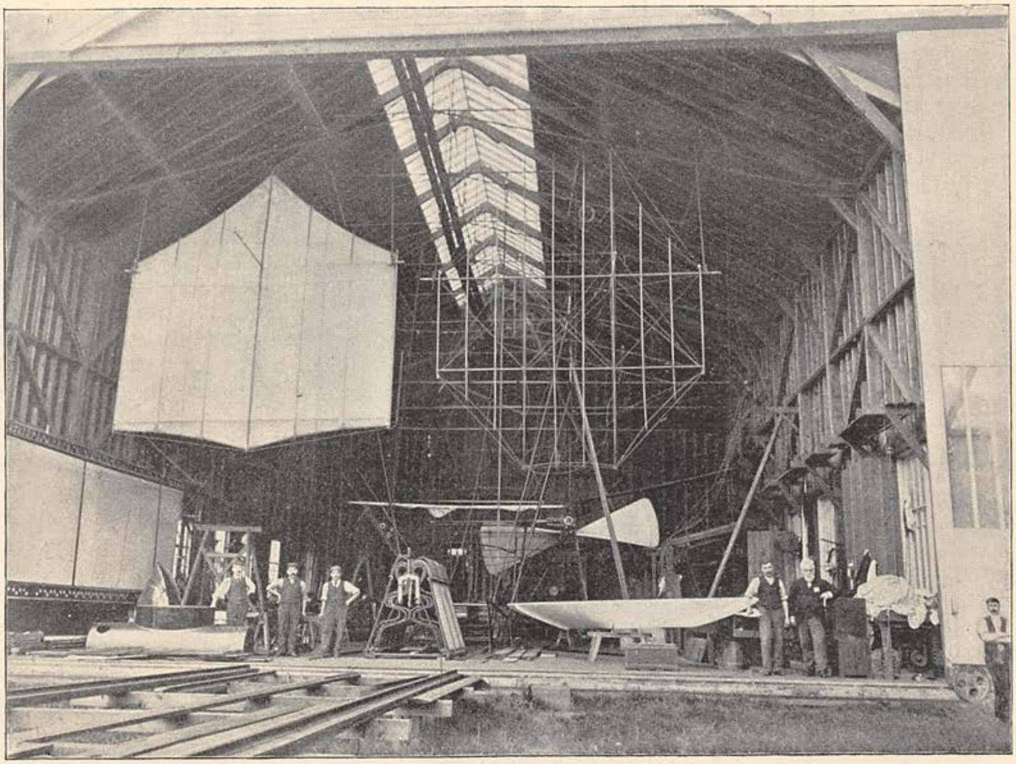
The gas-generator shown in fig. 12 is made in the form of a small vertical boiler. It is of a fine quality of steel, about $\frac{1}{20}$ of an inch in thickness, and is provided with a number of steel tubes which pass from the fire-box through the liquid, and take the products of combustion to the smoke-stack. These tubes are placed near the walls of the generator, leaving a space completely without tubes in the center, through which a hollow stay-bolt passes. The top end of this stay-bolt is provided with a valve arranged in such a manner that when there is a pressure of 50 pounds per square inch in the generator, it springs the top plate of the generator upward, and closes the valve. If the pressure be *less* than 50 pounds, the plate springs downward, opens the valve, and allows the gas to pass down through the stay-bolt, and to the burner that supplies the flame which heats the generator. The liquid in the gas-generator is therefore heated by a portion of its own contents, while the pressure is automatically regulated so as to be maintained always at 50 pounds to the square inch. The weight of the gas-generator is also made to operate directly on the pump which supplies the naphtha. If the weight of naphtha in the generator exceed 40 pounds, the generator drops downward about $\frac{1}{8}$ of an inch, and operates on a mechanism which rapidly shortens the length of each stroke of the pump; but if the weight should be less than 40 pounds, the generator is raised $\frac{1}{8}$ of an inch above its normal position by a spring operating through the bell-crank lever on which it rests, when the same mechanism causes the stroke of the pump to increase, and so keeps the weight of the naphtha practically at 40 pounds.

