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THE GREAT EARTHQUAKE OF JAPAN AS RECORDED BY THE SEISMOGRAPH OF THE ROYAL OBSERVATORY, CAPE OF GOOD HOPE.

The frontispiece represents the record of the Great Earthquake of Japan taken with the Milne-Shaw seismograph at the Royal Observatory, Cape of Good Hope.

The recording instrument is of the well-known type invented by the late Prof. Milne. It consists of a delicately suspended horizontal pendulum, whose departures from a normal position on account of the passing of seismic waves are photographically recorded on a sheet of sensitized paper. For this purpose the free end of the pendulum is connected with a small mirror which can rotate on a vertical axis in such a manner that a movement of the pendulum causes a greatly magnified angular deflection of the mirror. A beam of light is sent from a lamp upon the mirror, and from there upon the sensitized paper, which is mounted on the surface of a cylinder maintained in uniform rotary motion by clock-work at the rate of one revolution per hour. The rotating drum is uniformly shifted forward by means of a screw connected with the clock, so that the hourly paths of the beam are recorded side by side along the sheet. The movement of the pendulum is therefore traced by the path of the beam recorded on the paper. Under normal conditions this path consists of a series of more or less parallel straight lines, each of which represents a record of one hour's duration.

The upper half of the diagram exhibits the records of the instrument under these normal conditions. For fixing the time a shutter, which is actuated by a mean-time clock at every full minute, cuts off the beam for a few seconds, and thereby produces the evenly spaced bright interstices shown in the path of the beam, the full hour being marked by the omission of the minute signal.

In the original type of the Milne seismograph the pendulum is allowed to swing freely with its natural period. Such undamped oscillation makes it difficult, however, to determine the periods and amplitudes of the seismic waves, especially when these happen to possess, as they often do, a period nearly that of the pendulum. To record the true periods and magnitudes it is essential that the pendulum should be as nearly as possible a "dead-beat" or "aperiodic" pendulum. This is effected by electro-magnetic damping. A copper plate attached to the pendulum moves in a field produced by a pair of strong permanent horseshoe magnets. The eddy currents induced in the plate when the pendulum moves retard the motion, so that the pendulum comes to rest almost immediately after the seismic impulse has ceased. The instrument with which the above record was taken is provided with this damping apparatus.

Turning to the earthquake record in the lower part of the photograph, it will be noticed that the beginning of the disturbance is fairly sharply marked, the time noted on the record being September 1 3 h. 21 min. M.T. Greenwich. The first part of the curve up to about 4 h. 9 m. consists of a series of irregular small oscillations. These constitute the preliminary phase and contain two sets of impulses, the first and the second phase. In our diagram the transition from the one to the other is not well marked; it is probably at about 3 h. 38 min. where there is a noticeable sudden change in the character of the oscillation. In striking contrast to the irregular tremors of the preliminary phase, however, are the regular oscillations of the large waves making their appearance at 4 h. 9 m. The diagram shows that the phenomenon consists now of a series of waves of a strictly sinoidal character, which is preserved throughout the remainder of the disturbance.

In accordance with what has been said there exist three characteristic points on the seismic curve, the point P (at 3 h. 21 min.) where the first preliminary phase begins, the point S (at 3 h. 38 m.) which marks the starting point of the second preliminary phase, and the point L (4 h. 9 m.) where the large waves begin. The time intervals between these points depend on the distance between the centre of the shock and the observing station. From earthquakes of known origin the relations between distance and the times of reception of P, S and L have been ascertained and laid down in the form of curves, which enable us to find approximately the time interval between, say, P and L on the one hand, and the distance between the station and the centre of the disturbance on the other. In the present case, for instance, the distance between Cape Town and Tokio is about 14,700 km. According to the curves published by seismologists the time interval between P and L should be 53 m., whereas the record shows 48 m., a rather large discrepancy, which shows that for great distances the tabular values are not reliable. It may be mentioned that the assumption that the preliminary waves travel along the chord joining the centre with the observing station, whereas the large waves proceed along the great circle, appears to account roughly for the time differences in the arrival of these waves, at least for moderate distances.

An excellent agreement would be obtained if, in accordance with views held by scientists, the assumption was granted that the preliminary waves reaching Cape Town have struck the surface first at a point midway between Tokyo and Cape Town, and have been reflected from that point. In this case we have to deal with waves travelling along two chords, each corresponding to an arc of roughly 7,350 km. The tables show that

P requires $2 \times 642 = 1284$ seconds $= 21.4$ minutes,
S requires $2 \times 1162 = 2324$ seconds $= 38.7$ minutes,

while L, which travels uniformly along the arc Tokyo-Cape Town at the rate of 3.5 km. per second, requires 70.0 minutes. Hence the time of the beginning of the earthquake at Tokyo as derived from P : 3h. 21m. —21m. = 3h. 0m.
from S 3 38 —39 = 2 59
from L 4 9 —70 = 2 59

To find the *direction* of the incoming waves the simultaneous records of two instruments whose pendulums are oriented at right angles to one another (NS and EW) are required. From the ratio of the amplitudes the azimuth of the direction in which the waves strike the instrument can be determined.

