Letter from Alexander Graham Bell to Mabel Hubbard Bell, May 14, 1899, with transcript

ALEXANDER GRAHAM BELL TO MABEL (Hubbard) BELL Thoughts Beinn Bhreagh, C. B. Sunday, May 14, 1899. At B.B. Hall. Mrs. A. Graham Bell, 1331 Connecticut Avenue, Washington, D. C. My darling Mabel:

How can I write properly to you without feeling that I am stealing time from my thoughts and experiments. The best thing I think is to tell you what I am thinking about and let Beinn Bhreagh and its news take care of itself.

I am still bewailing the shortness of the time at my disposal here — only about a month so far as I can see — and I know from past experience how little can be accomplished in that time experimentally. Then the inevitable break for a much longer time — and the difficuly of starting again where I left off. I am now trying to pull my thoughts together so as to utilize to the best advantage the little clear time I see ahead. I have been looking over the records of the multitudinous experiments I have made relating to aerodromics — and asking myself the question “Where am I at?”

The invention of the balloon by the Brothers Montgolpier threw the world of inventors off the right track — in their attempts to conquer the air for navigation. It is now very generally recognized that a body specifically lighter than the air in which it moves must over be at the mercy of the wind — just in proportion 2 to its specific lightness. The lighter it is the more effect will the wind have upon it — and vice versa. The greater the specific weight the more independent of the wind will the motion of the body be — the less effect will the wind have upon its motion.

The world has come back to the idea of a flying machine modeled after the bird rather than the balloon — a machine specifically heavier than the air. But still the old balloon idea clings — and the effort is to make everything as light as possible — even to the verge of fragility. The world has not yet realized — the point which is basal in my thoughts — and which I believe to be a great conception certain to bear fruits in the future — if only I can have leisure of mind to think — and quiet uninterrupted time for experiments — vis — that the greater the specific weight the better . What is wanted is velocity — or rather momentum. Directed velocity — (I am writing for myself — and won't attempt to explain — simply trying to classify my ideas by writing them down.) An arrow flies without wings — and would continue to fly if its velocity could be sustained by reaction against the air behind — something to take the place of a propeller to above it along. It would fly in a vacuum if it had the velocity — and the air actually retards it in its flight. It is the heaviest end of the arrow that flies best — not the feathered end. You couldn't make an arrow fly tail first if you tried. Experimentors like 3 Langley and others, have realized that a practical aerodrome must be specifically heavier than the air in which it moves — but they have not yet realized as I do that the greater the specific weight the better.

Nature's model of a flying machine is the bird . Two kinds of flight — (1) That accomplished mainly by the muscular exertion of the bird and (2) Soaring flight in which the bird utilizes an external source of power — the wind — with very little exertion on its own part.

Soaring flight has chiefly been taken as a model by Langley and others — Hence the long array of aeroplanes — and supporting surfaces of various kinds — to similate the extended wings of a soaring bird. But much surfaces (excepting in the case of experiments like those of Lilienthal) are not employed to gain support from the wind — but from an internal source of power — a steam-engine or its equivalent — acting by means of propellers. Thus they seek to obtain the analogue of the first form of flight (muscular) by the mechanism adapted to the second (souring flight). A mechanism adapted to utilize the force of the wind — will be acted upon by the wind with great power — so that — when employed in a self-propelling machine — the wind will affect it powerfully. The aeroplanes — or other extended surfaces adapted to catch the air — will — just in proportion as they are efficient for this purpose — retard self-propulsions and injure independent flight. The ideal aerodrome is that which can be moved in 4 any direction independently of the wind — one that can even fly against the wind if desired. The more independent of the wind it can be made the better. Wind power may be utilized — and doubtless will — but a self-propelling machine that can fly in any direction will be as much superior to a soaring device — as a steamer is to a sail-boat.

If the bird is to be taken as our model — muscular flight should be studied rather than soaring flight. And here it is obvious that large extended surfaces are by no means necessary. Many quite heavy birds have quite small wings. (Wild ducks for example).

In such cases the wings I think act as propellers chiefly — and in a machine similating muscular flight the wings (or extended surfaces — should themselves constitute the propellers.

Great attention has been paid to supporting surfaces and comparatively little to propellers. The true analogue of the bird's wing (in a self-propelling self-sustaining device) is, I think, the propeller and not fixed aeroplanes or curves. Wing propellers to gain headway small fixed surfaces to act as rudders to direct the motion — not to sustain the apparatus. The momentum of the machine itself (if the motion is in the proper direction — properly steered that is) — will cause sustentation.