Before deciding upon the exact form of the screw propellers, I made a series of experiments with various forms of screws. In marine engineering the skin friction on the screw-propeller is so great that it has been found advantageous to make the blades narrowest at the points; but with a well-made screw running in the air, the skin friction is so small that it need not be considered as a factor at all. I therefore have made the ends of my screws very wide. I was told by the secretary of the Aëronautical Society that a screw propeller working in air operated very badly, and that there was a great loss of power due to what he called the fan-blower action. He said that the air would be drawn in at the center of the screw, and discharged at the periphery, thus wasting a great deal of energy. In my experiments, however, I found that when the pitch of the screws was no greater than three times the diameter, there was no fan-blower action at all; in fact, that a well-made screw *drew in* air at the periphery, and discharged it almost in a straight line in the direction of the axis. The first large screws which I made had two blades; they were 17 feet 10 inches in diameter, and had a mean pitch of 24 feet. This pitch, however, was found to be too great, and another pair was made of the same diameter, but with a pitch of only 16 feet. These screws gave exceedingly good results; but a pair of 14 feet diameter and 18 feet pitch gave very bad results, the engine-power being too great for the area of the screw-disk.

Ordinary steam-motors, as every one knows, are provided with safety-valves which are held to their seat either by a weight or a spring, and are so attached that when the internal pressure rises above a certain point, the valve opens, and the steam is discharged into the air. This, of course, puts an absolute limit on the amount of power that can be delivered by the engines. Upon testing my boiler, I found that it would be quite safe to carry the pressure as high as

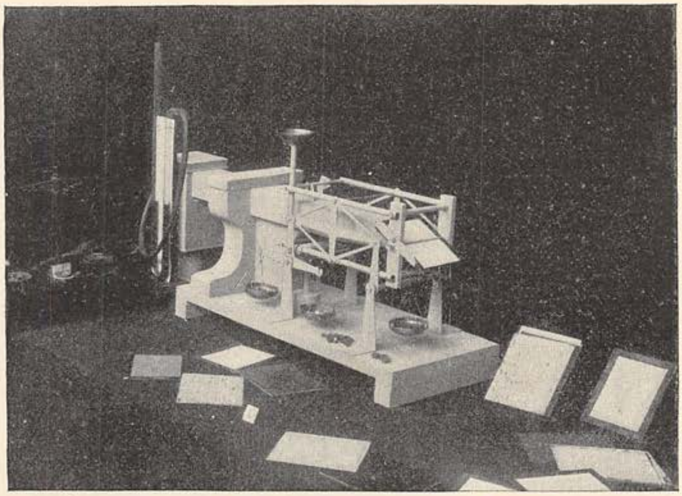


THE RAILWAY TRACK.
Extending across the park for a distance of eighteen hundred feet.



INTERIOR OF THE WORKSHOP.

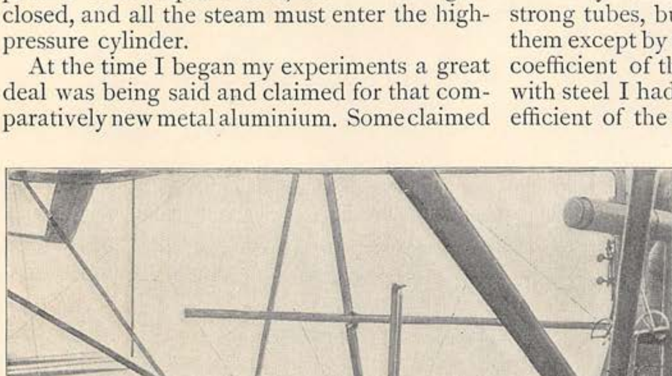
335 pounds to the square inch. I accordingly set my safety-valve so as to blow off at this pressure; but in addition to the safety-valve I provided the engines with the device shown in fig. 2. This consists of a species of injector, connected directly with the high-pressure steam-pipe, with a steam nozle-valve adjusted in such a manner that when the pressure rises above 310 pounds to the square inch, the nozle is opened, and the steam escapes into the pipe leading to the low-pressure cylinder, where the pressure is nearly 200 pounds less. This great fall of pressure is made to work on the surrounding steam, relieving the back pressure to some extent on the high-pressure cylinder, and greatly increasing the direct pressure on the low-pressure piston. By this device the boiler may be forced to almost any extent, and the engines may develop an immense amount of power without any dangerous increase of steam-pressure; and whenever the pressure falls below 310 pounds to the square inch, the valve is again closed, and all the steam must enter the high-pressure cylinder.



7.—APPARATUS FOR TESTING DIFFERENT KINDS OF FABRIC.

The fabric, stretched upon a small steel frame, was mounted at a slight angle in a blast of air, and the tendency to lift and the tendency to drift were accurately measured. The material which gave the greatest amount of lift with the least drift was selected.