The records taken at the Royal Observatory are forwarded to the University Observatory at Oxford, where, in conjunction with the records from other stations, the position of the centre of the disturbance is located by a careful analysis of all the data available.

J. H.

THE OBSERVATION OF VARIABLE STARS.

By W. M. Worssell, F.R.A.S.

The usual method of observing variable stars is by direct visual comparison of the variable with other stars. Whenever possible, two comparison stars should be used, one a little brighter and the other a little fainter than the variable, and the smaller the difference between the variable and the comparison stars the greater the accuracy of the result. When comparing two stars, no attempt should be made to look at both at once, as, owing to the varying sensitiveness of different parts of the retina, this method is sure to introduce errors, and often very large ones. Also the position of the stars in the field usually affects their apparent brightness, an effect which can be easily shown if the telescope is fitted with a zenith prism. With the prism attached, two nearly equal stars are placed symmetrically in the field and their difference of magnitude carefully estimated; the prism is then turned round until the field of view is reversed and a fresh estimate made, when it will usually be found that there is a considerable difference between the two estimates. For this reason, when making a comparison, each star should be brought to the centre of the field in turn and a good long look taken.

The ordinary programme when making a comparison should be as follows: One of the comparison stars should be brought into the middle of the field and a good, steady, direct look taken at it so as to let the realization of its brightness, as it were, soak into the observer's mind; then the variable should be examined in the same way, and finally the other comparison star. The series should then be observed in the reverse order, and the observations repeated in alternate order until the observer is satisfied that he has fixed the brightness of the variable with respect to the comparison stars.

The best method of fixing the brightness of the variable with respect to the comparison stars is probably that of dividing the difference between the comparison stars into any convenient number. If we call the brighter star A, the variable V, and the fainter star B, then when V is exactly halfway between A and B, the entry in the observing book would be A 1 V 1 B; if the variable is a little nearer A than B, the entry would read, say, A 3 V 4 B or A 4 V 5 B, and so on. When the variable is equal to one of the comparison stars it will be found that the observations are not consistent—sometimes the variable and sometimes the comparison star will appear the brighter; if each is estimated to be the brighter about the same number of times, then the stars should be considered equal in magnitude; if one star, say the variable, is estimated to be the brighter twice as often as the other, it may be considered as being 0.1 magnitude brighter, and the entry in the book should read V 0.1] A or V 0.1>A. The same difficulty occurs with all the observations, although it is most noticeable when the stars are equal, or nearly so. If the variable is exactly midway between the two comparison stars, it will appear to be sometimes nearer the one and sometimes nearer the other; a little care and practice, however, soon enables the observer to obtain good results, and the observations are really not so difficult, and do not take so long as the description seems to indicate. When more than two comparison stars are available they should all be used. If, for example, the comparison stars are 8.9, 9.1 and 9.8, and the variable is between the last two, it should be compared with the 8.9 and the 9.8, as well as with the 9.1 and the 9.8.

A trouble with the long-period variables, which are mostly reddish or red, which the observer soon meets, is the Purkinje phenomenon, which causes a red star to appear to increase in brightness up to a certain point the longer it is looked at. This phenomenon may be illustrated as follows: Let two lights, one red and one white, be adjusted to be of equal brightness to the eye; if now the intensity of both lights be increased by an equal amount the red will appear the brighter, and if they are decreased by an equal amount the red will appear the fainter. Owing to this peculiarity of the eye it is especially necessary, when observing a red variable, to take a good long look at it, otherwise its brightness will be underestimated. It is also necessary, when changing from one instrument to another, to have some overlapping observations, as a change in aperture will affect a red star more than a white star. Brightness of the background also has a disturbing effect, red stars gaining in brightness on a bright background as compared with white stars. During the fine season the brightest moonlight nights can usually be dodged, but during the wet season, and when the variable is rising or setting in the twilight, this disadvantage has to be endured.

When the sky is partly clouded the observer must use his discretion, but in any case must be quite certain that the part of the sky under observation is perfectly clear at the time. When the clouds are large and have well-defined edges there is usually no difficulty, but when they are moving rapidly and have ill-defined edges the greatest care should be exercised, and no observation entered unless the observer is quite certain that the part of the sky under observation was perfectly clear at the time. The presence of cirrus clouds will usually quite prevent observation; there is no doubt that the unsuspected presence of cirrus is responsible for some of the anomalous observations.

