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EXPLORING THE STRATOSPHERE*

by Dr. J. Edmund Woodman

New York University

[The field of usefulness of the rocket has been widely discussed in a general way. Such use extends from what might be possible within a very few years, to the ultimate development of the rocket to explore other worlds. The immediate practical uses of the rocket, such as for the exploration of the stratosphere, must precede more ambitious uses. The article that follows, by Professor Woodman, who is professor of Physics at New York University and lecturer on Aeronautic Meteorology at the Guggenheim School of Aeronautics should be of especial interest in determining how the rocket can aid the established sciences.—Editor.]

Why should we be curious about, or interested in, conditions in the stratosphere? First, because man is always, inevitably, reaching out into the unknown, to increase knowledge for its own sake. Second, because we hope to use the lower part of the stratosphere for traffic purposes. Third, because other and more remote parts may be made to yield information of indirect importance to human welfare; e. g., the Kennelly-Heaviside layers, cosmic and ultra-violet rays, etc.

The objects of rocket exploration should be, of course, the acquisition of knowledge of the more remote regions of the atmosphere through the agency of rockets. Rockets can legitimately be used, because theoretically they should be capable of going higher than any other engine now known..

At the present stage of development, or at any stage now possible to forecast, it is futile to dream of what might happen to a rocket if it should be propelled into interplanetary space.

If knowledge is to be gained by the use of rockets, obviously (1) observations must be made at regularly controlled intervals and must be automatically recorded; and (2) the rocket must return to earth under measurable control and must deposit its load of records and samples intact.

At the same time it would appear that rockets *may* eventually furnish the only direct means of

*An address delivered before the American Interplanetary Society on April 29, 1932.

getting this information; since any machine depending upon the lifting power of a gas, or upon the propulsive force of an ordinary internal combustion engine, must always have a "service ceiling" that is absolutely and relatively low.

Present Knowledge as to the Upper Air

Direct observation has been by balloon (Piccard's 52,000 feet), airplanes, kites, sonder balloons, and a few high altitude pilot balloons. By means of visual study and self-recording instruments, these have brought us quite a mass of data as to composition, temperature, pressure and circulation. But the highest sonder balloons have gone only about twenty miles up, and pilot balloons, good only for circulation study, only 26 miles.

Our knowledge gained by direct observation thus is limited to a few thousand feet of altitude. In comparison with the whole height of the atmosphere it is of the order of somewhat less than two per cent.

By indirect observation we know a little about some ten per cent of the air's thickness, or a trifle more. Thus the lower limit of the aurora is 50 to 95 miles. The two Kennelly-Heaviside layers are about 30 and 50 miles up. The layer of most frequent appearance of meteors is 110 km. (about 70 miles.) The average height of the "noctilucent clouds" is only a little over 50 miles. The last twilight arc is about 450 miles up.

We know that in the troposphere the composition is rather constant, owing to convective mixing of the gases. Thus we have discovered that up to about 11 km (36,000 feet), oxygen increases from 20.75 per cent at the surface to 20.99 per cent; that the argon-nitrogen group increases from 78.01 per cent to 78.96 per cent; and that moisture decreases from an average of 1.20 per cent below to 0.01 per cent at 11 km. In other words, as far as the tropopause there are no vital changes in the atmosphere's chief ingredients.

Assuming that barometric pressure is a measure of density, which is not strictly correct, we can get some idea of the rate and extent of "thinning out" or rarification of the atmosphere as far up as our instruments have recorded it. From an average normal pressure of 29.921 inches or 760 mm at the surface, the decrease is at a general rate of an inch for each 910 feet of ascent to 6.614 inches or 165 mm at the troposphere. We have measured it as far as a little above 15 km. or, say, 50,000 feet: and at 15 km. the pressure is 3.53 inches or 89.66 mm of mercury.

In other words, at 11 km we have about 22.1 per cent as much air in a given volume as at the surface; and at 15 km we have only 11.7 per cent as much.

Countless measurements of temperature have been made from sea level up into the stratosphere for a short distance. From them we learn that the vertical temperature gradient with which we deal up to the tropopause is approximately 1° F for each 300 feet of ascent in free air, or 6° C per km. Variations common at regular and irregular intervals near the surface become slight aloft.

At about the tropopause where convection ceases, the gradient drops to zero, and the temperature apparently rises slowly—at least to 20 km. which is as far as direct measurement has gone.

