

there was practically no vibration, even at the stern, and absolutely none forward and amidships—a fact which called forth enthusiastic comment from the seagoing officers who were aboard during the trial.

The advantages claimed for the American type of turbine, as clearly brought out in these trials, are that because they admit of a slower speed of rotation, and the use of larger propellers, it becomes possible to develop the power in two turbines working on two shafts; that it is possible with these two turbines to operate economically both at high speed and at low cruising speed; that a larger percentage of the total power can be developed when going astern; and, finally, that because of the simplicity and compactness of the plant, only from sixty to seventy per cent as much engine space is required as is necessary to secure the same results with Parsons turbines.

The engine room of the "Chester" contains six turbines, operating on four shafts. When going ahead, steam is admitted to two high-pressure turbines, exhausts from them into two low-pressure turbines, and then passes to the two condensers. It has been found impossible to run a Parsons equipment of this kind economically at the slow speed of from 10 to 12 knots, at which most of the cruising of naval vessels is done, and in order to reduce the coal consumption to a reasonable figure, it has been found necessary to provide a pair of cruising turbines, which, in the "Chester," are mounted forward of the low-pressure turbines and upon the same shafts. When cruising, steam is led from the boiler to the cruising turbines; from them to the high-pressure, from the high-pressure to the low-pressure turbines, and from them to the condensers. With this arrangement the "Chester" showed a better economy at cruising speed than the "Birmingham"; but the arrangement is subject to the disadvantage that two extra units have to be employed, which ordinarily are idle; and, as we have before mentioned, proportionately larger engine-room space is required. The Curtis turbines, as installed on the "Salem," however, have the advantage that the steam, always at high pressure, is fed through a series of nozzles placed around the circumference of the casing, and that the power is reduced by simply closing down the proper number of nozzles. The advantages of the Curtis system are clearly stated in the following extract from an article entitled "Experience with Marine Turbines" in the 1908 issue of Brassey's "Naval Annual": "At full load, and for turbines of large size, the Parsons system has undoubted advantages, but when it is desired to reduce the ship's speed, there is nothing corresponding to the adoption of earlier cut-off in the piston engine. The only alternative is to reduce the pressure of the steam by throttling it, and in this way some of the advantage of the expansive property of high-pressure steam—and, therefore, some measure of economy—is forfeited. The Curtis turbine has, perhaps, some advantages in this respect. The change from kinetic energy to work is achieved by the 'impulse' due to jets of steam acting upon blades formed on 'wheels' mounted on the shaft to be rotated. The steam expands in a number of sets of nozzles or pressure 'stages' successively from the high-pressure to the exhaust end of the turbine. Thus, after expanding in the nozzles of the first 'stage,' the steam issues in jets against the first row of buckets on the rotating wheel, a large part of the energy being absorbed. It then flows to a row of stationary vanes, which guide the steam into a second row of moving buckets. These may be followed by a second set of fixed vanes and a third set of moving ones, after which the steam leaves the 'stage,' as it is called, through a second set of nozzles, where further expansion takes place, again generating velocity. From these nozzles it flows once more in sinuous fashion through successive sets of moving and fixed blades, and thence to other 'stages.' The important point to note is that expansion of the steam takes place only in the nozzles, and not in either the fixed or moving blades. Hence the pressure of the steam does not alter between one set of nozzles and the next. At the low-pressure end the nozzles cover the whole periphery of the wheel, but at the high-pressure end they extend only over an arc often not more than one-eighth of the whole circumference. It is thus possible to reduce the power of the turbine by cutting out a proportion of the total number of nozzles, instead of by reducing the pressure of the steam supplied by throttling it at the valve. Thus, whereas in the Parsons system cruising turbines are fitted to attain reasonable economy at low speeds, they are unnecessary with the Curtis system."