The symbols] and [, for "brighter than" and "fainter than," are preferable to the symbols > and <. The latter are the mathematical symbols for "greater than" and "less than," and are used by an occasional observer to indicate that the numerical magnitude is *greater* or *less* than a given magnitude, and that the star is therefore *fainter* or *brighter* than that magnitude.

The observing lamp should be well shaded, and only bright enough to allow the charts to be read and entries to be made. Many observers prefer a dim red light.

The entries made in the record book should show for each star the following particulars, viz.: the date and time (clearly indicating what time is used), the instrument and power, the state of the sky (bright moonlight, good or poor seeing, good or bad definition, etc.), the comparisons made and the resultant magnitude. For long-period variables the time to the nearest hour is sufficient, but for short-period variables the nearest minute should also be given.

THE ORBIT OF A COMET.

By H. E. Wood, M.Sc., F.R.A.S.

The information given in regard to the elements of a cometary orbit is generally in the form of an astronomical shorthand. As South African amateur astronomers have discovered quite a number of comets during the past few years, it may be of interest to explain here the terms used in connection with orbits.

Theoretically any body moving round the sun under the influence of the solar gravitation will move in a path which has the form of a conic section—*i.e.*, the path is either a circle, ellipse, parabola or hyperbola. Whereas the orbits of the planets are all nearly circular, no comet has ever been known to have anything like a circular orbit. Their orbits are always very eccentric, *i.e.*, the sun does not stand at the centre of the orbit, and the form of the orbit is an ellipse, parabola or hyperbola. Of these, the ellipse is a closed curve, but the parabola and hyperbola are open infinite curves. If the observations of a comet show definitely that it is moving along an elliptic curve, then the comet is a periodic comet, and may be expected to return again after a period which is computed from the shape and size of the ellipse.

Following upon the discovery of an unexpected comet, the astronomical computer requires to have three positions of the comet at three different times before he can begin to determine the orbit. For a rough preliminary orbit, three observations obtained on three consecutive days will suffice. These positions fix a short portion of the comet's orbit. At this stage the computer knows nothing about the distance of the comet from the sun, and, as this information is required in the work, he proceeds by a method of trial and error to calculate a parabolic curve which will best pass through the three given positions. For a beginning it is generally assumed that the distance of a comet from the sun at the time of discovery is the same as the distance of the earth from the sun, and, starting with this for a first trial, the distance is varied so as to get the most accordant result.

The results of the work are usually expressed in the following notation. The example given refers to the first comet of 1923, which was independently discovered in Spain and Russia, and also by Mr. Watson at Beaufort West. The position of the comet was determined photographically at the Cape Observatory on November 5, 6 and 7, and a preliminary orbit was computed by Dr. Halm from these three positions.

Comet 1923 *a.*

T	1923, November, 16.7 G.T.
ω	$254^\circ\ 32'$.
Ω	$227^\circ\ 36'$.
i	$114^\circ\ 17'$.
log q	9.8976.

Here "T" denotes the time at which the comet is passing through its perihelion, or that point in its orbit at which the comet is nearest to the sun. The quantity "q" gives this minimum distance of the comet from the sun. The unit in which "q" is expressed is the astronomical unit of distance, *i.e.,* the mean distance of the earth from the sun, or roughly 92,900,000 miles. In the example given $\log q = 9.8976$, therefore $q = 0.7900$ astronomical units, or about 73,380,000 miles. This, then, would be the distance of this comet from the sun on November 16.

The orbit of a comet will lie in a plane which is, in general, inclined to the plane of the ecliptic or the plane of the earth's orbit around the sun. The inclination of these two planes to one another is given by the quantity "i." This inclination may have any value between 0° and 180°; if the value is less than 90°, the comet is moving round the sun in the same direction as the earth, or is said to have "direct" motion; if the value is greater than 90°, the motion of the comet is opposed to that of the earth, or is "retrograde." If the comet's orbit has only a small inclination to the ecliptic, then it is rather probable that the comet is a periodic one, and may eventually be found to have a decidedly elliptic orbit.

As, in general, the orbit of the comet will be inclined to the ecliptic, a portion of the orbit must lie below (or south of) the ecliptic and the remainder above (or north of) the ecliptic. In other words, the two planes must intersect one another in a straight line which lies both in the plane of the ecliptic and in the plane of the comet's orbit: this line is known as the line of nodes. In one direction along this line the comet will be passing from south to north of the ecliptic. This direction is, then, the direction of the ascending node, and the longitude fixing this direction is given in the elements of the orbit by the symbol "Ω." The ascending node of a comet's orbit thus corresponds to the vernal equinox in the earth's orbit, and is equally an important reference point.

