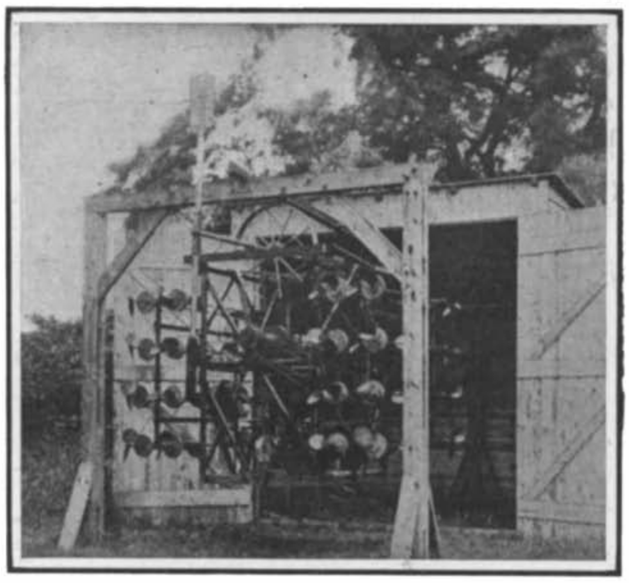
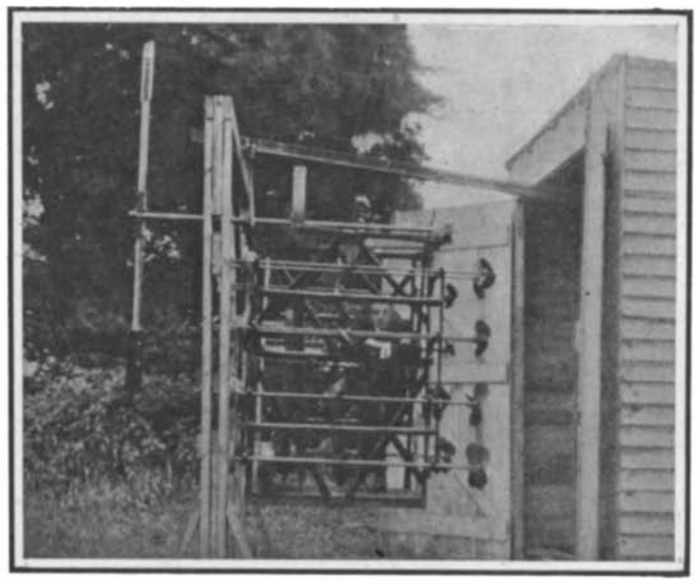
THE MULTIPLE AIR PROPELLER. ITS AERONAUTIC POSSIBILITIES FOR DIRIGIBLE AIRSHIPS, AEROPLANES, AND HELICOPTERS.

An air propeller is merely a plane surface moving through the air in a spiral path. According to a well-known law, the resistance offered by the air to such a surface increases as the square of the velocity. If a propeller of one square foot area, traveling at a speed of 20 miles per hour, meets with two pounds resistance, when driven at 40 miles per hour the resistance will be eight pounds. This law holds good for all practical speeds, although the recent experiments of M. Eiffel, the builder of the Eiffel Tower, tend to show that at extremely high speeds there is a slight variation. In the case of an air propeller, the resistance or pressure of the air against its blades constitutes the thrust of the propeller, and this thrust increases with the square of the velocity. But in order to double the speed of the propeller, eight times the horse-power is required, since the horse-power needed to drive such a propeller increases as the cube of the propeller's speed. The accompanying curve shows this. Up to a certain point, such as *A*, the thrust is fairly efficient, but beyond this point the gain in thrust obtained per unit of horse-power is out of all proportion to the energy expended.



The small propellers which collectively take the place of the single 9-foot large propeller are mounted on ¾-inch shafts, three on a shaft, with eight shafts on each side of the framework of the car. All eight shafts are driven by round leather belting and pulleys from the central countershaft. The aggregate area of the small propellers is 19 square feet. That of the single big propeller is 2 square feet.

Three-quarter View of the Hammond Multiple Air Propeller.



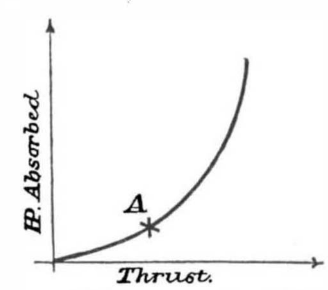
The framework of the car is 7 feet high and 5 feet square. It carries at its front end a large two-bladed propeller having an effective blade area of 2 square feet and driven by a belt at a speed of 60 miles an hour at the radius of gyration of the blades. The total weight of the propeller, its shaft, and pulley is 180 pounds. The total weight of the multiple propeller system taking its place is only 150 pounds.