We know, by a multitude of observations of various kinds, the general or permanent or planetary circulation of the winds within the troposphere. We know that the general tendency is for a west to east movement of the air; and that wherever and whenever the lower air blows otherwise, there is an upper limit to these departures, generally far below the tropopause; and that in the upper part of the troposphere the circulation is chiefly from the west.

Within the stratosphere, as far as we have personal knowledge, there is no definite wind. Upper air observations quoted by Sir Napier Shaw, from localities in various latitudes, show variable directions, and velocities often less than at the surface. Piccard's ascent in 1931 indicated that in the first few thousand feet of the stratosphere there was no evidence of a strong and persistent west wind, as we were once taught.

Speculations as to the Upper Air

These speculations are based upon our knowledge of physics and chemistry. To a large degree they await confirmation or modification by direct observations, many of which apparently will be made possible only through the use of rockets.

What gases constitute the upper air? Basing judgment upon a consideration of the conditions of equilibrium of gases of different densities and upon Dalton's law of mutual independence of the composition of a mixture of gases as to pressure, several physical meteorologists have calculated the variation in these gases presumed to be found in the stratosphere or "advective zone".

Humphrey's, Chapman's and Wegener's are illustrations. Differing radically in detail, they agree in certain features. Thus oxygen is considered to be reduced rapidly and to be eliminated at 80 km (Wegener), 90 km (Humphrey), and

140 km (Chapman). Nitrogen, entirely inert and incombustible, increases up to 40 km (Humphrey), to about 90 km (Chapman), and to about 50 km (Wegener). It dies out rather rapidly, reaching zero at 100 km (Wegener), 110 km (Humphrey) and at 200 km (Chapman).

It is the upper part of the stratosphere about which the three authors differ radically. Humphrey postulates a small amount of helium, and an atmosphere otherwise pure hydrogen. Wegener allows a small amount of helium, and the remainder nearly evenly divided between hydrogen and a rather hypothetical element which he calls "geo-coronium". Chapman's concept has no hydrogen whatever, but an atmosphere of pure helium.

Such wide divergence of views well merits further study; whose truth the rocket should ultimately settle.

For studies involving behavior in the upper air of any body that depends upon low altitude pressure for its start, the densities at great heights are especially interesting.

The vertical pressure gradient appears to be such that, starting with 29.921 inches or 760 mm pressure normally at the surface, it is reduced to 0.34 inch or 8.63 mm at 30 km (only about 18½ miles); to 0.001 inch or 0.0274 mm at 70 km; to 0.0059 mm at 110 km, and to 0.004 mm at 140 km.

One can search through literature for any satisfactory conjectures relating to temperature in the stratosphere. For the most part, and judged solely from physical laws, it would appear that the temperature does not become lower with increase of altitude above the tropopause. Rather, if the stratosphere is really "isothermal", the temperature should remain somewhere near the figures that have been recorded up to about 22 km.

There is no reason to expect temperatures down to near absolute zero anywhere in the atmosphere; and the temperature problem may be dismissed as by itself not especially important.

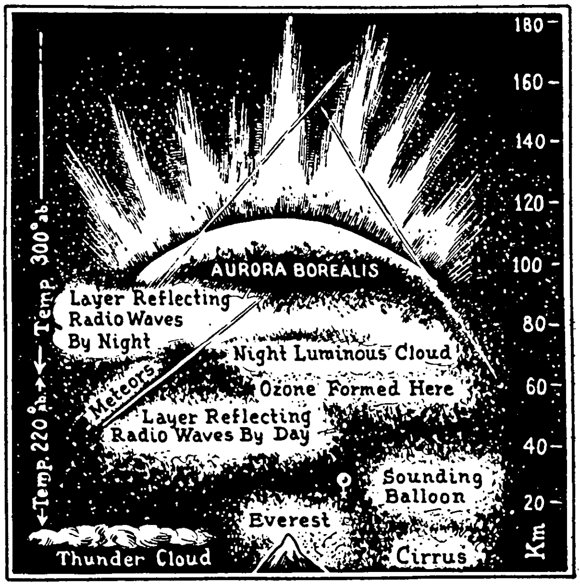
The only importance of atmospheric circulation arises when the rocket is falling under a parachute. Briefly, it is believed that in general the wind in the lower part of the stratosphere is prevailingly from the west but not strong; and that in the upper part it is from the east, representing a lag under the rotation of the globe.

