

greenheart compared with that of other kinds of wood used.

You will find inclosed a sketch giving the form and dimensions of the immersed parts of these piles.

The result of the examination of these piles (which were 0.250 m. square when they were put down) was:

1. The pile of greenheart showed no traces of the borer worm (taret) or deterioration of any kind.

2. The entire submerged part of the oak pile was very much injured by the worm, and it had penetrated so far into the thickness of the wood as to reduce the part affected to a section of 0.180 m.  $\times$  0.180 m. at A in the annexed sketch, and to 0.200 m.  $\times$  0.200 m. at B.

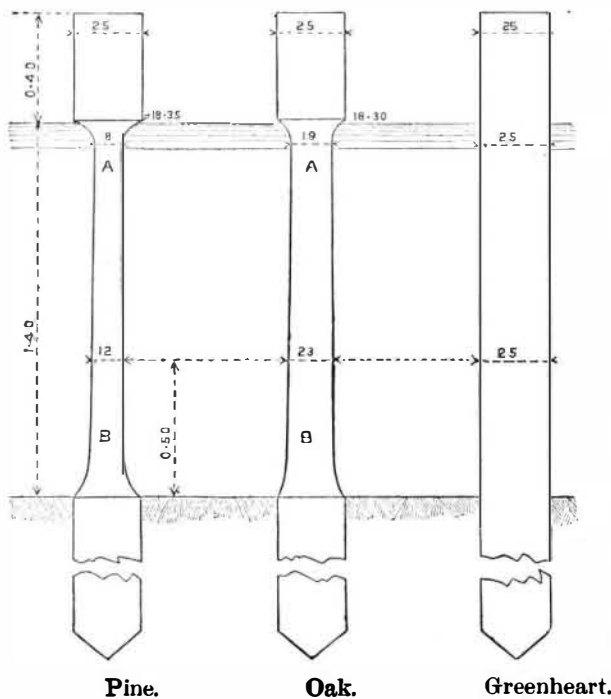
3. The pile of pine was so eaten by the worm as to be useless. The affected part was reduced at A to a section of 0.070 m.  $\times$  0.070 m., and at B to 0.140 m.  $\times$  0.140 m.

These experiments have, therefore, demonstrated that the wood of the greenheart offers much greater resistance to the worms than that of the oak or pine.

In order to determine whether it would be advantageous to substitute the greenheart for oak and pine in submerged structures, we would have to know the cost per cubic meter delivered at Port Said, so as to be able to compare this price with the price of oak and pine.

Believe me, sir,

LAMASSON,  
Chief Engineer of the Company.



The following detailed information respecting the characteristics and uses of greenheart timber may be usefully appended:

"The greenheart is an exceedingly valuable tree, yielding timber of perfectly straight growth, of from 24 to 50 feet in length and 12 to 24 inches square.

"The wood is of a dark greenish or chestnut color, the center part being often nearly black; it, however, varies slightly, and the darker kinds are considered the best in quality. It is clean and straight in the grain, very hard and heavy, tough, strong and elastic. In a transverse section it resembles a cane in being very full of minute pores, and the concentric layers are only in rare instances distinguishable.

"The heartwood is considered very durable, and is generally believed to be proof against the ravages of the worm when used for piles or other purposes under water, a property which would greatly enhance its value if it could be relied upon; but its immunity under such circumstances is thought to be doubtful.

"Of the durability of the greenheart timber, we have had sufficient evidence in the large stock of this wood kept in the royal dockyards, where it stood the test of many years' exposure to the weather without being in any but the least degree affected by it. At Woolwich, the only place, I believe, where any attempt was made to protect it for preservation, the experiment to some extent failed, the ends of the logs splitting open rather more in the covered stacks than in those which were left exposed, while, in other respects, there was absolutely no difference observable between the two parcels.

"It is characteristic, however, of the greenheart timber to split in this way, and to open clean across the pith in seasoning, there being frequently two such splits crossing each other at nearly right angles, and cleaving the log, at the end, into four segments; but these do not usually extend more than two or three feet up from the end.

