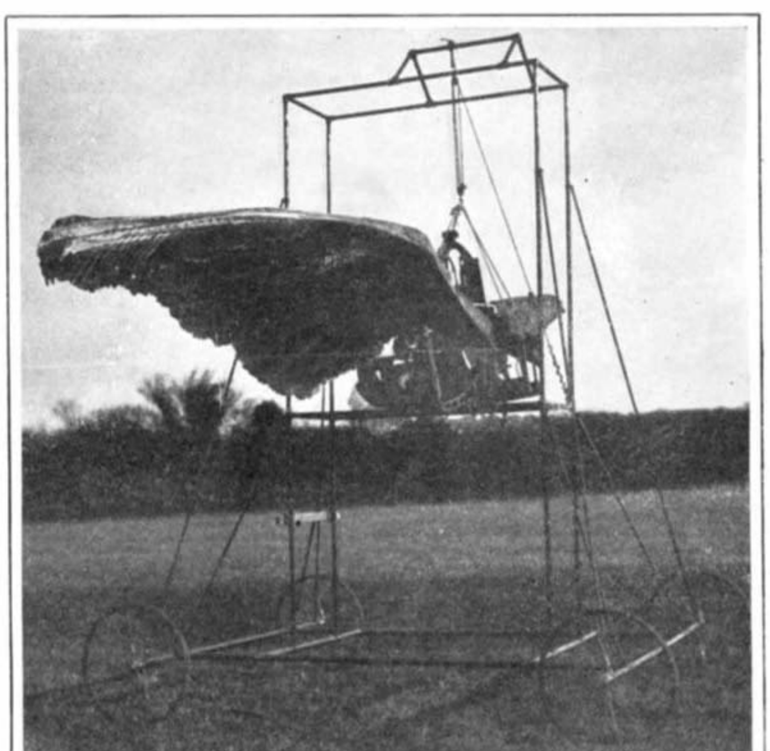
ly, and consequently to obtain an infinite and insensible gradation of the sounds. Very great difficulties, however, are met with in the way of satisfying another requirement of great importance in apparatus of precision—and that is the regular and uniform modification of the pitch of the sound. When the piston ascends, the sound does not rise in a regular manner, but with an ever-increasing velocity, because the pitch is not inversely proportional to the height of the column of air in vibration, but to the square root of such height. An inconvenience therefore presented itself. Upon turning the crank in order to raise or lower the piston, each revolution had a different effect upon the variation of the sound. This difficulty has been surmounted in the following manner: The piston rod is displaced by means of a roller upon the edge of a disk revolving vertically. When the roller rests upon the point at which the radius of the spiral is smallest, the bottom of the cylinder will be situated in its lowermost position. If, on the contrary, it rests at the point at which the radius is maximum, the bottom of the cylinder will be in its uppermost position. The spiral is so planned that at the minimum radius it is very narrow, and that in measure as the radius increases it becomes more open. In this way, in proportion as the crank is turned, the elevation (per revolution) of the piston becomes less. It is in this way that the irregularity mentioned above has been overcome. Upon the same axis with the spiral, and turned toward the experimenter, there is a graduated circle that carries the indication of the number of vibrations and of the musical tone, and that revolves at the same time as the spiral and passes before a stationary index. On this, it is possible at every instant to read the number of vibrations obtained. This axis is connected, through a 1:10 transmission, with another to which the crank is fitted. To the crank is adapted a second graduated circle, which permits of inserting fractions between the vibrations indicated on the principal dial.

As may be seen in Fig. 2, several of these apparatus are fixed upon the same table. Their scales of sounds encroach upon one another because it is sometimes necessary to obtain the same sound from two instruments at once.

A front and a rear view of the apparatus are given in Fig. 1. In addition to this type, the maker is constructing one that is less precise, and is adapted for less accurate researches and for school demonstrations. In this the spiral is done away with, and the piston is actuated directly by a rack and pinion. Owing to a special arrangement, it has been possible, despite the unequal variation of the sounds, to indicate exactly the number of vibrations of each sound upon the scale.

Apparatus for Demonstrating the Lifting and Propulsive Effect of a Bird's Wings.



The Experimental Apparatus with Wing-Planes.