We know at first hand little about electrical potentials and discharges in the upper air, and nothing whatever as to the lines of magnetic force. The aurora is regarded as a discharge phenomenon in an atmosphere rarer than our best artificial vacua. Beyond that we do not go. Whether it can be studied in any way, as to characteristics and causes, by instruments in a rocket, cannot be told without trying.

Rocket Flying in the Stratosphere

The legitimate objects of rocketeering today are two:—long-distance flights in the lower part of the stratosphere, such as between Europe and North America; and extreme high altitude exploration for scientific purposes. This excludes such bizarre dreams as the traversing of interplanetary space.

Within these limitations, it is allowable to seek answers to the following questions. First, what are the environing and limiting conditions of rocket flight, and how may they be met? Second, what types of observations and records should it



Showing the extent of the earth's atmosphere and the various phenomena that may be studied by meteorological rockets. The greatest height yet achieved by man-made instruments (about 30 km. by sounding balloons) is seen to be quite small in comparison with the great extent of the atmosphere.

The figures at the right are a kilometer scale of the atmosphere. (One kilometer is about 0.65 miles.) The scale at the left represents the temperatures existing at various layers, in degrees absolute. Thus from about 18 to 60 km. the temperature is about 220 ab. or —53 Fahrenheit. About 60 km. it rises to 300 ab. or about 30 Fahrenheit.

The troposphere extends to about the 12 km. level, above which is the vast unexplored stratosphere, awaiting the rocket. Between the two, is the "twilight" layer known as the tropopause.

be possible to make and what samples to collect—and how?

The characteristics of the air must of necessity have much to do with the operation of a rocket. The latter is to be propelled by successive explosions, accurately timed. If the explosions produce any considerable heat and flame, it may well be—if Humphrey is correct—that at great heights each flash will be made into a homogeneous medium, itself of high explosibility.

Probably more important practically is the "thinness" or rareness of whatever kinds of atmosphere occupies space up there. The rocket will be packed in a normal low-altitude pressure. It is difficult if not impossible to decrease the pressure within the case of the rocket, or of its instruments, in all parts of its mechanism, to correspond with the results of the rapid drop of pressure from without.

With the high speed of ascent of the missile, there is likely to arise, and to continue increasingly, a condition such as is found in connection with tornadoes; in which doors, windows and walls burst outward with explosive force. The bursting pressure within the rocket will be terrific at high altitudes. Explosions that in the early stages of propulsion through the lower air are merely ordinary explosions, may become so intensified as possibly to wreck the whole rocket. They may be relatively far more forcible than explosions of liquid air, which, when we first attempted to use it, smashed every engine built for it.

Another effect of the great differences in pressure without and within the rocket, and of the suddenness of explosion, may be to render inaccurate the timing devices, upon whose reliability the time spacing of the explosions and the taking of samples or observations must depend. In fact, in view of the shocks and vibrations to which the whole mass will be constantly subject, it is difficult to see how regularity of any of the operations necessary or accessory to the success of a high altitude flight can be achieved.

Temperature of the surrounding air will be low, but perhaps not lower than has been experienced, and successfully coped with, in power flights to the tropopause. But another element enters. The same friction that produces luminosity of meteors at a height of sometimes 200 miles, must have an effect upon a rocket moving more slowly but in less rare medium through at least most of its flight.

The Use of the Rocket

What would we like to bring back from one of these flights of exploration? How would we succeed in gathering and preserving the data?

For one thing, we should certainly observe and record the ordinary phenomena—temperature and pressure. An adaptation of the meteorograph used for sonder balloons would attend to that. But in addition, various electrical and magnetic phenomena must be caught; zones of ionization spotted and recorded; and the action of "cosmic rays" as well. For this the proper instruments have yet to be devised, and these must result from much experimentation.

Samples of the atmosphere must be automatically collected at stated intervals, corresponding with calculated altitudes. The problem of sampling is a troublesome one. So little air can be trapped in a small container, where there is so little air to trap, that the boxes must have a capacity several times the volume needed for similar work in the lower air. They must shut absolutely tight after the sample enters or on the return journey increase of inward pressure may cause leakage from without.

And finally this inward pressure will be so great in the lower air that none but extremely strong containers will fail to be crushed in. This means greatly increased weight for each container, in turn decreasing the lifting power of the explosives. Indeed, the question of the size and weight of the considerable number of sampling jars necessary for this part of the study is one of the most puzzling before the scientific rocketeer.