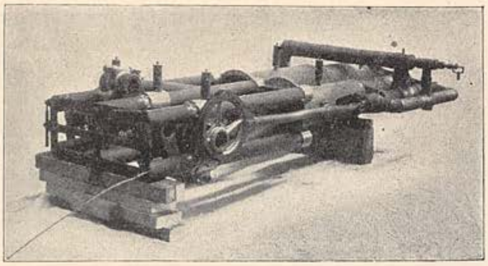
At the time I began my experiments a great deal was being said and claimed for that comparatively new metal aluminium. Some claimed that by the addition of a small percentage of silver, copper, or titanium, its tensile strength might be increased so as to equal that of mild steel. I communicated with all the principal manufacturers of this metal, but in all cases I found it was very much inferior to steel, weight for weight. It is true that I could obtain in Germany some very fine and comparatively strong tubes, but there was no way of uniting them except by riveting, which would make the coefficient of the joint very low (.40), whereas with steel I had no trouble in bringing the coefficient of the silver solder joints fully up to .98, or nearly as strong as the whole steel. Moreover, steel tubes could be obtained in large quantities, and at a price very much less than that of aluminium. I therefore constructed the framework of my machine of steel tubes, the greater part of which were 1 millimeter ($\frac{1}{25}$ of an inch) thick, the diameters ranging from 3 inches to ¼ of an inch.



6.—DYNAGRAPHS.

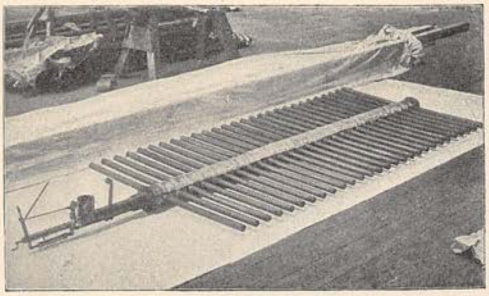
Each of these is provided with a paper-covered cylinder which rotates as the machine advances. A pencil makes a diagram of the lift at the various speeds.

The completed machine consists of a platform about 8 feet wide and 40 feet long, on which is mounted the boiler, the water and gasolene tanks, the gas-generator, the pump, the steering-gear, etc., and to which are attached the tubular brackets for holding the steam-engines in position;



8.—ONE OF THE STEAM-ENGINES.

There are two of these on the machine, each weighing 320 pounds, and each has developed over 180 horse-power.



9.—THE BURNER AND APPARATUS FOR INDUCING THE AIR.

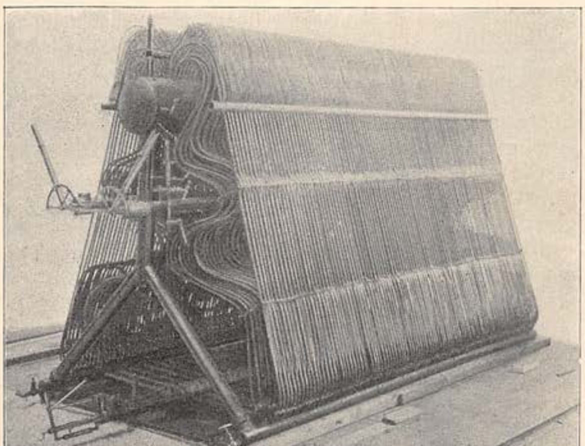
The air combines with the gas before it is burned.

also the tubes and wires which support the aëroplane. This platform is mounted on four flanged wheels, and is made to run on a steel railway track of 9 feet gage. Considerable experimenting was necessary in order to get all the automatic feeding, pumping, and gas-generating machinery to work to perfection. A great deal of experimenting was also necessary so to perfect the burner as to enable it to consume the very large amount of fuel—without smoking or blowing—necessary to develop 300 horse-power. As soon as everything was in readiness, the machine was run over a track from the shop by the propulsion of its own screws, when it was found that a very high speed could be attained.

Having perfected the motive power so that it worked to my satisfaction, I began experiments on the aëroplane. I found that there was a great deal of divergence of opinion, especially in France, as to what was most suitable for aëroplanes. Some argued that as birds were covered with fibrous or fluffy feathers, in all probability velvet or plush would be found to be the most suitable material. I therefore decided to make experiments with a view to ascertain the best possible fabric to be used. An apparatus (fig. 7) was designed expressly for this purpose. It is constructed in such a manner that a piece of the fabric to be tested can be tightly stretched on a small steel frame, and mounted at an angle in a blast of air, with suitable weighing apparatus for ascertaining the lift and the drift—"drift" in this sense meaning the tendency of the object to move in the direction of the wind, while "lift" means its ascensional force.