A further quantity is required definitely to fix the position of the parabolic orbit in space, and that is the direction in which the perihelion lies. The symbol "ω" is used to express this, and represents the angle measured round the cometary orbit in the direction of the comet's motion from the ascending node to the point of perihelion. In some orbits a quantity "π" or the longitude of the perihelion is given: this expresses the angle from the vernal equinox to the ascending node plus the further angle measured along the comet's orbit in the direction of its motion round to the point of perihelion. Thus in the symbols used $\pi = \Omega + \omega$.

When the preliminary orbit of the comet has been satisfactorily obtained, an ephemeris is prepared from it. This enables the astronomer to set his telescope on the comet, if it is a faint one, but its chief use ultimately is to test the preliminary orbit. With the aid of an ingenious code, the orbit and ephemeris of a comet can be cabled to all observatories in a very brief message. Thus it may happen that a comet has been discovered in the Northern Hemisphere, and its motion is such that it will very rapidly travel southwards out of reach of northern astronomers. The code message then sent to observatories in the Southern Hemisphere will give sufficient information for locating the comet so that continuous observations may be secured.

When the comet has been observed over a longer portion of its orbit, it may be found that the actual observations begin to deviate from the predicted places of the comet, *i.e.*, that the comet is not travelling along the parabolic path indicated by its preliminary orbit. A further orbit is now calculated, but this time a lengthier process is followed in which it is not assumed that the shape of the path is a parabola. The parabola is a particular limiting form of a conic section. If a simple cone is cut through at right angles to its axis, the section will be a circle; if the cutting plane is inclined, the section passes into an ellipse, and the shape of this ellipse will gradually change, the ellipse becoming longer and longer, until the cutting plane is parallel to the side of the cone. At this stage the ellipse ceases to be a finite closed curve and becomes a parabola. If the inclination is increased further, the parabola at once changes into a series of two-branched curves called hyperbolas. The parabola is thus a transition stage between a family of ellipses and a family of hyperbolas. The characteristic of these curves is their "eccentricity." The circle is a curve of zero eccentricity; as the cutting plane of the cone is gradually inclined the eccentricity increases as we pass through the ellipses, and reaches unity when the curve becomes a parabola. When the eccentricity becomes greater than unity the curve is a hyperbola.

If it can be satisfactorily proved that the comet is moving in an orbit the eccentricity of which is decidedly less than unity, then it is known that the comet is a periodic comet, and further information relating to the actual dimensions of the orbit are given. The following are examples of two periodic orbits:—

Halley's Comet.		*Encke's Comet.*	
T	1910, April, 19.67.	T	1924, October, 31.5.
ω	$111^\circ\ 42'\ 16''$.	ω	$184^\circ\ 44'.5$.
Ω	$57^\circ\ 16'\ 12''$.	Ω	$334^\circ\ 37'.2$.
i	$162^\circ\ 12'\ 42''$.	i	$12^\circ\ 30'.0$.
e	0.967281.	ϕ	$57^\circ\ 48'.8$
μ	$46''.669$.	μ	$1076''.14$.
log a	1.253986	log a	0.34612.

The new symbols used in these elliptic orbits are "e" and "ϕ," which indicate the shape of the orbit, "μ" the mean daily motion which determines the period of the comet, and "a" the length of the semi-axis major of the ellipse.

Consider first the quantiy "μ," which represents the average angular motion of the comet round the sun in one day. From this quantity the period of the comet in days can be found easily, for it will be 360 degrees converted into seconds divided by the mean daily motion.

Thus the period of Halley's comet is $\dfrac{360 \times 60 \times 60}{46.669}$,

i.e., 27,770 days, or 76 years.

Similarly the period of Encke's comet is $\dfrac{360 \times 60 \times 60}{1076.14}$,

i.e., 1,204 days, or 3.3 years.

The term "log a" fixes the actual size of the orbit. The unit of distance is again the mean distance of the earth from the sun. The length of the long axis of the ellipse is "2a." For Halley's comet, log a $= 1.2540$, therefore "a" $= 17.95$ and "2a" $= 35.9$ units, or 3,334,000,000 miles. For Encke's comet log a $= 0.3461$ and therefore "a" $= 2.219$. Then "2a" $= 4.44$ units, or 412,500,000 miles.