Finally, the success of everything depends upon accurate timing of each operation, properly recorded. With a speed that would make the swiftest airplane appear to be standing still, an error of seconds become serious. Timing devices and their reliability are going to give a lot of trouble to the inventor working upon the rocket problem.

To sum up the results of this brief glance at the project of stratosphere exploration. The author believes that stratosphere exploration by means of direct observation is highly desirable; and that, properly checked against errors, such observations will be not only of great scientific interest but of important practical application. He believes, moreover, that some development of the rocket offers the only possibilities now in sight for accomplishing this end; and further that such use of the rocket is one of its most legitimate ones.

He feels sure that within a reasonable time most if not all of the difficulties that now stand in the way of success will have been vanquished. Trained and ingenious inventors have labored long. Flights have been made, with rockets that, while crude and incapable of assisting in scientific work, are nevertheless a beginning.

But invention is not sufficient. Getting a rocket into the air for some few thousand feet, or for many miles, is not sufficient. Testing of every piece of apparatus that is to enter into the complete whole, and of every instrument designed to observe, record, sample, must be made under conditions as near those of actual flight as possible, and under as rigorous control as the experiments of the U. S. Bureau of Standards.

Especially is it necessary to conduct tests in chambers containing an atmosphere of the composition assumed to be present at various great heights; and under the conditions of temperature and pressure expected there. The test pieces must have begun their tests under low-altitude conditions, which must be changed as rapidly as the rocket is calculated to rise, to conditions involving almost as near an approach to a vacuum as can be created (for .004 of a millimeter of mercury is pretty low—scarcely more than 1/2000 of one per cent of sea level pressure).

Then the return journey must be begun in the tests, and the pieces of apparatus brought back to sea level conditions as rapidly as the rocket would descend. The timing devices must still be functioning accurately. The sample boxes must have descended tight and uncrushed, having collected samples of the greatly reduced atmosphere at proper intervals. The automatic recorders must have withstood successfully the vibration and shock consequent upon the terrific explosions that earlier occurred in the artificially rarified air.

In short, every variable should be studied, and every contingency provided for, by vacuum tank testing.

NEWS OF THE MONTH

EARTH'S NEW NEIGHBORS INTRIGUE ASTRONOMICAL INTEREST

The earth's closest neighbor in the sun's family, the Reinmuth object, just revealed by Harvard computations, is one of the most important heavenly bodies discovered in recent years. Not since the discovery of the ninth planet, Pluto, have astronomers been so interested.

The Reinmuth object will come six million miles closer to the earth than the famous asteroid, Eros, discovered in 1898, which until a few weeks ago was known as the object, that approached the earth closer than any other member of the solar system except the moon.

By a coincidence, it was found just a few days ago that the Delporte object, also an asteroid discovered the middle of March in Belgium, comes closer to earth than Eros but the Reinmuth object's distance of eight million miles now breaks the Delporte object's record of ten million miles.

The asteroids are minor planets, most of which rotate about the sun in the wide gap of the solar system between Mars and Jupiter. More than a thousand asteroids have been discovered in that region and the one theory is that they represent the remnants of a single planet that was spoiled in the making.

No asteroid has crossed within the orbit of the earth. If the Reinmuth object proves to be an asteroid and not a comet, it will be unique since the computations show that it will come within not only the earth's orbit but that of Venus as well.

This Reinmuth object discovered by Dr. Karl Reinmuth on April 27 should not be confused with the "Reinmuth object" discovered by the same German astronomer last year and found to be a new member of the famous Trojan group of asteroids.

There is no hope that the interesting Reinmuth object, although comparatively close to the earth will be seen with the unaided eyes. It is only about three miles in diameter and it is twelfth magnitude. Telescopes larger than six inches are necessary.

INVENTOR EXPECTS ROCKET TO ASCEND 100 MILES

Maurice Piorier of Los Angeles, Cal. has devised a new rocket, according to newspaper despatches, to explore the uppermost layers of the atmosphere. It is nine feet long, shaped like a bullet and is propelled, say the stories, by a newly-discovered gas, said to be more powerful than any explosive known.

The rocket will carry scientific instruments designed to record atmospheric conditions in the stratosphere and the mysterious layer of ionized gases beyond. The designer confidently expects it to attain an altitude of 500,000 feet.