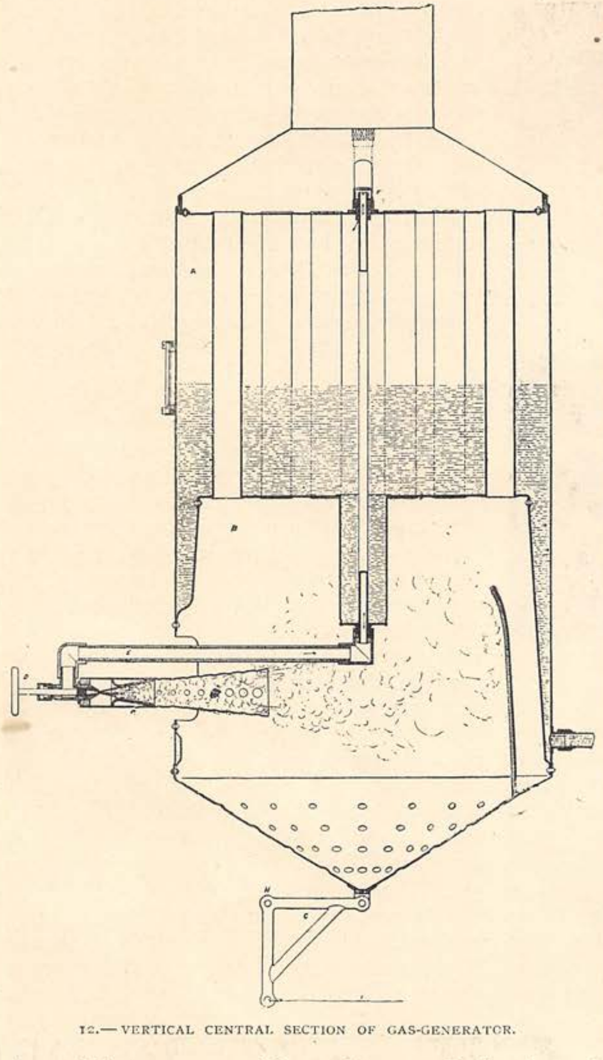
I first mounted a piece of tin at an angle of one in ten, and found that the lift was exactly ten times the drift. This I considered as unity. A piece of tracing-cloth tightly stretched on the frame produced identical results. I then tried experiments with velvet, plush, woolen goods, and all sorts of silks and cottons. Some of the silks which were apparently very closely woven did not lift nearly as much as the sheet of tin, and had a much stronger tendency to travel with the wind, while with a piece of crape the drift was several times greater than the lift. With a piece of linen shirting the lift was about nine times the drift; but with a piece of Spencer's balloon fabric, which was woven from very fine material, and so closely beaten up and calendered that it was nearly impossible to blow through it, the lift mounted to ten times the drift, thus proving it to be quite as good as a sheet of tin.

But to make a large aëroplane is not so simple a matter as some may suppose. The first large one which I made had only the under side covered with the balloon fabric, and it took something like a month to stretch it on the frame. Upon trying this aëroplane, it was found that the resistance offered by the framework above the fabric was sufficient to retard greatly the velocity of the machine, so that the lift did not exceed the thrust of the screw necessary to drive the machine forward. Another



10.—THE BOILER AND FEED-WATER HEATER.

The products of combustion first pass through the steam-generating tubes, and then part with the greater portion of what caloric remains by coming in contact with the small tubes immediately above, which form the feed-water heater.



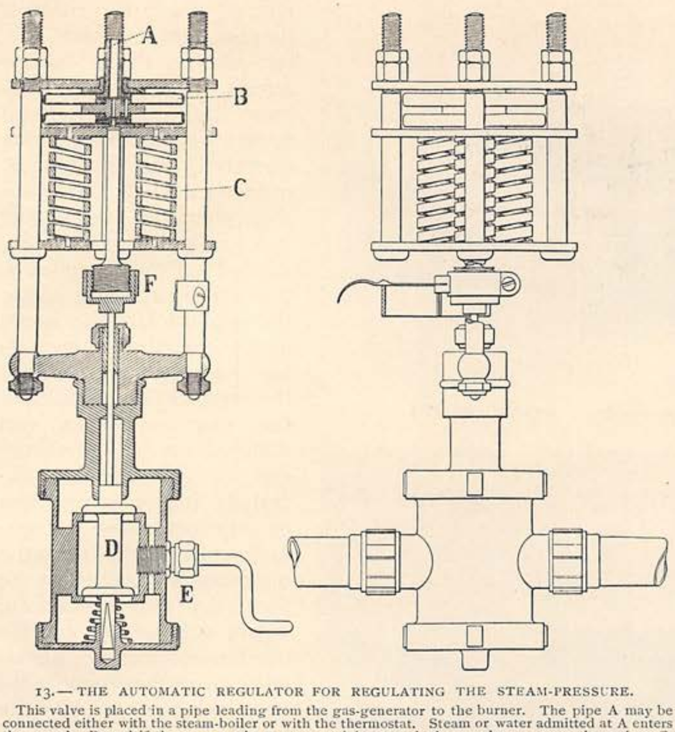
12.—VERTICAL CENTRAL SECTION OF GAS-GENERATOR.