The eccentricity of the orbit is either given directly by the quantity "e" or by means of an angle "ϕ," which is such that the natural sine of "ϕ" is equal to the quantity "e." For Encke's comet the eccentricity of the orbit is indicated by the angle $57^\circ\ 48'.8$. The natural sine of this angle is 0.8464. Thus the orbit of Encke's comet is decidedly less eccentric than that of Halley's comet. If the distance "q" of the comet from the sun at its perihelion passage is not given, it can easily be found for $q = a\ (1 - e)$. For Halley's comet $1 - e = 0.0327$; therefore $a\ (1 - e)$ or the perihelion distance equals 0.5869 units, or 54,500,000 miles. For Encke's comet $1 - e = 0.1536$; $a\ (1 - e) = 0.3407$, or about 32 million miles.

THE EARTH AS A PLANET.

By H. E. Houghton.

(*Read at a meeting of the Cape Centre.*)

"The world is too much with us," says the poet, and the astronomer is inclined to say the same when the world interferes with his contemplation of the heavenly bodies. He feels annoyed when clouds roll up and hide the object of his research, or when invisible vapours smudge the image. Even more insistent is the upward tilt of the western horizon, or the slow rising of the Sun. Then there are the calls of sleep and food. However, we must turn from the "Cosmos," or world of the poet, which is that associated in some minds with the flesh and the devil, and concern ourselves with the *Earth,* the solid globe on which we stand. And, of course, the astronomer, especially in America, can select a site for his observatory where his view is less hindered by clouds and vapours than is that of us who live at sea-level and near great mountains.

If we could detach ourselves from the Earth, we should find that it was not borne on the shoulders of Atlas, nor supported on the backs of four elephants, who were standing on the back of a tortoise—as some mythologies tell us—but that it was a globe hanging in space, in which there is no preference shown for up nor down, nor for North, South, East, or West, but merely objects such as the neighbouring Moon, the distant Sun, and other heavenly bodies all poised in space. The motions of the Earth are varied and complicated. The diurnal rotation with respect to the Sun and the stars is the most apparent of these motions. This daily revolution was conclusively proved, by a method which does not depend on observations of the stars, by the famous pendulum experiment of Foucault at Paris. He found that if a pendulum suspended freely was swung in, say, a North and South direction, after a short interval its plane of swing changed in a clock-wise direction with respect to the surface of the Earth. We know that the direction of swing is really unchanged, therefore the Earth must be altering its position with regard to the plane of the pendulum's swing, and the rate of shift is found to be dependent on the latitude of the place of observation. At the poles such a pendulum would show the Earth rotating beneath it in twenty-four hours.

The period of rotation of the Earth on its axis provides the fundamental means of measuring time. As the measurement of time is of supreme importance in astronomical calculations, any variation would be most serious, and it is fortunate that such variation is exceedingly minute, being probably only about one-hundredth of a second in a century.

The Earth has also an annual motion round the Sun, which is complicated by the fact that the Earth is accompanied by a younger sister, the Moon. When we speak of *the* Moon, we must not think of those small bodies which the telescope reveals accompanying the giant planets Jupiter and Saturn. They are mere ornaments, or little more, of those planets, with masses one-ten-thousandth of their primary or less. But our Moon is a body with a mass one-eightieth of the Earth, sufficient to cause the Earth to rock or sway in its path round the Sun, and raising tides on the Earth as it rotates round it.

In its even path round the Sun, the regularity of the Earth's motion is modified by precession, which can be regarded as a reeling backwards of the Earth's axis, similar to that of an ordinary spinning top. This is due to the bulge of the Equator. One consequence is that the present North Pole Star, Polaris, has not always been so placed to fulfil its useful function, and that in years to come it will appear to drift away from its unique position. Similarly, we in the Southern Hemisphere, after some thousands of years, will have a splendid South Pole Star in Velorum, at present some distance from the South Pole of the heavens. The other swaying motion, given to the Earth by the Moon's circuit, is called nutation. Finally there is the combined attraction of the other planets which causes slight variations in the obliquity of the ecliptic and in the eccentricity of the Earth's orbit. It also results in the date of the Earth's perihelion passage—its nearest approach to the Sun—usually about the end of December, varying to the extent of several days.

Regarding the Earth as a body floating in space, we can imagine it comprising several concentric spheres. The atmosphere forms the outer shell. This is composed chiefly of a mixture of the gases oxygen and nitrogen, together with water-vapour, carbon dioxide and the rarer gases such as argon and helium. Dust particles may also be considered as a constant constituent of the atmosphere. A complete mixture of the oxygen and nitrogen takes place throughout the whole envelope, but the amount of water-vapour is continually changing by the ceaseless processes of condensation and evaporation. When, with a lowering of the temperature, water-vapour becomes rain or ice or snow, great movements are brought about in the atmosphere, warm moist and light air generally ascending and cool dry and heavy air descending. The gases of the atmosphere penetrate the soil and the rocky coast, being carried to the greatest depths by the circulation of ocean waters.