Intimately associated with the success of a turbine equipment is the propeller question. From the very first, the propeller has been at loggerheads with the turbine, the former requiring moderate speeds of revolution for the best results, and the latter, particularly the Parsons type, giving its best efficiency at the highest speeds of revolution. This is particularly true of vessels of large displacement; and it has become necessary to effect a compromise, so that in the latest ships, such as the "Lusitania" and "Mauretania," the propellers

are smaller and are run faster, and the turbines are larger and are run slower, than is desirable for the best economy. No such difficulty is experienced with the reciprocating engine, where large-diameter propellers and slow speeds of revolution may be adopted without reducing the efficiency of the engines. The Curtis turbine occupies a middle position between the high-speed Parsons and the low-speed reciprocating engine; and, because of the moderate speed of revolution and the fact that the power can be developed upon two instead of four shafts, it has become possible to secure a high propeller efficiency. The efficiency of the propellers of the "Lusitania" was given by Mr. Bell, the designer, in a recent paper read in London, as only 48 per cent. The propeller efficiency of the "Salem" rose from 55 per cent at 12 knots to a maximum of 62.8 per cent at the contract speed of 24 knots, then fell, with the increase of slip, to 62.4 per cent at 25 knots and 59.4 per cent at 26 knots. This is a remarkable result for a turbine equipment, and comes pretty near to the efficiency of the propellers of the crack German liners, which have shown as high as 67 and 68 per cent. The present propellers were adopted after a series of trial runs with four different designs of propellers; one by the Navy Department; another by the Denny firm, Scotland; a third by the Vulcan Works, Germany; and the fourth by the Fore River Company. The government design broke down through excessive cavitation early in the trials. The Denny propellers showed 50 per cent efficiency at 24 knots, the Vulcan 54.04 per cent at 24 knots, and the Fore River type, which was designed by the Chief Engineer, Mr. Charles T. Edwards, showed 62.7 per cent at 24.5 knots. We present two illustrations of these propellers, which are 9 feet 6 inches diameter with a pitch of 8 feet 8 inches, that will possess strong interest in connection with these comparative figures.

The standardization trials held to determine the number of revolutions of the propellers corresponding to various speeds, from 12 knots to the highest speeds of the vessels, took place off Rockland in from 40 to 60 fathoms of water. The start and end of the mile are marked by pairs of posts set up on shore, and the time is taken from the bridge from the moment that the first pair come in line to the instant that the finish line is crossed. Meanwhile, the revolutions of the engines are accurately recorded by a mechanical counter. The effect of the tide, whose velocity is measured by a government vessel stationed at the center of the course, is eliminated by making the alternate runs with and against the tide. The "Salem" made five runs over the course, the fastest, with a favorable tide of 0.8 of a knot, showing a speed of 26.88 knots an hour, and the mean of all five runs working out at 25.957 knots. The mean displacement during the runs was 3,745 tons. On the fastest run of 26.88 knots, the propellers made 382.4 revolutions per minute. The steam pressure at the steam chest on the turbines was 253 pounds. The peripheral speed of the blades, at the above speed, was 1,200 feet per minute, and the horsepower was 20,200, or over 25 per cent more than was required by contract. It was estimated that the ship would make 24 knots with sixteen nozzles open on the turbines; but she actually made 25.4 knots under these conditions, and 26.88 knots with the full number, twenty, open. The coal used on these trials was a screened Pocahontas.

In the starting and stopping trials the engines went from full speed ahead to full speed astern in 1 minute and 30 seconds, and from full speed astern (at which they develop 70 per cent of the full speed ahead power) to full speed ahead in 1 minute and 4 seconds.

EXPERIMENTS WITH A HELICOPTER.

BY OTTO G. LUTTIES.

The purpose of the experiments here described has been to collect data for the construction of rotary flying machines.

For practical purposes, it was thought desirable to make preliminary tests on a full-size model, particularly as the best proportions appear to vary greatly with the diameter. The experimental machine is mounted on springs of known tension, the lift in pounds being ascertained by measuring the increase in the height of the springs.

The rotating surfaces are made of light canvas stretched between steel tubing. They are 35 feet in diameter, and have a total area of about 850 square feet. In the test here recorded they were set at an angle of 12 degrees with the horizontal for the upper blades and 13 degrees for the lower, and allowed to assume a slightly concave form.

