SCIENTIFIC AMERICAN

ESTABLISHED 1845

MUNN & CO., - - Editors and Proprietors

Published Weekly at

No. 361 Broadway, New York

TERMS TO SUBSCRIBERS

One copy, one year for the United States, Canada, or Mexico $3.00
One copy, one year, to any foreign country, postage prepaid, £0 16s. 5d. 4.00

THE SCIENTIFIC AMERICAN PUBLICATIONS.

Scientific American (Established 1845) .... $3.00 a year
Scientific American Supplement (Established 1876) .... 5.00 "
Scientific American Building Monthly (Established 1885) .... 2.50 "
Scientific American Export Edition (Established 1878) .... 3.00 "

The combined subscription rates and rates to foreign countries will be furnished upon application.

Remit by postal or express money order, or by bank draft or check.

MUNN & CO., 361 Broadway, New York.

NEW YORK, SATURDAY, APRIL 30, 1904.

The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

THE AQUEDUCT COMMISSIONERS AND THE NEW YORK CITY WATER SUPPLY.

The object of constructing the new Croton dam, which was begun in 1892, was to relieve the pressing danger of a water famine in the city by increasing the storage capacity of the Croton system to its fullest extent. The Jerome Park reservoir was begun in 1895, with the object of providing an adequate distributing reservoir within the city limits, capable of impounding between two billion and three billion gallons of water, and providing Manhattan and the Bronx with from a week's to ten days' supply of water, which could supply the city temporarily, should there occur any break in the thirty-five miles of the new Croton aqueduct. It was the intention of the contracts that the new Croton dam be finished by July 1, 1899, and Jerome Park reservoir by November 1, 1902. As matters now stand, four years and ten months have passed since the contract date of completion of the Croton dam, and over two years more will be required to complete the structure. That is to say, if we may be so optimistic as to hope that the intolerable delays that have marked the construction of this dam in the past will not be repeated, it is possible that this urgently-needed work will be ready for public use seven years after the date on which it should have been completed, the contract taking fourteen instead of the seven years contemplated and promised for its execution. In 1903 the Acting Chief Engineer, in an official report to the Aqueduct Commissioners, stated that the Jerome Park reservoir, at the then rate of progress, would not be finished in less than four years from that date, that is to say, five years after the original contract date for completion.

In the presence of these astounding facts, it is not surprising to learn that the Merchants' Association of this city, whose good work in the safeguarding of the city's interests is on record, have considered the matter to be so serious as to call for the preferring of charges against the Board of Aqueduct Commissioners, upon whose shoulders they consider that the chief blame for this inexcusable neglect of the city's interests is to be laid. The Association states that it can be clearly shown, by the records of the Aqueduct Commission, that the Commissioners had knowledge of the grave exigencies confronting this city in the way of a possible water famine, and that they have explicitly recognized the need for expedition in providing new reservoirs; that these Commissioners have been specifically informed, by their Chief Engineers and by the Department of Water Supply, that action was urgently necessary for the due progress of the work; and that although they were thus informed, they refrained during several years from taking any steps toward compelling the active prosecution of the work and, indeed, that at no time since 1898 have they taken any effective or proper steps to compel the contractors of either the Cornell dam or the Jerome Park reservoir to observe their contract obligations as to time. The Merchants' Association claims that it is shown by the Aqueduct Commissioners' report that, in the case of the new Croton dam, the Chief Engineer, as far back as 1899, protested officially to the Aqueduct Commission against "the inexcusably flagrant delay" of the contractors, and recommended measures to compel satisfactory progress; but that no measures to compel progress were adopted at the time or since. It is further charged that in the case of Jerome Park reservoir also, the Aqueduct Commissioners have taken no action of any kind to enforce a reasonable degree of progress, despite the obvious and unjustifiable delay in every branch of the work, including the complete stoppage for about four years of work upon the northern half of the reservoir, on which expedition had been previously ordered by the engineers.

