# POPULAR ASTRONOMY

A REVIEW OF ASTRONOMY AND ALLIED SCIENCES

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*VOL. XXXVIII*

1930

Published by the GOODSELL OBSERVATORY OF CARLETON COLLEGE
NORTHFIELD, MINNESOTA, U. S. A.

PRINTED BY THE NORTHFIELD NEWS, INC.
NORTHFIELD, MINNESOTA

brass, kerosene lamp. In the face of the lantern is an opening, 9 inches by 9 inches and covered with window glass. In front of this is a frame, circular on the outer edge, so as to revolve in a groove. A rectangular opening in the frame receives the blue print. On the inside of the lantern, the wood at the top is protected by tin from the heat of the lamp. At the back and base and at the top are small holes for the circulation of air and escape of gases. A curtain is arranged to fall over the glass so as to exclude all light, if desired.

When in use the lantern is placed on a stand close to the observer, the light is adjusted to just the degree necessary to show clearly the stars and numbers, and the chart is turned to correspond with the telescopic field. The observer's hands are entirely free to work the instrument, and by removing the chart there is all the light needed for recording. When working on faintest stars, the observer should never use the observing eye either for recording or for glancing at the blue print. That eye should constantly be kept at the extreme of sensitiveness. The chart-lantern can not be used for the reading of circles. In this observatory that is done by the aid of an old-style bulls-eye lantern which gives a very soft light.

The writer hopes that, if the description of his outfit offers no other suggestions, it may lead members of the A.A.V.S.O. to profit by the advantages of a chart-lantern. Once tried, it will not be cast aside.

ST. PETERSBURG, FLORIDA.

## THE NAVIGATION OF SPACE IN EARLY SPECULATION AND IN MODERN RESEARCH

By NOEL DEISCH.

It is a curious fact that the Greeks never in any of their exuberant flights of fancy attempted a voyage to the moon. They had, of course, from the earliest ages formed a luminous picture of the hypothesis of the plurality of worlds. Orpheus alluded to the conception at a very early date, and it was definitively set forward in the sixth century B.C. by Pythagoras, who, as is well known, taught that the earth is a sphere like the sun and moon, that it rests without support in space, and that the moon is an inhabited world like our own. Anaximander, Anaximenes, Xenophanes, Leucippus, Anaxagoras, Democritus, Metrodorus, and a number of other Hellenic philosophers also cherished the idea of an extra-mundane life,—an idea peculiarly congenial to the Greek fancy, it would appear, as being exceptionally well fitted to give abundant range for the more speculative efforts of the imagination.

Yet the fact remains that in spite of all this fertile preparation none of the older generation of Greeks marshaled the enterprise to venture a voyage to the worlds overhead. It was left to Lucian of Samosata,

Syria, recognized as the foremost of the second-century sophists, first to take that heroic flight and to establish himself as the Columbus of all lunar discoverers. Lucian in fact broke ground with two tales of adventure among the stars,—*Icaromenippus* and his famous *True Story* (Αληθοῦς ιστορίας). The latter is much the more interesting of the two tales, and in fact takes rank as one of the most spirited stories of exploration in space that have ever appeared.

The *True Story* relates how Lucian and his party ventured out in a staunch and well-equipped vessel into the gloomy expanse of water that stretched outward from the Pillars of Hercules. On this forlorn sea, for a space of seventy-nine days, he was driven westward by a furious and unabating gale, when at last the entire expedition was hurled up into the sky on a gigantic waterspout. "But when our boat was hung up aloft," says Lucian, "a wind struck her sails and drove her ahead with bellying canvas. For seven days and seven nights we sailed the air, and on the eighth day we saw a great country in it, resembling an island, bright and round and shining with a great light. Running in there and anchoring, we went ashore, and on investigating found that the land was inhabited and cultivated." All hands agreed that this land could be none other than the moon. "We also saw another country below, with cities in it and rivers and seas and forests and mountains. This we judged to be our own world."[1]

Lucian and his companions met with all manner of thrilling adventure on this strange island that was the moon. Still keen for exploration, they struck out even farther into the ocean of space, visiting the sun, several of the constellations, the antipodes, and other regions that had long been familiar in mythology or conspicuous as subjects of poetical or philosophical speculation. At length, having roved all the expanse of the heavens, they trimmed their sails for the Hellespont.

After the publication of Lucian's story the theme rested for thirteen hundred years without attracting a single author of any notice. All of Europe was afire with the spirit of adventure (Columbus having but recently discovered the new world) when Ariosto gave free wing to his fancy and visited Cynthia's orb anew. With a due regard to congruities the lofty poet accepted St. John as his guide in the precarious business of scaling the heavens. Fontenelle suggests that it may have been by way of compensation for this somewhat risky poetic license that Ariosto dedicated his work, *l'Orlando Furioso,* to Cardinal Ippolito d'Este.