"This serious defect is, to some extent, compensated for by the fact that the logs do not split and form deep shakes along the sides in the seasoning, as do most other woods; so that there is not, after all, more than the ordinary amount of waste in the conversion of this kind of timber. Further, it is remarkable for its freedom from knots, and also for its general soundness, the only defect, beyond the splitting of the ends, before mentioned, being a cross fracture of the longitudinal fibers, which is occasionally seen, but can seldom be detected before the log is under conversion.

"The alburnum, or sap of this wood, is of a dark greenish color, and differs so little in appearance from the heartwood, that it is often difficult to distinguish the one from the other. In quantity it is usually excessive, frequently amounting to a fifth, and sometimes even to a third, of the diameter of the tree. Few people, however, regard it when appropriating this timber to works of construction.

"Owing to the difficulty of distinguishing the sap, many either dispute its presence altogether, or assert that if it exists it may be safely employed the same as the sap of *lignum vitæ*; this is, however, by no means certain, as I have found that if it is placed in any damp or imperfectly ventilated situation, it decays much

sooner than the heartwood; but if used under more favorable circumstances its durability is very great.

"In connection with this question a merchant and importer of greenheart timber said upon one occasion, when we had a parcel under survey, that he was confident a certain log had no sap wood upon it, for if it had, it would be liable to the attack of a small worm, but that the worm would not touch the heartwood. The log referred to was accordingly tested by cutting off a thin cross section, and upon examination of the piece, there were found in it several marks or traces of the worm, which had penetrated to the depth of 2 to 3 inches; the heartwood, or duramen, had not, however, been touched. The gentleman at once admitted that, with such evidence, he would take it as conclusive that there was sap to the depth of 3 inches on the log, but that its appearance had entirely deceived him.

"The case was no doubt exceptional, as the worm is very seldom seen in this wood.

"Greenheart is extensively employed in shipbuilding for keelsons, engine bearers, beams, shelf pieces, etc., and for planking. It is also used for piles, and many other purposes, but its application to the domestic arts is somewhat limited by its great weight.

"The strength of this wood exceeds that of most others, whether it be tried by the transverse or tensile strain or by a crushing force in the direction of its fibers. Tried by the latter process, it exhibits a peculiarity unshared, I believe, by any other timber except Sabicu. It bears the addition of weight after weight without showing any signs of yielding; and, when the crushing force is obtained, it gives way suddenly and completely, with a loud report, nothing being left of the pieces but a loose mass of shapeless fibers.

"The greenheart timber is not usually hewn in the perfect manner that teak, mahogany, and many other woods are when prepared for shipment to the markets of this country, but comes from Demerara only partially dressed, a great deal of waste being left upon the angles. The butts are also almost invariably left with the snapped ends, as prepared for drawing out of the forest, instead of being cut off square. Its form should therefore be considered with the price quoted per load, as it will not compare favorably with well-squared timber."—*Timber and Timber Trees*, Laslett, 1875, p. 151.

#### DO PLANTS THINK?

UNDER this heading an interesting paper recently appeared in the *Newcastle Weekly Chronicle*. The freaks and marvels of plant life are subjects which have engaged the attention of the botanists for many years, and though their investigations gave rise to much speculation, some interesting facts have also been ascertained. Some of these are summarized in Dr. M. C. Cooke's book on this subject. A story of one of the most interesting freaks of vegetable life is told by Mr. Edward Cooper, of Santa Barbara, California. On reading this story one may well ask, Do plants think? Mr. Cooper considers they do, and he puts forward reasons for thinking so. Through Mr. Cooper's garden there ran some years ago a sewer made of redwood timber. This sewer was again cased by an outside sewer, which in course of time became partially decayed. Across the sewer there was built a brick wall many feet in height, and in such a way that it was pierced by the inner sewer, which it enclosed tightly, while the outside sewer ended abruptly against the wall. As already stated, the outside casing had in course of time become decayed, and an eucalyptus tree, standing some sixty feet away, had taken advantage of this, and sent one of its roots to the coveted spot in as direct a line as possible. Here the root entered the outside sewer, and followed its course as far as it could. At last it came to the wall, which shut off its course, the inner sewer being perfectly tight. But on the other side of the wall the sewer and its double casing continued, and the eucalyptus tree evidently knew how to get there. Some three feet high in the brick wall there was a little hole, one or two inches in diameter, and this the eucalyptus tree appeared to be aware of, as its root began to climb the brick wall and face the sun and wind until it found the hole, through which it descended on the other side, entering the sewer again and following it along as formerly. Taking this statement as being accurate in every respect, we may well put the questions asked by the writer of the paragraph: "Was ever such instinct known before, or are similar traits in plants of daily occurrence without our knowledge? How did the tree know of the hole in the wall? How did it know that the sewer was on the other side? Did it smell, and if it did, how could it direct the roots to go and find the place with such precision?" There is, of course, another explanation of this curious phenomenon: the roots of any plant grow always unerringly in the direction of its food, just as those of the eucalyptus tree did.