ECLIPSE PHOTOS NEW EVIDENCE AGAINST MYTHICAL PLANET VULCAN

A new nail has been driven into the coffin of the mythical planet Vulcan by Dr. H. von Kluber, of the Astrophysical Observatory at Potsdam. Vulcan was once supposed to revolve around the sun in an orbit within that of Mercury. Such a body would never be seen in the night sky, but would be visible either when it passes in front of the sun, or during a total eclipse, when the bright solar disc is temporarily hidden by the moon, and faint objects in the same part of the sky are made visible. For many years observations to detect it were made at eclipses, without success. It had been quite definitely decided that no such planet exists.

In May, 1929, Prof. Erwin Freundlich, director of the Einstein Tower at Potsdam, photographed the eclipse of the sun visible in Sumatra. Though made for other purposes, these plates showed such a profusion of star images that Dr. von Klüber decided to examine them carefully to make sure that Vulcan was not concealed there. For purposes of comparison photographs of the same part of the sky, but without the sun, were made six months later, with the same telescope, set up at Potsdam. If a planet were present, it would betray itself by its motion between the time of the two exposures.

The search proves conclusively that there is no planet as bright as the ninth magnitude, considerably below naked eye visibility, up to a distance of 40 minutes from the sun. This is approximately equal to one and a third solar diameters. Closer than this the bright solar corona, visible at eclipse time, might have made faint objects invisible, but even there, believes Dr. von Klüber, a planet as bright as the seventh magnitude, also too faint to be seen with the naked eye, would have been found. Thus, he has decided, if there is a planet closer to the sun than Mercury, it is extremely small.

ASTRONOMERS EXPLAIN LUNAR RAYS

A convincing explanation of that puzzling phenomenon—the lunar ray system—has been put forward by E. N. Buell and J. Q. Stewart of Princeton University in *Popular Astronomy* for May, 1932. As a result of tests in a disused elevator shaft attempting to duplicate in miniature the ray effect, the conclusion come to is as follows:

> "A lunar ray consists of a streak of scattered rocks of dark material (matching in albedo the average surface of the moon) among which is spread the lighter colored powder resulting from the fragmentation of these rocks."

It is suggested that certain lunar craters were volcanic and from these centers, due to an explosive disturbance, come the rays. Other craters may have been due to other causes, such as meteoric impact, in which case no such ray system would be found—and many of the moon craters have, in fact, no ray system at all.

At the bottom of the elevator shaft were placed layers of small broken stone with a center strip of smaller fragments among which the powdered rock was scattered. When photographed from a height of 79 feet typical ray effects were noticed. Moreover, it was possible to reproduce the change in brightness which rays show on the moon when viewed from different angles—a phenomenon not readily explained otherwise.

Another note in the last issue of "Astronautics" under the caption: "Was the Moon Once a Second Sun?" is of interest in this connection.

MAN'S ABILITY TO WITHSTAND HIGH ACCELERATIONS STUDIED

Authoritative estimates of the capacity of a human being to withstand great acceleration are contained in two articles by J. L. Naylor in the *Journal of the Royal Aeronautical Society* for March, 1932 and in the *Scientific American* for June. His facts and figures are taken from actual experiences and would seem to remove acceleration problems entirely from the list of objections to rocket travel.

Mr. Naylor points out that there is a great difference in which direction the acceleration forces are met by the body—horizontally or vertically, i. e., down from head to feet. Acceleration rates which result in a pressure of three times gravity (3 g) can be easily stood by most pilots even when lasting for several minutes. Good men can go as high as 5 g. But at 8 times gravity the time element becomes important. Such forces are not serious for the first two seconds — but after that cause loss of consciousness.

A few surprising instances of high acceleration forces resulted in twelve and fourteen times gravity without injury.

Horizontal application of the force of acceleration is different. Even small intermittent accelerations cause physical discomforts—nausea, etc. Up to 3 times gravity seems not injurious, except where the head be unsupported. (Even 3 g might break a man's neck.) The danger of broken bones is a major problem with horizontal acceleration. The simple answer for rocketeers would be, of course, to place the crew in a reclining position, with feet toward the direction of acceleration.

