# BOOKS ON EARTH AND SKY

## THREE HUNDRED EINSTEIN ESSAYS IN LOWEST TERMS

EINSTEIN'S THEORIES OF RELATIVITY AND GRAVITATION. Compiled and Edited and Introductory Matter Supplied by J. Malcolm Bird. New York: Scientific American Publishing Company.

**Reviewed by AARON WYN.**

"EINSTEIN'S Theories of Relativity and Gravitation" is a collection of the best thought on this subject from among the 300 essays submitted for the $5,000 Eugene Higgins prize contest, conducted by the *Scientific American*. The essays were limited to 3,000 words. The first half of the book is an introduction to the subject compiled from more than fifty of the better essays, synthesized and supplemented by Mr. Bird, and is intended to prepare the reader to understand better the complete essays which follow. The book reminds one of a number of snapshops taken of the same object—no single one gives a clear picture, but there are so many of them, each from a different angle, that by the time one has seen them all one has a fairly distinct picture. The following is of the nature of a "composite photograph" in outline.

Newton's two laws of motion, explained in terms of Euclidean geometry, have hitherto been thought to be fundamental and absolutely accurate descriptions of physical phenomena. They are (1) "a body in a state of rest or uniform motion in the same straight line will continue so unless acted upon by some external force (law of inertia)," and (2) "every particle in the universe attracts every other particle with a force that is directly proportional to the square of their masses and inversely proportional to the square of their distances apart (law of gravitation)."

In his principles of relativity and gravitation Einstein shows (1) that we have no way of determining absolute space and time; (2) that inertia and gravitation are not, as Newton believed, two independent phenomena, but parts of a more fundamental aspect of nature, and (3) that Euclidean geometry, which has been used for the statement of general physical laws, is not universal in its application.

All investigation of reality presupposes an observer, and the first thing an observer must do is to measure. The basis of all measurement is a rod (yard-stick, meter-stick, &c.,) and a clock. In locating an object on or above the earth we assume that the earth is at rest as regards that object. If, however, we wish to determine the position or motion of the earth we consider the sun as at rest, and thereby ascertain that the earth has a uniform motion of 18½ miles a second relative to the sun.

But is the sun itself at rest? Astronomers, assuming that distance stars are at rest, have long ago discovered that the sun and its planets have a uniform motion of 400,000,000 miles a year relative to the star, Vega. Are we moving toward Vega, or is Vega moving toward us, or are we both moving together, or is Vega moving away from us, while our speed is so great that the distance between Vega and us is shortened about 14 miles each second, or vice versa—in short, what is our absolute motion in the universe, and not our relative motion? We do not know. For, to be able to determine absolute motion there would have to be a body in the universe at absolute rest, and there probably is no such body.

The only conclusion we can draw is that "an observer on a uniformly moving system can determine only the relative motion of his system." Which forms one part of Einstein's Special Principle of Relativity.

Now, the greatest speed that man has been able to discover in the universe, and, consequently, the only reliable standard for time (time is fundamentally motion—the motion of the earth, the motion of a clock's pendulum) is that of a ray of light—186,330 miles a second. It was found by scientific experiment as far back as 1887 that, whether the earth is moving toward or away from a ray of light, the velocity of light remains the same. The experiment has been repeated again and again, always verified, and must therefore be taken as an established fact. We have here the rest of Einstein's Special Principle of Relativity: "In a vacuum the velocity of light is constant for all observers, whatever the velocity of their relative motion."

What, you ask, is the significance of Einstein's special principle? Space and time measurements of one system by an observer on another system vary as the relative motion of the two systems approach the velocity of light. If, for example, an observer on another system were passing us at nine-tenths the velocity of light, objects on his system, in the direction of relative motion, would appear to us less than one-half the length that they appear to him, and a second on his clocks would seem like two and a half of our seconds. And to a same degree objects on our system, in the direction of relative motion, would appear shortened to him and our clocks too slow.