The indifference of the Aqueduct Commissioners to the needs of the city is claimed to be the more culpable, because they have repeatedly granted unmerited extensions of time, and this in the face of many reports made to them by their own engineers, that the contractors' delay was extreme and altogether unnecessary. These are grave charges, and in view of the unparalleled delay on both these urgently-needed public works, the public will not fail to draw its own conclusions as to the inefficiency of the Aqueduct Commissioners, and their apparent indifference to the trust that has been reposed in them.

The Commission is a body of laymen who were appointed for the express purpose of safeguarding the city's interests and seeing to it, not merely that contractors do their work well, but that they do it within contract time. Now, the SCIENTIFIC AMERICAN is perfectly well aware that there have been justifiable causes for some of the delay. There has been a change from core wall to solid masonry on a portion of the Croton dam, while at Jerome Park further delay has been occasioned by a similar change from core-wall embankments to solid retaining walls. We are perfectly willing to admit that these changes were necessary at the Croton dam, and that they may have been to a certain extent necessary at Jerome Park reservoir; but having admitted this much, we must confess that after reviewing the history of these two works, and going carefully over the charges made by the Merchants' Association, we cannot but feel that the Commission has done very little to justify its existence. Amid the continued and reiterated complaints against the delay in these works, we fail to remember a single instance in which the voice of the Commission has been heard in similar expostulation. Judging by its silence, the citizens of New York might well believe that the delay was causing the Commission but very little uneasiness.

It is gratifying to know that the charges of the Merchants' Association will be presented before a Mayor who has shown himself to be thoroughly independent and fearless in protecting and promoting the welfare of the city over which he presides.

LONGITUDINAL BULKHEADS AND BATTLESHIP STABILITY.

A correspondent has asked us to give an editorial discussion of the probable cause of the Russian battleship "Petropavlovsk's" capsizing so suddenly. At the outset we must frankly confess that in the present state of our knowledge of this disaster, it is impossible to give a definite answer; but we are inclined to think that, when our correspondent asks if the capsizing of the ship was due to a too great subdivision of the water-tight compartments, he has failed to understand the true functions of the multiple-compartment system. The primary object of subdivision is to localize the effect of under-water penetration of the hull, so that should a vessel run aground, the entering water would be confined to certain compartments of a limited capacity, and her buoyancy would not be too seriously impaired. An ordinary grounding of the vessel, a ripping open of the outer shell by a jagged point of rock, will usually admit water only to the double bottom. This has been shown in the majority of the accidents of this character to our own ships that have happened of late years. As a defense against the smashing in of a considerable area of the under-water hull by the ram or by the torpedo, it is customary to divide the ship transversely by several bulkheads, and also by a continuous longitudinal bulkhead that bisects the ship in the line of the keel from stem to stern. The various compartments thus formed are further subdivided both longitudinally and laterally, particularly in the wake of the magazines and engine and boiler rooms.

Our correspondent is under the impression that the capsizing of the "Petropavlovsk" was largely due to the existence of the longitudinal bulkheads, and he asks whether, had there been no bulkheads of this kind, the water would not have distributed itself across the vessel, and, by preventing the ship from listing heavily, have delayed her sinking until the majority of the crew had been rescued. The question is not by any means a new one, for it was brought into prominence many years ago by the sinking of the British battleship "Victoria," when she was rammed by the "Camperdown" during naval maneuvers in the Mediterranean, and went down with Admiral Tryon and most of her officers and crew. The hull was perforated on the starboard side a little forward of the 16¼-inch gun turret. The water entered rapidly, and, filling the starboard compartments, it caused the ship to list so quickly that she "turned turtle" before the boats from the other ships of the fleet could rescue her crew.

A naval board of inquiry that investigated the disaster considered the question of removing the longitudinal bulkheads, with a view to preventing the quick capsize of a rammed or torpedoed warship. But it was decided that, all things considered, longitudinal bulkheads were desirable; and they remain to-day a most important feature in the design of all modern warships. Furthermore, it is a mistake to suppose that all longitudinal bulkheading is water-tight. The keel of the ship in the double-bottom, and some of the other longitudinal members there, are perforated for the express purpose of allowing the water to flow freely across the ship in case of injury to the bottom. To follow out the same principle, however, on the various decks, would be to double, and in some cases quadruple, the amount of water that would be admitted to a ship were she rammed or torpedoed, a result which would merely mean that buoyancy was sacrificed to stability.