The question arises, What is thought? What is meant by thinking? A modern writer has remarked that thought is the result of nature—of the outer world—first upon the senses—those impressions left upon the brain as pictures of things in the outward world—and these pictures are transformed into or produce thoughts, and as long as the doors of the senses are open thoughts will be produced. Do plants think in this sense? The botanist examines the structure of a plant and ascertains its ways of living, how its blood—the sap—circulates, and how it breathes; but behind these things he has failed to penetrate, and is possibly scarcely prepared to regard the plant as a sentient being. Whoever looks at anything in nature, thinks. Whoever hears any sound, or any symphony, no matter what—thinks. Whoever looks upon the sea, or on a star, or on a flower, or on the face of a fellow-man—thinks, and the result of that look is an absolute necessity. The thoughts produced depend upon the brain, upon experience, upon the history of one's life. Can a plant be said to think and be affected in this manner?

In their observation of the gyrations of plants, in the case of the heliotropes or sunflowers, which conspicuously turn themselves toward or from the sun, in the action of twiners and climbers, and of sensitive plants in their sleep, their methods of dispersion, of mimicry and luminosity, we see plants exhibiting faculties coming very near to what we term reasoning; but they may do all this in a merely mechanical way,

and without being actuated by anything like thought directing these movements.

It is a hasty conclusion to assert that brain is essential to the evolution or quality of thought. Thought is a necessity, and thought depends upon the brain. Each brain is a kind of field where nature sows with careless hands the seeds of thought. Some brains are poor and barren fields, producing weeds and thorns, and some are like the tropic world where grow the palm and pine—children of the sun and soil. But it is asked, Does a man or an animal think when he or it does one thing or declines to do another? Volition would seem to be surely involved in the process of choice. We know that plants and animals persistently decline to do certain things, and persistently do others, as if by the power of volition. What moved the eucalyptus of Santa Barbara to leave the redwood covering of a sewer and creep to a hole in a brick wall three feet away, go through it, and again turn for sustenance to the sewer? Did man or animal ever discover finer sagacity in self-preservation?

As bearing upon this subject, we have the benefit of another testimony, the writer stating: "In the yard before the window near which I sit, is a fine healthy plane tree, which springs from the ground about nine feet from the tall gable of a coachhouse and hayloft, and higher than the gable; it has grown to the height of from forty to forty-five feet from the root. On every side but from that toward the wall issue branches equally as long as on the other sides, but they deliberately turn round both the corners, but not a twig ever touches the gable." This characteristic can, no doubt, be accounted for by the natural tendency of the branches to seek the light; but the why of the act of volition is doubtless hidden with much of the silent mystery of the plant's nature.

This is an exceedingly interesting subject, and it is to be hoped the publication of the foregoing will have the effect of leading to some interchange of opinion in reference thereto. Gardeners are often closely observant men, and they are doubtless in possession of the knowledge of incidents which may throw additional light upon the problem—Do plants think?

R. D.

#### INTERNATIONAL CONFERENCE ON AERIAL NAVIGATION.\*

By O. CHANUTE.

IT is well to recognize from the beginning that we have met here for a conference upon an unusual subject; one in which commercial success is not yet to be discerned, and in which the general public, not knowing of the progress really accomplished, has little interest and still less confidence.

The fascinating, because unsolved, problem of aerial navigation has hitherto been associated with failure. Its students have generally been considered as eccentric, to speak plainly, as "cranks," and yet a measurable success is now probably in sight with balloons; a success measurable so far that we can already say that it will probably not be a commercial one; while as to flying machines proper, which promise high speeds, we can say that the elements of an eventual success, the commercial uses of which are not yet very clear, have gradually accumulated during the past half century.

