BULLETINS

OF THE

Aerial Experiment Association

Bulletin No. XXVII Issued MONDAY, JAN. 11, 1909

MR. McCURDY'S COPY.

BEINN BHREAGH, NEAR BADDECK, NOVA SCOTIA

BULLETIN STAFF.

ALEXANDER GRAHAM BELL.....Editor

GARDINER H. BELL.....Assistant Editor

CHARLES R. COX.....Typewriter

MABEL B. MCCURDY.....Stenographer

Bulletins of the Aerial Experiment Association.

BULLETIN NO. XXVII ISSUED MONDAY JAN. 11, 1909.

Beinn Bhreagh, Near Baddeck, Nova Scotia.

TABLE OF CONTENTS.

----------oOo----------

EDITORIAL NOTES AND COMMENTS.

Father Lana's Book of 1670.

More than 100 years before the invention of the Balloon by the Brothers Montgolfier (1783) a remarkable work, foreshadowing the balloon, had been written by a Jesuit Priest named Francis Lana. The work was entitled, "Prodromo dell' Arte Maestra"and was published in Brescia in 1670. The book contained " A demonstration, how it is practically possible to make a ship, which shall be sustained by the air, and may be moved either by sails or oars". The appearance of the work made a profound impression upon the world at the time and is probably responsible for the expression aerial "navigation" which has persisted down to the present day. All works dealing with the history of Aeronautics refer to Father Lana's book, but none, so far as I know, have quoted from the work itself, so that the book is only known by its title and by the picture of Father Lana's machine which has been widely reproduced.

On the 29th of May 1679, and again on the 5th of June 1679, Dr. Robert Hooke read before the Royal Society of England a translation of a portion of Father Lana's book "Prodromo". This translation, with the remarks of Dr. Hooke concerning it was published in a work entitled, "Dr. Hooke's Tracts and Collections 1674-1679", a copy of which may be found in the Boston Public Library.

A few years ago, at my request, Mr. Edwin P. Grosvenor visited the Boston Public Library and made a copy of Hooke's

translation which I give below. A.G.B.

AERIAL LOCOMTION DISCUSSED BY THE ROYAL SOCIETY, GREAT BRITAIN IN THE 17TH CENTURY (1661-1679).

No work relating to the history of Aerial Locomotion so far as I know, makes reference to the fact that the art of flying was discussed by the early members of the Royal Society and that aeroplane experiments were made by them in the 17th Century. It is true they were not called 'aeroplane' experiments but they were really the same thing. For example:- Dr. Wrenn (Sir Christopher Wrenn), the designer of St. Paul's Cathedral, made experiments with several round pasteboards to test their velocity in falling; Dr. Hooke proposed experiments to ascertain the strength requisite to make a wing, or expanded area sustain a determinate bulk in the air, and suggested "that it was not sufficient to have a theory for the descent of an expanded area perpendicularly downward, because the descent of an expanded area, moved edgewise horizontally in the air, was extremely different; in which way, however, all motion of flying must be performed".

I give below quotations from the "History of the Royal Society" by Thomas Birch referring to experiments and discussions having a bearing upon Aerial Locomotion between the years 1661 and 1679, and a few biographical notes concerning Hooke, Petty and Wrenn. A.G.B.

DR. ROBERT HOOKE.
1635-1703

An original ingenious experimental Philosopher born 1635, died 1703. About 1655 he was employed and patronized by the Honorable Robert Boyle who turned his skill to account in the construction of his celebrated air-pump.

Between 1657 and 1659 Hooke's inventive faculty exercised itself in devising thirty different methods of flying according to the Encyclopedia Britannica.

In 1662 he was appointed curator of experiments to the Royal Society and filled the office with extraordinary diligence and skill during the remainder of his life.

During this period he translated into English the 6th Chapter of Lana's work "Prodromo" which appeared among his posthumous philosophical contributions.

Birch's History of the Royal Society contains references between 1661 and 1679 to discussions concerning the art of flying participated in by Hooke, but I have not found any description of his ideas relating to artificial flight produced between 1657 and 1659. It might be well to institute a search through his published writings for some descriptions of his ideas.

He seems to have been an invalid all his life. His limbs were shrunken. His hair hung in dishevelled locks over his haggard countenance. His temper was irritable, his habits penurious and solitary. He was, however, blameless in morals and reverent in religion. His scientific performances were varied and original, and he has left behind him the reputation of being one of the greatest experimental philosophers

SIR WILLIAM PETTY.
1623-1687.