That the accepted system of subdivision is the correct one has received most emphatic demonstration in the present war; for there seems to be very little doubt that the quick loss of the "Petropavlovsk" was due to the fact that when the burst of flame of the exploded mine or torpedo tore its way into the ship, it ignited and exploded the magazines and rent the ship asunder, the action being similar to that which occurred in the case of our own battleship "Maine" in Havana Harbor. Therefore, the sinking of the "Petropavlovsk" can scarcely be quoted against the longitudinal subdivision system. The true test came in the case of the two battleships "Czarevitch" and "Retvizan," and the cruiser "Pallada," which were torpedoed in the opening engagement at Port Arthur. These vessels were undoubtedly saved by their elaborate system of subdivision of hull; for they were able to proceed from the outer roadstead under their own steam and beach themselves, thereby rendering subsequent salvage operations and repairs possible. Naval constructors, generally, consider that the salvage of these ships is a great tribute to the efficiency of the present cellular system of construction.

THE PREPARATION OF PURE ARGON.

In a paper recently read before the Academie des Sciences, Messrs. Henri Moissan and A. Rigaut describe a method which they use for preparing argon in large quantities in a pure state. In their first experiments, Lord Rayleigh and Sir Wm. Ramsay used the action of the spark on a mixture of oxygen and nitrogen, in order to separate the argon of the air. Afterward they used metallic magnesium, which retains the nitrogen in the form of nitride. In more recent experiments, Ramsay used the action of a mixture of lime and magnesium on the nitrogen of the air.

M. Moissan had previously shown that calcium combines easily with nitrogen at a low red heat, giving a crystalline nitride having the formula Ca_3N_2. As metallic calcium also has the property of absorbing hydrogen at the same temperature, giving a crystalline hydride CaH_2, and as this hydride is not dissociated at 500 deg. C., the writers proposed to apply these properties of the metal for the extraction of argon from the air. The preparation of the argon includes four different operations. 1. Preparation of 100 liters of nitrogen. 2. Increasing the proportion of argon contained in the gas. 3. First purification. 4. Second purification by circulating the gases over calcium. In this way a practically pure argon is obtained. The first operation is carried out by using two tubes 4 feet long and 1.2 inch inside bore, filled with copper turnings which had been first oxidized in air, then reduced by hydrogen. The gas is drawn through the tubes by suction into a gas-holder. The proportion of argon in the gas is then increased by making it pass through an iron tube 3 feet long filled with copper turnings; then, after a set of sulphuric acid and potash tubes, the gas passes through two iron tubes 2.5 feet long, filled with a mixture of 5 parts powdered quicklime and 3 of powdered magnesium. The tube containing the copper is heated to redness. After driving off the hydrogen, a rubber bag is placed at the end of the apparatus. Then 100 liters of nitrogen are passed in the apparatus, and in two hours it becomes diminished in volume and is brought down to 10 liters. The gas which is collected in the rubber bag contains 10 per cent of argon.

The next step (purifying the gas) is carried out by passing the gas through a potash drier into a large tube of Berlin porcelain 3 feet long and 1.5 inches diameter. The tube is heated in a Mermet furnace. It receives a sheet iron trough containing 80 grammes of the lime and magnesium mixture. After it comes a second tube of Jena glass containing the same mixture, then a smaller tube full of copper oxide. A sulphuric acid and potash drier complete the apparatus, which is connected to a mercury pump for the purpose of drawing the gas through and sending it into a large glass collecting cylinder 2.8 feet high and having a capacity of 1,100 cubic centimeters (67.14 cubic inches). By repeated operations, the pump empties the gas-bag in 2 hours. The gas which is finally collected is nearly pure argon, containing only 5 to 10 per cent of nitrogen.