The reason that measurements on one system in the direction of relative motion appear shortened to an observer on another system is that, no matter how accurate the measuring instruments, some time will elapse in making the measurements, and during that time the system under observation will have advanced. In the case of a system moving at nine-tenths the velocity of light the advance would be one-half of any length measured in the direction of relative motion. Measurements at right angles to the direction of relative motion would naturally be unaffected.

A rough and only onesided analogy for the apparent difference in time measurements is the case of a man travelling around the earth. If he went at the same speed as the earth's rotation (this would be about 1,000 miles an hour at the equator) the sun would to him remain in the same position; if he started with the sun directly overhead it would always be noon to him. Were he going at one-half the speed of the earth's rotation what would be an hour to us as measured by our clocks or by the sun would be half an hour to him as measured by the sun.

In his Special Principle of Relativity Einstein considers only uniform motion (inertia) ; in his General Principle of Relativity he takes up the question of accelerated (increasing or decreasing) motion (gravitation). The velocity of a body falling to the earth increases 32 feet each second, and the velocity of a body thrown up from the earth decreases 32 feet each second. And wherever there is matter there is gravitation and accelerated motion.

The velocity of light, although a constant to observers on uniformly moving systems, is not constant to observers in gravitational fields, because it is subject to gravitation. A ray of light coming from a distant star is deflected as it passes our sun; the velocity of the ray of light is increased as it approaches it, just as an object falling to the earth, and decreased as it passes away from it. The deflection of light rays as they pass our sun, one of Einstein's three predictions, was verified by astronomers in 1919.

There is an epoch making conclusion to be drawn from this, which is that inertial mass and gravitational mass are the same. For if a ray of light having only uniform motion (inertia) is subject to gravitation then the mass of matter itself must be affected by its velocity; that is, if the velocity of a body increases or decreases its mass increases or decreases.

This explains the moving forward of the perihelion (point nearest the sun) of Mercury a short distance each year, a fact which Newton's laws failed to account for. Having its greatest speed at this point, as is the case with all planets, Mercury will therefore have its greatest mass here, and this sudden increase in mass will cause it to shoot forward slightly. Einstein's third prediction, that the lines of any element in the solar spectrum will, because of gravitation, be slightly shifted toward the red rays, has not yet been verified.

According to Euclidean geometry the straight line is always the shortest distance between two points. But, the nearest approach to an absolutely straight line in space is a ray of light, and the path of a light wave is not straight in gravitational fields, as we have seen in the case of a light wave passing the sun. The reason for this, according to Einstein, is that the space around matter is curved, and, consequently, the shortest path for a ray of light, which is a measurement for both space and time, is a curved path. Euclidean geometry, which rests on the axiom that the shortest distance between two points is always a straight line, is therefore not applicable in gravitational fields.

The system of geometry offered by Einstein as equivalent for the statement of general physical laws is an intricate form of mathematics, formulated by the mathematicians Gauss, Lobatchewsky, Minkowski and others.

The significant aspects of Einstein's theories for the layman are:

1. Space and time measurements are purely relative.

2. Inertial mass and gravitational mass are the same; in other words, energy and matter are only different manifestations of a more fundamental aspect of nature.

## Practical aviation

THE COMPLETE AIRMAN. By G. C. Bailey. E. P. Dutton & Co.

Although the text of this volume is based on British practice and is illustrated entirely with British types of machines, it will serve any American student of aviation as a good groundwork for the study of aviation and the how and why of flying. In view of the lack of interest in aviation in general in this country and also in view of the many American works in this field, it would seem that there was not much demand for an English work of this kind at this time. But, nevertheless, Mr. Bailey has done his work in good sound British fashion, particularly in the chapters devoted to Mechanics, the Theory of Flight, the airplane itself and Materials and Principles of Construction.

There are further chapters on the Control System, the Fuselage, the Air-Engine and its details, with separate chapters on the starting and running of engines, their faults and care, the instruments used in air navigation, the technique of flying, aerodromes and buildings, a separate chapter on other types of aircraft, and one on the weather.