He was born in 1623. About 15 years of age went to Normandy trading with a little stock of merchandise and so maintained himself while studying. On his return to England was in Royal Navy for a time. In 1643 went abroad again and remained for three years in France and the Netherlands. In 1647 Petty obtained patent for the invention of double writing, or in other words of a copying machine. In 1648 occurred his first publication "Advice for the Advancement of some particular parts of Learning". Some year deputy Prof. of Anatomy in Oxford and gave instructions in Anatomy and Chemistry. 1649 Dr. of physic and Fellow of Brasenose College. 1650 succeeded in restoring to life a woman who had been hanged. 1651 Prof. of Anatomy in Oxford and also Prof. of Music at Gresham College. 1652 physician to the Army in Ireland and in 1654 he made a survey of the lands granted to the soldiers in Ireland by which he gained 9000 pounds which he invested profitably. He thus ultimately became the owner of about 50,000 acres of land in Ireland. Set up iron works, opened lead mines and marble quarries; established a pilchard fishery and commenced a trade in timber. In 1663 attracted much attention by the invention of a double-bottomed ship. One of the first members of the Royal Society. Died 1687. Petty was a man of remarkable versatility, ingenuity and resource. Evelyn declared he had "never known such another genius", and said of him, "if I were a Prince I would make him my second councillor at least." A.C.B.

SIR CHRISTOPHER WREN.
1632-1723.

Born 1632. He invented several ingenious instruments when he was about the age of fourteen. In 1646 went to Oxford as gentleman commoner. Early distinguished for proficiency in mathematics and anatomy and was regarded as a protegy in College. Prof. of Astronomy in 1657. One of the first members of the Royal Society. In 1661 was appointed assistant to the Surveyor General and began to turn his attention to architecture. In 1667 he succeeded Denham as Surveyor General and Chief Architect. His master-piece is St. Paul's Cathedral. Generally regarded as the greatest of English Architects. Contributed several treatises on Astronomy and other sciences to the Philosophical Transactions. He was knighted in 1673, and was elected President of the Royal Society in 1681. None of the biographical notices I have examined make any reference to his interest in Aerial Locomotion. He is perhaps best known to the world as the Architect of St. Pauls' Cathedral in London. He died in 1723 and was buried in his own Cathedral and a conspicuous tablet there bears the epitaph "Si monumentum requiris, circumspice" - "If a monument is needed look around". A.G.B.

A DEMONSTRATION, HOW IT IS PRACTICALLY POSSIBLE TO MAKE A SHIP, WHICH SHALL BE SUSTAINED BY THE AIR, AND MAY BE MOVED EITHER BY SAILS OR OARS.

(A translation of the 6th Chapter of Father Lana's book, "Prodromo dell' Arte Maestra," Brescia, 1670, by Dr. Robert Hooke, read before the Royal Society of England May 29, 1679, and published in Dr. Hook's Tracts and Collections 1674-1679).

The Curiosity and Ardor of Humane Wit hath not been so bounded by preceding Inventions, as not to be yet further inquisitive after some other waies how men themselves may, like birds, Fly in the Air. Nor is it, perhaps, a meer Fable which is recorded of Daedalus and Icarus, since 'tis reported for a truth, that even in our times, a certain Person whose name I know not, did by some such artifice of Flying, pass over the Perusine Lake; though afterwards, his descending to light upon the Earth, being too quick, he fell down, with the loss of his life. But no one yet thought it possible to make a ship which should pass through the Air, as if it were sustained by the Water, because they have judged it impossible to make an Engine which should be lighter than the Air, which is, nevertheless, necessary to be done in order to produce this effect.

But I, whose Genius and desire hath alwaies prompted me to endeavour, to my utmost, to find out difficult Inventions, do hope, at length, I have light upon a way of making such an Engine as shall not only by its being lighter than the Air, raise itself in the Air, but together, with itself, Buoy up and carry into the Air Men, or any other weight. Nor do I believe I deceive myself, since I confirm the thing both

by certain Experiments, and by Demonstration, drawn from the Eleventh Book of Euclid, hitherto thought infallible of all Mathematicians.

I will therefore premise some Suppositions, and from those afterwards, deduce a practicable way of making this Ship, which, though it may not deserve, like Jasons Argo, a place among the Stars, yet that way shall it of its own nature tend.

I suppose then First, That the Air hath weight, because of the vapours and exhalations, which are raised from and incompass our Terraqueous Globe to the height of many miles. And this will not be denied me by such Philosophers, as are but any way versed in Experiments. And the proof of it may be made by evacuating, if not all, yet a great part of the Air, out of a Glass-vessel, which having been first weighed, and after the extracting of the Air weighed again, will be found notably lessen'd in weight. How how much the weight of the Air is, I have found in this manner: I took a large Glass-vessel, the neck of which could be shut and opened by a Stop-cork; and being open I heated it at the fire, so that the Air in it being rarified, issued out of it in great part: Then I suddenly shut it, so that the Air could not re-enter, and weighed it: which done, I sunk the neck under water, the body of the Glass remaining all above the water; and opening it, the water ascended into the Glass, and filled the greater part of it. Then I opened it again, and let out the water, which I weighed, and measured the Bulk and quantity thereof. Whence