THE BIRD AS A MODEL FOR THE AEROPLANE.

THE BIRD AS A MODEL FOR THE AEROPLANE.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Since the fatal results that attended the experiments of Lilienthal and Pilcher in the solution of the problem of aerial flight, further investigations in this direction have been somewhat neglected in favor of aeroplane and balloon researches. During the past few months, however, an impetus has once more been imparted to the problem of flying by three British investigators, Messrs. E. P. Frost, Dr. F. W. H. Hutchinson, and C. R. D'Esterre. The result of their efforts and the data they have gathered from their investigations were recently communicated to the Cambridge University Society, and have aroused considerable interest.

These experimentalists have taken the wings of a bird as the basis of their efforts. As is well known, a bird's wing consists essentially of two portions: (1) That part to the outer side of the wrist joint, the main feathers of which are about ten in number and are known as the primary feathers; and (2) that part to the inner side of the wrist joint, which may be described as the body of the wing, and the main feathers of which vary according to the length of the wing.

The salient characteristic of a bird's wing as a whole is the comparatively rigid and heavy anterior edge and the light, yielding, elastic posterior margin. If the primary feathers be examined carefully, it will be observed that each one differs from its fellows and that they differ in a graduated series. The quill is curved in, and the feathered portion or penna is set around this in a helicoidal curve. Here again the portion anterior to the quill is stiff as compared with the portion behind it. Another feature of a bird's wing is that a fore-and-aft vertical section through the body of the wing discloses a curve somewhat of the following shape:

Front  *Rear*

This curve is somewhat more pronounced about midway between the wrist and the shoulder joint, viz., in the region of the elbow. When the wing is in its extended position for flight, this joint is distinctly behind the front edge of the wing.

For the past quarter of a century Mr. E. P. Frost, who is a well-known member of the council of the British Aeronautical Society, has made a close study of the structure of a bird's wing, its functions, and operations. As a result of these examinations, he concluded more than twenty years ago that for ordinary flight the wing is merely beaten up and down. It is therefore obvious that owing to the yielding elastic posterior edge of a bird's wing, on the wing being beaten downward both a lift and a drive forward are obtained. Furthermore, it is apparent that when the wing is elevated, a forward and downward resistance is imparted. But owing to the shape of the wing, the down stroke must perforcedly encounter greater air resistance than the up stroke, apart from considerations of the amount of energy invoked to the up and to the down stroke. Also the arrangement of the wing feathers causes a valvular suction. Air passes through the body and the wing on the up stroke.

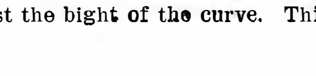
Mr. Frost contends that the result of the arrangement of the primaries must be that on being struck downward in the air, their ends travel forward and upward. In flight the wing tips of a bird, for instance a rook, can be seen to be curved upward. If a shed primary feather be taken and held in its natural orientation and struck smartly down in the air, the tip can be observed to spring smartly forward. Then the posterior edge of the penna becomes tense. But when the feather is not so stressed, the posterior edge is sinuous and has a fullness. Other—normal—movements have been described, notably the so-called "figure of eight" curve generated by movements of the wing tips; but Mr. Frost concludes that the movements of the wing tips (particularly the "figure of eight" curve) in what may be considered normal steady flight, are the automatic results of the peculiar construction of the wing, and of its being beaten up and down against the air.

If, during the down stroke, the primary feathers are strained forward and upward within their elastic limits, it is obvious that energy is stored in them, and its restoration may in part occur even in the up stroke.

Major B. Baden Powell, who is also intimately interested in the problem of flight, recently obtained the interesting results shown herewith. The curve shown was obtained in the following manner: A number of small birds were procured, and tubes of paper were prepared, the internal diameters of which were approximately the distance between the tips of the outstretched wings of these birds. The internal surfaces of the tubes were covered with a coating of lampblack. A tube was then arranged with one end in a room and the opposite end pointing out into the open air through a window. A bird was then liberated within the inner end of the tube. As it flew toward the light at the outer open end, a record of the movements of its wing tips was obtained. Several observations were made, a fresh tube being requisitioned each time. The curve thus obtained is clearly shown in the diagram. The dotted portion was only faintly visible on the record. Major Baden Powell considers this to represent the up stroke, and that it shows the wings to be slightly flexed on the up stroke.