## Rapid writing

BREVIOGRAPHY: A SYSTEM OF WRITING BY CONTRACTED FORMS. New York: Breviograph Systems Company.

FEW public men but will welcome this little book which teaches an easily acquired system of reducing words, phrases and sentences to contracted form. Few men who wish to write fast, unless they aim to be stenographers, are willing to give time to the latter acquirement. This new system is a natural way of shortening labor and takes no unusual trouble. Yet it cuts down long hand from 50 to 75 per cent. and it is easily read after it is down.

The book contains complete instructions. A practice lesson does more for a person than any amount of description. For instance, you write the letter "p" in a certain way and you have written "pa"; also you write the letter "t" in a certain way and you have "th." Combine the two and you have written "path." By use of simple contractions you have reduced the necessary strokes from 15 to 6.

## Of a marvellous voyage by air

THE LOG OF H. M. A. R 34: JOURNEY TO AMERICA AND BACK. By Air Commodore E. M. Maitland. George H. Doran Company.

**Reviewed by H. L. PANGBORN.**

GEN. MAITLAND modestly says that this "is not a literary effort—neither, therefore, am I an author." Nevertheless he is, in spite of himself, and the book is literature; in fact, a masterpiece of narrative of a very high order, largely because of its lack of self-conscious artistry, its direct, honest, vivid record of events, just as they happened, and of the thoughts and feelings of the participants in a great adventure. Again and again one is tempted to cry out, with Kipling's "Eustace Cleever," of the culprit who used his tooth brush for stirring the mustard at lunch! Found a tabby kitten in forepart of keel . . ."

Here is the perennial small boy that persists in any soundly grown-up adventurer—it is a part of the very spirit of adventure, this zest in minor absurdities in the midst of strenuous achievement. It crops out frequently, but never bulks too large or distracts attention from weighty matters. It helps one to see these pioneers as live human men instead of vaguely heroic matinee idols.

This sort of detail also emphasizes the strangeness and novelty of the situation. Major Cooke, the navigating officer, has climbed to the top of the ship to get an observation on a cloud horizon—"his eye being practically on a level with the cloud horizon, the only thing peeping up above the top of the cloud bank being the top of his head, which is functioning in the same way as a submarine periscope! What a strange sight it would have been to another passing aircraft to see a man's head skimming along the top of a cloud bank at forty knots!"

Above the Clouds. View Taken From the R 34.

It is safe to say that this glimpse of Major Cooke's periscopic head will live in the reader's imagination, whether he is interested in meteorological data or the commercial possibilities of flying, or not.

Naturally, most of the book is taken up with the weighty, practical affairs of the voyage; the study of winds, weather, clouds, the use of the wireless, the difficulties of taking accurate observations, the demonstrated need of certain new or newly modified scientific instruments, and a mass of minor detail. It might have been called a journey in the clouds, since the airship was never out of them for very long periods, and travelled either in the clouds, or above them, or in a stratum of air between upper and lower layers of clouds, an eerie, uncanny limbo in the present state of human knowledge, but one that is assuredly destined to become more familiar.

For the one conclusion that sticks out above all else is that the dirigible airship is destined eventually to become a regular means of travel across the seas; that it is perfectly practicable, and capable of very great things. The problem is not now so much one of science as of commercial factors. The trip can be made safely enough and with much greater speed than that reached by the experimental R 34. The only serious difficulty is to make it financially profitable, and one can scarcely doubt that that will come about in due time.