I inferred, that so much Air had issued out of the Glass, as there was water that had entered to fill the part left by the air. I again weighed the Vessel, first well wiped dry, and I found that it weighed an ounce more whilst it was full of Air, than it did when the greater part of it was evacuated. So that that surplus of weight was a quantity of Air, equal in bulk to the water that had entered into the place thereof. Now that water weighed six hundred and forty ounces: whence I conclude, that the weight of the Air, compared with that of the Water, is, as one to six hundred and forty ounces, that is, if the Water, which fills a Vessel, weighs six hundred and forty ounces, the Air filling the same Vessel weighs one ounce.

I suppose, Secondly, That a Cubic foot of Water weighs "80 L." or 960 ounces, according to the Experiment of Villalpandus, which agrees very near with mine; forasmuch as I found that that Water which weighed 640 ounces, was little less than 2/3 of a Cubic foot; whence it follows, that if 2/3 of a foot of Air weighs an ounce, a whole foot will weigh 1-1/2 ounce.

I suppose, Thirdly, That any great Vessel may be altogether evacuated of Air, or at least of the greatest part of the Air: And this I shall show to be feasable many waies, in my Work Del Arte Macstra; the mean time I shall transcribe hither one of the most easie waies.

Let any great Glass-vessel be taken, that is round and hath a neck, and let to the neck be fastened a Brass or Latten Cane, at least 47 modern Roman Palms long; the longer the surer

the effect will be. Let there be near the said Vessel a Stop-cork, so closing the Glass that no Air can enter. Fill the whole Glass, and the whole Cane full of Water; then shutting the Cane in the extream part, let the Vessel be inverted, so as that it stand on its upper part, and let the extreme part of the Cane be immersed in water; and whilst it is immersed in the water, let it be opened, that the Water may issue out of the Vessel; which will all go out of it, the Cane remaining full to the height of 46 Palmes, and 26 Minutes, and the remaining space above will be empty, there being no way for the Air to enter: then shut the neck of the Vessel with the Stop-cock, and the Vessel will be empty. He that disbelieves it, let him weigh it, and he will find, that as many Cubic feet of water as there are issued out, so many ounces and half ounces less will it weigh, than what it weighed first, when it was full of Air: which is sufficient for my purpose.

I suppose, Fourthly, The truth of the Demonstrations of Euclides 11 and 12 Books, which are also evident by Experiment, which proveth, that the Superfice of Balls or Spheres increaseth in a duplicate proportion to their Diameters, and their solidity in a triplicate. Duplicate proportion is, when three numbers are such, that the third contains the second as often as the second contains the first, as 1,3, 9. or 1,4, 16. And triplicate proportion is when 4 such numbers are taken of which the 4th contains the 3rd as often as the 3rd contains the 2nd, and the 3rd contains the 2nd as often as this contains the 1st, as in 1, 3, 9, 27. or in 1, 4, 16, 64. So if you take two Balls, one of which have a Diameter twice as big

as the other, the surface of the Ball of two Palmes (e.g.) shall be four times bigger than the surface of the Ball of one Palm; and the whole solidity of the Ball of two Palmes Diameter, increasing in a triplicate proportion, shall be eight times as great, and consequently eight times heavier than a Ball of one Palme in Diameter: so that the surface of the greater to the surface of the smaller shall be as 4 to 1, and the solidity as 8 to 1.

I suppose, **Fifthly**, That where one body is lighter **in Specie** than another, the lighter ascends in the other that is heavier, if the heavier be a liquid body; as a Ball of ordinary Wood on Water, because it is lighter **in Specie** than water; so also a Ball of Glass full of Air will swim at the top of water, because though Glass be heavier than water, yet taking the whole complex of the Ball, Glass and Air together, it is lighter than that, which is only a body of water.

These things being supposed 'tis certain, that if we could make a Vessel of Glass, or other matter, that might weigh less than the Air that is in it, and should draw out all its Air, after the manner above directed, this Vessel would be lighter **in Specie** than Air itself, so that by the **Fifth** Supposition, it would swim on the top of the Air, and ascend on high. **Ex. gr.** if we could make a Vessel of Glass, holding a foot of water, that is 80 lb. and were so thin and subtile as to weigh less than an ounce and a half: The Air being thence evacuated, which by the **First** and **Second** Supposition