Record of Wing Motion of Birds During Flight. The Bird Flew from Left to Right.

According to Dr. Hutchinson, however, the difference in distinctness between the two portions is due to the wrist being in a slightly flexed condition on the up stroke, in what may be considered the normal position, and that on the down stroke the stressing of the primaries automatically increased the distance between the wing tips, and opened the wrist automatically against its elastic reaction. The wing *as a whole* is essentially an elastic structure. The absence of recurvation at the lower portions of the record, taken in conjunction with the form of the down stroke record, would seem to prove that owing to its being in the tube the bird was not flapping at full vigor, or quite normally, and that the stored energy of the primaries was given out during the latter part of the down stroke. During flapping flight the primary feathers automatically exert a clawing, swimming action.

Referring to the curve mentioned in the earlier part of the article, Mr. Hargrave, of New South Wales, has demonstrated that when air is blown against such a curved surface, thus:  a lift is obtained against the bight of the curve. This is doubtless due to the formation of eddies of air flowing over the rigid lip.

It is obvious that a bird's wing, both as a gliding and a propelling surface, is a beautifully efficient instrument. To test these conclusions, Mr. Frost and Dr. Hutchinson in co-operation with Mr. D'Esterre in 1902 arranged the apparatus which is illustrated herewith. The experimenters used a pair of natural dried wings with an area of approximately three square feet, in conjunction with a small electric motor and a reduction gear to flap them up and down. The apparatus was suspended by a spring balance from a balanced arm. The following are the best results that were obtained by this crude experiment:

Volts.	Amps.	Estimated loss in motor and gear transmission.	Estimated horse power on wings.	Number of flaps per minute.	Maximum lift.
24	12	75 per cent	$\frac{1}{10}$	350 to 400	5 lbs.

The effect was striking. The bird flapped itself round and round, although it fell between the down strokes. But against this must be set the fact that its rate of progression was only four or five miles an hour, no doubt due to air resistance and friction, which were considerable, for the apparatus was primitive, while the bird also weighed about 21 pounds, which would of course tend to pull down on the up strokes, and the primary feathers were stiff. The oscillations, however, diminished to a very marked extent when the tail was fitted.

It will be observed that the ratio of horse-power to weight was one horse-power to 50 pounds. This ratio coincides with that given by various authorities as that obtaining with birds, and is not in marked contrast with the ratio obtained with the large machine of Messrs. Wright in this country.

Owing to the highly successful results obtained with this primitive apparatus, the investigators resolved upon a larger model with which to continue their researches, and this is shown in another photographic illustration. For the purposes of future experiments, this car is to be run on a special trough section track, and it is intended to arrange in the frame four vertical guides, one at each corner, of stretched cord or wire. The machine is suspended from a spring balance. The model, although possessing certain crudities in the motive portion, will serve adequately for the purposes of the tests it is intended to carry out. It is only intended to act as a testing model, from which some reliable conclusive data may be obtained.

The wings are of special construction, designed in accordance with the principles described in this article. They have a total wing area of about 60 square feet, while the machine measures approximately 20 feet across from tip to tip.

The motive power is transmitted from a gasoline motor of from 3 to 3½ horse-power, through a coned friction clutch and chains in two stages to the connecting rod. The crank throw is adjustable for altering the size of angle or flap. The top sprocket of the second motion can be raised or lowered for altering the limiting positions of the wings (i. e., the position of the arc). The lower end of the connecting rod actuates the inner ends of the levers for wagging the wings by a simple device of two oscillating roller-carrying links attached to the crosshead, whose pin is constrained by vertical guides. Attached to the brackets below the wings are "pectoral cords" of elastic. These serve to store up the energy on the up stroke, and so obviate too violent alterations of load in the driving mechanism.

The wings are at present adjusted to flap one hundred times per minute. This is of course considerably less than proportionately corresponding to the increased area and horse-power. But increased area does not necessarily imply proportionally increased resistance.