The truth of these assertions, which will be justified further on, seems to indicate that it is not unreasonable for us as engineers, as mechanics, and as investigators to meet together here in order to discuss some of the scientific principles involved and to interchange our knowledge and ideas.

The present is, I believe, the third international conference upon aerial navigation. The second took place in Paris in 1889, and a fourth is projected to take place in that city during the exposition of 1900.

The conference of 1889 undoubtedly forwarded the possible solution of the problem, by making the public aware that a number of sane men were studying it in various parts of the world, by making these men acquainted with each other's labors, and by disseminating information concerning the scientific principles involved, the mechanical difficulties to be surmounted, and the practical details of aerial construction generally. Probably as a consequence of this, very considerable advance has been made during the last four years, as will be indicated hereafter, and a number of promising proposals are now in progress of experiment and development.

We may fairly expect similar results to follow from the present conference. We may hope to collate here considerable knowledge concerning the scientific principles involved, to gain information concerning the latest researches, and to establish some concert of action.

Indeed, we shall begin our proceedings with the presentation of a paper by Prof. Langley concerning what may be said to be the exposition of a new natural law, hitherto but dimly suspected, which seems to hold out promise of important consequence.

We neither expect nor desire the presentation here of new projects for navigable balloons or for flying machines. We have endeavored to secure instead the statement of general principles and of the results of actual experiments; as facts and positive knowledge are deemed more instructive than projects or speculations.

Success, when it comes, is likely to be reached through a process of gradual evolution and improvement, and the most that we can hope to accomplish at present is to gain such knowledge of the general elements of the problem as to enable us to judge of the probable value of future proposals, both as mechanical and as commercial enterprises.

More important still, we may, perhaps, help to enlighten a number of worthy but ill-equipped inventors who are retrying old experiments, with no proper understanding of the enormous mechanical difficulties involved.

As a preliminary to our proceedings it will probably be interesting to you to have a brief survey of what has already been accomplished, both with balloons and with flying machines, and of the advance which has been achieved since 1889.

\* Presidential address delivered at the World's Columbian Exposition, Chicago, 1893.

As regards navigable balloons, the latest reliable information is probably contained in an interesting and carefully prepared paper, read by Mr. Soreau, C.E., before the French Society of Civil Engineers, in February last, and discussed at the April meeting of that society.

You know that it has been abundantly proved that elongated balloons of large size can be made sufficiently stiff by internal gas pressure to stand driving at low velocities. The best speed hitherto obtained in any public trials has been fourteen miles per hour, which is quite insufficient to stem the wind upon any but rare occasions.

This speed was achieved by Commandant Renard, of the French Military Aeronautical Department, in 1885. The balloon was 165 ft. long and 27½ ft. in diameter, carrying an electric motor weighing 1,174 lb., which developed nine horse power. The motor, therefore, weighed 130 lb. per horse power.

Now the French technical papers announce, and Mr. Soreau confirms, that during the past winter Commandant Renard has been constructing a new war balloon, 230 ft. long and 42½ ft. in diameter, which is provided with a new motor, said to be of 45 horse power and to weigh, with 10 hours supplies, between 2,640 and 3,080 lb., or at the rate of about 66 lb. per horse power. With this apparatus and with a screw some 30 ft. in diameter, it is said that Commandant Renard expects to obtain a speed of 24½ miles per hour, and this will enable him, for about three-quarters of the days in the year, to stem the winds that blow.

Granting that the statements made about the motor are true (and there is nothing improbable about them, as we shall presently see), and also that the motor (the details of which are kept secret) shall not break down upon trial, I see no good reason to doubt the attainment of the speed estimated, and we may learn any day that it has been performed; although it is understood that the French authorities are maintaining such secrecy as they can concerning this new war engine.

But the Germans also, as well as several other European nations, are said to be in possession of navigable war balloons, and should war break out in Europe (which heaven avert), we might be very soon made aware of the fact that speeds of twenty-five miles an hour are practicable.

I have no doubt about it myself; but the attainment of this moderate speed requires very large and, therefore, costly balloons, which carry very few passengers, and it is clear that while such craft may be justified by the exigencies of war, they cannot compete, commercially, with existing modes of transportation.