would weigh 1-1/2 ounce, that Vessel would remain lighter than Air it self, and mount on the top of it, supported by its own lightness. It may be, that this Vessel capable of one foot of water, and yet so subtile withal as to weigh less than 1-1/2 ounce, cannot be made of Glass, neither of any other matter that shall remain consistent and stiff: But then let us make a much bigger Vessel, with double the quantity of Glass, then we shall have a Vessel that shall contain four times as much water, that is four foot water, and consequently six ounces of Air; since, that, according to the fourth Supposition, the capacity of the Vessel increases in a duplicate proportion to the surface. So that he that should make a Vessel capable of four foot of Air, and weighing less than six ounces, the six ounces of Air being thence evacuated, would have a Vessel lighter than Air. And the making of this second Vessel lighter than Air, is twice easier than of the First. But because even this second Vessel may possibly not be made so light, as to be less than six ounces weight, and to be capable of four foot of Air, let a bigger be made, holding twice as much as the second, viz. of eight foot, and consequently containing twelve ounces of Air, which vessel doth weigh less than twelve ounces; and the making of this third Vessel will be yet easier than the second. In a word, let the capacity of the Vessel be increased more and more, forasmuch as this will alwaies increase more than that of the surface, that is, the matter and the weight of which 'tis made; and we shall arrive to such a bigness, that although it be made of a dense

and heavy matter, yet the weight of the Air, it shall contain, shall exceed the weight of the matter that makes up the surface of that Vessel; because, as hath been said, the capacity increases in double proportion to the surface.

Let us see then of what determinate bigness a Brass Vessel may be made; and let us suppose, the thinness of the Brass to be such, that a plate of it, a foot broad and long, do weigh three ounces; which it not difficult to make. Let us make of such a thin plate a round Vessel, of the Diameter and bigness of fourteen foot: So that the Air being exhausted out of it, and the bare Vessel remaining lighter than an equal bulk of Air, must needs of itself mount up into the Air. To demonstrate which, there needs no more than the sure rule of Archimedes for measuring a Sphere: which is, that the Diameter to the circumference of a circle is as 7 to 22, more or less: So that supposing our Vessel to be of fourteen foot in Diameter, the circumference will be forty four. Further, to know, how many square feet must be in the whole surface of a circular Vessel, the same teaches, that the Diameter must be multiplyed by the circumference, which when done in our case, will give us our surface of 616 square feet of Brass-plate, each of which we have supposed to weigh three ounces, so that 616 multiplyed by three we shall have 1848 ounces: which is the weight of all the Brass the Ball or Sphere consists of, that is 154 pounds. Now let us see, whether the Air contained in that Vessel do weigh more than 154 pounds; for if it do, the Air being evacuated, the Vessel will be lighter than it; and the lighter it shall prove than it, so much weight may it

carry up along with it into the Air. To estimate the weight of the Air contain'd in it, we must consider how many Cubic feet of Air it holds, of which we have shown that each weighs an ounceand a half. To do which, Archimedes teaches us again, that we must multiply the Semidiameter (7) through the third part of the surface, which will be 205-1/3; which done, we have the capacity of the Vessel, viz. 1437-1/3 feet; and because each foot of Air weighs 1-1/2 ounce, the weight of the whole Air contain'd in that Vessel will be 2155-2/3 ounces, or 179 pounds and 7-2/3 ounces. But now, the Brass of which the Vessel is made, weighing only 154 pounds, the Vessel is 25 pounds and 7-2/3 ounces lighter than Air; which was to be demonstrated, so that the Air being evacuated, the Vessel will not only ascend into the Air, but also carry with it on high a weight of 25.L and 7-2/3 ounces.

But to raise a greater weight, and to elevate even men into the Air, let us take the double of Brass, viz.1232 foot, which are 308 pounds of Brass; with which double quantity of Brass we can make a Vessel, four times bigger than the former; and consequently the Air that shall be contain'd in such a Vessel will weigh 718 pounds and 4-3/4 ounces; so that that Air being drawn out of this Vessel, the Vessel will remain 410.L and 4-2/3 ounces lighter as so much Air, and consequently will be able to raise on high two or three men.

Whence 'tis evident, that the bigger the Sphere or Vessel is, the Brass may be the thicker; because that as the weight of it increaseth, so tha capacity of the same increases

still more and more, and consequently the weight of the Air; whence it can still raise more weight into the Air.

Whilst I thus relate this matter, I cannot chuse but smile to hear a Fable, which to me seems not less incredible and extravagant than those Chimera's which sprung out of the phantastical brain of that rational merry mad Droll Lucian. And yet on the other side, I clearly know that I have not erred in my Demonstrations, and when I had co municated them to divers Learned and prudent men, they could not find any error in my Discourse, and desired nothing more than to see an experiment of it in one Globe, raising itself up into the Air of its own accord, which I should willingly have prepared before I had published this my Invention, if the Religious poverty which I profess had not disabled me from laying out a hundred Ducats, which would have been adundantly sufficient, on the tryal of so pleasant a Curiosity. For which cause I do earnestly intreat my Readers, that they would acquaint me with their success, because though, perhaps, from some failour or mistake in the operation, it may not succeed so happily at first, I may perhaps supply a way of amending that error. And that I may excite and put courage into some of them to make a tryal of it, I shall here remove some difficulties which may seem to obstruct the Practice of this Invention.