Some satisfactory results have already been obtained by means of this apparatus. When suspended from the bough of a tree and set in action under power, at each down stroke the whole machine, apart from the carriage weighing 232 pounds, was lifted bodily up into the air, and at the same time propelled forward. It rises about two feet with each stroke. At the down stroke the suspending rope left the vertical, and became markedly inclined. The pull on the rope then hauled the machine back, so that even if it were capable of flight, it could not fly under these conditions. At the down stroke it appeared that if the rope were then severed, the machine would travel up and away with the powerful sweep of the wings.

The spring balance here is obviously fallacious so far as registering the lift is concerned, because the rope exerts a restraining or backward pull on the machine. However, at the rough test already carried out, the balance showed a diminution of reading of from 80 to 160 pounds at the down stroke when the machine springs upward and also forward.

At the preliminary trial with this apparatus, the wings described a diminished angle as compared with that obtained with the first and smaller model. But with this angle and a velocity of one hundred flaps per minute the wings were capable of evoking a resistance of about 100 pounds each, and the machine was raised about two feet at each stroke. The conditions, however, at this test were not favorable to the machine, as it was near the ground in eddying air, and was not free to get proper forward velocity.

The investigators are of opinion that a feathered wing made of a number of units can exert a greater resistance than a single wing such as that of the insect or bat type, or the various mechanical wings that have hitherto been adopted in wing flapping machines. They are also inclined to the contention that resistance is more dependent on periphery of an aeroplane than on its superficial extent. Furthermore, the primary feathers almost certainly act as a series of stepped aeroplanes, each acting on air from a different level, which has not had a downward velocity imparted to it by having had to sustain the weight of a previously acting supporting surface.

Considerable interest is being evinced in the experiments with this machine in aeronautical circles in England. It is anticipated that some highly interesting data concerning aerial flight will be gathered from the tests that will be carried out by these investigators with this apparatus.

Peat in the United States.

The peat industry can hardly be said to exist in the United States at the present time. A few small operations are now going on, however, and a great number of prospective schemes are being exploited, so that a paper by Mr. Henry H. Hindshaw entitled "Peat in the United States in 1904," which the United States Geological Survey brings out as an extract from the forthcoming volume "Mineral Resources of the United States, 1904," should find numerous readers.

A number of companies have been organized in the Middle and Northwestern States to produce peat fuel by various methods. Some of these are building plants to operate during the summer of 1905. Others do not seem to have advanced beyond the prospectus stage. Many of them promise extraordinary profits by the use of patented processes, often involving the use at some stage of electric devices.

Besides various plants in Canada and Mexico, Mr. Hindshaw makes particular mention of certain plants now in operation in the United States. The Pompton Fuel Developing Company is producing machine peat near Lincoln Park, N. J., and sells all its product to local consumers. Its success on a small scale will probably result in building a much larger plant this year. The machinery in use was imported from Germany and includes a Dolberg breaker and mixer. This company controls a large acreage of peat land in the vicinity of Pompton Plains, N. J. Another plant is in operation near New Rochelle, N. Y., by the Peat Koal Company, of New York, which uses a Schlickeysen machine. At Orlando, Fla., machine peat is manufactured on a machine designed by Mr. T. H. Leavitt, of Boston. A company has been organized in California to manufacture briquettes composed of peat and oil. Some tons of fuel have been made and tested, both for domestic and steam-raising purposes.

The many uses of peat are reviewed by Mr. Hindshaw. Persons interested in the subject on which he writes should procure a copy of his report from the Director of the United States Geological Survey. It will be mailed free of charge, on request.

Foundry Transportation Cables.

The Aumetz-Friede Company at Reutlingen has introduced, according to Stahl und Eisen, important improvements in the transportation of ore from the Aumetz mine to the Friede foundry. The capacity of the system (Pohlig) is five and a half millions of kilometric tons per year, or seventeen hundred tons per day of twenty working hours. There is a principal line from the mine to the factory, with two branches for the blast furnaces and the deposit of ore. The line is 10,750 meters in length and operated by electro-motors installed at the Friede factory. The motor of the principal line works directly a length of 22 kilometers of traction cable. The incline not being great and the line being quite direct, the expenditure of energy is low. The cost of transportation is only 25 pfennigs per ton as against 1.20 marks per ton by the ordinary railway.