The cases reported might prove interesting, as similar cases have previously been reported in these columns:

In London in September of 1931 a man fell on to a pile of gravel ballast 50 feet and was unhurt	12 g
Case of a man falling off a roof onto a hard path 40 feet	12-14 g
Common practice to dive 100-120 feet into water	12 g
Airplanes—4½-5 g common for a few seconds	4½-5 g
Airplanes—4½-5 g causes loss of consciousness after a few seconds	4½-5 g
Airplanes catapulted from ships, pilot's head carefully supported and no ill effects	3 g
Broken bones very common in records of high acceleration.	
Almost any bone, unsupported, will be broken at	12 g
Swings operated by children in parks often attain an acceleration force of	3 g

Mr. Naylor refers to possible high rates of acceleration in rockets as follows:—"With rockets the difficulty of landing safely will be great even with an airplane structure; in fact, Herr Opel's experiments on rocket cars and airplanes have not been so successful as to warrant a vigorous prosecution of this line of research."

However, this statement does not agree with the facts such as they exist now available from the many other experimenters in the field. And Mr. Naylor's figures seem to render it practically certain that an acceleration of three times gravity is a conservative figure which may be safely used. Such a rate of acceleration is entirely adequate for rocket design.

WORLD'S WEATHER HAS ORIGIN IN CONTRASTED HEATS OF EQUATOR AND POLES

Weather changes are due mainly to the differences in intensity of the sun's rays received in equatorial and polar regions, according to Dr. Herbert H. Kimball of the U. S. Weather Bureau, Washington.

Great temperature differences exist between these regions, said Dr. Kimball.

"Gravity causes the heavy cold air to displace the lighter warm air at the surface," he explained, "and a polar-equatorial circulation is set up, turbulent in character, especially in winter when the temperature difference is most marked.

"It is to studies of this turbulent polar-equator movement of air that meteorologists look for improvements in weather forcasting, and it is for such studies that the meteorological work of the Jubilee International Polar Year 1932-33 is being organized."

Changes in the distance of the earth from the sun cause variations of nearly 3.5 per cent. in the total radiation received by the earth, stated Dr. Kimball. The great dust clouds following explosive volcanic eruptions may also cut down the intensity of the sun's rays by as much as 25 per cent. for several months. The Swedish scientist, Prof. A. Angström, believes, said Dr. Kimball, that the earth is slightly hotter than usual on account of the small amount of dust now present in the stratosphere.

Periodic changes in the sun's radiation of from 68 to eight months, have been taken in some quarters to be the explanation of major changes of weather, Dr. Kimball said. The amount of these short period changes is never more than one per cent. of the total radiation from the sun falling on the earth. Dr. Kimball does not believe that such small fluctuations can be the cause of great weather cycles.

SHOOTING STAR TRAILS SHOW DIRECTION OF UPPER AIR WINDS

Bright trails of meteors, or "shooting stars" tell scientists the direction and speed of winds in the high atmosphere, miles above the earth. Data thus obtained are valuable in the understanding of the behavior of radio waves and for the progress in our control over them.

Dr. E. O. Hulburt of the U. S. Naval Research Laboratory has summarized what has been done to date and pointed out how amateur star watchers as well as professional astronomers can help in filling the gaps that still exist in our knowledge of these phenomena.

All the observations thus far on record were obtained in North America and Europe, plus a few made on shipboard on the North Atlantic. They indicate in general that the winds at levels from somewhat under twenty to about fifty miles blow toward the west during daylight hours at least. Meteor trains observed at night were at higher levels — fifty to eighty miles up — and showed winds blowing in opposite directions.

Not all the trains drifted in the "orthodox" directions, however; some were observed at various levels that indicated cross-currents, eddies or calms.

The total number of accurately observed meteor trains is still small, Dr. Hulburt said, because relatively few observers have taken the trouble to make even moderately accurate records of them. Elaborate equipment is not necessary, however, for obtaining data of this kind, that may prove invaluable to radio and other lines of scientific work. A small telescope, equipped with the usual graduated scales to give celestial latitude and longitude, and capable of quick maneuvering, is all that is required. The special type of small telescope known as a "comet sweeper" is ideal for this kind of work, Dr. Hulburt said.

A SEARCHLIGHT TO REACH THE MOON

(An editorial in the New York Times of June 5, 1932.)