Beneath the Earth's atmosphere we can distinguish the hydrosphere—the waters of the ocean, with lakes and rivers. Most of our information about the great ocean basins has been gained through the voyage of the *Challenger* and subsequent expeditions. A large number of devices have been used for exploring the depths of the sea. The instruments so used are removed from direct observation, and various contrivances must be made to control their action and record the results. The sounding machine, self-recording thermometers, bottles which fill with water at low levels, and trawls and dredges can be used, even at depths of 3,000 fathoms.

The question arises as to the permanence of the present great ocean basins. There is found on the sea-floor, at the greatest distance from land areas, a dark red or brown clay, containing numbers of sharks' teeth, bones of whales, etc., some of existing and some of extinct species; also volcanic ash and pumice, and particles of metallic matter—iron or nickel. These last have probably fallen from space—the dust of meteors—and are found more abundantly on the sea-bed than elsewhere simply because they are not covered up by any large amount of other materials. The red clays are being deposited at an exceedingly slow rate and, when consolidated, they would form a heavy rock.

The curious thing is that no such deposits (which take thousands of years to accumulate) as are now being laid on the ocean floor have been found among the many stratified rocks which comprise the dry land. Another point to be mentioned is that it is generally believed that the continental areas of land are the lighter portions of the Earth's crust, and the deep-sea beds the heavier portions. Consequently, as one writer says: "Concerning the dispute as to whether the oceans have always had the same general extent and positions since the waters were gathered together, or whether, by alternate rising and sinking of the Earth's crust, oceans and continents have successively occupied the same areas, the deciding stroke appears to have been delivered in favour of the permanence of the ocean basins, on account of the improbability that there could be such a shifting of materials in the depths of the Earth's crust as would cause the sub-oceanic heaviness to give place to the sub-continental lightness which has been found to subsist."

If this permanence of the ocean beds is accepted, what then is to be said about the sunken continents and land-bridges which have been constructed by geologists and biologists to explain the distribution of fossils and living organisms? There is the supposed continent of "Atlantis" lying between Europe and America about which various theories have been held. Perhaps the distribution of fossils and living creatures can be explained by supposing animal life to have originated near the North Pole, during warmer conditions there than at present, and to have slowly spread down the great tongues of land which are now known as Europe and Africa, Asia and Australia, and America.

Below the hydrosphere is the lithosphere, consisting of the hard rocky crust with which we are familiar on the continents and islands and on the floor of the sea. We can explore the continental rocks by borings and mines to the depth of several thousand feet, but that portion of the lithosphere on which the ocean rests is known by actual observation only to the depth of a few feet, since after all sounding apparatus and dredges will not penetrate very far.

The study of the materials of which the Earth is composed is called geology, but no single science is comprehensive enough to embrace the whole subject. We can only hope to deal with such parts of the Earth as are accessible to our observations or to our study by reasoning. We may define the Earth's crust as so much of the outer part of the Earth as we can see in quarries, cuttings, mines, or borings, or can reason about by means of conclusions drawn from our observations. It is the business of geology to ascertain what this crust is made of, and to employ the conclusions of chemists and mineralogists as to its composition; to observe the arrangement of these constituents and their relation to one another; then to go a step further and endeavour to ascertain how each part of it was made and how it came to be where it is. It is the past history of the Earth that we try to read. Geography, botany, and zoology tell us about the present and surface conditions; physics tells us about the forces now at work on the Earth's surface; geology endeavours to use all these branches of knowledge in explaining and interpreting the past.

If we care to pursue further the idea of the concentric spheres composing the Earth, we can speak of what Sir John Murray calls the "tektosphere," lying beneath the lithosphere. This is regarded as a more or less heterogeneous or stony layer which under varying conditions of temperature and pressure becomes solid, viscous or even liquid. It is supposed to be a plastic region where adjustments take place. The lower central portions of the Earth, or centrosphere—to name the last of the spheres—may be thought to contract through loss of heat, and the outer lithosphere is adjusted to the diminished volume through a flowing movement of the rocks of the tektosphere. Earthquakes are transmitted by waves—two separate disturbances are recorded, one due to waves which travel through the interior of the Earth and the second due to waves which travel over the surface. From the first wave, which travels through the Earth, the rigidity of the centrosphere can be calculated, and Lord Kelvin considered it to be more rigid than steel, but not quite so rigid as glass.