The whole question of the plurality of worlds was being actively debated about this time by astronomers and by theologians, most ingenious and often most vehement arguments attacking or defending it being set up on exceedingly precarious foundations by some of the cleverest thinkers of the age. The slender line which divides such license in

[1] The above passages are from the racy translation of the *True Story* by A. M. Harmon of Princeton University.

speculation from acknowledged flights of fancy was overstepped by the great astronomer Kepler in a story of an actual visit to our satellite which he was frank enough to style a Dream.[2] This book, however, was not published until death had safely placed its author beyond the reach of vexatious criticism.

Duracoto, the hero of the story, is presented to us as an Icelander of adventurous bent who, while engaged in explorations in the vicinity of the North Pole, had the fortune to discover a road that led him directly to the moon. The narrative abounds with anecdotes of hardship and preternatural exertion: Kepler seems to have felt that any person who aspired to such lofty achievements should act out the maxim, *ad astra per aspera.* Considered as a story the Dream will hardly bear comparison with other productions in this field, in great part being simply a weary exposition of certain astronomical theories and preconceptions of the author, who used the device of a visit to the moon merely as the most ready means of giving descriptions of the conditions that prevail there, as he imagined them to be.

In point of exuberance of narrative, very little criticism can be made of another voyage that appeared only eight years later, bearing the jaunty title *The Man in the Moon.* Its author, Francis Godwin, was an Englishman, but the hero, Domingo Gonzales, was a Spaniard by birth, by birth also a gentleman, and by inclination an adventurer,—a proclivity to which he owed the misfortune of having become marooned on the island of St. Helena. Life there became tedious business, and since no prospect of an early escape presented itself, the castaway settled himself to while away the time as best he might. There were swans living on the island in great numbers, and these he tamed and domesticated. As a final triumph of patience and skill he succeeded in training the powerful birds to carry parcels from place to place on the wing. The feat set Domingo's fertile mind into a ferment. If these swans can carry small parcels, he reflected, why may they not, in fact, be harnessed together in such a way as to carry a burden of some consequence? That burden was of course Domingo himself, and when his harness was completed he was delighted to find that he had at his command a flying equipage to do credit to his mettle.

One day while our hero was out taking the air in his phaeton his team of birds "ran away." The sober-headed Spaniard decided he had as well lean back and see where they would land. However, the swans showed not the least inclination to land at all; they were bent only on vaulting up into the sky, and as time went on it was brought home to Gonzales that he had left St. Helena and the earth for good. Meanwhile the moon grew larger and larger, and, to be brief, Gonzales landed there after twelve days of travel.

It may be of interest to naturalists to know that these swans were not

[2] *Mathematici olim Imperatorii Somnium, seu opus posthumum de Astronomia lunari.* Frankfort, 1634.

indigenous to the earth at all, but rather were denizens of the moon, and merely paid our planet a casual visit in their yearly migrations. This point was a fortunate one for Gonzales, for it enabled him to take his place in the seat of his phaeton the following spring, after a season filled with extravagant adventure, and make his way back to earth.

Another work bearing on ethereal travel that appeared in England about this time is unique in being the only sincere attempt at a study of the problem of navigating space undertaken until very recent years, or at least the only one which its author succeeded in having set to print. It is a treatise in two books, entitled *A Discourse Concerning a New World and Another Planet,* and first appeared in 1638, though the part most directly relating to the present subject was added only at the third impression, issued in 1640. John Wilkins, one of the founders of the Royal Society, was its author. Wilkins bore the title of Bishop of Chester, and was Warden of Wadham College, Oxford, and Master of Trinity College, Cambridge, during the most trying period of their development. In spite of this literary vagary he was really a scholarly man, and his varied experience, his wide fund of knowledge, and his ingenuity, all go to make his opinions of peculiar interest.

Unlike many another author who had touched on our subject, Wilkins was honest enough not to attempt to evade difficulties by circumlocution. He sets down at once fourteen *Propositions that are proved in this Discourse.* The first thirteen of these deal with the moon considered as a habitable heavenly body. The fourteenth, however, states boldly that "'Tis possible for some of our posterity to find out a conveyance to this other world, and if there be inhabitants there, to have commerce with them."

Our author had the modesty not to assert outright that he himself could construct such a conveyance; for that consummation his chief hope lay in the resources of the future, and he declares his belief that "time, who has always been the father of new truths, and has revealed unto us many things which our ancestors were ignorant of, will also manifest to our posterity that which we now desire, but cannot know. Time will come, when the endeavors of after ages shall bring such things to light as now lie in obscurity. Arts are not yet come to their solstice. But the industry of future times, assisted with the labors of their forefathers, may reach that height that we could not attain to. As we now wonder at the blindness of our ancestors, who were not able to discern such things as seem plain and obvious to us, so will our posterity admire our ignorance in as perspicuous matters."

After this encouraging foreword Wilkins took up some particular aspects of the outstanding problems concerned in his project, and did his best to show that the difficulties that block the way to their solution may not be insuperable. The want of correct knowledge concerning gravity (Newton was not yet born), magnetism, the height of the atmosphere, and other facts of nature whose explanation is now a commonplace to every schoolboy, was both a challenge and a spur to specu-

lation, and naturally led him into many grave errors. By long and involved argument he sought to show that there must be but little gravitative action at no great height above the earth, and that, if once that point of advantage could be attained, there would be but little further hindrance to progress toward our satellite.

