

tween the outer and inner arcs of the circles only quarter of an inch. This would give greater elasticity and more room for the expansion of the sound, and I think would be strong enough, provided that the arcs of the outer circles should not be produced until they touch each other, but should be joined by a short curved line so as to leave at least half an inch of wood between the arcs of the circles. I have shown in two of the circles in the margin an illustration. There would thus be half an inch depth of wood along the whole bar.

I do not claim the origination of this contrivance; it is merely a modification of a central bar from block to block, for which a patent was, I believe, obtained about fifteen years ago, and which, Mr. Furber tells me, had an extensive run for some time. This bar was solid and stiff, and had for its object the tightening of the belly and preventing its being forced up by the longitudinal tension of the strings which sometimes does happen, especially to weak instruments. My modification of this bar gives a certain amount of elasticity which assists vibration, while it is sufficiently firm to strengthen the belly.

It seems strange that the violin should have remained unchanged for centuries, while almost all other musical instruments have been improved; modern makers usually follow the modes of the Italian school, but, however exactly they may gauge and measure a Stradivarius violin, and imitate its form and structure, the copy gives an inferior result. The art of violin making appears never to have been reduced to exact and scientific rules; even the eminent Italian makers scarcely made two instruments exactly alike in power and tone, and it is difficult to assign the reason for the great superiority of their instruments. I think, however, that one of their secrets was the careful choice of sonorous wood; and here I think is a hopeful field for investigation, in which the use of the microscope would, perhaps, give us an advantage over the ancients.

In the process of seasoning wood, the moist portions of the sap are dissipated, and on examining the wood with a powerful glass I have observed that the wood is traversed by minute cells and little ducts, and that the sides of these diminutive veins and arteries (so to speak) which run through the wood are varnished, as it were with a very thin film of the resinous or glutinous remains of the sap; the substance of the seasoned wood is, in fact, a series of minute air cells and pipes, and the form and arrangement of these differ much in different woods, and even in different parts of the same tree. I have not made any experiments to enable me to form an opinion on the relation between the microscopic appearance of the wood and its sonorous properties. The investigation of this subject, to any useful purpose, would involve long and laborious experiments and researches; but it seems probable that the Italian makers had some rough and ready rules to guide them in the choice of sonorous wood, for we find, as noticed in Mr. Hart's book on the violin, that much time and labor were employed by some of them in neatly joining small pieces of wood in their instruments, which evidently showed a desire to economize rare material.—*H. Walden, in Journal of Society of Arts.*

[In the U. S. Patent of M. H. Collins, No. 129,653, dated July 23, 1872, and in patent of E. R. Mollenhauer, No. 218,761, dated August 19, 1879, is shown a sounding board which joins the sides of the violin, instead of being separated from them by a narrow space, as in the above cut. In M. H. Collins' patent for a banjo, No. 191,629, dated May 22, 1877, is a sounding board which touches no side, but is supported by an annulus or wide ring. A sounding board or "tongue" has also been arranged to project downward within a banjo or guitar, at an angle of about 45°.—Ed. S.A.]

## THE ORIGIN OF FALLING MOTION.

By CHARLES MORRIS.

WHY do bodies fall? The attraction of gravitation may be the active cause of their passing from a state of rest into a state of motion. But attraction of gravitation does not create this motion. Nor can we well imagine gravitative energy to be a mode of motion convertible into other modes. However great the effect produced, the force of gravitation remains unchanged. It is not transformed into motion of masses.

Whence, then, arises this motion? It is a form of energy, and must be derived from some diverse form of energy which it replaces. If, for instance, a body begins to fall to the earth from a position of rest, we can safely assert that the motion it displays pre-existed either in the earth, in the body, or in surrounding space. It was certainly not created for the occasion.

The theory of gravitation declares that the earth moves toward the falling body with a momentum equal to its own. If the body be supported above the earth, the support performs a double duty. It at once hinders the body from falling to the earth, and the earth from falling to the body. They compose parts of one rigid system. But if the support be removed the earth and the body at once become separate individuals, and they fall together, with equal momentums, until they again enter into rigid relations with each other.