To obtain a practically pure argon, the following operation is carried out: The gas is passed from the cylinder through a tube of Jena glass containing 45 grammes of lime and magnesium mixture. After it comes a second tube containing four troughs of nickel in which are placed 3 or 4 grammes of metallic calcium in small pieces. Two mercury pumps are connected to the apparatus by a three-way cock. The first pump serves to produce a vacuum in the apparatus in the beginning. The second causes the circulation of the gas in the tubes, which are heated to low redness. In this way, by applying the characteristic properties of calcium noted by M. Moissan, the small quantities of nitrogen and hydrogen are retained by the calcium and the argon comes off in a practically pure state. The gas is collected in bottles of 250 c.c. capacity. To find out whether the argon is pure, it was studied by the spectrum of an induction spark, which showed the characteristic lines for argon, while nitrogen was practically absent. This new method therefore affords a good working process for preparing pure argon in considerable quantities.

SOARING FLIGHT.

BY GARRETT P. SERVISS, JR.

Among the many phenomena exhibited by flying birds, and observed and studied in attempted solution of that most interesting and baffling of all engineering problems, mechanical flight, there is one which is so remarkable in its paradoxical nature, that it has attracted perhaps more attention than all the others together. I refer to soaring, or, as it is sometimes called, sailing, and, in one of its aspects, aspiration. In performing this feat, the bird holds its outstretched wings absolutely motionless, and remains suspended in the air, traveling in any desired direction without, so far as can be observed, the expenditure of the slightest amount of energy. This feat seems so absolutely impossible on first sight that men have doubted their own senses, and have taken photographs of soaring birds, hoping that the camera plate, more rapid than the eye, would be able to detect some lightning-like movement of wing which would account for the bird's support. So far as the writer is aware, no such movement was ever detected. It remains then for us to explain the phenomena on mechanical principles, or else to admit that our theories of the action of elastic fluids, such as the air, are erroneous. Such explanations have been given, it is true, but so many of them are erroneous—indeed, I hope to show that only one of them is entirely reasonable—that it seems desirable to review them, and to endeavor to show that there is one other way in which the birds frequently use the energy of the wind for their support and propulsion.

For convenience in reviewing the explanations already suggested, it will be well to divide them into three general classes:

1. Attempts to explain soaring in uniform horizontal winds.

2. Explanations which require the assumption of ascending wind currents.

3. Explanations depending upon a wind continually varying in velocity or direction, or both.

The advocates of the first class of explanations have held that some particular shape of the bird's wings might have a peculiar action upon the air, so deflecting it that the wing would be forced upward and forward into the teeth of the wind. Others have invented highly ingenious but totally inadequate evolutions, by the performance of which the bird would be enabled to gain elevation, and eventually travel in any direction by sailing down an inclined path. It is not necessary here mathematically to treat in detail these explanations, though it is entirely possible. It will suffice to show by very simple considerations, the essential fallacy involved in any theory of soaring in uniform horizontal air currents. In the first place, consider a bird being supported stationary in the wind. The downward pull of gravity upon the bird must be counteracted by an equivalent upward force. This upward force on the bird has its reaction upon the air particles under the bird's wings, and the downward force on the air produces a downward acceleration of the air particles, which, combining with their forward motion, produces a resulting velocity greater than the original velocity. This means that the air, in passing the bird, has its energy increased, which is contrary to the law of the conservation of energy. In case the bird is performing evolutions instead of remaining stationary, the force upon the bird and air particles varies both in direction and amount, but an integration still shows an increase of total energy in the wind.

This is the basis of an exact treatment, and is given because the increase or non-increase in total energy of the wind when passing the bird furnishes a universal criterion for determining the possible correctness of any explanation of the phenomenon in question. A much simpler conception, however, has been suggested by someone, and we will give this briefly before taking up the next class of explanations. The air confined in a railroad car in motion constitutes a true uniform horizontal wind with regard to the earth. Yet no one could conceive of a bird performing evolutions with motionless wings, and remaining supported indefinitely in the air carried by the car.