"Sir Charles Parsons, inventor of the steam turbine, advocated the sinking of a shaft twelve miles in diameter to tap the internal heat of the earth and thus do away with coal. Georges Claude spent at least a million dollars in proving that there is enough heat in the surface waters of the tropics to run a low-pressure steam engine. Piccard boldly ascended to a height of ten miles in a balloon-car which was a veritable laboratory. Professor Goddard is now experimenting in a lonely Western hamlet with a type of rocket out of which may come the space-ship of those who long to voyage from planet to planet. Who says that scientists are an unromantic lot whose imaginations are imprisoned in test-tubes and chained to measuring apparatus?

"To this distinguished company of adventurers in science we must add Dr. F. Jentzsch of Jena, who boldly discusses before the German Society for Technical Physics the possibility of casting a light on the moon and reflecting it back to the earth. With special carbons and a searchlight over six feet in diameter he calculates that a spot as bright as a first magnitude star could be produced. Alas, no one could see it, drowned out as it would be by earthlight. There are just two moments in a total lunar eclipse when the moon is illuminated only by the stars, two moments when a finger of light might be seen stroking the moon's countenance.

"With the resources of a great optical company behind him Dr. Jentzsch has erected in Jena a searchlight visible at a calculated altitude of twenty-one miles. And the moon is 238,857 miles distant! But is it all futile? Jentzsch knows that he cannot illuminate the moon, but discovers in the atmosphere's luminosity unexpected breaks that may bear some relation to the amount of hydrogen, helium and other gases that occur at different heights. So his adventuring may yet be of value in broadening the horizon of science. Let us have more of these Columbuses who set out to discover Cathay and end by landing on new territory. They are the romanticists whose dreaming points the way to the realities of the future."

ROUND TABLE DISCUSSION AT LAST SOCIETY MEETING

Plans for extending the experimental program of the Society, were discussed at the final meeting of the season of The American Interplanetary Society at the American Museum of Natural History, May 20.

The meeting was the first of a series of informal round-table discussions for members only, and it was so successful that a number of similar meetings will probably be scheduled for next fall and winter to bring closer together the members of the Society living in and near New York.

Highlights of the meeting included a statement by William Heyer of Greenwich, Conn. relative to the progress of his experiment with a rotating jet-driven blade, and a discussion lead by Konrad Schmidt, of the Rockefeller Institute, outlining biological experiments in which he, Laurence Manning and several other members expect to participate this summer and next season. Franklin Pierce described the laboratory tests of the Society's rocket and reported that the rocket is now ready for ground tests as soon as a suitable place near New York can be found upon which to make them.

Mr. Heyer's experiments were carried on during the last year, using compressed air as a source of energy for driving small hollow propellers. The air was introduced into the interior of the propellers through the axle and was expelled through slits at the outer edges, whirling the propellers by a reaction effect similar to that which would have been experienced had the slits been replaced by rocket combustion chambers. Several different types of propellers were made by Mr. Heyer to test the efficiency of various kinds of orifices.

A more complete report in this experiment will probably be made next season. In the meantime Mr. Heyer will continue with his experiments, looking forward ultimately to the application of rocket motors to revolving blades.

Mr. Schmidt, who with Thomas W. Norton performed several interesting experiments with mice a year ago to determine the resistance of these animals to acceleration, plans to continue experiments of similar kinds this summer, not only with mice but perhaps with larger animals, including small monkeys.

Another biological experiment contemplated by Messrs. Schmidt and Manning is a test of the reaction of animals to low pressures. A partially exhausted chamber will be constructed, efforts being made to approximate the pressure conditions of Mars, and in this chamber successive generations of mice will be raised.

Mr. Schmidt stated that he thought it possible, after other experiments have been made, to try the effect of acceleration upon human subjects, and this experiment may be undertaken with the aid of a large specially constructed centrifuge.

E. Vinagradov, in response to a question put by the Chairman as to the aims of the Society, suggested that more experiments be undertaken on a group basis. Several other members present stated that they would like to take part in such a program of experimentation. It was also suggested in a general discussion that fewer public meetings of the Society be held next year and that the few public meetings which are held should be of such a nature that large groups of people would be interested, with the idea of encouraging them to join the Society.

The chairman of the meeting was the President, G. Edward Pendray. Among those who attended were Konrad Schmidt, Alfred Africano, C. P. Mason, Dr. Samuel Lichtenstein, H. F. Pierce, Nathan Schachner, Alvin Powers, William Hever, Laurence Manning, Russell F. Schneider, Richard Welling, Stephen F. Harriss, Nathan Carver and E. Vinagradov.