The revolving blades are attached to concentric hollow steel shafts rotated in opposite directions by two bevel gears driven by one pinion. The bevel gears are held in an inverted yoke bolted to a piece of light channel iron, which forms the main longitudinal portion of the frame. To this there is bolted a somewhat shorter cross piece. From the ends of both the main frame and the cross piece, rods made of light steel tubing extend upward, meeting in a collar which forms a support for the vertical shafts. This support as well as the upper thrust bearing of each of the two

main shafts is fitted with ball bearings. The friction is so moderate that the machine can be turned slowly by hand.

The entire apparatus, which weighs a trifle over 1,000 pounds, is arranged to rest upon carriage springs, of which four were used at first and later three. The springs are connected at the bottom by a frame of light angle iron. The deflection of the four springs shown in the photograph was 220 pounds to the inch.

The main pinion is driven by the eight-cylinder air-cooled motor through spur gears, a single reduction having been used at first, and later increased by the addition of a small countershaft. The gear ratio last used was one to fifty. During the test here referred to the propellers made 31 revolutions per minute, and the motor 1,550. A brake test made after this experiment showed that the motor gave 20 brake horsepower at this speed, the motor being slightly out of order. The vertical lift was approximately 700 pounds, or 35 pounds to the horse-power.

The experiments were greatly hampered by the wind, which wrecked the machine on several occasions, causing continual delay and expensive repairs. The construction was commenced in the spring of 1907. There was a long wait for the motor, which unfortunately broke down during the first trial in October, and had to be returned to the factory for repairs. Experiments were resumed on its return, the photographs being taken on December 19 and 28, 1907, the maximum lift obtained at that time being 550 pounds. The lifting test of 700 pounds here referred to was made during the first week of April, 1908. Another windstorm again stopped the experiments, which have been discontinued for the present for lack of available funds.

Making use of the information obtained from these experiments, the writer has designed a machine weighing about 700 pounds, and which should be capable of lifting about 1,100 pounds, or 400 in excess of its own weight, with 40 brake horse-power. The construction of this practical machine will be commenced whenever all the conditions permit.

In the meantime the following suggestions are submitted for the consideration and use of experimenters interested in the helicopter type of flying machine. They are based partly upon theory and partly upon these experiments.

The author recommends the use of: 1. Very large areas. 2. Slow rotation. 3. Moderate, uniform angles. 4. Four-bladed propellers. 5. Concentric shafts. 6. Progression by inclination.

1. The obtainable lift per horse-power increases slightly with the area, approximately with its cube root. The author strongly urges the use of very large areas for helicopters as a means of securing high efficiency combined with reasonable safety in case of accident to the motor. From one-quarter to one pound per square foot appears to be advantageous, although these large areas are comparatively difficult to construct and handle.

2. The lift per horse-power varies inversely as the speed if the angle be fixed. This is simply because horse-power is foot pounds, and the less the linear speed per minute with any given horse-power, the larger the obtainable thrust and lift. Skin friction and head resistance of bracing and wiring are also relatively least at the lowest speeds. A linear velocity of about forty miles an hour for the center of pressure of the blades should be about sufficient for present use.

3. The smallest possible angle of incidence is theoretically most favorable. In practice it appears that about 5 degrees is the minimum, because for smaller angles skin friction and head resistance of the bracing become relatively excessive. Large blades made of silk or canvas require still larger angles, such as about 10 degrees, because it is practically impossible to stretch the fabric sufficiently to prevent flapping and to obtain a proper curvature if the angle is small.

The reason for suggesting approximately uniform angle rather than uniform pitch, as in a helix, is that high thrust is desired rather than high efficiency as a vertical propeller. Although uniform pitch is correct for a screw progressing rapidly along its axis, it is not desirable for a slowly-rising thrusting screw, as it gives surfaces that are too steep for a good thrust near the center of the shaft. The maximum thrust per given area is reached when the angle approaches 40 degrees, and the maximum thrust per horse-power in a large helicopter is reached with 5 or 10 degrees, with possibly a trifle more near the center.

4. Four-bladed propellers were found preferable to two-bladed for purely structural reasons. It is very difficult to brace large two-bladed propellers properly, whereas the four-bladed kind can be conveniently braced by diagonal wires between the blades. It is believed that the loss in lift per horse-power is more than balanced by increased strength.