And first, some Difficulties may occur in the way above prescribed of evacuating the aforesaid Spheres, where it is required to invert the Sphere upon a Tube or hollow pipe, by lifting that up to a great height which formerly laid on the ground, which could not indeed be done without some great

Machine, and greater difficulty, by reason of the greatness of this Spherical Vessel, and that filled with water. To this evil I can easily supply a remedy that the Sphere shall not at all need to be moved out of its place. Let the Sphere therefore be placed when empty about 33 foot high, and to its under-part or neck, let there be added a Tube of 33 foot long, carefully stopped below, afterwards let the vessel and Tube be filled by a hole at the top; and when that is done, let that hole be carefully stopped with a value: then to evacuate the vessel, there will need nothing but to open its lower end of the Tube under water, that the air may not get into the place left by the water; then the water being all run out of the Globe, turn the Stop-cock at the neck of it, and remove the Tube from under it, and we shall have the vessel evacuated. Which if it be not wholly evacuated of air (of which I will not now dispute) this is at least certain, that its weight shall be by so many ounces and half ounces lighter, as there were Cubical feet of water before contain'd in its capacity, which is sufficient for our purpose. This is now a proved Experiment, as I have said above; great care only must be had that the value or Stop-cock, with which the Vessel is closed, be made very good and exact, that the air may not get into it by its chinks.

Secondly, A difficulty may arise about the slenderness of the Vessel, because the air seeking to enter with great impetuosity to hinder the vacuum, or at least the violent rarefaction, may seem to be able to compress it, and though possibly not to break it, yet to crush it so as to make it

lose its roundness.

To this I Answer, That this would happen, were not the vessel round, but since it is Spherical, the air compasses it equally on all sides, so that it does rather strengthen it than break it, which is observable in Glass-vessels, which though made of thick Glass; yet if they were not round, would be broken into a thousand pieces: whereas on the other side, round Glass vessels, though very slender, are not broken, nor is a perfect roundness necessary, but it will suffice if it does not much vary from a Spherical Figure.

Thirdly, In the forming a Sphere out of Copper, there may be made two Hemispheres, which may be afterwards joyn'd and soder'd together with Tin, after the usual manner, or else the sevral parts of the Sphere may be made apart, and after the same manner joyned, in which there cannot remain any great difficulty.

Fourthly, A doubt may arise to what Altitude in the Air our Ship will rise, since if it should be raised above all the Air, which is commonly esteemed to be fifty Miles, little more or less, in height, as we shall afterwards see: It would follow that men would not be able to breath.

To which I answer, That by how much the Air is higher, by so much the more thin and light it is, so that the Ship being Buoyed up to a certain height it cannot rise higher, for that the upper Air being lighter, it would not be fit to sustain it, and thence it will stay in that place where it finds the Air so subtil as to be of equal weight with the whole Engine, and the men in it.

Then least it should be carryed too high, it will be convenient to burthen it with weights, heavier or lighter according to the height to which it is designed to rise; but if it should be carryed higher than it ought, there is an easie remedy by opening a little the Stop-cocks of the Spheres, and admitting a little Air, for so losing some part of their Levity, they will, together with the Ship, descend. As on the contrary, if it should not ascend to its desired height, we can help it by removing the weights which it carryed up. In the like manner, being to descend to the Earth, we must turn the Cocks of the Spheres, whereby the Air entering , it will lose its Levity, and so descend till the Ship be quietly plac'd on the Ground.

Fifthly, Some may Object that this Ship cannot be moved by Oars, because these only move a vessel on the Water; in as much as the Water resists their motion, but the Air cannot resist.

To which I answer, that the Air, though it does not resist the Oars so as the Water, because 'tis more subtile and moveable, yet it does notably resist and sufficiently to move the Ship. Since by how much the less the resistance of the Air is to the motion of the Oars, by so much the less is it to the motion of the Ship; from whence a little resistance to the Oars may make it move very swift; besides, that it will be seldom necessary to use Oars, because we always have in the Air Winds, which though they be never so weak, will yet be sufficient to carry it with great swiftness: And if the Wind should happen to be contrary to our

voyage, I will in another place teach how to place the Mast of a Ship, so as to Sail with any Wind, not only in the Air, but in the Water.