The falling motion manifested by the descending body cannot, then, have been in some mysterious manner transferred to it from the earth; for the earth's own motion is equally to be accounted for, and in that case we would have to look to the body for its source. No active motion could appear in such an equal mutual transfer of motive vigor. We must, therefore, look elsewhere for the source of the motive energy displayed.

Nor can it well have been derived from contiguous space. It is too instantaneous in its appearance, and too regular in its increase, to arise from any such transfer of moving energy.

It must, therefore, have had its origin in the moving bodies themselves. Not, however, as an ideal "potential energy" converted into a real "actual energy;" but as a real motion, existing previously in some other form, and converted as needed into the form of mass motion.

Such motive energies exist as constituent forces of all matter. They present various modifications, and are named electrical, magnetic, chemical, cohesive, and temperate energies. These are partly modes of motion, partly modes of attraction: they are specialized manifestations of the general attractions and motions native to matter. The generalized form of attraction we possess in gravitative energy. The specialized forms are the organizing attractions of substances, such as cohesion, chemism, and possibly magnetism. It is the same with motions. The generalized form is the free movement of gas particles; the specialized forms are electricity, and heat as it exists in liquids and solids. But these two modes of motion are differently related to masses. Electricity is an organizing energy. It only

manifests itself through change in the organization, or in the relations of bodies. Its only ready transformation is into heat.

Heat is a disrupting energy. It is the individual energy of the separate particles, and has nothing to do with the organization of molecules into masses; yet it is a generalized condition of motion only as it exists in gases. In liquids and solids it appears to be partly specialized; most probably becoming some form of rotation in liquids and of vibration in solids.

Heat force is neither concerned in the organization of the mass, nor is it closely related to the particle containing it. It is capable of ready transfer from particle to particle, and of ready change in direction.

We may look upon every separate molecule or distinct particle of a solid body as dwelling within a nest of attractions. The fixed organization of the body most probably causes these attractions to become definite in direction, so that it is not improbable that the motion of each particle is confined to a fixed center upon which these attractions converge, through which center it must vibrate, or around which it must rotate.

But the forces acting upon the particle are not alone the attractive energies and the repulsive impacts of contiguous particles. The attractive or gravitative energy of the earth is also a powerful factor in the result. This energy must influence the direction in which the particles move. It is, therefore, one of the various active forces to which this direction of motion must conform.

And gravitative energy is constant in vigor and direction. It does not vary as the forces of the surrounding particles may do. Thus every vibration or other movement of the particle has a vertical component, in response to gravitation, which must exercise a constant and unvarying influence upon the result.

Every particle, in fact, is incessantly falling. What we call a position of rest is really a position of constantly-arrested fall. If the surrounding attractions tend to force the particle towards a fixed point in space, the attraction of gravity tends to force it below the point. Thus it never moves to the exact point required by its contiguous attractions, but to a point nearer the earth, which forms a center of all its attractions, that of gravitation included.

The distance between these two points is the distance to which the particle falls during every vibration. It is arrested at this point by the surrounding attractions, the real ultimate arresting force being the repelling impact of the particles of the supporting substance.

Every downward movement of the particle is thus aided by gravitative attraction. Every upward movement is retarded. These invigorated downstrokes become themselves an element in the problem; they add, by their impacting force, to the descending energy of the particles below them. Therefore the lower plane of particles manifests the combined gravitative energy of all the particles of the mass. This is what we call weight, this energy of impact, produced by gravity, of the particles of every substance upon its support. It constitutes an incessant rain of down-beating particles: they strike downwards with a vigor depending, primarily, upon their own response to gravity; secondarily, upon the gravitative pressure of the particles above them. The support must be strong enough to bear its load, or it will inevitably give way under this fierce and incessant rain. If the support be removed, what follows? The forces surrounding the particle remain the same. It descends in response to the gravitative component of these forces. This descent is not resisted by the surrounding energies, since all the particles descend at the same time from the same cause. The only real resistance to fall is the upward compact of particles occupying the space through which the fall must take place. If this resistance be removed or sufficiently decreased every particle of the mass must simultaneously descend in response to gravity, and the whole mass change its position.