But though the mere question of locomotion did not appear to oppose any insurmountable obstacles, several collateral matters seemed deserving of very careful consideration. Says he: "Though a man could constantly keep on his journey thither [toward the moon] by a straight line, though he could fly a thousand miles a day; yet he would not arrive thither under 180 days or half a year. And how were it possible for any to tarry so long without diet or sleep?" Wilkins grappled with these difficulties with a boldness worthy of his subject, nor did he permit a mere appearance of singularity in any proposal to debar it from impartial treatment at his hands. He took up the possibility of sleeping through the journey so as to do away with the necessity of eating, out-and-out fasting, using odors as a substitute for food, and deriving sustenance from no more substantial medium than the air itself. The advantages of each of these various proposals he examined in a scrupulously orthodox manner, bracing the most whimsical assertions with imposing Latin citations and references to classical or more or less contemporary authors. "I suppose there could be no trusting to that fancy of *Philo* the *Jew*" admits Wilkins "who thinks that the musick of the spheares should supply the strength of food," yet he appears rather inclined to defend the feasibility of eating air, pointing out that ". . . the chameleon is merely nourished by this [air]: and so are the birds of Paradise, treated by many; [here he gives references] which reside constantly in the air, nature not having bestowed upon them any legs, and therefore they are never seen upon the ground but being dead. If you ask, how they multiply? Tis answered, they lay their eggs on the backs of one another, upon which they sit til the young ones be fledg'd . . . Rondoletius, (*De Piscibus,* lib. 1, Cap. 13) from the history of Hermolaus Barbarus, tells us of a priest (of whom one of the Popes had the custody) that lived forty years upon meer air." In justice to Wilkins it must be stated that he also took up and discussed as a possibility, along with his other suggestions, the feasibility of taking along ordinary material food as a viaticum.

The matter of making provision for sleep rightly gave him little apprehension. "Again, seeing we do not then spend ourselves in any labor [because not working against gravity] we shall not, it may be, need the refreshment of sleep. But if we do, we cannot desire a softer bed than the air, where we may repose ourselves firmly and safely as in our chambers." For all this security, there appeared opening for discomforts incident to the coldness and rarity of the atmosphere in the regions that would have to be traversed.

On the whole Wilkins evidently thought that a trip to the moon, while a matter of no small difficulty, could likely be managed. He sug-

gested using wings, actuated by human power. He thought also that the great Madagascar *Ruck,* which the credible account of Marco Polo declared to be so immense that its wing-feathers were twelve feet long and so powerful that it could catch up an elephant like a hawk does a mouse, might be taught to carry a rider, and perhaps be persuaded to take him to the moon. "Or if neither of these ways will serve: yet I do seriously, and upon good grounds, affirm it possible to make a flying chariot," says he, and continues, "this engine may be contrived from the same principles by which Archytas made a wooden dove, and Regiomontanus a wooden eagle." . . . "I conceive it were no difficult matter (if a man had leisure) to show more particularly the means of composing it." The pressing nature of the Bishop's duties, it would appear, never gave him opportunity for the undertaking.

Wilkins anticipated that his work would present a very fair target for the wits of the time. For, as he observed, often have great men who advanced ingenious, practical, but daring theories been ridiculed by those "whose perverseness ties them to the contrary opinion," and "If these men were thus censured, I may justly then expect to be derided by most, and to be believed by few or none; especially since this opinion seems to carry in it so much of strangeness, and contradiction to the general consent of others. But, however, I am resolved that this shall not be any discouragement, since I know that it is not common opinion that can either add or detract from the truth. For,

1. Other truths have been formerly esteemed altogether as ridiculous as this can be.

2. Gross absurdities have been entertained by general opinion."

Wilkins' apprehensions were not altogether baseless. So well was the *Discourse* remembered that over a hundred years later it was parodied by Robert Paltock in the tale *Peter Wilkins' Journey to the Moon.* He was even absurdly accused of having plagiarized Godwin's story. One day the Duchess of Newcastle,—a clever and eccentric lady, the authoress of many "fancies" philosophical and poetical,—asked him where she might bait her horses if she undertook the journey. "Your grace could do no better," the Bishop replied, "than stop at one of your own castles in the air."[3]

So much for the sober findings of seventeenth century science when sitting in judgment on the question of the feasibility of realizing a journey to the moon. The same century proved quite prolific of fictitious assaults on our satellite. One of these, the *Voyage to the Moon* by Cyrano de Bergerac, which appeared some ten years after the publication of Wilkins' monograph, is of course quite well known to present-day readers.

Fearless explorer that he was, Cyrano little heeded the obstacles in-

[3] This anecdote is told by Wright-Henderson in his *Life and Times of John Wilkins,* London, 1910.

terposed by nature between himself and the land of his ambition. Questions of gravitation, air, sleep, food, and the other matters that caused Wilkins no end of concern perturbed him not at all; his formula for meeting them was action. "I lashed about myself a number of vials filled with dew," says he, "on which the sun darted his rays so vehemently that the heat, which attracted them as if they had been the largest clouds, raised me up so high that at last I found myself above the middle region."[4]

This was encouraging progress by way of a start, but since the dew-engine fell short of furnishing a fully satisfactory solution, de Bergerac cast about among various other expedients—he tried skyrockets without success—until finally he discovered quite accidentally that the moon exercises a powerful attraction on bone-marrow. He was then in a position to carry his project fully into effect.