Sixthly, The Difficulty is greater in stopping the too great impetuosity, with which a violent Wind may carry our Ship, so that there will be danger of dashing against the tops of Mountains, which are Rocks in this Ocean of the Air, or else of overturning it utterly. To the second, I say 'twill be diffult for the whole Engine to be over-turned by the Wind, with all the men in it, which are a counterpoise to the Levity of the Spheres; whence these will be alwaies uppermost, and the Ship can never be above them. Besides that, since the Ship can never fall to the Ground unless the Air gets into the Spheres, there is no danger of suffocation of the Air as there is in the Water; besides all this, the men being bound to the Beams or Ropes of the Ship, are safe from fear of their falling. But as to the first, I confess this our Ship, may undergo many dangers, but none greater than what Water Ships are subject to. For as these, so ours can make use of Anchors to fasten to Trees. That I may say nothing of the Ocean of the Air, which though it has no Shores, has yet the conveniency of Ports, where the Ship may be in safety, since when there is any danger, it may descend and remain on the Ground.

Other difficulties I see not, which may be objected against this Invention, besides one which to me seems greater than all the rest, and that is, That it may be thought, that God will never suffer this Invention to take effect, because of the many consequencies which may disturb the Civil Govern-

ment of men. For who sees not, that No City can be secure a-gainst attack, since our Ship may at any time be placed directly over it, and descending down may discharge Souldiers; the same would happen to private Houses, and Ships on the Sea; for our Ship descending out of the Air to the Sails of Sea-Ships, it may cut their Ropes, yea without descending by casting Grapples it may over-set them, kill their men, burn their Ships by artificial Fire works and fire balls And this they may do not only to hips but to great Buildings, Castles, Cities, with such security that they which cast these things down from a height out of Gun-shot, cannot on the other side be offended by those from below. Thus far the Ingenious Father.

DR. HOOK'S REMARKS CONCERNING THE ABOVE.

A man that hears all these things, and should believe the terrible and mischievous consequences, would possibly be of the Author's mind, and think also that he very much deserved to be punisht himself, who had thus unluckily discovered so Diabolical an Engine, that should at once subvert the Government, peace and security of mankind, and bring in swarms of Barbarians to disturb the quiet and civilised World. But hold a little, let him alone till inquiring into matter of Fact he be found Guilty. Let us examine therefore, whether his grounds and process of Demonstration be true, that we may in time think of waies of defending ourselves against these evils that may hover over our heads, if such there be.

First, Then I find Dr. Wilkins, in his discovery of a new World, quotes Albertus de Saxonia, and Francis Mendoca, for the Inventors of this opinion, that the Air is Navigable; and that upon this Statick principle, any Brass or Iron vessel whose substance is much heavier than that of the Water, yet being filled with the lighter air, it will swim upon it and not sink. The same thing is quoted also by Schottus. And several Experiments to this purpose, were made here in the year 1664, but without the wish'd for success. Now to the matter itself, he supposes the air to be heavy, so far he is right, and the consequence, that an exhausted vessel is lighter by the weight of the air extracted, has been here proved. But then supposing it to be but 660 times lighter than water, he supposes it much too heavy, for I find it to be above 800 times lighter than water. Now a Cubic foot of Water weighing 912 ounces Troy-weight, a Cubic foot of air weighs about 1 14 ounces, or one ounce and one seventh of an ounce: so that upon this account it is much more difficult than he imagines by reason of the greater levity of the air. But yet that were superable.

Next 'tis granted, That Spheres are to one another, as the Cubes of their Diameters, whereas the surfaces of them are only as the squares of their Diameters.

But whereas he supposes Copper of three ounces in a foot square to be sufficient thickness to resist the pressure of the air in a Globe of 14 foot square, nay of any Dimensions we can no wise assent to him; for the pressure from without inwards, though it be alwaies the same upon equal surfaces,

yet upon unequal surfaces the case is quite otherwise, for there the pressure will be found not the same, but to increase alwaies in the same proportion with the surface, and thence consequently the thickness of his Copper, or any other Mettal or material, which he shall make use of, must increase in the same proportion with the Diameter of the Sphere, and consequently the weight of his Copper must alwaies increase in the same proportion, at least to the solidity of his Sphere, so that by the augmenting the quantity of his Sphere, he has no manner of advantage of making it proportionably lighter than the Air, and proportionably strong, But the contrary; for it is manifest that a bigger Sphere so made of any matter, we yet know, has less power of resisting the same pressure of the air than a less, because of the finite resistance of matter to pressure, there being some degree of pressure that will crush every body. And therefore he that cannot make the experiment succeed in small, will be sure never make it do in great.

But in this lies the fallacy of the Authors Reasoning, and this is the Rock that has precipitated his Ship to the Ground, and not the tops of the Mountains, nor the Whirl Winds of the air, whereby all those Direful presages vanish, so that I hope I have cleer'd the Author in your opinions of his doing any great harm by this Invention to the Civil and Peaceful Government of the World.

----------oOo----------

EXTRACTS FROM THE HISTORY OF THE ROYAL SOCIETY BY THOMAS BIRCH, RELATING TO AEROPLANE EXPERIMENTS AND THE ART OF FLYING (1661-1679).