Thus the heat movements of the particles are made to conform in direction by the attraction of the earth, this conformity constituting a movement of the mass as a whole. And this is a regularly increasing movement. As the mass moves its motion constitutes an energy. The motion caused in each instant by gravitation remains the same. But it has a separate effect in every separate instant, and these effects are persistent and constantly accumulate, producing a regularly increasing motion of descent.

Falling motion, then, appears to be a partial specialization of the heat movements of the particles. These movements are made to conform in direction to a certain degree, under the influence of a fixed and persistent attraction. This descent is continuous, whether it be resisted or not. If resisted it cannot accumulate. Each momentary fall makes itself felt as weight by the resisting body; but these momentary falls are each obliterated by a reverse impact, and cannot be added together, constituting an increasing energy of fall. Only when the resistance is removed, and the particles are no longer driven back by impact, does the falling energy manifest itself in a downward movement of the mass.

Thus, when a body falls, part of its heat motion has been transformed, and has become a motion of the mass as a whole. The generalized motion of heat has become partly specialized into motion of the mass. This is readily transformable again into heat; but it can only be so transformed by resistance. It is persistent as mass motion until some resisting energy overcomes it, when it again becomes heat.

And from this fact two conclusions necessarily arise. The first is, that a body whose mass motion is resisted must display an increase of temperature. The conformity in the motion of the particles is broken; they again move individually instead of collectively. Temperature effects appear in consequence.

The other conclusion is, that a body yielding to gravitation, in increasing its mass motion, must decrease in temperature. Its temperature is being converted into another form of force, and cannot continue to display its usual effects. The body grows colder in every direction except that of its mass motion, the movements of the particles being specialized in this direction, and their impacting force partly decreased in all other directions.

The heat thus lost, as heat, is probably regained from the radiations of the matter through which the body moves, so that its sum of forces is increased in consequence of a special transformation of a portion of them.

Where the motion of the body is decreased or increased by gravitation, without radiation of heat from other sources, certain interesting and perhaps important effects must ensue. If a mass be driven upward against gravitation its particles must continue to fall. The downstroke of their vertical component of motion, as caused by gravitation, is constantly more vigorous than the upstroke. The fall of the body is simply masked by its upward motion, and accumu-

lates in the same manner as if the mass was descending. Thus the upward motion is more and more rapidly obliterated, and soon ceases to exist, the mass becoming momentarily at rest. What has become of the mass motion? Evidently there has been a simple change in the character of the motion of the particles. Instead of moving upward more rapidly than they descended, they now move upward and downward with the same vigor. The special mass motion has fallen back into the body, and has become vibratory movement of its particles. It has, in fact, become temperature, and the sum of temperature energy has increased through this loss of mass motion.

If now we apply this idea to the movement of the planetary bodies, some interesting deductions may be made. In the case of a comet moving from the sun we have an exact counterpart of that of a body thrown upward against gravity. The particles of the comet continue to fall toward the sun. These slight falls are masked in the mass motion of the comet, but they slowly consume this motion. They constantly accumulate, precisely as if the reverse motion did not exist. The comet is thus at once moving outward from the sun and falling inward to the sun, and its real motion is the difference between these opposite energies. Its mass motion is, in short, falling back into its substance, and becoming vibratory motion. Eventually the fall increases in vigor until it equals the outward motion of the mass. At this point the comet ceases to remove from the sun. The outward and inward movement of its particles have become equal; the vertical component of their motion through space has become converted into a vibration about a fixed point in space. It has, in fact, become heat motion.

Thus the strange fact displays itself of a rapidly-increasing temperature in the comet, as a necessary consequence of its movement outward from the sun. In its return to the sun the opposite effect occurs. Its vibratory motion is gradually transformed into mass motion. Every new increment of mass motion thus gained is at the expense of the heat vibration, and the temperature necessarily decreases in consequence.

