

**OUTSTANDING ERRORS
OF THE NAUTICAL
ALMANAC, PP. 5-54**

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Outstanding Errors of the Nautical Almanac, pp. 5-54 by Dodge P. Blackstone

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DODGE P. BLACKSTONE

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OUTSTANDING ERRORS

OF

THE NAUTICAL ALMANAC



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BY DODGE P. BLACKSTONE, A. M., C. E.

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OUTSTANDING ERRORS OF THE NAUTICAL ALMANAC.

A correct nautical almanac is of unspeakable value to the astronomer, while an incorrect one makes it perilous for ships at sea. For a definite understanding of these outstanding errors the following quotations are made.

The first quotation is from the pen of Simon Newcomb, as published in Harper's Magazine July, 1902; the second was written by C. A. Young and published in The Cosmopolitan June, 1894; and the third is a production by John Elfreth Watkins, Jr., and published in the Ladies Home Journal July, 1903.

First:—

"Our own moon is one of the enigmas of the mathematical astronomer. Observations show that she is deviating from her predicted place, and that this deviation continues to increase. True, it is not very great when measured by an ordinary standard. The time at which the moon's shadow passed a given point near Norfolk during the total eclipse of May 29, 1900, was only about seven seconds different from the time given in the Astronomical Ephemeris. The path of the shadow along the earth was not out of place by more than one or two miles. But, small though these deviations are, they show that something is wrong, and no one has as yet found out what it is. Worse yet, the deviation will in all likelihood go on increasing rapidly. The mathematical problems involved are of such complexity that it is only now and then that a mathematician turns up anywhere in the world who is both able and bold enough to attack them.

"Twelve years ago a suspicion which had long been entertained that the earth's axis of rotation varied a little from time to time was verified by Chandler. The result of this is a slight change in the latitude of all places on the earth's surface, which admits of being determined by precise observations. The National Geodetic Association has established four observatories on the same parallel of latitude—one at Gaithersburg, Maryland, another on the Pacific coast, a third in Japan, and a fourth in Italy—to study these variations by continuous observations from night to night."

Second:—

"THE Wobble OF THE EARTH'S AXIS.

"We do not refer to the long-known shifting of the direction of the axis of the earth, which produces the so-called 'Precession of the Equinoxes.' This does not in the least affect the position of the pole upon the surface of the earth, while that which we have in mind is an actual travelling of the pole over the ground, and is due to a slight change of the position of the axis within the globe itself. This, of course, manifests itself by a minute change both in the latitudes of observatories, and in the direction of meridian lines. If the pole of the earth approaches Berlin, the latitude of Berlin is necessarily increased, and at the same time the latitude of Honolulu, on the other side of the earth, is correspondingly diminished.

"The fact that such a thing is really happening was first clearly brought out in 1889 in Germany, and ever since the subject has greatly interested the astronomical world. All recent latitude observations made by methods of precision confirm the fact, and within a few months Socoloff has shown that the azimuthal observations upon the Pulkowa meridian-marks between 1880 and 1887 tell the same story. The latest results of Chandler, based upon a very thorough discussion of several thousand observations made at seventeen different observatories, between 1840 and 1893, and combined with earlier series at Greenwich (by Pond, between 1820 and 1830, and by Bradley about the middle of the last century), show that this motion is unexpectedly regular.

"It seems to be made up of two superposed revolutions of the pole from west to east; one with a period of just a year, in a circle of about thirty feet in diameter, and the other in a circle of similar size, but with a period of 428 days. As a consequence of this combination of motions, the actual annual displacement varies greatly. Once in about seven years the two practically destroy each other, and the pole remains for a time nearly stationary (as in 1885), while at intermediate epochs (as in 1890), it describes a sort of circle fully sixty feet in diameter.

"It hardly need be said that a motion so slight becomes sensible only in observations of the last degree of precision, but its discovery has already explained certain important anomalies and apparent errors in work of that class.

