Can a Man Fly With Wings?

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A superficial observation of the bird brings out the following facts: The wing is attached by its front edge forward and above the center of gravity of the body of the bird; and the center of gravity of the body and the center of figure of the two wings are situated in nearly the same vertical plane. This relation is fundamental.

The pectoral muscles that lower the wing are attached to the front edge of the wing near the body, and the elevator muscles are found underneath the large pectoral muscles. They send a tendon up around the hinged joint between the wing and shoulder. This tendon attaches to the upper front edge of the wing, nearer the joint than does the lower muscle. The remarkable fact to be noticed is that the elevator muscles are very small and weak compared with the depressor muscles. The muscles that elevate and depress the wing therefore oppose one another. This makes a lever of the third class of the wing, whereby power is converted into speed, forming a lever similar to the arm, at the elbow.

In Fig. 1, let A be the body of the bird, B the large pectoral muscle, D the hinge joint, and E the elevator muscle. In this lever, for striking the air D is the fulcrum, E and B the power, while C is the long arm to receive a long and swift sweep. Consequently, a short and powerful contraction of the muscle B resulting in a small movement at O throws the end of the wing C, through a long distance quickly. Since the reaction of the air upon the wing C is proportional to the square of the speed with which it is driven, we can see at once the advantage of this arrangement. Here is a factor that makes the length of the wing much more effective than its width. In fact the wing must be narrow and long in order to develop the greatest reaction, and it is not a mere matter of the relation between square surface and weight with which we have to deal. The less the surface and the shorter the wing, the greater the speed with which it must be driven in order to develop the same reaction. The wider the wing and the shorter it is, the square surface remaining the same, the faster it must be driven in order to develop the same lift. The longer the wing, the slower it can be driven in order to develop the same lift. In fact, its speed will vary inversely as the square of its length and

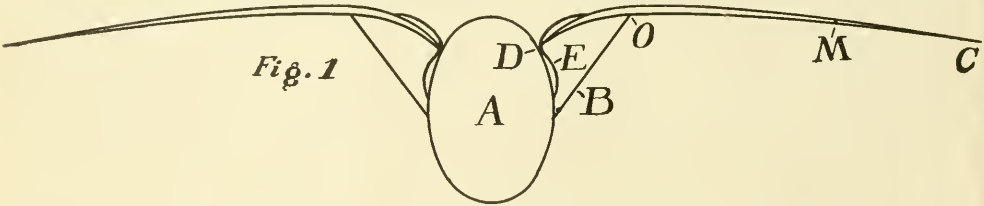

Fig. 1

inversely as its width. It is readily seen that it is the outer end of the wing that really does the work. In fact, the inner part of the wing can be entirely cut away, and it will remain just about as effective. Either in soaring or in flapping flight, it is the end of the wing that is the most effective.

The next feature to be noted is this: In order to obtain support a 10-lb. turkey must develop 5 lbs. reaction under each wing.

We shall suppose that this 5 lbs. reaction to exist at the center of pressure which we shall suppose to be two-thirds of the way out towards the tip, at least. Since the pressure increases with the square of the distance from the center of motion, this is very nearly true. The turkey that I mentioned before has a wing spread of 5 ft., with an area of 3 sq. ft., and an average width of 7½ in. This would locate the center of pressure about 20 in. out from the shoulder. The pectoral muscle that depresses the wing is attached about 1½ in. from the shoulder. Here an important point presents itself. In a lever, the power times the power distance equals the weight times the weight distance. In Fig. 1, if we regard the power applied at O as represented by X, D being the fulcrum, the power distance is OD. The reaction, which is equivalent to the weight, is at M and hence MD is the weight distance. OD is 1½ in., MD is 20 in. and the reaction at M is 5 lbs., hence (X) (1½) equals (20) (5). Solving X, equals 66⅔ lbs.

If the above analysis be correct, then the turkey must pull with a force of 66⅔ lbs. on each wing in order to fly, if it is continuously to support its weight. That is to say the turkey must maintain a pull of 133⅓ lbs., while flying or soaring, provided it is continually supporting its weight.

This means the expenditure of .24 h. p. in order to rise 1 ft. in 1 sec. or .12 of a h. p. to rise 6 in. per sec.