This effect is, of course, masked in its increased reception of radiant heat in approaching, and its rapid radiation into space while leaving the sun. It is in this like a falling body whose lost temperature is regained from the radiations of surrounding matter.

A precisely similar effect must occur in the case of every planet which has an elliptical orbit. The earth, for instance, after passing its perihelion point, begins to move outward from the sun against gravitation; but the fall of its particles toward the sun at once tends to consume this outward movement. The earth possesses really three movements, from whose composition its orbital movements result. One of these is a movement at a tangent to the radius of its orbit. This is resisted by a falling motion toward the sun in response to gravitation. These two energies are exactly balanced; neither can accumulate at the expense of the other, and they result in a circular orbit. But there is a third motion, a vertical vibration in the line of the radius, a vibration of some three millions of miles in extent, each phase of which occupies six months. This vibratory movement has its full effect upon the resultant motion of the earth, changing its orbit from a circle into an ellipse.

But the vertical vibration is resisted by gravitation in its outward phase, and aided in its inward phase. The result is that a portion of the motive energy of the earth is consumed, by the resistance of solar gravitation, during its outward movement. This lost mass motion must fall back into the earth and become a vibration of particles, constituting an increase of temperature. Its inward movement is, on the contrary, aided by gravitation. The mass motion increases at the expense of the temperature energy.

The loss of mass motion in the earth, from this cause, between perihelion and aphelion, is about  $1\frac{1}{4}$  miles, or 6,600 feet, per second. It will consequently not be difficult to obtain an idea of the amount of variation in temperature from this cause. For we know that a mass of water, when arrested after a fall of 772 feet, gains  $1^{\circ}$  F. in temperature from a conversion of its mass motion into heat vibration. Now a fall of 772 feet yields a final velocity of about 220 feet per second. If the loss of this velocity yields water a temperature of  $1^{\circ}$ , the loss of 6,600 feet per second of velocity by the earth should yield it an increased temperature of  $30^{\circ}$  F., supposing its mean specific heat to equal that of water. If the specific heat equaled that of iron the increased temperature would be about  $270^{\circ}$ , and if equal to mercury it would be  $900^{\circ}$ .

We have here a very marked result, but one that is not strikingly evident, from the fact that this lost motion is not an instantaneous arrest, but a gradual arrest extending over six months. The true result, then, is, daily increase in temperature, for every particle of water in the earth of one-sixth of a degree, of  $1\frac{1}{2}^{\circ}$  for every particle of iron, of 5 per cent. for every particle of mercury, and a like result for every other substance in accordance with its specific heat. During the return movement of the earth, from aphelion to perihelion, the opposite effect results. Its mass motion increases, at the expense of its temperature, to an equal degree.

This variation in temperature cannot have any very evident effect at the surface of the earth, where it is lost in the much greater effect of the solar radiations. But in the earth's interior it may possibly produce important results. The variation in the earth's internal temperature, through loss by conduction, is exceedingly minute. But we have here a source of a considerable increase during six months of the year, and a like decrease during the succeeding six months.

These daily variations cannot be lost by radiation, but must accumulate, so that the temperature of internal water must vary  $30^{\circ}$  yearly, of mercury  $900^{\circ}$ , and of other substances in like manner. Although we do not know what results are likely to arise from such an annual variation in temperature, yet it is very possible that these results may be of an important character.

In the case of a planet of short period and great simplicity of orbit, such as we have in the planet Mercury, the effects resulting from this cause must be much greater than in the earth. It, indeed, must produce a marked effect on the surface temperature of Mercury, and an annual variation sufficient to partly neutralize the variations in the amount of solar heat upon this planet.

An interesting conclusion from the hypothesis here advanced is in regard to the simple and natural method in which one mode of motion becomes converted into another. The change from heat vibration into mass motion needs no special machinery or no difficult transfer of energy. Motion seems to be constantly at the command of attraction. The least definite pull in any fixed direction, if unresisted by opposing energy, at once converts heat motion into mass

motion. This latter, in its turn, is persistent until resisted, when it immediately becomes converted into the independent movement of particles.