5. Concentric shafts permit of strong and simple design even for large diameters, and are therefore recommended. The lift of superposed rotating surfaces seems to be somewhat less than for the same surfaces on separate shafts, but the actual interfer-

ence of air currents does not appear to be prohibitive, even large blades passing in the air without excessive shock.

6. Progression by inclination of the shafts, or even of the whole machine, is recommended on account of its simplicity. It is interesting to note the unexpectedly high horizontal velocity obtainable by a slight inclination of the shafts if the writer's new theory is substantiated. It is also interesting to observe that the sum of the vertical thrust and horizontal thrust obtainable with a given horse-power is larger when exerted diagonally upward along one axis than if divided between one upward and one forward propeller. This is due to the fact that in the triangle of the resolution of forces, two sides are longer than the hypotenuse, provided that, in this case, little or no vertical motion takes place along the vertical side. Although a given horse-power cannot be divided into components totaling more than itself, a given thrust may be so divided, provided the motion is limited and determined.

Judging from these experiments and from theory, the author believes the following lifts per horse-power to be obtainable in actual practice, using small angles and large areas, such as one square foot for each pound and not more horse-power than is required in each instance:

	Pounds.
Narrow two-bladed fans, separate shafts.....	40 to 60
Wide four-bladed fans, separate shafts.....	30 to 40
Narrow two-bladed fans, concentric shafts...	30 to 50
Wide four-bladed fans, concentric shafts.....	25 to 35

It should be remembered that the last type is recommended for its structural advantage in spite of its lesser lift per horse-power.

In later practice, if reliable high-weight motors are obtainable, it will undoubtedly be found preferable to use somewhat smaller areas, as large areas are so difficult to construct and handle. It will be convenient to remember that one-quarter of the area with double the speed will give the same lift with the same angle, but that a trifle over twice the horse-power is required.

The advantages of the helicopter over the aeroplane, as the author sees them, are presented in the current SUPPLEMENT.

Success of Our Wanted-to-Buy Column.

Each day our mail brings us numerous inquiries for articles of all kinds, from the smallest novelty to the complicated machinery used in manifold industries. Where the article is advertised in the SCIENTIFIC AMERICAN, it is of course easy to find the same by a reference to our handy Manufacturers' Index, which has just been issued for free distribution, but there are many cases, however, where we are unable to give the address wanted. We then enter the correspondent's name and address in a book and give his inquiry a number. The inquiry is then published in the Classified Advertising Column, being interspersed with the classified advertisements. Manufacturers see these inquiries, and write us for the name and address of the correspondent, which is given. Thus buyer and seller are brought into business relations, we merely acting as a clearing house for our readers. There is no expense connected with this service, but it should be thoroughly understood that the free inquiries are only for buyers; the advertising columns are always open for sellers. Our readers are requested to avail themselves of this opportunity. Since we have started this column the number of inquiries has swelled in volume to over one hundred weekly so we feel that it is of real service to our readers.

Peary Ready for His Polar Expedition.

Commander Robert E. Peary has announced that the "Roosevelt" will probably be on her way north by the time this number of the SCIENTIFIC AMERICAN is printed.

Every obstacle to the expedition has at last been overcome. The "Roosevelt" is bound for Sydney, Cape Breton, the first stage of the expedition. She will be gone two years. All of the \$50,000 needed fully to equip the ship for such a voyage has not been raised, but only about \$5,000 is lacking now. The largest gift received was \$15,000, but many small gifts have been received, down to \$10, with letters that made them as acceptable and as much appreciated as if the sum had been thousands.

Commander Peary himself will go to Sydney by rail, joining the "Roosevelt" there. The vessel will be coaled at Sydney, though the real stocking of the ship's larder for two years and more has been done here.

The ship's supplies include 160 cases, or 16,000 pounds, of flour; 1,000 pounds of coffee, 800 pounds of tea, 10,000 pounds of sugar, 400 cases of kerosene oil, about 2,500 gallons; 7,000 pounds of bacon, 400 cases of biscuit, or 10,000 pounds; 100 cases of condensed milk, 50 cases of roast beef hash, 30,000 pounds of pemmican, 3,000 pounds of dried fish, and 1,000 pounds of smoking tobacco. Game and other meats will be obtained in the Arctic regions.