There is an abundance of material for the scientist and student of aeronautics in this record, though Gen. Maitland does not pretend to be giving a technical report. The suggestions of novel scientific interest are incidents on the way. Perhaps the chief item in this category is the use of cloud study, observations of their shape and character as indices of weather. Commander Scott and Lieut. Harris, the meteorological officer, were able to attain some surprising results in this field; surprising in the accuracy of their prognostications. The obvious need of the airship navigator of the future will be fuller information as to what is going on in the upper air, over the whole ocean and over both continents. The suggestion is made that "one good method of getting information at small cost would be to equip all cable repair ships with a meteorological observer and a suitable outfit of kites and instruments." It is found that kites can be flown at 2,000 feet in winds up to seventy-five miles an hour, bearing the "Marvin meteorograph," which records force of wind, altitude, temperature and humidity. Doubtless some day the international weather bureaus will be able to tell in detail what is happening throughout many thousands of square miles of clouds for the benefit of aerial navigators.

The outward trip of the R 34 was made under difficulties that are easily avoidable. The return voyage, the diary says did not present half the difficulties of the outward journey. The crossing to the east took only 75 hours and 2 minutes, as compared with 108 hours and 12 minutes for the westward trip, though the home journey was slightly longer, the landing being made at Pulham, England, instead of the East Fortune base in Scotland. The time can be reduced considerably with more accurate knowlege of air conditions and experience.

The airship is said to be steadier and potentially more comfortable than its sea travelling ancestor, but it has its "bumps," which may be dangerous as well as uncomfortable. On the outward trip Gen. Maitland records several such trying experiences:

"Violent temperature bumps, evidently caused by rapid variation of sea temperature beneath us. Ship is first lifted 400 feet and then dropped 500 feet—measured on our aneroid. Scott, who has his head out of a window in the forward car, states that he saw the tail of the ship bend under the strain, whilst her angle is so steep at one moment that Cooke, resting in his hammock in the keel, is unable to get out for a minute or two, as he is head downward." But in spite of the actual violence of these bumpings the passengers were in no case the victims of any feeling of seasickness, as the movements seemed to them to be gradual. "As aerial liners undoubtedly will increase considerably in size," says Gen. Maitland, "this immunity from seasickness should prove one of their most valuable commercial assets."

The voyagers had plenty of excitement, especially in violent squalls and thunderstorms, and the diarist remarks, incidentally, during one storm that "we wear our parachutes, and life belts are all ready."

They ran it pretty fine coming over and used practically all their fuel, thinking until the last moment that they might be forced to land short of their goal at Mineola But skilful piloting and good luck just brought them through. Their provisioning also was not as well managed on the first leg of their trip as it might have been; a defect that was remedied on the return voyage by the addition of some delicacies, including a case of rum. "We thought America had gone dry," says the log, "but were quickly undeceived on this point!"

Unforseen difficulties, of course, turned up, but their ingenuity was ready to meet them. In one case of engine trouble a loose screw was made secure "with a piece of copper sheeting and the entire supply of crew's chewing gum (which was hastily chewed first by engineer officer and two engineers!)—we will never be without a good supply in the future."

One less comic and more persistent difficulty lay in correctly estimating the ship's altitude. "Aerial navigation," says he, "is more complicated than navigation on the surface of the sea, owing to the existence of this third dimension; but there is no reason why, when directional wireless has been perfected and when we know more about the air and its peculiarities, it should not become very accurate." Sometimes they were able to work out their height in an ingenious way. "The airship is throwing a very dark shadow on the surface of the sea on starboard side—almost immediately under the ship. By taking with a sextant the angle subtended by length of the shadow and knowing the length of the shadow to be 640 feet, he gets the true height. In this case it works out at 2,100 feet, whilst the aneroid gives us only 1,200 feet—a variation of 900 feet." To correct the aneroid reading otherwise it was necessary to speak a ship in the immediate vicinity and get her barometer reading. And of course it is impossible for the navigator to get his true position unless he knows the exact height above the sea, as well as other factors. Here is a nice little problem for the scientists and instrument makers to solve.