The change from electricity to heat is probably as simple in its nature. The impelling cause, in all cases, seems to be some variation in attractive conditions, to which the moving particles instantly respond, their modes of motion becoming special results of the attraction.

And as there is but one motion, so there is, in all probability, but one attraction. Gravitation, chemism, and magnetism are probably modes of attraction, as heat, electricity, and mass movement are modes of motion. The different forms which these assume very likely result from the different relations of position assumed by the particles of matter. It is probable, also, that molecules have special relations of position between their constituent parts, and that their outward attractions become specialized in consequence. The relations of position between particles or masses at a distance from each other are general, and their attraction takes the generalized form of gravitation. The relations of position between particles in close contiguity are special, and their attractions become specialized. The modes of motion resulting are in direct response to the mode of attraction, and are readily convertible into each other at every variation in attraction.

As the generalized mode of attraction is gravitation, so the generalized mode of motion is the movement of the gas particle. This is so vigorous in its action as to resist the attracting energies of contiguous particles. Its motion is, therefore, influenced in vigor only through impact, and in direction only through impact and gravitative attraction. It is constantly falling in response to gravity, and constantly rebounding in response to impact. Wherever the resisting impacts are reduced in quantity the gas particles move in greater number, this movement constituting a wind, which increases in force as the resistance to the individual movements of the particles decreases in quantity.

Give the particles an opportunity to strike together with special ease in one direction, and a wind necessarily ensues. A fall, in response to gravitation, only ensues when the particles near the surface are separated by increased temperature, or through some other cause so that their resistance to impact is decreased.

Attraction of gravitation, therefore, has no influence in increasing or decreasing the motive energy of matter. Its only influence is directive. It controls the direction of the motions of particles, so far as its control is not resisted by some other controlling attraction. The direction and mode of motion of the particle, at any instant, is a resultant of all the attractive and repulsive forces acting upon it at that instant, gravitation being simply a constant component of these forces.

The vigor of motion possessed by the particle can vary only in two ways. One of these is by impact, in which the energies of the two impacting particles may become changed, their sum remaining unchanged. The other is by the resistance of attraction. Here the particle loses motion, but gives its lost motion to the attracting particles, which it drags into swifter speed.

Motion cannot die nor be born. It can only be transferred in amount and changed in direction.—*Journal of Science.*

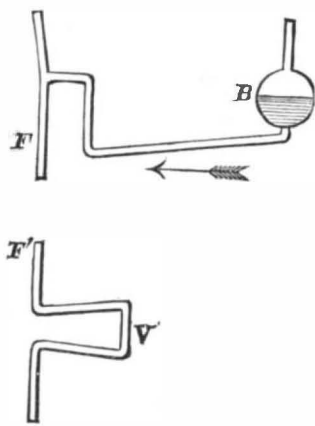
#### ON AN IMPROVEMENT IN THE SPRENGEL PUMP.

By Professor O. N. ROOD, of Columbia College.

IN this notice I propose to indicate very briefly the nature of an improvement that I have lately made in the form of the Sprengel pump, which enables the experimenter easily to obtain a vacuum as high as 800000 or 1000000, reserving the details of manipulation, etc., for more extended notice hereafter.

(1.) The improvement consists, first, in an arrangement by means of which the mercury, instead of being at once introduced into the pump, passes beforehand through an exhausted bulb, B, thus freeing itself in great measure from air and moisture. It afterwards passes through a nearly horizontal tube, finally reaching the fall tube, F, as shown in the diagram.

(2.) The second part consists of what amounts to an almost theoretically perfect fluid valve, which prevents the



air that has passed out of the fall tube from returning into it; this is accomplished by merely bending the fall tube as indicated at V. As for the rest, the pump is contrived so as to be free from stop cocks and grease.