GOVERNMENT TESTS OF MINE EXPLOSIVES.

Plans for a government experimental station, to be devoted to the testing of explosives used in coal mining, have been perfected by the Technologic Branch of the United States Geological Survey. The station is to be erected at a point in one of the large coal districts, the exact site not having yet been selected.

This line of investigation is one of several recently entered upon by the government in pursuance of its determination to reduce the waste of the fuel resources of the United States. The use of improper explosives in coal mining, as well as the improper use of suitable explosives, results annually in the waste or destruction of great amounts of coal. The use of too high charges in blasting or the use of unnecessarily violent explosives shatters much good fuel, converting some even into dust, which is itself explosive, and may thus be productive of further damage. Such explosions often loosen the roof of a coal mine, which may fall later, to be thus wasted, or productive of fatal accidents.

In addition to conducting experiments on explosives in a testing laboratory, the Geological Survey will carry on actual experiments in mines, with a view of determining methods of reducing waste of fuels in mining operations. Several of the best explosives, as determined by experiments at the testing station, will be purchased in open market and used in different mines in blasting different types of coal, and the lump and slack coal produced will be carefully screened, weighed, and compared. The classification of these explosives will be made with reference to cost per ton of fuel produced, and various methods of using explosives in mines will be investigated with special reference to increasing safety and efficiency in coal-mining operations.

These explosive investigations will also be conducted with a view to reducing the enormous loss of life in the mines of this country, as compared with the low death rate from mine accidents in those European countries in which testing stations have been maintained for several years. The number of men killed and injured in the coal mines of the United States in 1906, according to Mr. E. W. Parker, chief statistician of the Survey, reached the total of 6,861, the number killed being 2,061 and the number injured 4,800. In 1900 the number killed was 1,493; 1901, 1,594; 1902, 1,825; 1903, 1,794; 1904, 1,959; 1905, 2,097.

The total number of fatal accidents in the coal mines of the United States since 1890 is 22,842, the number practically doubling since 1895.

It has been thought that the very great increase in the production of coal which has taken place in the last decade is responsible for the increase in the number of fatal accidents, but this is not borne out by the figures. In 1895 for every 1,000 men employed in the mines, 2.67 met violent deaths; in 1900, the number killed per 1,000 men employed was 3.24; and in 1906, 3.40 for every 1,000 men.

While the mine-death rate in the United States has been increasing at an alarming pace, all European coal-producing countries show a decided decrease, due, it is believed, to the establishment of government testing stations for the study of the use of explosives and other factors relating to safety in mining. Belgium in 1860, before it commenced its experimental work, had a death rate in its coal mines of 3.28 per 1,000 men employed. In 1904, several years after the testing station had been in operation, the rate had been reduced to 1.07 per 1,000 men employed, which is about one-third of the number killed in the mines of the United States to-day.

In the last period of five years the number of men killed for each 1,000 men employed in Great Britain was 1.53; in Germany, 2.49; in the United States, 3.64.

Belgium, which has the lowest rate, maintains the most thoroughly equipped testing station in the world. In all European coal-producing countries the use of excessive charges of explosives is prohibited by law, and definite limits are set as to the amount of any explosives which may be used. The United States has no such precaution.

An analysis of the figures for the United States shows that 50 per cent of all the fatal accidents and 39 per cent of all non-fatal accidents are the result of falls of roof and coal. In the European countries the number of accidents from this cause is much less, which leads to the conclusion that in the United States the very great disturbing and jarring effect which the discharge of large amounts of explosives in a mine exerts is one of the most important factors which bring about the fall of roof and coal. In 1906 gas and dust explosions cost 228 lives in this country; powder, 80; falls of roof and coal, 1,008; and other causes, 732. It is believed that although the actual fall of the rock or coal may not occur at the time of firing the charge, the heavy shots weaken the walls and roof, so that months after, without warning, it falls.