The production of quicksilver in 1904 is estimated at 3,391 tons, not including the output of Mexico and Russia, of which no statistics have been received as yet. In 1903 these countries yielded 190 and 362 tons respectively. The production in 1904 of the United States, Spain, Austria, and Italy was 1,480 tons, 1,020 tons, 536 tons, and 355 tons respectively. Counting the output of Mexico and Russia, the world's production for 1904 will probably amount to 4,000 tons.—Richard Guenther, Consul-General, Frankfort, Germany, April 3, 1905.

Correspondence.

Do Animals Reason?

To the Editor of the Scientific American:

Under the above heading the Scientific American of June 3 told of a cat that had learned to open a door by climbing to the old-fashioned thumb catch, and pulling it down with its paw. I can confirm that story. My father had a cat that would open a similar door by jumping up, and while falling pull down the thumb catch with its paw. Afterward the door was changed to open by a turning knob, and, though he could not then turn the knob from the outside, he soon learned that his efforts to do so attracted attention, and he was let in; so he called for admittance in that way instead of mewing. But as a table was so near the door that he could mount the table and reach the knob on the inside, he would paw the knob to try to open the door from the inside, and occasionally succeeded. No one taught him to do these things.

Such cats must have observed how people opened doors, and to my mind they certainly possessed reasoning powers. C. W. Bennett.

Coldwater, Mich., June 5, 1905.

A Tornado's Freaks Explained.

To the Editor of the Scientific American:

I note with some interest and amusement the communication of your correspondent in your issue of May 27 relating to the experience of those caught in the Oklahoma tornado who had their shoes and hair removed by its action. Your correspondent hints at "phenomena which cannot be explained by our accepted physical laws." So far as relates to the shoes, this is in entire accordance with the general action of tornadoes in causing the explosion of receptacles containing inclosed bodies of air, which are suddenly brought into the immediate path of the tornado; and I do not doubt that such an explanation would serve equally well in the case of the hair, more especially if it may be taken for granted that, like the shoes, it was more ornamental than natural.

As relates to the other incidents mentioned by your correspondent, I would suggest the propriety of having these incidents properly authenticated before discussing the reasons for them. While the things which occur are undoubtedly wonderful, they are really nothing to the power of human imagination that is invariably displayed on like occasions. (See Hume "On Miracles.") George W. Colles.

Milwaukee, Wis., May 31, 1905.

Where Did the Photographer Stand?

To the Editor of the Scientific American:

The article in your issue of June 10, 1905, entitled "Where Was the Camera Set Up?" by Prof. William F. Rigge, has been of special interest to me.

I wish to thank the professor for his novel solution of a somewhat difficult problem; and at the same time I take the liberty of calling his attention to the fact that his last statement appears to be somewhat erroneous.

Were the picture plane parallel with the front of the observatory, the mortar lines in the front of the transit room would have retained their normal position in the photograph, but as near as I can tell from the reduced cut, accompanying the article, they vanish at a point on the horizon 347 feet to the right of O. This is the vanishing point of east-and-west lines, or *V R*. If a transit is set up at this point and trained on the optical center of the camera, the line will be found to be due east and west, or at right angles with the line from the camera to point O. Then train the transit on O, and the angle will be found to be very nearly 10 deg. 45 sec. and the course will be N. 89 deg. 15 sec. W., showing that the plate in the camera formed an angle of about 10 deg. 45 sec. with the front of the observatory, instead of about 8 deg., as stated, and the entire front of the building would measure 9/416 inch instead of 4¼ inches, as it does in the cut, showing that the lines are reduced a little more than 10 per cent. The angle of the picture plane with the front of the building also accounts for the apparent shortening of the wall space at the left of the door to the equatorial room, which, were they parallel, would show a trifle larger than that between the door and angle at the right. B. F. Crawford.

Pittston, Pa., June 13, 1905.

The British government has decided to secure and protect the ancient ramparts erected by Edward I. around the town of Berwick-on-Tweed for the nation. These ruins are of great antiquarian and historical value, since they form one of the most interesting monuments of the bitter strife that existed for centuries between England and Scotland, as they are situated right on the border. The walls include the old bell tower, from which a flaring beacon gave warning to the English farmers of the approach of the bands of marauding Scots. The ruins are to be inclosed and placed under the charge of a curator and guide.