There is an embarrassing wealth of quotable material, tempting one to cite it at length, but only a few can be given. Here are some bits, picked almost at random:

"7:30 P. M.—Cup of hot cocoa. Lay down for half an hour before evening meal and read 'Emerson's Poems.'" (One would like to know which!) "Noticeable leakage from petrol tanks when ship takes up big angle by bow or stern, causing unpleasant smell of petrol vapor in keel. This must be remedied in future."

"8 P. M.—Ship very heavy—12 degrees down by stern—owing to change of temperature. Height 3,000 feet. We are just on top of the clouds now—alternately in the sun and then plunging through thick banks of cloud."

"5:40 P. M. Specimens of 'flocculent cirro stratus' rather resembling a diamond tiara, high in the centre and sloping away on both sides, also begin to appear to the south." (Cirrus clouds had also been noted.) "The appearance of these two types of cloud are interpreted by Harris as a first and infallible indication of a depression coming up from the south." The guess proved correct.

"It is a remarkable fact that nearly every member of the crew owns a mascot of some sort. The engineer officer wears a pair of his wife's silk stockings as a muffler."

"Standing out conspicuously in this blue patch of ocean we see an enormous white iceberg. Looking down we can clearly see treacherous green ice protruding under the water in all directions. As this underwater ice could under no circumstances be seen from a surface ship, it brings home one of the dangers that oceangoing vessels are liable to meet." An obvious advantage for the airship.

"12 Midnight. Intercepted on wireless that Dempsey had knocked out Jess Willard in third round. And so to bed." Shades of Pepys!

"It is wonderful what detail we see when flying at this low level." (800 feet above Nova Scotia.) "The trees each settler cut down last winter are neatly stacked and look like little bundles of asparagus. The character of the soil is clearly visible to us, the natural drainage of the country is revealed, and we get an insight into the rainfall, the types of trees which do best, the bird life and the depth of the lakes."

"10:15 A. M. Turned in for an hour, but unable to sleep. Became absorbed in Kipling's story of 'The Night Mail.' Every time I read it the more impressed I become with the reality of its prophecies—that we are actually experiencing during every moment of this journey."

One of the most interesting of the appendices is the complete wireless log. It is estimated that about 20,000 words were sent and received during the two voyages—a most important, vital part of the mechanism of such travel. Naturally most of the messages deal with weather conditions. They indicate what must be the future field of development if air service is to become a popular, everyday affair, as it probably must some day.

The book is amply illustrated.

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Rudyard Kipling, we are told, is resting and enjoying the sunshine of the North African coast. Accompanied by his wife and daughter, Mr. Kipling has been spending the spring motoring in Algeria.

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In addition to having had many books come out on top of the lists throughout the year, Houghton Mifflin, or rather the Riverside Press, closely related to that firm, have shown that they could not let slip by a small item such as the workhorse parade. Two of their teams took first prize in the parade which has been a feature of Memorial Day in Boston for a number of years.

## Seven centuries of research

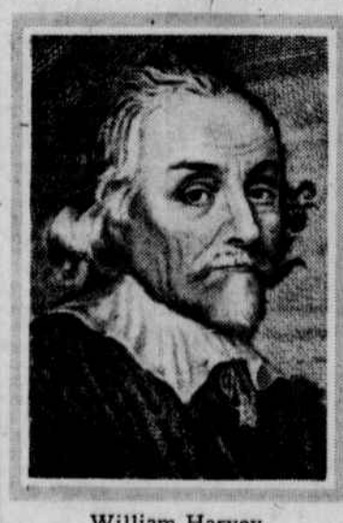
BRITAIN'S HERITAGE OF SCIENCE. By Arthur Schuster and Arthur E. Shipley. E. P. Dutton & Co.

**Reviewed by T. COMMERFORD MARTIN.**

AN excellent summary this of what Britain has done for the advancement of physical science, but the word "heritage" seems to be rather oddly used. The more appropriate expression would be "achievement," perhaps. An underlying purpose apparently is that of implying continuity with the work of Roger Bacon, William Gilbert and Isaac Newton as foundation and chronological points of departure for a narrative brought down to the time when it was finished, at the very moment in 1917 when the great war was at the height of its intensity and uncertainty.