In the second class of explanations, it is assumed that the lower strata of air moving over the earth's surface are retarded by friction and piled up, thus deflecting the strata above, and giving the wind a slight trend upward. Marked upward wind currents also exist over natural wind breaks, and on the slopes of hills when the wind is blowing toward the higher ground. Soaring birds, it has been stated by careful observers, seem to prefer such places in which to perform their aerial evolutions. Granting the existence of upward wind currents, we can understand one way in which soaring is accomplished.

Consider a kite against which a horizontal wind is blowing. The pressure of the air is normal to the kite surface, and is thus a force directed upward and backward. If now the backward component is neutralized by the pull of the string, the kite will remain suspended in the air through the vertical component of the wind's pressure. If we release the string, the kite will drift backward by virtue of the horizontal component of pressure, and sink to the ground. Suppose, however, that the wind takes an upward trend. The kite may now be tipped down in front; and if the wind is rising at a sufficient angle, the kite may even take a horizontal position, and still present the same angle to the wind. In this case the pressure upon the kite, always normal, will become a vertical force. If the wind tends upward at a still greater angle, the kite may be tipped down in front until the front edge is lower than the back, in which case the horizontal component of the pressure is directed forward opposite to the direction of the wind. If the kite could maintain equilibrium, it would advance into the wind under these conditions, and remain in the air indefinitely. Kite experimenters have observed this very action at times, and it is a true case of soaring, or better, aspiration.

Thus we see that the existence of upward wind currents is sufficient to render flight without exertion possible, but that soaring is always or even frequently due to such currents is very doubtful. We must then look to our third class of explanations to complete the theory.

Prof. Langley, by careful measurements of air velocities, has shown that all winds are extremely variable, his readings having indicated changes in velocity of ten miles or more per hour in a small fraction of a second. His investigations are fully described in his paper, "The Internal Work of the Wind," but his theory will be briefly stated here. A bird flying in such a variable wind would be carried along at the average velocity of the air, while the alternate puffs of high and low velocity would constitute alternate virtual winds, first blowing by him in the direction of his motion, and then against him in the contrary direction, his inertia preventing him from following the rapid fluctuations. Under these conditions, the bird by facing about first toward the virtual wind in one direction, and then toward that in the other, could always present his inclined wings to a current of air, and obtain a supporting reaction. The facing about might be accomplished by sailing in circles, an evolution often observed. This in brief was Langley's theory, and highly ingenious it is. It may under exceptional conditions be the manner in which soaring is accomplished, but in ordinary winds the variations in velocity certainly cannot exceed fifteen miles an hour, and even if these variations occurred extremely rapidly, the bird would only be subjected to a virtual wind of less than seven miles per hour, which is totally inadequate to support any known soarer.

Looked at in a slightly different way, however, the writer believes that the variations in velocity of the wind may be shown to be sufficient to account for all the observed phenomena of soaring. In the first place, the relative velocity of the bird to the air, which is effective in supporting the former, must be quite high. Langley has shown that at certain velocities a plane may support as much as three hundred pounds per horse-power expended, but this velocity is much higher than the five or six miles an hour which is secured in the action just described. The bird, then, cannot drift with the same velocity as the average wind, but must possess a velocity of perhaps twenty miles an hour with regard to it, to obtain support with the energy available. How, then, can this internal energy existing in the wind by virtue of its streakiness be utilized to propel a body traveling at twenty miles an hour with regard to it? Obviously, only by taking advantage of changes in velocity occurring at *right angles* to the direction of the bird's motion. Each time such a change occurs, the bird has added to its velocity a perpendicular component, which, combining with the motion which it already had, produces a resultant velocity greater than the initial. Since the kinetic energy due to the bird's motion is proportional to the square of the velocity, and since the square of the resultant velocity is the sum of the squares of the initial and the impressed velocities (being perpendicular to each other) it is evident that the bird has absorbed all the energy which the variation in the velocity of the wind could impart, and converted it into energy of motion in its new path. Of course, if the acquired energy is being continually used for support, no increase in velocity will result.