The difficulty with navigable balloons is that they must be of very great dimensions for even moderate speeds and very light useful loads. As the cubic contents of the gas bag increase at a higher ratio than the surface of its envelope, the relative lifting power increases with the size, and, therefore, a more powerful motor can be taken up, and more speed attained, but we soon reach the limits of practicability.

The new French war balloon is 230 ft. long (as large as a lake steamer), and it will carry but three or four passengers, at twenty-five miles an hour, so that it is difficult to conceive how, if they be made of sufficient size to carry a score of passengers, such enormous and frail craft can be handled, housed, or operated without peril of casualty or disaster.

The conditions as to resistance, lifting power, propellers, and motors are now pretty well known, the speeds can be calculated with approximate accuracy, and, while improvement can doubtless be achieved in the energy of the motor, in the efficiency of the screw, and especially in the form of the navigable balloon to diminish the resistance, it may be affirmed with confidence that railway express train speeds cannot be attained with balloons of practicable dimensions. They may be used for war purposes, or for exploration, but while we may say that the balloon problem is approximately solved, we may also say that the solution does not promise to become a commercial success, or to yield a large money reward to inventors.

With artificial flying machines proper, should a practical one eventually be developed, very much higher speeds may be expected. The pigeon flies at 60 miles an hour, the duck at 90, the swallow at 125, and the martin is said to flash through the air at something like 200 miles an hour. Professor Langley has lately shown that, within certain limits, high speeds through the air will be more economical of power than low speeds, and recent advance in light steam engines seems to have reduced them to a less weight per horse than is generally thought to obtain with the motor arrangements of birds. It seems, therefore, not unreasonable to entertain the hope that man may eventually achieve a mechanical success (if not a commercial one) in the attempt to compass a mode of transportation which so strongly appeals to the imagination, and that it may result in greater speeds than pertain to our present journeyings.

The mechanical difficulties in obtaining safe support from so intangible a fluid as air are, however, so great that men would long ago have given up the attempt if it had not been for the birds. But then there are the birds, and some of them, at least the sailing birds, concerning which you will hear something in some of the papers to be read here, seem to be able to soar indefinitely upon the wind with no muscular effort whatever, so that the argument that has been made that man cannot hope to float his greater weight than theirs upon the air would seem not to be well founded.

But, as already stated, the mechanical difficulties are very great, and it is not surprising that they should have deterred many men competent to advance the solution of the problem from considering it at all, and that it should have mainly been left in the hands of the more imaginative and ill-informed inventors, who, with imperfect knowledge of the elements of the problem, believe that success is to be achieved through a single happy thought.

It is a mistake to suppose that the problem of aviation is a single problem. In point of fact, it involves many problems, each to be separately solved, and these solutions then to be combined. These problems pertain to the motor, to the propelling instrument, to the form, extent, texture and construction of the sus-

taining surfaces, to the maintenance of the equipoise, to the methods of getting under way, of steering the apparatus in the air and of alighting safely. They each constitute one problem, involving one or more solutions, to be subsequently combined, and these are the elements of success already alluded to as having gradually accumulated, which I propose to pass in review, more particularly to appreciate what has been accomplished since 1889.

First, as to the air resistances and the support to be obtained from its inertia, we have the magnificent labors of Professor Langley, published in 1891, showing by careful experiments that something like 200 pounds can be sustained in the air by the exertion of one horse power. One-half of this weight has already been supported per horse in some experimental machines.

Then, as to the motor. Mr. Maxim has recently announced that he has constructed two steam engines of 300 horse power, which, with the engine proper, the boilers, pumps, generators, condensers and the weight of water in the complete circulation, weigh but eight pounds to the horse power.

With respect to the propelling instrument, Mr. Maxim has, since 1889, made a great many experiments with aerial screws. He finds, like Commandant Renard before him, that some forms are very much more effective than others, so that the coefficient of the efficiency, which was less than 35 per cent. in the earlier aerial serial screws, may now be said to be at least double this amount.

On the other hand, Mr. Hargrave, who now has built and experimented some eighteen different flying machines, all of which fly, says that he has obtained equal propulsive effects from screws and from beating wings, although he rather prefers the latter. A paper from him, giving the results of his latest experiments and describing his steam engine and boiler, which weigh only 10.7 pounds per horse power, will be submitted to this meeting.