Side View of Hammond's Multiple Air Propeller.

In order to overcome this difficulty, two inventors on opposite sides of the Atlantic have independently conceived substantially the same idea of using, instead of a single large propeller, a number of small propellers of relatively low speed and consequently developing the maximum thrust per unit of horse-power. One of these inventors, Mr. E. V. Hammond, of London, England, has constructed such a multiple propeller and has conducted a series of valuable experiments. The other inventor, Mr. Wilbur R. Kimball, has constructed a helicopter, the lifting propeller of which is constructed on the multiple principle. Mr. Hammond's experiments seem to show that by increasing the number of propellers, the thrust can be increased directly as the horse-power. Consequently, a large thrust can be obtained with much less horse-power than would be required were one or two large propellers used.

A single propeller of very large area running at a very slow speed would give the same results as the system of small multiple propellers; but such a propeller would be so heavy and cumbersome as to be practically out of the question when a large horse-power is to be used. Moreover, every part of the single propeller's effective area is revolving at a speed different from that of every other part, thus considerably diminishing its efficiency. On the other hand, with small multiple propellers of light construction, the pressure is practically the same over the entire blade area, and besides this there is a great saving in weight.

In order to show how much increase of thrust is obtained per unit of horse-power by the multiple propeller arrangement, the following concrete examples may be given: A two-bladed propeller having an effective area of one square foot, and the blades of which are set at an angle of 45 deg., if run at a speed of 20 miles an hour at its radius of gyration will exert 2 pounds thrust with an absorption of 0.105 horse-power. Because of its low speed and small thrust, this propeller can be made very light. It can, for instance, be constructed of goldbeater's skin stretched on a light aluminium frame. A single large propeller, designed to exert the same thrust as a given number of such small, lightly constructed propellers,



The Thrust of a Propeller Does Not Increase Commensurately with Increased Horse-Power.

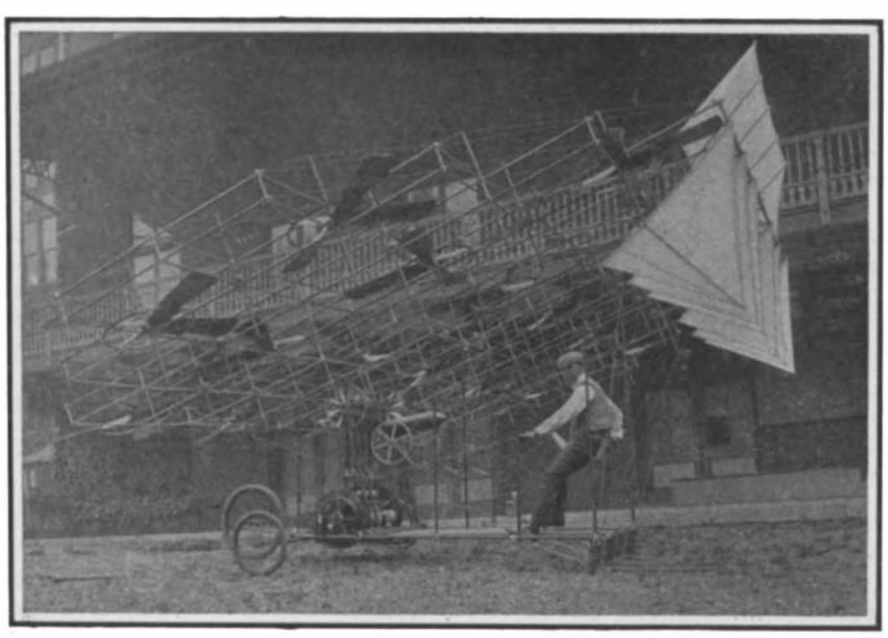
would necessarily be made of metal, because it could not otherwise withstand disruption by centrifugal force.

Let us suppose that we desire to obtain a thrust of 12½ pounds. In order to obtain this, it would be necessary to run the large propeller at a speed of 50 miles per hour at its radius of gyration. The horse-power required to drive it at this speed will be 1.64. If, in place of the large propeller, six small propellers be used, running at 20 miles per hour speed at their radii of gyration, the same thrust will be obtained with an absorption of only 0.63 horse-power ($0.105 \times 6 = 0.63$). If the metal propeller is made stronger and its speed is increased to 75 miles an hour, a thrust of 28 pounds is obtained with an absorption of 5.5 horse-power, while fourteen of the small propellers revolving at 20-mile speed will give the same thrust with a total absorption of 1.47 horse-power. These figures give the power absorbed by the propeller blades in both instances. On account of their small weight, the additional horse-power required by the multiple propellers for their extra bearings is so small that it may be neglected in the comparison.