By inclining the pump somewhat, the bulb can be exhausted once for all, as matters can easily be arranged so that when the atmosphere is allowed to enter the pump, the exhaustion of the bulb remains intact.

The action of this pump is very rapid, two hours or less sufficing to reduce the vacuum from 80000 to 1000000, the total capacity of the pump being 100 cubic centimeters.

The exhaustion in these experiments was always accomplished by mechanical, not by chemical means; chemical substances being introduced solely for the purpose of drying the air. In the total absence of all such substances I have obtained a vacuum as high as 800000. The means of measuring these vacua and other details will be given as soon as a set of experiments that are being made on the caliber of the fall tube is finished.—*Am. Jour. of Science.*

#### NAVIGATION OF THE AIR—FLIGHTY ASPIRATIONS.

By FRED. W. BREAREY, Hon. Sec. to the A.S.G.B.

ADVENTITIOUS circumstances sometimes place men at the helm, who, being ignorant of all duties save one, assume the possession of all, upon the faith of having steered wisely in times past. So long as he retains the helm he will probably retain the confidence of his passengers; but let him act upon his assumption of knowledge in another sphere, and his ignorance may entail contempt. The human barnacles which fastened themselves upon the ship called Progress—sometimes the vehicle for the conveyance of such passengers as gas, lightning, steam on rail, etc.—have, it must be acknowledged, been nearly rubbed off, so rapidly has the Progress rushed through the waves of success.

So the helmsman has learned at last to stick to his tiller and observe with respect, among other vessels, one freighted with such a cargo even as aerial navigation. I have preserved an old barnacle. It will be found in the *Quarterly Review* for the year 1819. It was stuck to a ship that was being freighted with ideas for a railway.

"We are not partisans of the fantastic projects relative to established institutions, and we cannot but laugh at an idea so impracticable as that of a road of iron upon which travel may be conducted by steam. Can anything be more utterly absurd or more laughable than a steam-propelled wagon, moving twice as fast as our mail coaches? It is much more possible to travel from Woolwich to the Arsenal by the aid of a Congreve rocket."

Don't you see that this barnacle was stuck upon a passing ship by the helmsman who quitted his tiller, and thereby manifested his intense ignorance?

This greatly dead and much-stained editor—as we may call him—may now be pictured laughing uproariously in presence of an enlightened audience, who look upon him with grave pity that so intelligent a man should be making such a humiliating exhibition of himself.

I am afraid that my remarks are not very respectful toward those editorial commentators who are apt to limit the aspirations of science to their own conception of what is possible. What, then, can be said of a barnacle stuck on with the authority of an acknowledged scientist such as Dr. Lardner, who, in his "Cyclopaedia" of the edition of the year 1836, under the head of Hydrostatics—which is too lengthy here to quote in full—gives his reasons for asserting the impracticability of accomplishing, with any advantage, the then discussed employment of steam for ocean-going ships? He says: "But we have here supposed that the same means may be resorted to for propelling boats on a canal, and carriages on a railroad. It does not appear hitherto that this is practicable." He says again: "The friction of a carriage on a railroad moving 60 miles an hour would not be greater than if it moved but one mile an hour (!); while the resistance on a river or canal, were such a motion possible, would be multiplied 3,600 times." By friction he means resistance, because in another place he says: "The resistance on the road, instead of increasing, as in the canal, in a faster proportion than the velocity, does not increase at all." So that we have it, upon the dictum of Dr. Lardner, that a wind blowing upon a surface at 60 miles an hour—the conditions are only reversed—produces no greater pressure than if it were blowing with a velocity of but one mile an hour. In each assertion of the rate of resistance Dr. Lardner was intensely wrong.\*