The theories regarding the origin of the Earth and the Solar System have always been of interest. There is something to be said in favour of the belief that a system like ours is of much less frequent occurrence than was at one time supposed. The famous Nebular theory has been subject to many alterations in recent years. Professor Jeans, in dealing with this theory, says: "If our gaseous nebula is of mass equal to a million suns, or something of this order, it developes, we believe, into an ordinary spiral nebula. The matter ejected by its rotation forms spiral arms, and then condenses around nuclei in these arms, until finally each separate nucleus forms a star. Each such star is initially a mass of shrinking rotating gas, and the life history of the parent nebula is reproduced. . . . But now, on account of the smallness of the mass concerned, neither spiral arms nor condensations appear. The ejected matter merely forms an enveloping atmosphere; ultimately the central mass, continually shrinking, first assumes an egg-shaped or pear-shaped figure, and then, after cataclysmic motion, emerges as two distinct masses, rotating about one another. The cool enveloping atmosphere gradually settles around the two stars until we are left with the normal double star." Possibly one or both of these may break into two parts, but no other changes are to be expected. Professor Jeans says that we have not found what we set out to find—the Solar System. Another theory requires the close approach of a second body to produce the ejection of jets of matter from the first star; these jets of matter would condense into planets. But such collisions or near approaches of stars are regarded as of very infrequent occurrence, and so we come to the conclusion that there are probably comparatively few parallels of our Solar System in the Universe. However, that is only one of the many problems of astronomy which still await solution.

The Editor acknowledges the receipt of the following:

Gazette Astronomique, October and November, 1923, *published by the Société d'Astronomie d'Anvers (Antwerp): Publication No.* 560, *Astronomical and Terrestrial Object Glasses, issued by Messrs. Cooke, Troughton and Simms, Ltd.; Journal of the Manchester Astronomical Society, Sessions* 1920-1922; *Die Himmelswelt, August and December,* 1923, *January-February,* 1924, *published by Die Vereinigung von Freunden der Astronomie und kosmischen Physik (E.V.) (Berlin).*

Publications, Tome XXV, No. 7, *Photographic Observations of the Brightness of Neptune; Second Paper, Variability and Period of Rotation, by E. Opik and R. Livländer,* received from the Tartu (Dorpat) Observatory, Esthonia.

Journal des Observateurs, Tome VI, published by the Observatory of Marseilles.

THE SKY IN MAY.

By Arthur W. Long, F.R.A.S.

THE CONSTELLATIONS.

The Southern Cross is standing nearly erect at about its greatest altitude almost due south at the time for which the map is set. The Cross may be regarded as the hour hand of a great celestial clock. It will be erect and due south at about 10.30 p.m.* on the 1st; six hours later it will be lying in a horizontal position towards the west; at 10.30 a.m. it will be inverted on the horizon due south; after a further six hours it will lie horizontally towards the east; and at 10.30 p.m. it will again be, approximately, erect on the meridian and at its highest altitude. This apparent rotary movement of the Cross is caused by the daily rotation of the Earth on its axis. If we observe our celestial clock for a few days we will find that it is running fast by nearly four minutes each day. If we take nightly observations at 10.30 we will notice that the Cross advances a little towards the west each night until, after an interval of three months, we find it in the western horizontal position at that hour; in six months it will attain the inverted position on the southern horizon at the same hour; three months later it will have gained another quarter circuit, and at the end of twelve months it will have gained a complete circle, and stand erect at 10.30 p.m. This extra circuit is the effect of the annual revolution of the Earth round the Sun. Each year the Southern Cross accomplishes 366 revolutions round the South Pole, because the Earth has turned 366 times on its axis.

Centaurus is nearly overhead, the head of the Centaur being due east. Triangulum lies below the brilliant stars which mark the fore feet of the Centaur and point towards the Southern Cross. Musca is below the Cross. Pavo is below Triangulum. Toucan is near the horizon almost due south, and Indus is on the horizon south-south-east. The greater portion of Sagittarius has risen above the south-eastern horizon. Scorpio is a very conspicuous figure. Its head is nearly half-way to the zenith due east; its tail-tip, marked by a pair of stars of 2nd and 3rd magnitudes, lies above Sagittarius. Ara is between Scorpio and Pavo. Lupus is between Scorpio and Centaurus.

Ophiuchus is close to the horizon in the east, and towards the north Beta and Gamma of Hercules have appeared; above these is Serpens; higher up and towards the south is Libra.

* Cape Town, 10.30 p.m.; Bloemfontein and Port Elizabeth, 10 p.m.; Johannesburg, Pretoria and East London, 9.52 p.m.; Durban, 9.40 p.m.

Bootes with Corona Borealis is standing on the north-eastern horizon; above Bootes is Virgo, and higher still is Hydra, which stretches from Libra through the zenith to Cancer, the latter being low down in the north-west. Corvus and Crater appear suspended from Hydra in the north, Corvus on the eastern, and Crater on the western side of the meridian.