The Experiment Station.—The station which is to be erected in the expectation of reducing the number of mine explosions in this country will consist of an explosives gallery, rescue room, observation house, lamp-

testing rooms, and explosives laboratory. The explosives gallery is to be made of boiler plate, and will be in the form of a cylinder, 100 feet long and 6 feet in diameter. A series of safety valves on hinges will be arranged along the top to allow the escape of gas following an explosion. Port holes along the sides, covered with half-inch plate glass, will allow those in the observation house to see whether an explosion has taken place in the gallery during the tests. The cylinder will be filled with natural gas or coal dust and air, and the explosives will be hurled into the gallery by means of a cannon fired by electricity from the observation house, sixty feet away. The cannon will be imbedded in a mass of masonry at one end of the explosives gallery, being backed by a rubber disk on heavy timber which absorbs the recoil. Ten cubic meters of an explosive gas mixture is to be used with each shot, the portion of the gallery next to the cannon forming the explosive chamber by placing a paper diaphragm five meters from one end.

Natural gas is to be used in all the tests because it corresponds most closely to fire damp. It will be purified before using, special care being taken to remove the carbon dioxide, if any is present. The necessary amount of natural gas for each experiment will be measured by a gas meter, and led into the gallery by a two-inch iron pipe for a distance of ten feet along the bottom of the gallery. The pipe is perforated with holes in a manner to insure from the start a more equal distribution of the gas. A fan on the outside of the gallery connected by six-inch iron pipes to the explosive chamber insures the thorough mixing of the gas and air. When the tests are to be made, the fan will be cut out of the circuit by closing the valves situated between the fan and gallery.

The experiments in the gallery will be carried out at a temperature of 25 to 30 deg. Cent., to be regulated by the radiation from steam pipes.

An eight per cent mixture of methane is considered the most dangerous mixture with air. The necessary amount of methane displaces a like amount of air in the explosive chamber, and by experiments and calculation the exact cubic meters of gas to admit in the explosive chamber to produce an eight per cent mixture can be determined.

Before each shot is fired, a sample of the explosive gas mixture is taken from the explosive chamber and tested in the laboratory. It is diluted with a known quantity of air and then ignited. This experiment determines whether the mixture is properly made before the shot is fired.

The cannon in which the explosives are to be fired is made of cast steel with a tool-steel liner. The bore is 46 centimeters in length and its caliber 5.5 centimeters. The axis is at an angle, so that its prolongation intersects the top of the gallery 25 feet from the farther end.

The Testing of Lamps.—The apparatus for testing lamps will consist of a small gallery, through which the natural gas or fire damp will be drawn by an electric fan. Different velocities can be obtained, and the safety lamps can be subjected to an ascending, descending, or horizontal current of an inflammable atmosphere. At the farther end of the gallery the intimate mixture of the air and fire damp is produced by a mixing box, which consists of thirty-six tubes, each of them perforated in the circumference with narrow apertures disposed in spirals. The air passes inside these tubes, and the fire damp penetrates through the 432 small apertures, and the eddies which are produced mix the air and fire damp thoroughly.

Apparatus which is capable of sustaining life will be used, and miners will be instructed to enter a miniature mine which has previously been filled with fire damp, and search as they would for their fellow men. The apparatus consists of canvas jackets equipped with cylinders of compressed oxygen, connected with the operator's mouth by a flexible, rubber-lined metallic tube. The exhalation of the operator is passed through small lumps of potassium hydroxide, the carbon dioxide being absorbed and the remaining products together with more oxygen are again available for the operator.

All explosives, if used in large quantities, will ignite fire damp or coal dust. Tests will be made in the explosives gallery with various explosives, and the maximum quantity of each explosive that can be used safely in mines will be published under the head of "Permissible Explosives." Explosives known as "Safety Powders," in which the temperature at the point of detonation is low and the flame of short duration, will have a higher "limit charge" than the less safe explosives.