The unusual charm of the book lies in the fact that it is an admirable outline of scientific history through some 750 years associated cleverly with vivid biographies of all the great leaders and illuminating personal references to a remarkably large number of men, not always of the first rank, who have nevertheless made fundamental or important contributions to the sum of human knowledge.

One or two other features must be warmly commended. Welcome details are given as to the creation and growth of such institutions as the famous Greenwich Observatory, and of such useful learned bodies as the Royal Society and the British Association for the advancement of Science. An excellent chapter is also included with regard to some of the more notable industrial applications of the scientific discoveries noted. This more than atones for the curious neglect to accord a separate chapter to "chemistry," which is certainly now foremost in public attention as a fruitful domain of beneficent research. Warm praise is due the series of fifteen good portraits. One could well wish for a corresponding manual epitomizing what America and her scientific worthies have done in 150 years.



William Harvey.

Sir Humphry Davy.

## AN ASTRONOMER TURNS HIS LENS ON THE INVISIBLE

DEATH AND ITS MYSTERY. By Camille Flammarion. Century Company.

**Reviewed by DAVID COYLE.**

IT seems to me that the attentive reader can no longer doubt the existence of the soul and its purely psychic faculties. Before the knowledge of telepathy, in past ages, they attributed these sorts of warnings to angels or demons, or, fifty years ago, to disembodied spirits. To-day we can think that there is telepathic transmission from brain to brain; that cerebral waves overcome distance. This is possible, but it is also possible that the science of the future will smile at our present theories as we smile at those of the ancients. Whatever may be the explanation, premonitory dreams, visions of the future, are authentic, investigations have confirmed them. . . . To solve the mystery of death we first had to prove that the soul exists, individually, an existence proved by special, extra corporeal faculties which cannot be included among the properties of the material brain or among chemical or mechanical reactions; faculties essentially spiritual, such as the will, acting without the spoken word; auto suggestion, producing physical effects; presentiments, telepathy, intellectual transmissions, reading in a closed book, the sight by the spirit of a far off country, of a future scene or event—all phenomena outside the sphere of our physical organism, lacking any common measure with our organic sensations and proving that the soul is a substance which exists in itself"

So concludes the eminent French astronomer after some forty years of investigation, during which time he has studied and verified hundreds of cases of abnormal psychic manifestations. This present volume consists mostly of records of these extraordinary occurrences, with names, dates and witnesses; in many cases the evidence is so complete that the reader must either admit the fact or believe that an immense number of seemingly matter of fact people are really fantastically insane.

Beyond any reasonable doubt, there are people who do things that ordinary folks can't do every day with our ordinary senses, which certainly proves that there is more in the universe than the well known and obvious bodily activities. Whether this extra something is only a more elaborate form of chemical reaction or is a psychic force existing on its own is the question at issue. One may, perhaps, be permitted to observe that both the materialists and the believers in psychic force like Dr. Flammarion and Dr. Geley have to jump a certain logical gap in stating dogmatically that the facts prove this or that. Nine-tenths of the world believes that we are souls living in our bodies, and everybody acts in practice as if he believed in his own mental existence, so the burden of proof certainly rests heavily on the materialists. On the other hand, if these weird, abnormal spooks must sing in our ears to prove that we have souls, how about those of us who never have any spooks? If every human being has, or rather is, a spiritual person inhabiting a physical body there ought to be qualities common to the lot of us which indicate the fact.

One is inclined to think that it is more by the study of the spiritual faculties of the normal person that a convincing theory may be finally built up to explain what we are and why we act the way we do. Books such as this of Dr. Fammarion's may be useful in upsetting the two easy explanations of the mechanist school. But the less startling work of men like Josiah Royce and William James will probably leave more of a residue in the thought of those future philosophers who perhaps will solve the riddle of the universe.