As to the best form, extent, texture, and construction of sustaining surfaces, there is yet considerable uncertainty, but there will be submitted here two papers upon materials of aeronautical construction, one by Professor Thurston, and the other by Mr. Grosland Taylor, which are well calculated to advance knowledge on this subject, while the experiments of Mr. Phillips in England, a few months ago, have shown that with peculiarly shaped blades of wood, about 72 pounds per horse power can be supported in the air.

The equipoise is, in my judgment, one of the most important problems yet to be solved in aviation. No success is to be hoped for unless the apparatus is stable and safe in the air, safe in starting, in sailing and in alighting. Three quarters at least of past failures can directly be traced to lack of equilibrium. This problem seems to be in process of solution, and I may mention in this connection that during the summers of 1891 and 1892, Mr. Lilienthal, of Berlin, has been gliding downward through the air, almost every Sunday and sometimes on week days, upon an aeroplane with which he expects eventually to imitate the soaring of the birds, when he has learned to manage it safely.

Several of the papers to be read here propose various methods of first acquiring this necessary skill, for first learning to fly under safe conditions before venturing to launch forth in the air. This bird science seems to be the first requisite, for safety is indispensable, and it may not be secured in free air until skill has been acquired in handling a machine.

The problems of starting up into the air, of steering and of alighting safely upon the ground, cannot yet be said to be in process of solution. Various methods have been proposed for getting under way, the principal of which have been to gain speed upon the ground, or to get a lifting action from rotating screws, but neither has as yet been practically demonstrated as quite practical upon a working scale.

For steering it has generally been proposed to employ two rudders, one vertical and one horizontal, but it yet remains to be known whether they will prove quite effective under the varying circumstances of flight.

The lighting upon the ground is likely to prove the most difficult and dangerous of the problems to be solved. It has been much too little considered by would-be inventors of flying machines, and may long prove a bar to the success of such apparatus; for nothing but direct experiment, and that of a perilous kind, will determine how this operation can be successfully performed.

I hope, however, that you will agree with me that some of the elements of success have gradually been accumulating, and that there has been real, substantial advance within the last few years. There is still much to be done, but a number of experimenters have each been working on one or more of the several problems involved, and they have made it more easy for others to forward the general solution still further.

From this brief review of recent progress it would appear less unreasonable than it seemed a few years ago to hope for eventual success in navigating the air, and it may now be reasonably prudent to experiment upon a small scale, particularly if the inventor does so at his own expense, for the chances of commercial success seem still too distant to invite others to engage in the actual building of a flying machine, unless they do it with the understanding that they lose their money. This is the course which has thus far been followed by the three or four experimenters who now seem in the lead, and it may be long before they achieve such success as fairly to warrant them in proceeding to the construction of a full-sized machine.

In any event, without concerning ourselves with the possible commercial uses of such apparatus, we may hope here to advance knowledge upon this interesting problem, and to be of service to those ingenious men who are seeking for its mechanical solution.

PIXOL is a water-soluble form of wood tar, prepared by warming together three parts of tar and one part of green soap, and gradually adding three parts of a 10 per cent. solution of potash. It is a brown, clear, thick fluid and not greasy in water solutions nor caustic, and found valuable for the sterilization of cultures of bacteria, from which it is argued that it will prove a good disinfecting agent.

## THE END OF OUR WORLD.

By CAMILLE FLAMMARION.

THE following article by Camille Flammarion is from the New York Herald, from advance sheets of the *Cosmopolitan Magazine* for August, and presents an interesting forecast of the end of the world, based on scientific principles.

The last habitable regions of the globe were two wide valleys near the equator, the basins of dried-up seas, valleys of slight depth, for the general level was almost absolutely uniform. No mountain peaks, ravines, or wild gorges, not a single wooded valley or precipice was to be seen; the world was one vast plain, from which rivers and seas had gradually disappeared. But as the action of meteorological agents, rainfall and streams, had diminished in intensity with the loss of water, the last hollows of the sea bottom had not been entirely filled up, and shallow valleys remained, vestiges of the former structure of the globe. In these a little ice and moisture were left, but the circulation of water in the atmosphere had ceased, and the rivers flowed in subterranean channels as in invisible veins.