Methods of Testing Explosives.—Tests of explosives will also be made to determine their relative strength, for the efficiency of the explosive must also be considered as well as its safety. No. 1 dynamite, which contains 75 per cent nitro-glycerine and 25 per cent Kieselguhr, is taken as the standard. No two contrivances for measuring the disruptive force produced by explosives produce concordant results. Explosives which detonate at the same rate of velocity permit of

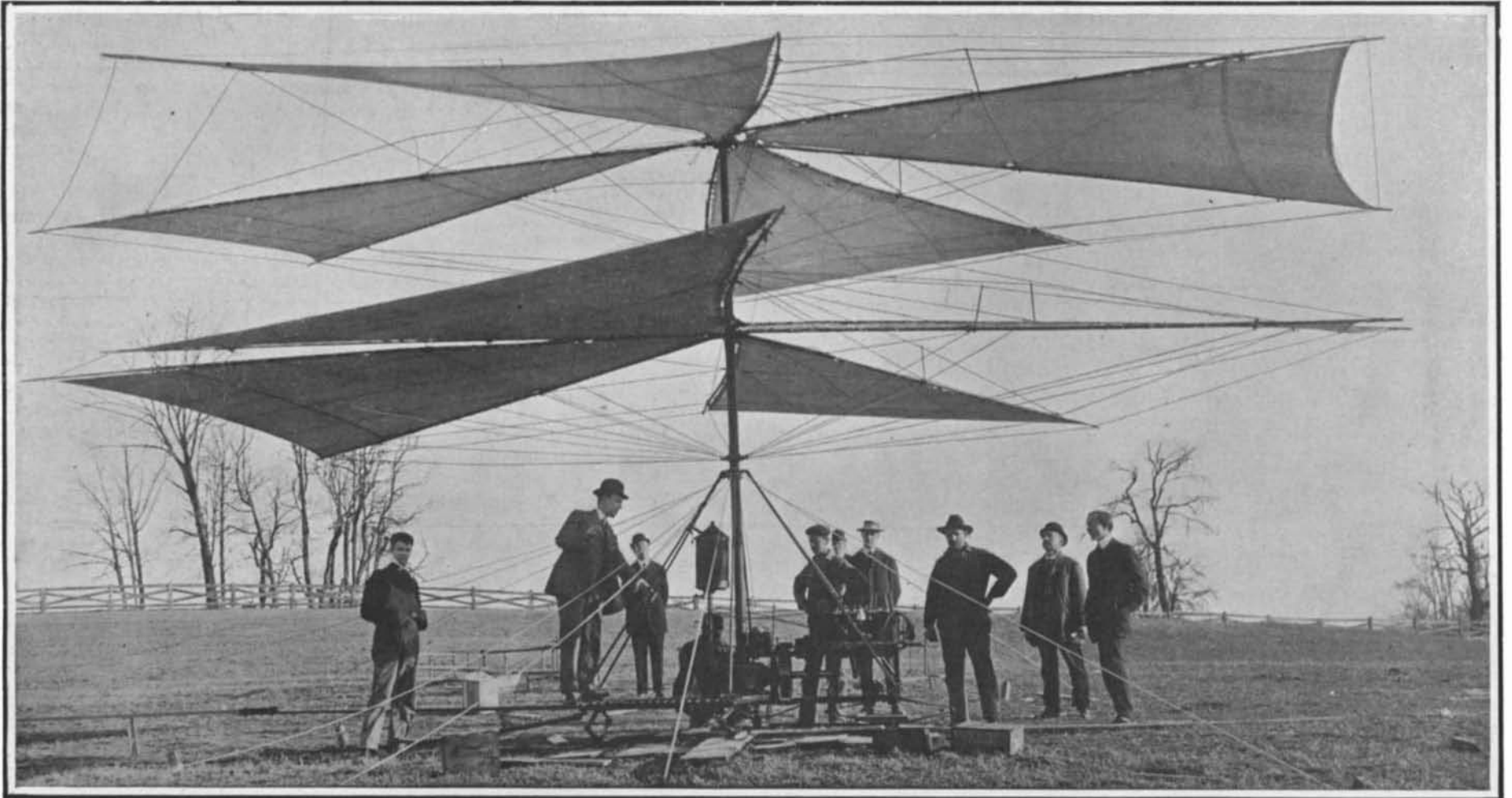
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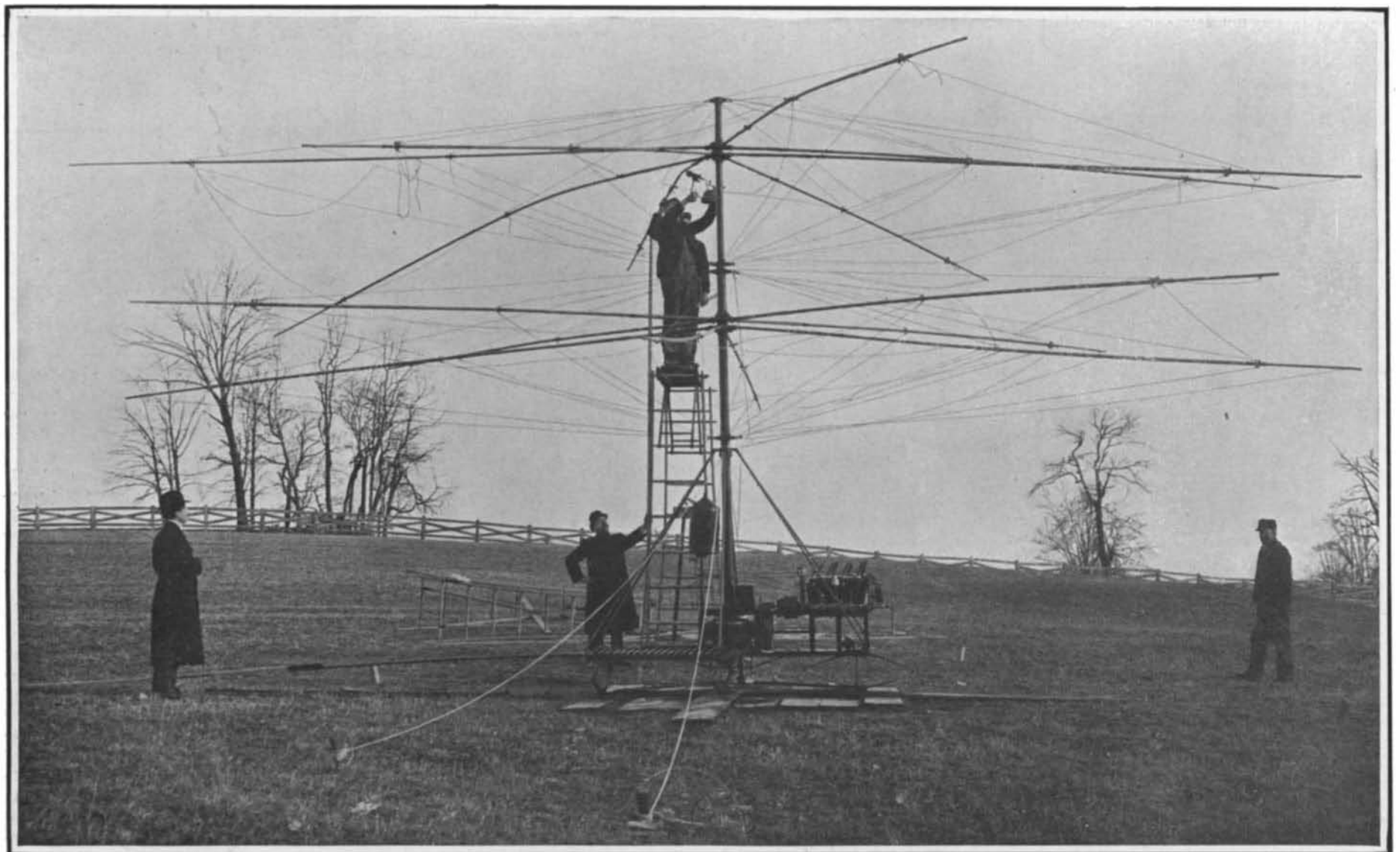
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THE LUYTJES HELICOPTER. PROBABLY THE LARGEST EXPERIMENTAL ROTARY FLYING MACHINE EVER TESTED.—[See page 26.]