it, and it is then very tightly stretched on a large frame. It is then wetted and dried several times, the tension being taken up whenever any slackness appears. When every tendency to stretch has been removed, it is cut to the exact size required, and is provided with a permanent linen tape for securing it to the machine. It is then remounted on the frame, stretched to the exact size of the aëroplane, and lightly varnished with boiled oil. When the oil is dry, the fabric may be relied upon to keep its shape: it will not be influenced by heat or cold, and will remain upon the frame as tight as a drumhead. In my experiments I found that any bagging or distortion of the under side of the aëroplane greatly increased the power necessary to drive it through the air, and it was quite impossible to devise any sort of framework for holding it straight which did not weigh too much. I found, however, by covering the upper side of the framework with a similar material, and by allowing some of the air to pass through the lower side, that the pressure of air between the two could be made to hold the lower side absolutely uniform, while the upper side was allowed to bag upward in longitudinal ridges, which did not offer any appreciable resistance to the air.

The new aëroplane is 50 feet wide and about 40 feet long in the middle, but with the corners cut off so that the length at the sides is only 12 feet. The sharp edges both fore and aft are formed by drawing the fabric tightly over steel wires. When the machine is run at a speed of about 36 miles an hour, this main aëroplane will lift from five eighths to three fourths of the whole weight of the machine. The long and relatively narrow wings which project 27 feet beyond this main aëroplane on each side, are found to be much more efficient than the main aëroplane itself; but I should not regard a machine without a large aëroplane as being safe at this particular stage of the experiments. In addition to the wings which extend on each side of the machine, a fore and an after rudder are provided, which are for the purpose of steering the machine in a vertical direction.

It will be understood that a flying-machine operating on the aëroplane system depends for its ascensional power upon being driven forward at a high velocity, the front side of the aëro-

piece of the same material was then stretched carefully over the top of the framework; but the edges were not very sharp, and the upper side was rather irregular. This change, however, greatly improved the lifting power, and at the same time greatly reduced the screw-thrust necessary to propel the machine at a given speed. In the last experiment made with this aëroplane, the front wheels of the machine were lifted off the track, and the aëroplane was broken. This led to a complete change in the system of making the aëroplane, and the one which I employ to-day is made very sharp forward and aft; both the upper and lower sides are very smooth and uniform; and it may be driven through the air without any great expenditure of power. The balloon material from which it is made is first cut and sewn together in approximately the right shape. An eyeleted tape is sewn completely around



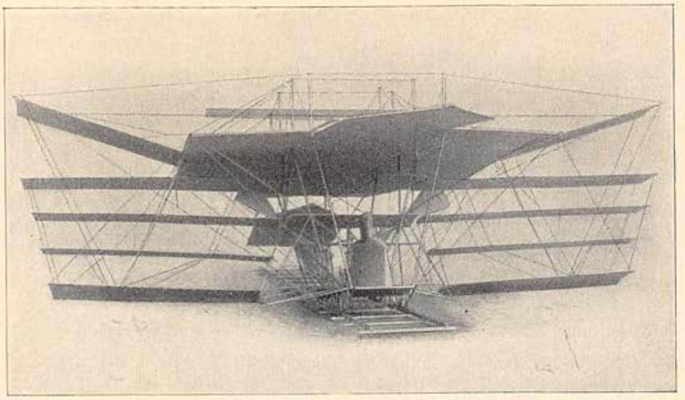
13.—THE AUTOMATIC REGULATOR FOR REGULATING THE STEAM-PRESSURE.

This valve is placed in a pipe leading from the gas-generator to the burner. The pipe A may be connected either with the steam-boiler or with the thermostat. Steam or water admitted at A enters the capsules B, and if the pressure is great enough it expands them and compresses the springs C, and closes the gas-valve D. The amount of pressure necessary to close the valve may be adjusted by the nut F. E is a by-pass for allowing a small quantity of gas to pass, in order that the burner may never be completely shut off.

