strength of the plane, or, in other words, its hull resistance, and to this again is added the probable friction of the air against the sides. These three items together give the total resistance to forward motion, and are also tabulated for ready reference.

Then, by combining these two tables and plotting the resulting curves, in order to ascertain at what angle there is a minimum of resistance to forward motion, while yet retaining a sufficiency of sustaining power, it is found that this occurs for one and the same angle at all velocities, this being 1° 50′ 45,″ and this M. Drzwieki assumes as the angle of flight.

I may here mention that these two reactions, or components of the normal pressure due to the angle of incidence and to the speed, formed the subject of the paper read by myself at the Paris Congress, and of a similar paper which I presented before the American Association for the Advancement of Science at its last meeting, and that I had reached the conclusion that the most favorable angle for soaring was between 1° and 2°.

Assuming 1° 50′ 45″ as the angle of flight, and allowing for the vertical and horizontal components of the normal pressure due to the speed at that angle, as well as for the hull resistance and friction, M. Drzwieki then gives four formulæ, supplemented by tables, which produce the following elements :

1. The weights per square meter, which can be sustained at this angle of 1° 50′ 45″ at various speeds.

2. The work done (kilogrammeters) to overcome the forward resistances under the same circumstances as above.

3. The proportion of the work done to the weight sustained.

4. The amount of surface required to sustain 1 kilogramme at various velocities.

The consequences which M. Drzwieki deduces from these formulæ and the plotting of their curves are the following :

1. An aeroplane progressing horizontally, with the angle of incidence (1° 50′ 45″) corresponding with the minimum of work, meets practically the same resistance at all speeds, so that the work done is approximately a function of the weight of the apparatus, multiplied by the velocity.

2. Aeroplanes designed for small speeds need relatively large surfaces and small weight ; these conditions he believes to be difficult of realization in practice.

3. The greater the speed, the less surface needed to support a given weight.

4. The less the surface, and therefore the greater need of speed, the greater must be the motive power.

These conclusions are believed to be approximately sound, and M. Drzwieki sustains them by showing that in flying birds the smaller is the sustaining surface in proportion to their weight, the greater is their customary speed, giving a table of the proportions of some 64 birds, which shows that the surfaces of the body and extended wings range from 7.56 sq. ft. to the pound for the bat, which flies at the rate of about 20 miles per hour, to 0.43 sq. ft. per pound for the male duck, who progresses at about 60 miles per hour. He estimates that for a speed of 90 miles per hour, the surface required will be but 0.22 sq. ft. to sustain a pound of weight.

It seems to follow as a conclusion that if aeroplanes are ever built to carry tons of weight, their proportion of surface to weight may be considerably less than those which obtain with birds, but that the speed will need to be greater than that of flying animals in order to obtain support from the air, while the motive power required will vary approximately only in the direct proportion of the weight carried. This important conclusion seems to hold out hopes that success may eventually be attained if the stability of the apparatus can be secured.

M. Drzwieki also discusses this question of stability. He shows that the transverse equilibrium can easily be maintained by a diedral upward slant of the wings of an aeroplane, arranging them like the sides of the letter V, but at a very obtuse angle, so that any tendency to tilt shall at once develop greater pressure in that direction, and thus restore equilibrium. This was pointed out as early as 1809 by Sir George Cayley, in a remarkable series of papers published in *Nicholson's Journal*, which are well worth reading.

M. Drzwieki states the law of longitudinal equilibrium to consist in placing the center of gravity of the whole apparatus vertically below the center of pressure due to the angle of flight, and he gives the rule, first formulated by Joëssel, for determining this center of pressure. He moreover states that these two centers, of gravity and of pressure, must be but a very short distance apart, in order to prevent oscillations. This solution is substantially, for flat angles of incidence, the same as that of Sir George Cayley, who states that the center of gravity must be at right angles to and below the center of pressure ; but it is to me doubtful whether this is the best solution for assuring the longitudinal stability of a flying apparatus, and this important, almost vital question is likely to prove a stumbling-block in the way of future experimenters.

Assuming it to be solved, M. Drzwieki estimates that an apparatus, built to the best possible proportions as to exposed surface and form, and sailing at an angle of 1° 50′ 45″, will require to drive it at 25 miles per hour but 5.87 H.P. per ton of its weight. This assumes the thickness of apparatus and consequent hull resistance to be but $\frac{1}{100}$ of its horizontal dimensions, while for birds it generally runs from 5 to 10 per cent. That is to say, that birds exposing a horizontal surface of say 100 sq. in. generally expose a maximum cross-section vertically of 5 to 10 sq. in., while M. Drzwieki believes this can be reduced to the proportion of 1 sq. in. per hundred for an aeroplane.

My own estimate of the power required by a common pigeon gliding at an angle of 1° with the horizon was 9.33 H.P. per ton of his weight, and 10.49 H.P. per ton at an angle of 2° for this same velocity of 25 miles per hour.

These are considerably less than the powers required to drive a balloon of moderate size at the same speed, for we have already seen that the air-ship *La France* would require 51 H.P. to attain 25 miles per hour ; or, as it weighs 2.2 tons, the motor would needs develop 23.2 H.P. per ton of the weight of the whole apparatus. For the balloon of double this size, the power required is at the rate of 10.34 H.P. per ton of apparatus. This power required would moreover increase in the case of the balloon, as the cube of the velocity, while M. Drzwieki shows that in the case of an aeroplane the power will increase only in the direct ratio of the speed, because as the velocity becomes greater the area of sustaining surfaces required becomes less, and he estimates that an aeroplane will require 10.43 H.P. per ton to go 44.72 miles per hour, and 20.62 H.P. per ton of its weight at 89.44 miles per hour.

(TO BE CONTINUED.)

ELECTRIC TRANSMISSION OF POWER.

(Condensed from *Le Genie Civil.*)

DURING the year just closed the paper-mill at Moutier, in the Department of l'Isere, has been the scene of an important series of transformations, the object of which was to replace the existing motive power by electric transmission. This was partly favored by circumstances, and has been a complete success. To describe properly the plan, it will be necessary to give some little description of the neighborhood.

The village of Moutier is situated about 500 m. (1,640 ft.) from Domene, and 11 km. (6.84 miles) from Grenoble. The track of the railroad line from Chambery to Valence, which runs the whole length of the Gresivauban Valley, passes close to the factory, not far from the station of Domene.

Below Moutier the river Isere receives the waters of a small stream called the Domenon, which issues from a mountain which overlooks the peak of Bellebonne, at a height of 2,980 m. (9,774.4 ft.) above the sea level. If we follow this stream from its mouth above the village of