The late Sir Wm. Fairbairn became a member of the Council of the Aeronautical Society of Great Britain. Now the supporters of this society entertain two diverse opinions, but both parties aim at macadamizing the aerial highway so as to make it subserve the purposes of transit. To the ordinary observer there is only one way. It is that which has been brought hitherto under his observation. Sir William was a balloonist. The balloon is a fact beyond dispute, so that all we have got to do, says he, is to propel it. It is given only to the man who has made its propulsion a study, and has been left gazing regretfully after the money which he has expended in his vain attempts after utility, to estimate rightly the opinions of that section which may be designated by the title "Gravitites," in opposition to that of "Levitites." The Gravitites contend that the object of aerial transit will be effected by opposing the resistance of the air to the action of gravity; that while gravity is a constant force the resistance of the air is under control, so that it can be made subservient to the support of any weight, the surface of which is sufficiently extended, and propelled with the requisite velocity. For instance, a sheet of stiff cardboard can be propelled horizontally by means of a finger loosely placed at the rear edge. By increasing the velocity beyond the necessary requirement, the cardboard or any plane surface will depart from the horizontal in an upward direction, in obedience to the increased resistance of the air; and the rate of velocity being increased, it will turn over toward the hand.

It is the desire of some workers to obtain support in the air by extending the area of such surface and propelling by screws; upon a small scale this has been proved practicable. Models of dimensions and weight capable of being launched from the hand are very effective; but when those of a larger size which cannot be thus manipulated are attempted to be put to practical use, a preliminary run upon the ground is necessary, and hitherto the velocity under those conditions—being retarded by friction, although upon wheels—has not been attainable. This velocity is an absolute condition, so as to enable the apparatus to meet with that atmospheric resistance which would force it to leave the ground and continue its flight in the air. Certainly no rails have yet been laid down with the object of reducing friction, but the aid of an incline has been enlisted without effect. No experiment worthy of the object sought to be attained has yet been attempted by any one holding the opinion that eventual success lies in this direction.

My idea of a satisfactory trial would be the employment of great power, large and strong surface, and as frictionless a road as could be devised; for instance, upon a straight line of rail.

The interest which is attached to many scientific subjects is, however, absent in this, so far as respects the public, and among scientific men generally. So little understood are the principles upon which the hope of flight is founded that it is well known that if a discussion is started in any scientific periodical there are scarcely any instructed minds to follow it up, and the subject dies away almost from its birth, eliciting nothing but worn-out ideas, and always drawing out the suggestion that gas should be used to take off the

\* A train of carriages and engine weighing 900 tons would meet with a resistance of 3870 lb. at 10 miles an hour, which would be increased to 12,470 pounds at 60 miles an hour, irrespective of its advance against the air.

dead weight. This suggestion is as absurd as the converse one of using an aerial machine to propel a balloon.

Those who saw poor De Groof when he left Cremorne Gardens, in the hour of his death, dangling from the balloon in his comparatively fragile framework, will call to mind the diminutive appearance of the apparatus compared with the bulk of the balloon. To take off the dead weight would require as large a balloon as usual, but still of such a capacity as would dwarf any attached apparatus, and it is quite certain that if the apparatus had any power over the balloon it would not be exerted to propel it, but to drag it at the stern.

So the earnest workers and students are a very small minority. For want of guidance and the dissemination of fundamental facts, the result of experiment, many have been working in the dark, and, doubtless, encouraged by the general ignorance, many pompous announcements have been made during the present century which have raised false hopes, and the reaction has had a most injurious effect upon the study of aerology with a view to the sustentation of heavy bodies. The fact is that a triumph over the difficulties of aerial transport presents to the mind which can grasp the future such an Aladdin-lamp romance that the individual is inclined at once to self-depreciation, and to say that "not for me is such a fate in store."

Some such effect has operated to produce apathy as is recorded by Stewart in his "History of the Early Days of the Steam Engine," as follows: "Every miscarriage thus added to the obstacles which at all times impeded the introduction of improvements, and the abortive attempts of ignorant and designing men were urged as reasons for disregarding the inventions of more honorable and meritorious individuals."