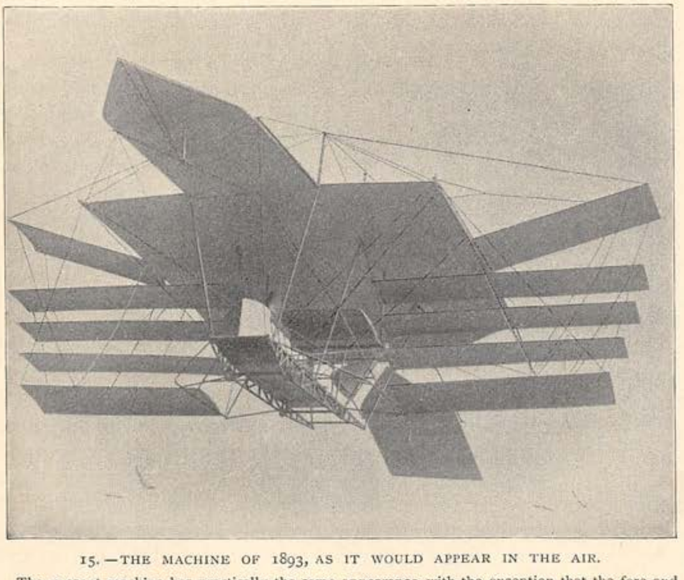
plane being tilted upward so that, as the machine advances, the air is pressed downward and the machine upward as with a kite. In the case of the kite, however, the air is moving and the kite is stationary, but with the flying-machine we must consider the air as stationary while the kite or aëroplane advances on it at a very high velocity. The kite is held up against the wind or drawn into the wind through the agency of the string, but the aëroplane of the flying-machine is driven forward by the thrust of its own screws.

As a great deal of experimenting was necessary before free flight could even be attempted, I constructed a railway track 1800 feet long, over which the machine could be run at a high velocity, not only for testing the lifting power of the aëroplanes, the thrust of the screws, and the efficiency of the atmospheric condenser, but also for ascertaining the exact center of the lifting effort, so as to enable me to balance the machine. Steel springs were interposed between the axletrees and the body of the machine, and levers were so arranged that the whole apparatus became a veritable weighing-machine or platform scales; but instead of the graduated lever which indicates the weight, a pencil was employed which drew a diagram on paper-covered cylinders connected in such a manner that they made one turn in 1700 feet. As the machine was run over the track, a graphic diagram was made, showing the exact lift for the entire length of the track. These dynagraphs are shown in fig. 6.

When the machine had reached a fair degree of perfection, it was found impossible to run it over the track at anything like full speed without danger of its leaving the rails; so I found it necessary to provide an inverted track. This was of 3 × 9 Georgia pine placed outside and above the steel rails. Four additional wheels on outriggers were provided, and so arranged that when the machine was lifted one inch clear of the lower steel rails they engaged the upper track. Upon running the machine at three-quarters power, it was found that three of the wheels were lifted off the lower track, while when it was run at full speed all four of the wheels were lifted from the steel rails, and the machine ran along the upper track without touching the earth at all. This upper track also enabled me to test the efficiency of my fore and my after rudder. If the forward rudder was adjusted at an angle considerably greater than that of the main aëroplane, and the after rudder at a considerably smaller angle, and the machine run over the track at about three-quarters power, the front wheels would be lifted off the lower rails in the manner shown in fig. 18 A. If the forward rudder was adjusted so as to be practically level, and not to lift at all, and the after rudder set at an angle considerably greater than that of the aëroplane, the exact reverse would happen—the rear end of the machine would rise, leaving the forward end on the rails (fig. 18 B), while if both the forward and the after rudder were set at about the same angle as the main aëroplane, all four of the wheels would be lifted from the track as shown in fig. 18 C. These experiments would seem to show that it would be possible to steer the machine in a vertical direction. The distance between the forward and the after rudder being very great, it is believed that if the machine had a tendency to rear and pitch, a man could think and act quickly enough to adjust the rudders and rectify the fault, and so bring the machine back on an even keel, before the deviation from the normal position was great enough to cause any injury. This



14.—THE MACHINE ON THE RAILS, AS IT APPEARED IN 1893.



15.—THE MACHINE OF 1893, AS IT WOULD APPEAR IN THE AIR.

The present machine has practically the same appearance, with the exception that the fore and the after rudder are slightly smaller, and the corners of the main aëroplane are cut off, so that it is octagonal instead of rectangular.