While well enough in its way and for its original purpose as a conveyance to the moon, this means of locomotion could by no means be trusted for a more important journey that Cyrano had long been meditating, a trip, that is, to the very orb of day itself.[5]

It is but reasonable that for this expedition he should have devoted somewhat more care to the design of his equipment. The new apparatus consisted of a good, solid, wooden box, six feet high and three and a quarter wide, made very light and with all care to the joinery. Both bottom and top of this box were pierced by a neat hole. In the upper hole snugly fitted the neck of a crystal flask of icosahedral form, each facet of which was a concavo-convex lens.

The theory of operation of this contrivance, so far as can be had from the few elliptic phrases in Cyrano's work that touch on that important point, is about as follows: The sun's rays, concentrated in the interior of the flask by the many lenses that constitute its sides, create a vacuum within the flask. A violent inrush of air through the lower hole is thus induced, and it is this jet of air that bears the machine aloft.

It is plain that all the magic of the apparatus resided in the mysterious flask of many facets. This must have been a shattery affair, and in fact Cyrano records that in the course of his journey to the sun the glass icosahedron was accidentally broken. One is curious to know how the versatile explorer made repairs and succeeded in forging his way back to our planet. Unfortunately history is tantalizingly silent on the point, since before our author had completed his commentary on the States and Empires of the Sun he departed this world in earnest.

The Père Daniel, in a little book styled by him a *Voyage to the World*

[4] The "middle region" or *Aura Aetherea* was thought to be that indefinite region which supervenes upon the "air of meteors,"—this last being the earth's own atmosphere. Certain ancient speculators supposed it to consist of fire, but more general opinion held it to be a "pure, thin, rarified air, free from humidity, wind, rain, or cold."

[5] De Bergerac, Cyrano, *États et Empires du Soleil.* 1662.

*of Cartesius*[6] had recourse to a psychological method to overcome the barriers of space, which he asserts to have been communicated secretly by Descartes to a friend. It is notorious that the Cartesian philosopher was persuaded that, in this life at least, the human soul is fettered to the pineal gland. Father Daniel's method consisted in temporarily emancipating it by the action of a drug. In that virgin state of detachment, the soul, free from all encumbrance of the body, could pass through space without hindrance. The author gave exercise to this new faculty by paying a visit to the moon; in fact he skimmed out beyond the stars to distances only recently envisaged by Dr. Shapley, and there in the vastnesses of space watched gigantic forces at work, shaping worlds in accordance with Descartes' theory of vortices. Fifty years later the same theme was given adequate justice in verse by Père le Coédic in a book bearing exactly the same title as that of Père Daniel. Both accounts would appear to have been anticipated in the story of Hermotimus, that prophet of old Ionia whose spirit, we are told, was wont to quit its clay and wander for lengthy periods through the universe in quest of the secrets of futurity.

We have seen that a man even of Kepler's genuine attainments did not disdain to direct his genius to the problem of flight in space. It is still more interesting to know that the noted Dutch mathematician, physicist, and astronomer Christianus Huyghens, inventor of the pendulum clock and discoverer of Saturn's rings, also considered it worthy of his attention. His work,[7] however, is devoted almost wholly to the question of the habitability of the stars and of the planets, as well as to the characteristics of the races that should be found on them, and gives but scant attention to the means of locomotion that might be chosen for the flight. Nevertheless his conclusions on this subject give evidence of some practical sagacity. Says he: "Since there's no hope of a Mercury to carry us such a journey, we shall e'en be contented with what's in our power: we shall suppose ourselves there." Huyghens will perhaps be gratefully remembered by some later investigators in these fields for his estimate of the true purpose and recompense of any study of the kind, to wit, that "in such noble and sublime studies as these, 'tis a glory to arrive at probability, and the search itself rewards the pains."

No doubt David Russen of London had in mind others of less lofty spirit than those sharing the sentiments of the noted author of Cosmotheoros when, in the preface of a little book published in 1703 he wrote: "The following Tract will find approbation from the Learned and the Ingenious, while those troubled with Moon-blind Intellects, like Dogs barking at the Moon, will carp at what I have written." In the event

[6] Daniel, Gabriel; *Voiage du monde de Descartes.* 1692. The English translation has the title *A Voyage to the World of Cartesius* and came out in 1694.

[7] The original work was written in Latin and bore the title Κοσμοθεωρος, *sive de terris coelestibus earumque ornatu conjecturae.* This appeared in 1698, but an English translation, *Cosmotheoros: or conjectures concerning the planetary worlds and their inhabitants* also came out later in the same year.

that a particularly callous reader should prove impervious to insinuation, Russen makes it clear that a discourse of this weight is not at all "calculated for those Blocks who are sick with the Stupidity of a lazy ignorance. It claims the Protection of more refined Genius's, whose thoughts soar above this Dunghill Earth, and read the Divine attributes in other Legible Characters besides what are imprinted on this TERRAQUEOUS GLOBE."