In performing such an evolution, the bird would be forced to bring its wings into a more or less vertical position, to take full advantage of these horizontal puffs of wind, and this probably accounts for the frequency with which soaring birds move in circles, for while moving thus, the centrifugal force allows them to tip up the plane of their wings. In describing this path, the center of the circle may drift with the average wind, while the bird takes advantage of every favorable puff to produce an acceleration perpendicular to the tangent at the time it occurs. The writer has many times observed sea-gulls soaring in just such distorted circles as would be produced by this action. In this action the bird takes full advantage of the "internal work of the wind" to maintain the velocity for support which its ratio of weight to wing surface renders most efficient.

Whether or not this proves to be the final solution of the problem, it is evident that soaring is much too complicated for man to imitate, at least until he has had long experience with motor-driven machines.

SCIENCE NOTES.

E. Salvioni has devised and accurately examined a microbalance which consists of a thin thread or very thin ribbon of glass or other material, fixed at one end and placed in a closed case; the case also contains a number of small weights (the larger of platinum wire, the smaller of silk thread) which, with the aid of a handle, can be placed on the flexible thread or ribbon. The flexure of the thread when loaded is observed by means of an ocular micrometer, and, as verified by the author for his instrument, is proportional to the weight which produces it; a conveniently placed spider thread serves as a sight-line for the measurement of the displacements. A glass thread 10 centimeters long, and one of two-tenths of a millimeter in diameter, will support by flexure a weight of more than 100 milligrammes, and, if provided with an optical arrangement which magnifies one hundred times, will serve to weigh to one-thousandth of a milligramme. To avoid the inconvenience caused by subsequent elasticity, the balance is provided with a stop, which enables the flexure to be maintained after unloading. Salvioni finds that the loss of weight of musk by volatilization is clearly demonstrated by this instrument. The loss is proportional to the time.

In a study of the circulation of the atmosphere of the sun, in the Monthly Weather Review, Prof. Frank H. Bigelow presents a mass of data and observations showing that "the sun should be regarded as an incipient binary star." Recent scientific work in investigating the circulation of the solar atmosphere in accordance with the laws governing the convective and radiative action of a large mass of matter contracting by its own gravitation, have led Prof. Bigelow to the hypothesis, that "the single fiery envelope conceals two disks." A series of observations extending over many years on the period of solar rotation at various points on the surface shows that "the same meridian of the sun is seen twice in a single rotation of the entire mass, first as the eastern limb, and second, thirteen days later, as the western limb. Whatever may be the intrinsic activity of the sun at a given zone and on a given meridian, that display becomes visible twice, first to the east, and second, to the west." The tables prepared by Prof. Bigelow giving the rate of angular rotation of various zones of the sun's surface show that it is far from uniform, being increased in proportion to the distance from the equator. As yet little has been done regarding "the fundamental problem of the mode of the internal solar circulation." This difference of external activity of the sun "on two opposite sides of its mass, as if a certain diameter had greater energy than the one at right angles to it," is similar to a recent discovery of Prof. Bigelow in regard to the earth's atmosphere, and leads him to the conclusion already stated, that "this persistent excess of outflowing energy on two opposite sides of the sun suggests the possibility that the sun should be regarded as an incipient binary star where the dumbbell figure of rotation prevails instead of the spheroidal. If this is really the case, and the evidence suggests it, then there would be a reason for the existence of the two primary centers of activity of the sun instead of its having a single center. From this we would expect to find that the sun has two magnetic and two meteorological systems, and indeed some double-acting system appears to impress itself generally upon the solar cosmical relations. This view is quite in harmony with the well-known fact of the existence of numerous binary systems of suns more or less widely separated, and it can not be regarded as unlikely that the sun is developing in the same way. The enormous mass of the sun would seem to entice its constituents to group themselves preferably about two centers for the physical processes involved in circulation and radiation, rather than about one, and I suspect that this is the correct explanation of several well-known phenomena."