1661-2, January 1 (Vol. I, p. 68):-"Dr. Wrenn was requested to prosecute his design of trying, by several round pasteboards, their velocity in falling.

1661-2, March 5, (Vol. I, p. 77):Mr. Rooke" (sic) "and Mr. CROUNE were desired to try the experiment mentioned by Monsieur HUYGENS of a feather to be let fall before and after the exsuction of the air in the said engine." (Boyle's engine)

1662-3, Feb. 25, (Vol. II, p. 203):"From Mr. HOOKE'S"scheme of Inquiries concerning the Air".

... "What the resistance of the air is to bodies moved through it? How much it retards the descent of heavy bodies? How much it stops the motion of a pendulum? and whether that be the only cause of a pendulum's losing its motion? How it bears up dust, smoak, &c. How it sustains birds? The strength requisite to make a wing, or expanded area, sustain a determinate bulk in the air? And here, what bulk may be raised by what kind of contrivance? As what by that contrivance, which children use to make their paper kites of? What means may be thought of for raising a man; for raising lights to a considerable height; for conveying intelligence? What contrivance may be made for letting bodies fall from certain hights, for knowing the swiftness of their descent? and what other experiments may be tried this way?

1662-3, March 4 (Vol. I, p. 205):- The following experiments, concerning the resistance of air to bodies moved through it, was brought in by Mr. HOOKE.

"For the finding out the resistance of the air to bodies moved through it, it will be necessary, that trials should be made with pendulums of all sorts, whose weights should be made with several sorts of materials; as of metals, stones, woods, feathers, wools &c. and these fashioned into several shapes, as round, elliptical, square, oblong, flat; to be moved flatways, or edgeways, and the like;" &c. &c. &c.

1665, June 21 (Vol. II, p. 59):- Occasion being given to discourse of the art of flying, and Dr. WREN being desired to leave with the Society what he had considered on this subject, promised to do so.

He, affirmed, that a man would be able so often to move the wings, as he could with double his own weight on his back ascend a pair of stairs built at an angle of forty-five degrees.

Mr. HOOKE suggested, that it was not sufficient to have a theory for the descent of an expanded area perpendicularly downward, because the descent of an expanded area, moved edgewise horizontally in the air, was extremely different; in which way, however, all motion of flying must be performed.

1668-9 Feb. 25, (Vol. II, p. 350):- At a meeting of the Society, some experiments were made, to find what would be the resistance of air to bodies moved through it with several velocities; and it seemed, that the larger the arch was, in which the pendulums body moved, the more impediment it suffered from the air: And the slower it moved through the air, as when it moved in a smaller arch of a circle, the less stop it received from the impediment of the air, and the impediment to motion decreased in a greater proportion that the decrease

of the velocity: But what the exact proportion of decrease was, was to be found out by farther trials.

It was ordered, that this kind of experiments should be prosecuted at the next meeting by employing boards or plates of several expansions, but all of the same weight; and with balls or boards of several weights, but of the same expansion.

(N.B. More experiments to find the resistance of the air to bodies moved through it with several velocities were made March 4 and March 11, 1668-9, see Vol. II, p. 352 & 354. A.G.B).

1673, Nov. 27, (Vol. III, p. 111):- Mr. HOOKE showed an attempt of his, of making a vessel so thin, that when evacuated of the air contained in it, it might swim in the air. He mentioned also, that a certain Italian clergyman, named Lana had written upon this subject; whose book he thought had been formerly presented to the Society by their Secretary, but was still in his hands.

1674-5, Feb. 11, (Vol. III, p. 181):- Dr. CROUNE read his discourse concerning the manner how flying is performed by birds; showing, in order thereunto, the structure of a duck's wing and body, especially of the muscles and their insertions into the humerus.

This discourse was ordered to be registered, though the doctor did not then have it with the Society.

He having intimated a quite different structure of the body of man from that of birds, and thence concluded his utter unfitness for flying, gave occasion to some of the members to remark, that what nature had denied to the body of man, might

be supplied by his reason and by art.

Mr. HOOKE intimated, that there was a way, which he knew, to produce strength, so as to give to one man the strength of ten or twenty men or more, and to contrive muscles for him of an equivalent strength to those in birds. He hinted likewise, that a contrivance might be made of something more proper for the feet of man to tread the air, than for his arms to beat the air.

Sir WILLIAM PETTY mentioned, that perhaps it might prove of use to consider, whether gun powder, being of so great and quick a force, might not be slackened to give a slower motion, as in the mortar-piece the shell is much more slowly carried through the air than a bullet out of a musket.

Some said, that it would be of real use to contrive to raise something for flying, if it were but a man so high, as to fly over a wall, and the besiegers of a town to carry and bring back intelligence.