This is preposterous. A man's rate of work is about .1 h. p. If a man climbs a mountain, rising at the rate of a foot per second he has to be a hustler. This requires .27 h. p. In fact to go upstairs at that rate will take the breath out of an ordinary man. If he climbs at the rate of 6 in. per sec. he will be doing pretty well. This is .13 h. p. A 10-lb. turkey is not very fond of flying. A turkey buzzard, however, weighing 4 lbs. and having a wing expanse of 3 ft. and an average width of 8 in. flies and soars with ease. Each wing is 1½ ft. long. This gives an area of 1 sq. ft. per wing, or 2 sq. ft.

In this wing then we have: (X) (1) equals (2) (12); the pectoral muscle attaches 1 in. from the shoulder; and ⅔ of 18 in. is 12 in.; a 2-lb. reaction is necessary at M. Consequently X equals 24. Hence the buzzard must pull 24 lbs. on each wing or 48 lbs. in all. This gives the turkey buzzard about .1 h. p. to rise 1 ft. per sec., whether soaring or flying.

An ordinary man weighs 37½ times as much as the turkey buzzard, and if the buzzard is expending energy at the same rate that a man expends energy, then it has to burn as much fuel as a man in a stove 1/37 as large. This does not look good to a reasonable mind, and there must be some mistake in it.

If, on the other hand, the fulcrum is not at D, Fig. 1, after the resistance of 2 lbs. is developed at M, but at M instead, then we have an entirely different proposition. In a lever the fulcrum is at the point of support when the weight is lifted. When the bird is lifted by the reaction of the air, it is resting on the center of pressure of the wing. Hence the fulcrum ought to be found at that point. If this supposition be true, then the weight arm and the power arm are very nearly equal. MD is the weight arm and MO is the power arm. Then (20) (5) equals (18.5) (X) whence X equals very nearly 5.4, in the case of the turkey. In the case of the buzzard X equals 2.18 lbs.

This shows that a bird in flying has to lift practically its own weight only. This looks more reasonable. This represents .02 h. p. for the turkey and .008 h. p. for the buzzard in rising 1 ft. per sec.

There are losses to be taken into account here, of course, that would increase this.

But the question is, is the fulcrum really out at the center of pressure on the wing? Experiment only can determine it, although to suppose otherwise does violence to the judgment.

In a recent experiment results were obtained, which point clearly to the conclusion that the fulcrum is really out at the center of pressure.

EXPERIMENTS WITH MACHINE.

Last summer I constructed a machine built on the principles of bird flight as I see it. The machine weighs about 100 lbs. My weight is 140 lbs., making 240 lbs. The wings are manually operated by levers, which attach to the front edge of the wings through links, giving a leverage of four to one. The links attach 3 in. from the shoulder of the machine. The point of attachment is thus located forward and above the center of gravity of the body and machine. The machine is mounted on three bicycle wheels. I had hoped to cause it to run along the ground when the wings were made to oscillate, and after getting up a speed of 8 or 10 miles per hour on the ground, I hoped to be able to develop enough lift to take it off the ground. But nothing of the kind happened. I could beat the wings some 52 half beats per min., and develop enough reaction to take the wind out of me in about 10 sec. The wings had 30 sq. ft. each of surface and were some 10 ft. long by 4 ft. wide at the widest part. It took only a one pound and a half pull to move the machine along the ground with myself in it.

We suspended the machine by a block and pulley attached to a spring balance, and with myself in it, it weighed 240 lbs. By beating the wings down the machine rose 2 in. and gave a 120-lb. lift on the scale. On the up stroke the machine rose slightly and developed forward motion.

Now if the fulcrum is at the shoulder we have the following: OD, Fig. 1, is 3 in., DM is 80 in., hence (3) (X) equals (120) (80) or X equals 3,200 lbs. That is it would take a pull of 3,200 lbs. at O to develop a reaction of 120 lbs. at M on both wings in order to lift the machine. It would take one-half of 3,200 lbs. or 1,600 lbs. to develop 60 lbs. at M in order to lift half of the weight.

As a matter of fact I was lifting half of the machine by making a 200-lb. pull at O. If the fulcrum were at D, I should have been able to have developed only a 9-lb. lift instead of 200 lbs. lift.

By an 18-in. motion between the hands and feet, the tip of the wings can be swung through 10 ft. The above results seem to indicate that the fulcrum is out on the wing, and if that is the case, there is no reason why flight with wings should be impossible.

There are other factors though that might favor or prove unfavorable to the above conclusion. If the wing is wasteful of power, or if the power is applied in a very disadvantageous manner, it might still be impossible.

[To be continued]