"As regards the cause of this peculiar motion, the theory is still more or less obscure. There can be little doubt, however, that the annual component is due, in part at least, as Lord Kelvin long ago suggested, to the course of the seasons—to the winter's deposit of snow and ice upon the northern continents, and its later return to the ocean.

As to the 428-day revolution, this seems to be a veritable 'wobble,' such as is produced by striking a spinning top. The 'blow' may perhaps consist in the annual disturbance just referred to; but the matter is not yet wholly clear."

"C. A. Young."

Third:—

"THE NORTH POLE IS CONTINUALLY MOVING.

"It is perpetually roving within the limits of a circle sixty feet in diameter. What is the North Pole to-day is not the North Pole to-morrow. The true North Pole has been known to travel more than four feet in a week, while sometimes it has required more than a month to cover a yard. Suppose that you and I were to sail from opposite points to discover this turning point. We will say that you, with your astronomic instruments, planted your flag upon the exact North Pole six months ago, and then went away. I, arriving to-day, make equally accurate calculations and plant my flag also upon the true North Pole. My flag is probably forty feet from yours, yet neither of us is in error. To-morrow the elusive little tip-top of the earth will have slipped away from both of us. And if I were to claim a building lot, the cornerstone of which was marked by this North Pole, a strange predicament would follow. I should have to place my fences upon casters and keep them continually moving in order to mark strictly my own reservation. Our Naval Observatory now employs an astronomer whose sole duty it is to keep track of the migratory and nomadic poles. And this he can do, by aid of his instruments, without leaving Washington."

These nomadic wanderings of the earth and the moon are all due to the same cause, and that cause stated verbally is very simple to comprehend. Under the condition of Kepler's first law that the radius vector of a planet revolving around the sun describes equal areas in equal times, the mean of the inverse squares or cubes of all the radius vectors of a planet is a very trifle greater than the semi-major axis of the elliptical orbit likewise taken.

This very small error not taken into consideration by the nautical almanac makers leads to outstanding errors between the computed tables of the nautical almanac for the moon and the results of observation. As determined by due mathematical demonstration and computation for the cause under consideration, the moon in orbit is in advance of its otherwise computed position, or right ascension, by angular gain of 1.06" per year. This angular gain is due to the eccentricity of the moon's orbit.

Ptolemy, the celebrated astronomer, made astronomical observations at Alexandria, Egypt, about the year A. D. 140. His record of observations is known by name *Almagest*. In this book there is recorded

the time of occurrences of eclipses observed by himself and Hipparchus and other ancient astronomers.

From the data of the *Almagest* for the ancient eclipses our modern mathematical astronomers by computation have determined that the moon has gained in orbital distance from time of Ptolemy to the present date about one degree.

As determined by the lately deceased generation of mathematical astronomers, the moon has gained in orbital distance about one-half of a degree, or 1836' since the time of Ptolemy to the present date, due to the cause that the earth's eccentricity of orbit is very slowly diminishing. This gain is accelerating, commencing at the time of Ptolemy, 6' for the first century, 24' for the second century, and so on for 1750 years to present date. The present generation of astronomers accept this result as very nearly true. Thus accepted, there yet remains 1836' to be accounted for. 1.06' multiplied by 1750 equals 1855', making a total gain of a trifle over one degree since the time of Ptolemy.

Due to the cause under consideration, the perihelion of the planet Mercury is ahead of its otherwise computed position by angular distance 37.67' for a period of one century. The distinguished French astronomer Leverrier determined by observation that the perihelion of this planet Mercury is in advance of its computed place by about 40' per century, and he concluded that this discrepancy was due to a group of small planets revolving nearer the sun. Persevering search has been made for these little planets, with the result that not one has been discovered.

The Newtonian law of attraction is a theory derived from observation and has been well tested. Thus taken, all new mathematical deductions from that theory must reasonably well meet the results of observation.

Again, due to the cause under consideration, the perihelion of the planet Venus is ahead of its otherwise computed position by angular distance .4908' for a century. Likewise the Earth is ahead .740", planet Mars 2.19", Jupiter .1790", Saturn .0839", Uranus .0235"