Russen has an altogether original suggestion to make by way of setting to rest the long mooted problem. It had better be stated in the author's own words. "Since Springiness is a cause of forcible motion; and a Spring will, when bended and let loose, extend its self to its length; could a Spring of well-tempered steel be framed, whose basis being fastened to the Earth, and on the other end placed a Frame or Seat, wherein a Man with other necessaries could abide in safety, this Spring being with Cords, Pullies, or other Engines bent, and then let loose by degrees by those who manage the Pullies, the other end would reach the Moon, where the Person who ascended landing, the Spring might again be bent, till the end touching the earth, should discharge the passenger again in safety." Really a comfortable issue, after such a harassing passage!

The Tale of the World of Mercury (*Rélation du Monde de Mercure*), published anonymously in 1750, contains some highly interesting descriptions of other worlds gleaned with the aid of a "philosophical" telescope. Two years later Voltaire gave out his *Micromégas,* whose hero had such an uncanny understanding of the laws of gravitation and of other forms of physical attraction, and a knack of applying it all to such good purpose, that—helped along sometimes merely by a ray of light, sometimes by a comet or a streamer of the aurora,—he contrived to flit from one celestial orb to another until he had traversed all the vast distance intervening between his original home on the star Sirius, and the planet Saturn. Arrived there, Micromégas had the luck to fall in with a companion worthy of his genius, and the two of them visited our own earth in company. They at first experienced no little difficulty in determining whether or not this paltry mud-ball might be the host of a race of living beings: "What makes me believe that nobody lives here" says the Saturnian "is that it appears to me that common-sense people wouldn't want to live here." "Well," ventures Micromégas, "perhaps the inhabitants are wanting in common sense." Conversation with the denizens of earth hardly dispelled this preconception, and when the visitors discovered that human affairs are not arranged as they are on Sirius or on Saturn they so far forgot their lofty origin as to descend to very sharp criticism of our institutions, thus revealing a failing known to be common among foreigners even at this day.

Incomparably the most sparkling and suggestive work touching on this subject that has ever appeared is Fontenelle's *Conversations on the*

*Plurality of Worlds.*[8] Though in it the author does not shed much light on the question as to whether we shall ever be able to build up a commerce with the men in the moon, what he does say in that direction is argued with such plausibility that he almost makes good his caution that he may constrain conviction against the reader's own better judgment.

The various imaginary voyages in space written by Swedenborg[9] and by Marie-Anne de Roumier,[10] as well as others which do not present any new suggestion as to means or appliances for traveling in space, nor indeed any particular evidence of originality, but rather represent the product of the operation of an extravagant fancy, need not detain us. However, several other tales written during the second quarter of the last century cannot be overlooked. One of these,[11] by Joseph Atterley, is remarkable as being the first book in which, so far as the writer has found, is set forth the conception of a substance which acts counter to gravity, which, in other words, has the property of being repelled by the earth instead of being attracted to it as it rightly should be, and which thus enables the hero of the story to escape from the earth into space. In this original case it is a metal which "when separated and purified, has as great a tendency to fly off from the earth as a piece of gold or lead has to approach it."

Among the many who have availed themselves of the diagravitational properties of the element in question, variously dubbed *lunarium, cavorite,* etc., should be mentioned Dr. J. L. Riddell, who in a curious story[12] that appeared in New Orleans about the middle of the last century somewhat modifies the original idea of Atterley, the metal being considered as acting as an impervious screen to gravity (much as more recently used by H. G. Wells in his book *The First Men in the Moon*), and thus conferring the property of negative weight on objects placed above it, rather than on itself. It is of interest to note that Riddell, even at this early date, suggests revitalizing the air entrapped in the machine by producing oxygen from potassium chlorate and absorbing carbon dioxide by means of lime.

One naturally wonders whether Edgar Allan Poe, who was so much given to daring flights of fancy, may ever have glanced over Atterley's novel. We have evidence in one of his criticisms that he had seen Godwin's story. The latter must have excited his curiosity, and perhaps his ambition. At any rate he is the author of what is unquestionably one of the cleverest excursions to the moon ever written. Poe paid his visit

[8] Fontenelle, Bernard de Bouvier de; *Entretiens sur la pluralité des mondes habités.* Paris, 1821.

[9] *Arcana Coelestia; De Telluribus in Mondo Nostro,* etc.

[10] *Voyages de milord Céton dans les sept planètes,* 7 vol., The Hague, 1765.

[11] Atterley, Joseph. *A Voyage to the Moon: with some Account of the Manners and Customs, Science and Philosophy of the People of Morosofia and other Lunarians,* New York, 1827.