I cannot leave the subject of plane propulsion without reference to a late attempt by Mr. Lenfield, of Winchester, whose design was suspended from the skylight of the large room at the Society of Arts, at a general meeting of the Aeronautical Society of Great Britain, in 1879. This formidable-looking affair was 40 feet long by 18 feet wide, attached to a framework upon four wheels, the whole rising about 15 feet; 300 feet of canvas was stretched upon an upper frame, and below this and upon the wheel-supported platform the operator stood with his feet upon treadles, by which he worked two fan blades, 9 ft. 6 in. x 2 ft. 9 in., in front of the apparatus. By this he obtained about seventy-five revolutions a minute, which enabled him, upon a macadamized road, to attain a speed of about 12 miles an hour—totally insufficient, however, to enable him to obtain any fulcrum upon the air, for its weight including himself was 304 lb. Nor was a subsequent attempt down an incline, by which he gained a speed of about 20 miles an hour, any more suggestive of aerial support.

In order to give some idea of the solid support which a body of air is calculated to afford to any surface passing over it in a horizontal direction, and which can be increased or diminished according to the angle in which it is propelled, I will quote some suggestive remarks of Mr. Glaisher, made at one of the Aeronautical Society's meetings, upon the subject of the captive balloon then lately exhibited at Chelsea by Mr. Giffard: "That balloon has spoken to me trumpet-tongued. All my life I have been accustomed to weigh the air by grains. In winter I find the cubic foot to be about 5.0 grains, and in summer 20 or 30 grains less. When we took grains we thought the airtight. When I saw the other day that the balloon would lift 16 tons or more, and consequently that the weight of air displaced by the balloon must be of greater weight, there must, I think, be something for members of the society to work upon. When you see that balloon as a small ball only, yet know that air to so many tons weight was displaced by it, surely it held out the hope that some means would be found to solve the problem of aerial navigation."

The method to be adopted to attack this thin though weighty medium, so as to wrest from it the means of support in safety, and the mode of propulsion, is of course the subject of discussion and of some difference of opinion among experimenters.

Sir William Fairbairn stuck another barnacle on the good ship Progress when he stated as his opinion, in a paper read at Stafford House, that "Man was never meant to fly; that if the Almighty had intended him to do so He would have given him wings, and that the unalterable laws of nature were against us." Now it is still a disputed point whether a man possesses the power to manipulate anything in the nature of wings so as to afford him support and propulsion. The few experiments which have been made in this direction are not sufficiently authenticated for us to deduce any reliable data from them.

Without wishing to dogmatize and especially without laughing like the writer in the *Quarterly Review* before referred to, I hold, with the Duke of Argyll, the opinion expressed in his own words when occupying the chair at one of our meetings: "I think it quite certain that if the air is ever to be navigated it will not be by individual men flying; but it is quite possible vessels may be invented which will carry a number of men, and the motive force of which will not be muscular action." I limit the application of these words to the action of wings by man's muscular efforts. I wish I could think that the late Sir Wm. Fairbairn had made the same reservation.

The laws of nature, fortunately for us, are unalterable, and as often as they have been questioned as to their adaptability for aerial support they have returned a favorable reply.

It may be conceded that a properly constructed plane surface, propelled against the air, will meet with sufficient resistance to enable its course to be deflected upward at an incline obedient to the angle at which such plane is driven, and sooner or later according to velocity.

An experiment is recorded in one of our annual reports which was made by M. de Louvrie. To a little carriage he fixed a thin plane surface the angle of which he could alter at will. Placing this machine upon a level spot, he drew it along horizontally by means of a cord which was fastened to a dynamometer, and increased the speed until the machine left the ground, suspended by the pressure of the air on the plane.

In a large machine such as Mr. Linfield's, where the balance cannot be adjusted with that facility which is readily attained with models launched from the hand, the difficulty will commence with the first tendency to rise. Supposing him to be unable to attain sufficient velocity with a new arrangement which he is constructing, his next step, I presume, would be to attach it to an engine on a railway, and repeat upon the largest scale the experiment just recorded. Now, in such cases the laws of nature are greatly in our favor, as proved by some experiments initiated by the society to which I have the honor to act as honorary secretary. It remains as a condition—hitherto unfulfilled—that man must attain to perfection in his appliances before he can