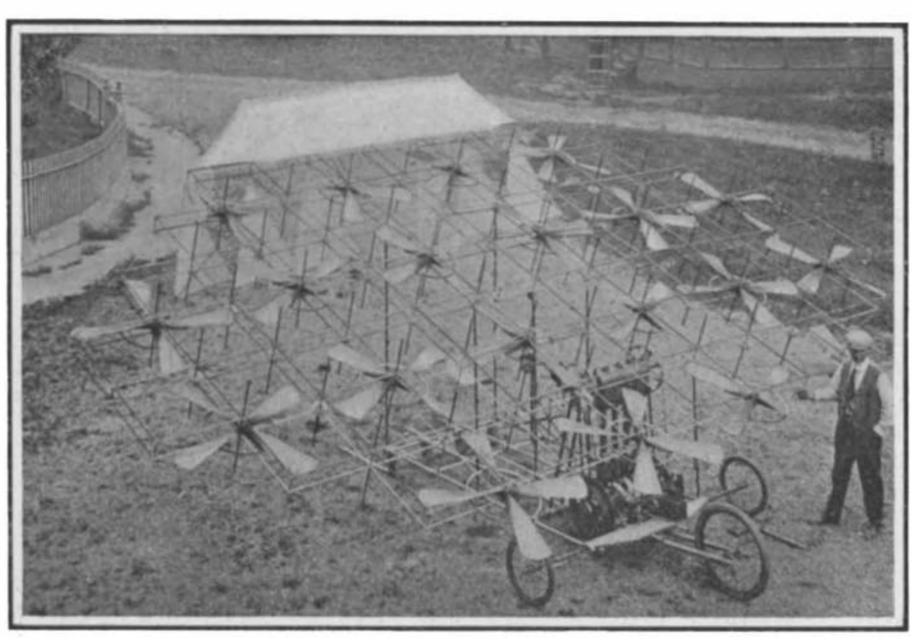
Mr. Kimball has not approached the subject in the same way as Mr. Hammond, but has empirically worked on the theory that better results can be obtained from a large number of small propellers, arranged in the same plane and revolving at a fairly high speed. As can be seen from the accompanying photographs showing his theory embodied in a helicopter, his propellers are arranged in a light framework 26 feet wide and 17 feet long from the front to the rear. There are twenty four-bladed wooden propellers, 4 feet in diameter and having a 2-foot pitch. This low pitch makes it possible to drive them frictionally at over 1,000 R. P. M. by means of a small ⅛-inch wire rope in contact with half of a 19-inch grooved pulley on each propeller. The frame which carries the propellers is set at an angle of 20 deg. with the horizontal. This angle is sufficient to give fairly rapid forward motion to the helicopter as soon as it rises off the ground. Theoretically, with an angle of 15 deg., a forward thrust equal to 25 per cent of the lifting power is obtainable, while the reduction of lift over what would be possible with the propellers placed horizontally is only 3 per cent. It is possible for the aviator to vary the inclination of the propellers with the horizontal by shifting his position slightly, or by moving the horizontal rudder placed along the rear edge at the highest part of the machine. At first Mr. Kimball expects to have this rudder stationary, as shown in the photographs, and he believes that it will maintain the fore-and-aft equilibrium automatically to a considerable degree. There are also a number of vertical rudders at the rear for the purpose of steering.

The helicopter is driven by a new type of four-cylinder, two-cycle motor, which is said to develop 50 brake-horse-power at 2,000 R. P. M.

The total weight of the helicopter, without the aviator, is about 500 pounds, so that, including the weight of a man (150 pounds), it is required to lift only 13 pounds to the horse-power in order to ascend.



The machine is carried on bicycle wheels at its forward end and on skids at the rear end. On a control board in front of the aviator are a number of levers by means of which he can cut out any or all cylinders.



All the moving parts run in ball bearings. The friction is so slight that the pressure of a finger on the starting crank of the engine turns all the propellers.

THE KIMBALL HELICOPTER IN WHICH THE LIFTING SCREWS CONSIST OF A NUMBER OF SMALL PROPELLERS.