As the atmosphere contained no aqueous vapor, the sky was always cloudless and there was neither rain nor snow. The sun, less dazzling and less hot than formerly, shone with the yellowish splendor of a topaz. The color of the sky was sea green rather than blue. The volume of the atmosphere had diminished considerably. Its oxygen and hydrogen had become in part fixed in metallic combinations, as oxides and nitrides, and its carbonic acid had slowly increased, as vegetation, deprived of water, became more and more rare and absorbed an ever-decreasing amount of this gas. But the mass of the earth, owing to the constant fall of meteorites, bolides and uranulites, had increased with time, so that the atmosphere, though considerably less in volume, had retained its density and exerted nearly the same pressure.

Strangely enough the snow and ice had diminished as the earth grew cold. The cause of this low temperature was the absence of water vapor from the atmosphere, which had decreased with the superficial area of the sea. As the water penetrated the interior of the earth and the general level became more uniform, first the depth and then the area of seas had been reduced, the invisible envelope of aqueous vapor had lost its protecting power, and the day came when the return of the heat received from the sun was no longer prevented. It was radiated into space as rapidly as it was received, as if it fell upon a mirror incapable of absorbing its rays.

Such was the condition of the earth. The last representatives of the human race had survived all these physical transformations solely by virtue of its genius of invention and power of adaptation. Its last effects had been directed toward extracting nutritious substances from the air, from subterranean water, and from plants, and replacing the vanished vapor of the air by buildings and roofs of glass.

It was necessary at any cost to capture these solar rays and to prevent their radiation into space. It was easy to store up this heat in large quantities, for the sun shone unobscured by any cloud and the day was long—fifty-five hours.

For a long time the efforts of architects had been solely directed toward this imprisonment of the sun's rays and the prevention of their dispersion during the fifty-five hours of the night. They had succeeded in accomplishing this by an ingenious arrangement of glass roofs, superposed one upon the other, and by movable screens. All combustible material had long before been exhausted; and even the hydrogen extracted from water was difficult to obtain.

The mean temperature in the open air during the day time was not very low, not falling below 10°. Notwithstanding the changes which the ages had wrought in vegetable life, no species of plants could exist, even in this equatorial zone.

As for the other latitudes, they had been totally uninhabitable for thousands of years, in spite of every effort made to live in them. In the latitudes of Paris, Nice, Rome, Naples, Algiers, and Tunis all protective atmospheric action had ceased, and the oblique rays of the sun had proved insufficient to warm the soil, which was frozen to a great depth, like a veritable block of ice. The world's population had gradually diminished from ten millions to nine, to eight, and then to seven, one-half the surface of the globe being then habitable. As the habitable zone became more and more restricted to the equator, the population had still further diminished, as had also the mean length of human life, and the day came when only a few hundred millions remained, scattered in groups along the equator, and maintaining life only by the artifices of a laborious and scientific industry.

Later still, toward the end, only two groups of a few hundred beings were left, occupying the last surviving centers of industry. From all the rest of the globe the human race had slowly but inexorably disappeared—dried up, exhausted, degenerated, from century to century, through the lack of an assimilable atmosphere and sufficient food. Its last remnants seemed to have lapsed back into barbarism, vegetating like the Esquimaux of the north. These two ancient centers of civilization, themselves yielding to decay, had survived only at the cost of a constant struggle between industrial genius and implacable nature.

Even here, between the tropics and the equator, the two remaining groups of human beings which still contrived to exist in the face of a thousand hardships which yearly became more insupportable, did so only by subsisting, so to speak, on what their predecessors had left behind. These two ocean valleys, one of which was near the bottom of what is now the Pacific Ocean, the other to the south of the present island of Ceylon, had formerly been the sites of two immense cities of glass—iron and glass having been for a long time the materials chiefly employed in building construction. They resembled vast winter gardens, without upper stories, with transparent ceilings of immense height. Here were to be found the last plants, except those cultivated in the subterranean galleries leading to rivers flowing under ground.

Elsewhere the surface of the earth was a ruin, and even here only the last vestiges of a vanished greatness were to be seen.

The earth was dead. The other planets also had died one after the other. The sun was extinguished.