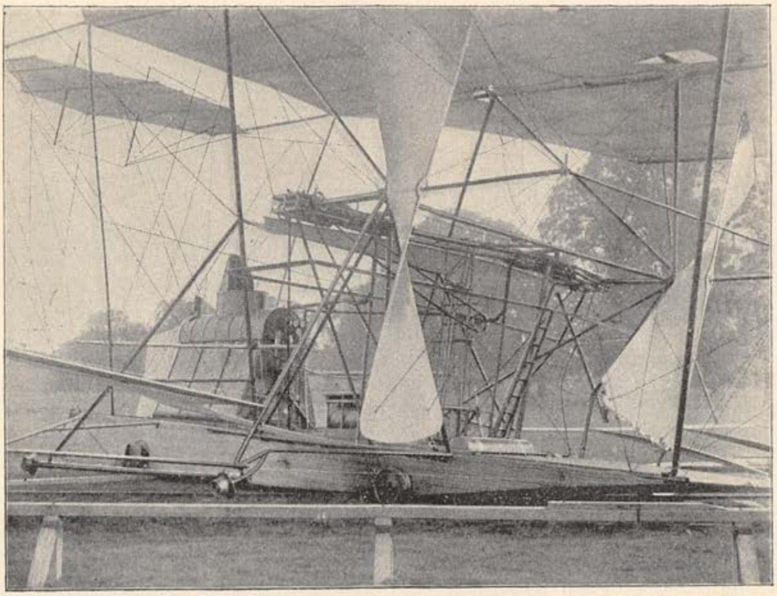
can also be done in an automatic manner by the employment of a gyroscopic regulator.

In regard to the question of stability, I find, by arranging the upper wings in the manner shown in fig. 19, that there is no tendency for the machine to roll. It will be seen by this illustration that whichever way the machine is tilted, the wing that is on the lower side is thrown into a position which greatly increases its lifting power, and at the same time diminishes the lifting power of the wing on the higher side. This makes the machine completely automatic so far as stability is concerned; moreover, the center of gravity is very much below the center of lifting effort, which also serves to keep the machine on an even keel.

On the last occasion that the machine was run over the track, the steam-pressure was run up to 320 pounds to the square inch, the machine being attached to a dynamometer which recorded the thrust of the screws. As the speed increased, the thrust ran up to over 2100 pounds. Upon liberating the machine, it instantly started off at a very rapid pace, and after 400 or 500 feet had been covered, it lifted off the lower rails, the wheels running along the top track. The speed increasing, the lifting effort became so great that the rear axletree holding the machine down was doubled up, and the rear end of the machine liberated. It rose some three or four feet above its normal position, and finally the upper track was lifted by the forward wheel, and broken. Steam was shut off, and the machine stopped, the wheels settling into the ground without making any track on the turf, thus showing that all four of the wheels had been completely clear of the earth. The broken timber of the upper track, however, did considerable damage to the lower framework of the machine, necessitating repairs which required some weeks to execute, on account of the time necessary to make the steel tubes.

At the time of making these last experiments, the aëroplanes were placed at an angle of one in eight; that is, as the machine advanced eight feet, it pushed the air down one foot. When the wings are on, the machine is about 105 feet wide over all, and the area of all the planes used in these experiments is 4000 square feet. The speed was from 36 to 37 miles an hour; the screw-thrust while running was 2000 pounds; the actual horse-power, with 320 pounds steam-pressure, was 363; the total weight of the machine, with water, fuel, and three men on board, was a little less than 8000 pounds; the total lifting effort, 10,000 pounds; the screws made between 375 and 400 turns per minute; and the fuel used was naphtha, 72° Beaumé.

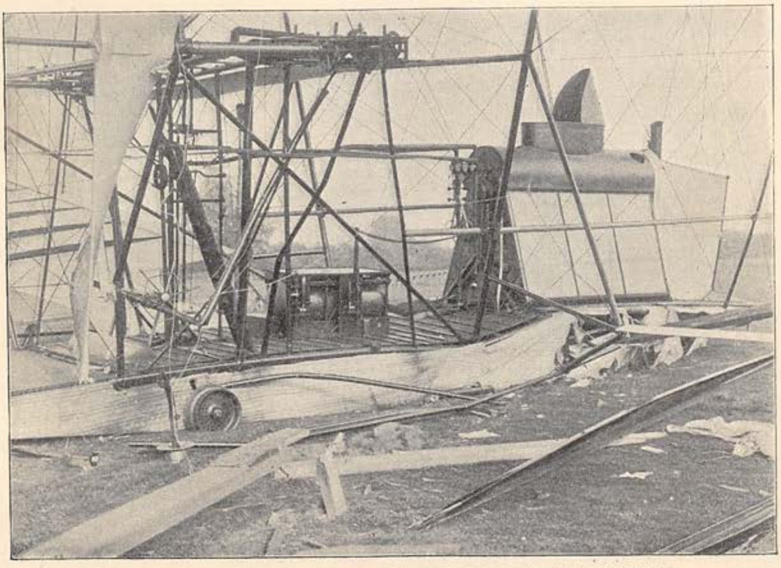
At the time of writing, the machine is practically finished, but in order to continue the experiments it appears to me that it will be necessary to obtain a very large and level field