1677-8, Feb. 21 (Vol. III, p. 385):- Mr. HOOKE produced an instrument to examine and show at all times the specific gravity of the air, in which it is placed, without anyrespect to the heat or cold, pressure or spring of the air; But the said property of the air was not showed singly by any other instrument; nor was it proper or capable to show any other quality of the air, as some had thought, except only the specific gravity of the air.*** This instrument made to demonstrate the said property of the air was a very large and thin ball of glass sealed up hermetically. It was supended at the end of an exact beam (which would easily turn either one way or the other)

and was counterpoised by a small weight of lead or brass; but lead was best for that purpose. Then Mr. Hooke explained the same, and showed the reason, why the ball would rise when the air, in which it hung, was heavier and sink when it was lighter; and that it depended upon the same ground with the improvement of ARCHIMEDES' experiment by GHETALDUS*. (Some discussion followed this. A.G.B).

1673, Apr. 4, (Vol. III, p. 398):- (In some discussion concerning the accelleration of the motion of falling bodies, Mr. Hooke drew attention to the fact that a feather let fall in a vacuum moved with accellerated velocity, whereas, in air it fell with uniform velocity, and added an interesting argument upon the subject. A.G.B).

"And farther, that in the thinnest medium, though the accelleration was pretty near what was supposed by the aforesaid authors yet that it was in none mathematically true, but that there would be in all mediums a certain degree of velocity, which the same descending body would never exceed, though other descending bodies might, and some others would never arrive to: after which degree was attained, the progress of the body would always be made by equal spaces in equal times, though ever so far continued, provided the gravitating powers remained the same."

1674, April, 18 (Vol. III, p. 400):- SIR JUDAS MOORE alledged that in shooting granades he had found, that the greatest random was below 45 degrees of inclination. And that shooting at 20 degrees would fly much further than shooting at 70; The reason of which was the density and resistence of the air to the body passing through it, whereby that, which was shot at 70 degrees, passing through a greater quantity of air, received a greater impediment and hindrance from moving exactly

in a parabolic line, than that which was shot at 20.

1679, May 8 (Vol. III, p. 481):-Mr. HOOKE produced and read a paper, containing a description of the way of flying, invented and practiced by one Mons. BESNIER, a smith of Sable, in the County of Mayne, the contrivance of which consisted in ordering four wings folding and shuttinglike folding, to be moved by his hands before and legs behind so as to move diagonally, and to counterpoise each other; by which he was, it was said, able to fly, from a high place, cross a river to a pretty distance.

Dr. CROUNE remarked, that in the Paris Gazette there was mention made of one, who had lately flown there from the top of the steeple to the ground at a considerable distance, and had lighted safe.

He observed likewise, that the bodies of fowls were made in all parts light ans strong, and particularly in their bones.

Mr. HOOKE produced a model of the contrivance of the wings made with pasteboard, whereby both the manner of the motion of them diagonally, and also of their opening and shutting, was explained; though he supposed that not to be the best way contrived for the performing that effect after that manner, but that the same sort of wings might be much more advantageously made and used for that effect.

SIR JONAS MOORE related, that one Mr. GASCOIGNE had, about forty years before, made a contrivance for flying, by which he had been able to make a boy at Knaresborough fly a considerable way; but that he being frightened in his flight by the acclamations of the spectators, fell down before he

designed to alight, and though not much hurt, would not attempt it any farther.

Mr. HENSHAW conceived, that by reason of the weakness of a man's arms for such kind of motions, it would be much more probable to make a chariot, or such like machine, with springs and wheels to move the wings, that should serve to carry one or more men in it to act and guide it.

Several relations were mentioned of the strength of the wings of fowls, and amongst the rest Mr. HENSHAW took notice, that he had known a man of fifty years old beat down by the stroke of the wings of a swan.

1679, May 29, (Vol. III, p. 487):- Mr. HOOKE read a translation of a chapter of the Italian book of Father Francisco Lana, intitled Prodrome, being an explication and demonstration, as he supposed, of a way to make a vessel to swim and float in the air, so as to carry in it one or more men with other heavy bodies, invented, as he says, by himself, in order to make flying practicable, which had before been thought impossible.

(A foot-note says see Mr. HOOKE'S Philosophical Collections No. I, p. 18 A.G.B).

1679, June 5, (Vol. III, P. 489):- Mr. HOOKE read a farther discourse of Padre Lana concerning flying, which he had translated; and added to it a discourse of the impossibility of that attempt by that means; and also showed wherein the author had been greatly mistaken in the grounds ans supositions of his demonstration, viz: in supposing the same thickness of metal to be sufficient to resist the pressure of the

-8-

air inward in a ball of twenty-four feet diameter as in a ball of one foot diameter: Whereas on the contrary it is necessary to increase the weight of the shall more than according to the proportion of the solidity or capacity of the ball.

----------oOo----------