[12] Riddell, J. L. *Orin Lindsay's Plan of Aerial Navigation; with a narrative of his Explorations in the Higher Regions of the Atmosphere, and his Wonderful Voyage Around the Moon,* New Orleans, 1847.

to our satellite through the columns of the *Southern Literary Messenger* in June, 1835, in a story that bears the title *The Unparalleled Adventures of one Hans Pfaall.*

It need hardly be said that the creator of Dupin was not at any loss for means to effect his expedition into the empyrean. As usual he based his results on plausible and logical, though not strictly conclusive, scientific reasoning. Hans Pfaall argued that since the air decreases in density at a constantly diminishing ratio, go as high as we may we cannot arrive at a limit beyond which no air is to be found; all space is permeated by a certain residuum of an atmosphere. This being so, the aeronaut would be assured of a supply of air at any height to which he might wish to climb. For the rest Pfaall relied on a balloon of unprecedented dimensions and filled with an inconceivably light gas to give him an upward velocity so prodigiously great that he would be carried to the point where the force of the earth's attraction would be equaled and superseded by that of the moon.

To overcome difficulties of respiration which would develop under the low barometric pressures existing at these great heights there was fitted to the balloon a large and strong canvas bag, which entirely enclosed the basket and extended up over the concentrating-hoop, being drawn together into an air-tight knot at its top to form a hermetic enclosure. This bag was rendered impermeable to air by means of rubber varnish, and fitted with small glass windows to permit observation. When Pfaall had reached a height such that the atmosphere became so attenuated that breathing was interfered with, he simply increased the pressure within the bag by forcing air into it by means of a hand-operated pneumatic pump. By experiment he found that the air required changing about every hour, and he admits that at the mid-point of his journey it required long and excessive labor to compress within the chamber sufficient air for the maintenance of life.

In *Hans Pfaall* Poe made free use of his powerful gift of lending plausibility to his narrative, but since the story is written largely in a tone of banter, it evidently was not, as has occasionally been affirmed, intended to deceive.

Deceit, however, was certainly the object of another account that began to appear in the columns of the New York *Sun* about three weeks after the publication of Poe's story, under the pretentious title: *Discoveries in the Moon Lately made at the Cape of Good Hope,* by Sir John Herschel, LL.D., F.R.S., etc. The story, whose author is commonly thought to be Richard Adams Locke, purports to be an account of marvelous discoveries in the moon, supposedly brought to light by a new and exceptionally powerful telescopic instrument conceived by Sir William Herschel and carried out to completion after that astronomer's death by Sir John Herschel, his son. According to the account the comparatively modest magnification of 6,000 was first realized, which brought the moon apparently to within forty miles of the observer; but subsequently the apparatus was greatly improved. By the expedient

of intensifying the feeble telescopic image by light thrown by an oblique mirror upon the "focal object of vision," joined with the light-gathering power of a speculum twenty-four feet in diameter, the most minute details of the lunar surface became observable. There were thus revealed exotic forests and flowers, strange animals, and especially a remarkable creature all covered with hair like a monkey and provided with an immense pair of bat-like wings, much as some artists have pictured Mephistopheles. All of these are described with a minute circumstantiality of detail well calculated to wile an incautious reader into the belief that the story was an authentic report of an extraordinary contribution to science.

The appearance of the "Moon Hoax," as it has since come to be called, immediately compelled attention, and it was read with unexampled avidity in America and in all parts of Europe. On the whole, one must admit that it was cleverly conceived and ably written, and represents what is undoubtedly the most audacious and the most successful piece of scientific trickery that has ever been perpetrated. Its success must have caused Poe some pique, for in a note appended to a later edition of *Hans Pfaall* he took elaborate pains to point out the inconsistencies of Locke's tale.

Shortly after the middle of the past century voyages began to spring from the press like mushrooms from the turf after a shower, and one of these, Jules Verne's classic tale *From the Earth to the Moon*[13] marks the high point of all lunar adventures. It is of course too well known to make necessary any extended review. Everybody has read of how Barbicaine and his friends took their place in a projectile which was shot from a monster cannon into space, where it pursued a parabolic orbit around the moon until deviated from its path by a meteor, and of how it at last fell back to earth.

Undiscouraged by Verne's achievement, a host of writers since his time have made their pilgrimage to Diana's orb. Camille Flammarion, in his *Contes Philosophiques; Lumen; Uranie;* etc., took occasion to make several such journeys, in all of which he seems to have favored a kind of telepathic flight, reminiscent of the *Itinerarium exstaticum* of Rev. Athanase Krischer, (Wurzburg, 1660). It is rather odd that the famous French romantic scientist should have adopted such an awkward device: surely anyone acquainted with the spirit of his work would hesitate to attribute this choice to any deficiency of imagination. Moreover, his acquaintance with the prior art in the field, as displayed in his book *Worlds: Real and Imaginary*[14] (to which interesting work the writer wishes here to acknowledge his obligation for a number of references to early "voyages") would have been expected to put him in line with some medium of travel possessed of a greater measure of scientific appeal. Simon Newcomb, following the example of Kepler and

[13] Verne, Jules. *De la Terre à la Lune,* Paris, 1865.

[14] Flammarion, Camille. *Les mondes imaginaires et les mondes réels,* Paris, 1865.