I have experimentally investigated the sustaining power of aeroplanes driven against the air at different 5 angles and with different velocities — by propellers acting directly against the air — and have found that the propellers alone (without aeroplanes at all if so directed as to shove the machine upwards at an angle yield as much support as quite large aeroplanes at an angle (with the propellers acting horizontally.)

In both cases the element of “lift” increases with velocity — but (apparently) at a greater rate in the former case than in the latter. That is — without aeroplanes or aerocurves — the propellers alone giving the lift by shoving upwards at an angle — the lift increases approximately as the square of the velocity. Double your velocity — and you get (nearly) four times the lift. When aeroplanes are employed and you double your velocity you get (apparently) a less proportionate gain of lift — something like three times the lift. If this is really so — and I see no reason to doubt it — the higher the velocity of propulsion the less are supporting surfaces needed. Another point: — In aeroplanes — the pressure of the air acting upon underside of surface can be resolved in two directions — (vertical and horizontal). The vertical element alone gives the lift — the horizontal element is an obstacle pure and simple — without any advantage. It simply retards around motion — and this retarding force increases with the lift — (Theoretically as the square of the velocity — practically I suppose at some less rate) — but at all events the resistance to onward motion increases at a 6 greater rate than the velocity — so that with high rates of speed — it would require a very much less expenditure of energy on the part of the engine to attain the high rate of speed without the aeroplanes than with them.

Pushing these results further theoretically than I can verify experimentally with the apparatus at hand — I conclude that at the high velocities it is desirable to obtain in a practical machine — the resistance to onward motion due to aeroplanes (or curves) would out-balance their value as supporters — and that the propellers alone (unencumbered by aeroplanes) would yield the same support or lift with less expenditure of energy — because freed from the horizontal component of “drag” — inseparable from large surfaces found at an angle through the air. The smaller the angle of tilt of course, the smaller the element of “drag” — but however small — the drag is there — and it increases in a greater ratio than the velocity — so that at high speeds considerable energy would be wasted in overcoming this undesirable element. In specifically light machines there is no reservoir of power to draw upon (excepting the engine itself) — and a considerable portion of even this power is frittered away in overcoming unnecessary resistance due to tilted planes. If the engine and propellers are employed in giving motion to a specifically heavy machine — we have a reservoir of power in the inertia of the moving mass. 7 It is this power that must be relied upon to combat the wind — and render the machine independent of moderate gales.

This brings me to the focal point of the whole problem — the propeller. What we want is that form of propeller — which, by reaction against the air, can impart great velocity to a heavy mass. My whole thoughts are focussed now upon the propeller.

Not only do we want it to impart great onward velocity to the mass of the machine — but we should also seek to utilize the disturbance of the density of the air caused by its action — as a source of lift.

The propeller acts by shoving against the air — thus compressed it — and rendering it more dense. The reaction moves the machine. It acts by dragging air away from some point (rarifying it) — and shoving it towards another place (compressing it there.) Now the compressed air in expanding, exerts pressure in every direction around it. At one point the machine is pushed by it — thus gaining velocity — at other points it acts only against surrounding air. If, however, there should be a surface above the condensed air — that surface will experience an upward above or “lift.”

If we consider the place where a portion of air is rarified by the action of the propeller in displacing it — the surrounding denser air has a tendency to rush in every 8 direction to restore the pressure. At one point — the machine itself is pushed forward by greater pressure from behind — but air also rushes in from in front, from above, and from below — and from side to side. If a surface should be placed under the rarified portion of air it will be shoved upwards by superior pressure of air from below — thus experiencing a lift. Theory indicates that these local disturbances of atmospheric pressure could by means of suitably disposed surfaces yield very considerable lifts.

For example — consider a surface of only one square inch. If the propeller could displace a layer of air above this inch surface — so that for a moment a slice of the atmosphere resting on this surface should be removed — the atmospheric pressure acting on the under side would exert an upward above equal to 15 pounds unbalanced by downward pressure from above.

Or again suppose that the propeller could cause a condensation of air under the surface so as to double the density of the air there — even for a moment — then at that moment — an upward pressure or “lift” equal to 15 pounds would be experienced. Think of the possibilities of lift due to this cause — 15 pounds to the square inch! — 144 pounds for only one square foot of surface!

And if it could draw air from above surface and condense it below — the possibilities would be doubled without increase of surface.

9

I have already tried a perliminary experiment with two rotating wing pieces — rotating in opposite directions. A surface of wood placed above these rotating surfaces of wood. This looks somewhat like the case of a man trying to lift himself by pulling on his boot-straps! but the case is materially different.

Vanes occasional a considerable lift. Without it balance was unaffected by rotation of vanes. When the surface was placed below instead of above — the whole machine (apparently) became heavier.

Your loving, Alec. P. S. Marie arrived in Baddeck Friday night — and case over here yesterday. AGB.