16.—VIEW OF THE PORT SIDE OF THE MACHINE AFTER THE ACCIDENT.
Showing one of the axletrees which was doubled up, and which led to the accident.

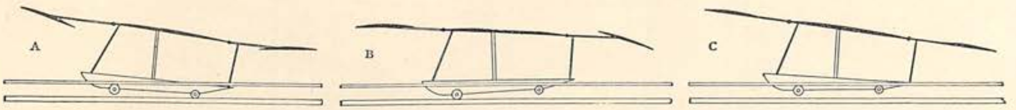
completely free from trees and houses, where experiments can be made in manœuvering the machine. I do not consider it safe to attempt free flight directly from a railway track with a great number of very large trees in every direction; the slightest hesitancy in manipulating the rudders, or the least mistake, might prove disastrous. What is required is to experiment with the machine running very near the ground, in fact almost touching it; and not until one has complete control of the machine should high or completely free flight be attempted. A suitable field for conducting these experiments is not easy to obtain in England, and is certainly not to be found near London.

The experiments which I have conducted have certainly proved that a machine can be made sufficiently powerful and light to lift itself in the air. They also prove that an aëroplane will lift a great deal more than a balloon of the same weight, and that it may be driven through the air at a very high velocity, and

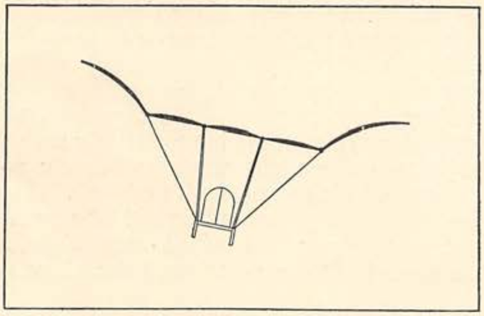


17.—THE STARBOARD SIDE OF THE MACHINE AFTER THE ACCIDENT.

with an expenditure of power very much less than that required to drive a balloon at even a moderate pace. The experiments have also shown that a well-made screw propeller obtains sufficient grip on the air to propel a machine at almost any speed, and that the greater the speed the higher the efficiency of the screw. Some of the leading mathematicians in England, after witnessing my experiments, have publicly stated that the lifting effect of an aëroplane placed at a low angle and traveling at a high velocity is very much greater than had heretofore been supposed, and all the conditions much more favorable. They all agree that the formulæ in text-books on this subject will have to be revised. Lord Kelvin has already published a new formula on the subject, which is from twenty to fifty times as favorable as the old one. Had this knowledge been available, and had it been known twenty years ago that a machine could be made on the aëroplane system which would really lift its own weight, its fuel, and its engineers, we should have had plenty of flying-machines in the world to-day. If one half the money, the time, and the talent which has been employed by the French balloon corps in their fruitless attempts to construct a navigable balloon should now be employed in the right direction, the whole question of aërial navigation would soon be so perfected that flying-machines would be as common as torpedo-boats, and the whole system of modern warfare would be completely changed.



18.—THE ACTION OF THE FORE AND AFTER RUDDERS AND THEIR EFFECT UPON THE MACHINE.



19.—DIAGRAM SHOWING THE MANNER IN WHICH THE LIFTING EFFECT IS INCREASED ON THE LOWER SIDE AND DIMINISHED ON THE HIGHER WHENEVER THE MACHINE IS TILTED TO ONE SIDE.

Hiram S. Maxim.

CHORDS.

THOUGHTS of deep pine-woods and of chanting seas,
Follow the magic hand-touch on the keys;
Now 't is the violin that loudest rings,
And now in saddest key the cello sings,
Blent with the lonely challenge of the horn,
Echoed, in seeming, from some height forlorn.
Again, the drums and viols with sullen roar
Break with their sound-waves on the mind's dim shore,
And suddenly die away. 'T is then there comes
Out from the cymbal-clash and roll of drums
Chords that are love and life, and even the sharp,
Hard pain of death — chords of the golden harp.

Meredith Nicholson.