Huyghens, tried his hand at a novel, *His Wisdom, the Defender* (Harper, 1900), which, though not a voyage to another world, features a machine wholly fit to negotiate such a voyage. It is notorious that Newcomb, at the dawn of the aerial age, pertinaciously contended that we must look for a solution to the problem of aerial navigation, which then appeared almost as unpromising an undertaking as ethereal navigation does now, to come from some revolutionary discovery in physics rather than from an application of the materials and agencies of engineering then at hand. In an article in *McClure's* of September, 1901, he hinted that this new agency might be something in the way of an interaction between the ether and matter,—and *His Wisdom* represents a somewhat unfortunate attempt to develop the potentialities of this idea in fiction. Thanks to a new kind of matter closely enough related to ether to react with it, called *etherine,* and a new kind of energy, *therm,* somewhat akin to electricity, the hero of the story was able to make vehicles with which he could skim about in the regions above the earth's atmosphere at a prodigious velocity. Realizing the wonderful resources of power invested in him by his invention, and being of altruistic aims, he used it to force an international *coup d'etat* and succeeded in putting an end to war forever.

The present period in the development of etheronautics* will likely be put down by future historians of the subject as one marked by the initiation of serious investigation of the problem of flight in space by men of the highest competence, as also by a strong centering of interest about the rocket or reaction motor. Writers of fiction long ago discovered and exploited the possibilities of this agency. The heroes of both de Bergerac and Jules Verne used huge squibs in the subordinate rôle of assisting or guiding their vehicle in its flight, and in a story by Achille Eyraud entitled *Voyage à Vénus* published serially in 1865, the rocket, unassisted by any accessory device, was featured as the propelling agency of the ship. It has been so used by novelists many times subsequently, notably by Kurt von Lasswitz in *Auf zwei Planeten,* 1897, in which the discharge of the reactant is achieved through electrostatic repulsion. In a lunar romance published in the *Cosmopolitan* magazine late in 1916, under the title *The Moon Maker,* it is proposed to utilize the reaction generated by the emission of $\alpha$ and $\beta$ particles from the element uranium, whose atomic decomposition is assumed to be enormously accelerated by the action of a peculiar radiation known only to its author, Mr. Arthur Train. It is significant that the story is announced as having been written in collaboration with Professor R. W. Wood of Johns Hopkins University. Other novels of this type are

*Esnault-Pelterie has introduced the term *astronautics* to designate the new art, but it may be a question whether this is as fitting a term as *etheronautics* (since we refer to the sea as being navigated, rather than the islands or the continents) $\alpha\iota\theta\eta\rho$ being of course understood here in its classic sense as signifying the region that extends beyond the earth's atmosphere, rather than the physical ether of the relativist.

those of K. E. Ziolkowski, *The Bounds of the Earth,* Kaluga, 1920, which features a reaction motor powered by liquid hydrogen and oxygen, and Bruno H. Burgel's *Der Stern von Afrika,* 1921, in which a kind of machine-gun reaction motor is used. Another recent novel by Miral-Viger, *L'Anneau de Feu,* Paris, 1922, uses substantially Train's idea, though the author, evidently deeming the existing radioactive elements altogether too feble for the purpose in hand, substitutes for them an imaginary one, *Virium,* whose activity is some 60,000 times greater than that of radium, and which moreover may be decomposed at will by the action of cathode rays,—though it conveniently escapes destruction by its own beta radiation!

Even as a subject of earnest speculation, the reaction motor may lay claim to a respectable history. Newton himself seems to have been the first to point out, in one of his lectures, that it would be possible by means of the rocket to travel in the vacuous reaches of outer space. Scherschevsky tells in a recent popular book on etheronautics[16] that Fedor Kibaltschitsch in 1882 proposed a plan to Tsar Alexander II (as lately uncovered from the secret archives by the Soviets) for the development of a planetary rocket. Hermann Ganswindt, a German "privatforscher," appears to have made some rather fanciful suggestions along the line of a planetary rocket-ship at a lecture delivered in Berlin in 1881, to which disclosure German writers attach considerable weight as proof of priority in this line of work. The Russian Ziolkowski is also declared to have begun his speculations in 1895, since which date he has from time to time published articles and books on this subject. Unfortunately no translation of his work *in extenso* has been published, and no really critical appreciation is available. The Peruvian chemical engineer Pedro E. Paulet in *El Commercio* of Lima, issue of October 7, 1927, gives some details of experiments with rocket apparatus using liquid explosives, which he declares he had performed in 1895. The Swedish astronomer and physicist Birkeland is also said to have conducted experiments during 1905-1907 with rockets powered with solid as with liquid propellants, and working in vacuum, but the results were not made public.

Not long before the war a well-known French aeronautic engineer, M. R. Esnault-Pelterie, read a paper on the subject of the reaction motor as applied to the navigation of space before the Physical Society of France. He made an estimate of the efficiency to be expected, and considered dynamite and radium as sources of energy. Unfortunately the complete paper was not published, and the abstract[17] omits the author's computations. Curiously, Dr. André Bing had actually made application in Belgium for a patent on a similar idea in 1911, and on hearing of Esnault-Pelterie's speculations claimed priority of conception on the basis of his patent.

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[16] Scherschevsky, A. B., *Die Rakete, für fahrt und flug,* Berlin, 1929, 134 pp.
[17] Soc. Franc. de Phys., *Proc. Verb.* (etc.), 1912, p. 90.

To Professor Robert H. Goddard of Clark University must go the credit of first having put the proposal of the reaction motor as applied to the navigation of space into good scientific form, applying to it exhaustive and rigorous mathematical treatment supplemented by carefully conducted experiments tending toward the design of a concrete apparatus,—specifically a rocket capable of reaching extreme altitudes in the atmosphere. The investigator's conception of "extreme altitudes" was sufficiently elastic to include the moon in their confines. This most interesting and valuable paper was printed by the Smithsonian Institution in its *Miscellaneous Collections,* Vol. 71, No. 2, 1919.*

Professor Goddard considers in detail the theoretical capabilities of rockets powered with various smokeless propellants, as also with hydrogen and oxygen, and derives the quantity of propellant required to lift a given mass to any height in the atmosphere, or to impart to it the escape velocity. The paper also includes a report of the experiments just alluded to, these having been performed in air and in vacuum with the object of determining the relation of various parameters to the velocities achieved by allowing gases released by the combustion of explosives to expand in a divergent nozzle; it touches also on various ancillary matters, such as the possibility of making a direct hit by a rocket on the moon visible by means of the flash produced by the combustion of a magnesium mixture, the probability of the collision of the rocket with meteoroids, and other questions.

A few years subsequent to the publication of Goddard's paper Hermann Oberth produced a work[18] which has deservedly attracted a great deal of attention, especially on the continent. Like Goddard, he bases his reasoning on the rigorous methods of theoretical mechanics. Oberth examines at length the capabilities of two types of rocket, both propelled by liquid fuels, one by alcohol and oxygen and the other by hydrogen and oxygen, and does not hesitate to give plans and descriptions of completely equipped apparatus. He likewise considers the physiological and psychological effects of high accelerations, problems of equilibrium, probability of collision with meteoroids, etc. Dr. Walter Hohmann some time later published a highly mathematical study[19] concerned especially with the evaluation of the quantities of energy required for negotiating a voyage to each of the several planets, and the methods that might be used in effecting a landing on various celestial bodies, more especially the earth. Esnault-Pelterie, continuing his earlier work, has

*As explained in a note printed in *Nature* (London), issue of Oct. 18, 1924, p. 574, Dr. Goddard's interest in this subject extends back to about 1899, and his first work to 1907.

[18] Oberth, Hermann, *Die Rakete zu den Planetenräumen*, Munich & Berlin, 1923, 92 pp. As we go to press the third edition of *Die Rakete*, which now bears the title *Wege zur Raumschiffahrt* comes to hand. This is a volume of 425 pages, with 159 figures and 4 folding plates.

[19] Hohmann, Walter, *Die Erreichbarkeit der Himmelskörper*, Munich, 1925, 88 pp.

also summarized his results in a thoroughly technical paper.[20] The popular expositions of Valier[21] and Ley[22] must not be overlooked, as having done much to arouse interest in the project among the public of Germany and Austria.

These references will not be understood as exhausting the literature of the subject. A bibliography compiled by Scherschevsky includes 23 titles of books and 55 titles of magazine articles. A respectable part of this material is in Russian; we are told in fact that Professor Rynin is at work on a twelve volume encyclopedic treatise on interplanetary travel, three volumes of which have appeared. There is even a magazine[23] devoted exclusively to rocket travel, which is now in its fourth year.

Nor must we forget the international Rep-Hirsch prize offered by the Société Astronomique de France for the best paper submitted in annual competition.[24] From newspaper reports we gather that Oberth, the first winner of this prize, has latterly secured backing for practical work. Goddard is also engaged in active experimentation. Altogether it would appear that the application of the reaction motor to the navigation of space is pressing very hard for a place as one of the accepted problems of mechanics; certainly it bears credentials from circles of the highest repute.

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## AMERICAN ASTRONOMICAL SOCIETY.

### ABSTRACTS OF PAPERS

*(Continued from page 32.)*

### THE RECENT SUN-SPOT MAXIMUM AS DEDUCED FROM MEAN MONTHLY AREAS AT THE U. S. NAVAL OBSERVATORY.

By G. H. Peters and N. E. Wagman.

The recent sun-spot maximum was unique in several particulars. The period of time covered was unusually long. The combined mean areas of spots or groups were moderate compared with former maxima.

The most notable feature was the occurrence of two peaks of greater activity separated by a period of about two years. The first was formed about the middle of April, 1926. This first peak developed somewhat abruptly and is shown in the graph with a fairly sharp summit.

[20] Esnault-Pelterie, R., *L'Exploration par fusées de la très haute atmosphère et la possibilité des voyages interplanétaires,* Paris, 1928, 96 pp.
[21] Valier, Max, *Raketenfahrt,* Munich & Berlin, 1928, 252 pp.
[22] Ley, Willy, *Die Möglichkeit der Weltraumfahrt,* Leipzig, 1928, 244 pp.
[23] *Die Rakete,* Breslau.
[24] Those interested in this prize may address the Comité d'Astronautique, Société Astronautique de France, 28 rue Serpente, Paris VIe.