At Cape Town a few stars of Ursa Major may be seen at a low elevation west of north. Where there is a clear horizon two stars of "The Plough" may be observed. Gamma, the most southerly of those in the Ploughshare, is due north, and Eta, which marks the end of the handle of the Plough, is towards the east near Bootes. At Johannesburg and at places north of latitude 28° South the whole of the Plough is visible, lying stretched out in an inverted position along the northern horizon.

Leo is in the north on the western side of the meridian, and dipping from it towards the west are Cancer and Canis Minor. Gemini is partially set in the north-west. Castor is below the Cape Town horizon, but is still visible at Johannesburg. All but one star in Orion have set in the west. Lepus is on the horizon in the west-south-west, above it is Canis Major, and from Canis Major the great ship Argo stretches up to the Southern Cross and fills the greater part of the south-western quadrant. The Beta of Hydrus is due south, the constellation reaching westward to the larger Magellanic Cloud, and downward to the bright star Achernar, which is nearly all that is showing at Cape Town of the river Eridanus. At Johannesburg this constellation is completely set.

THE PLANETS.

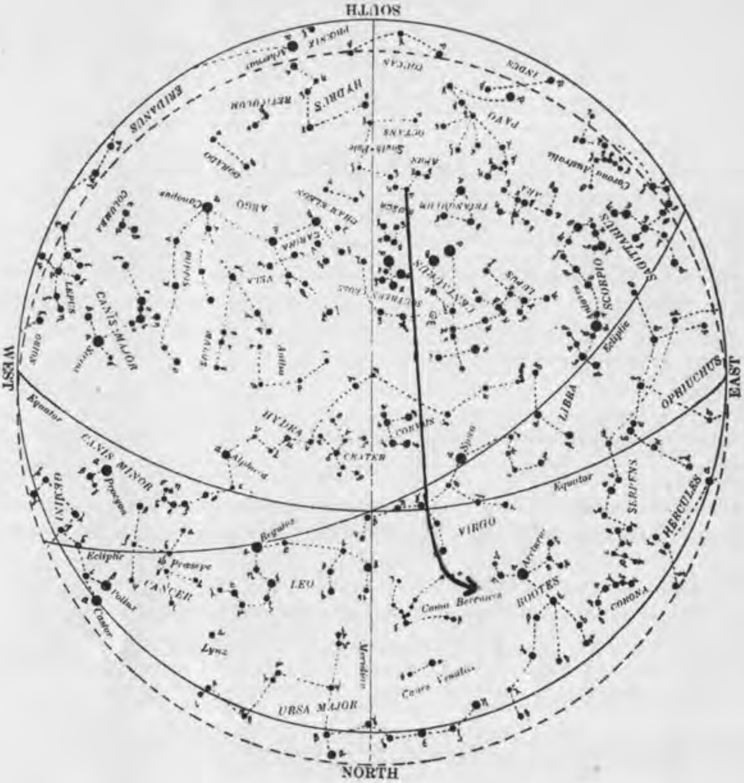
Transit of Mercury.

Mercury is in inferior conjunction with the Sun on the 8th, and as it then crosses the plane of the Earth's orbit it will pass immediately between us and the Sun, and appear as a small black dot passing over the Sun's disc. The greater part of the transit is invisible from South Africa, as the Sun does not rise until the transit is nearly over. Exterior contact takes place at 11.44 p.m. on the 7th. The least distance between the centres of the planet and the Sun will be 1′ 24″.8. This central phase occurs at 3.41 a.m. on the 8th. The transit ends at 7.39 a.m. The Sun rises at 7.28 a.m. in Cape Town, 6.48 in Bloemfontein, 6.37 in Johannesburg, and 6.31 in Durban.

The last transit of Mercury occurred on November 7, 1914. The two following will occur in November in the years 1927 and 1940.

Mercury will be visible in the morning sky in the latter half of the month. It rises in Cape Town at 6.30 a.m. on the 16th

(*Continued on page* 91).



This map indicates the appearance of the sky on May 1, at 10 p.m. in Cape Town, and at 9.22 p.m. in Johannesburg.

To find the time for which the map is correct on any later date, subtract from the figures given above four minutes for each day after May 1.

To find the time for which the map is correct on May 1 at any place in South Africa, subtract from 10 p.m. four minutes for every degree east of Cape Town, and add four minutes for every degree west.

The continuous circle represents the horizon at Cape Town, the broken circle the horizon at Johannesburg.

Only one-half of the map can be used at one time; the other half represents the sky behind the observer. The map is held correctly when the word which represents the horizon facing the observer is at the bottom. The centre of the map in all cases is the zenith.

and at 5.43 a.m. on the 31st. The corresponding times for Johannesburg are 5.42 and 4.55; for Durban 5.35 and 4.47. Greatest elongation (24° 15′ West) occurs on June 3.

Venus.

Venus is at its greatest brilliancy during the greater part of the month (—4.2). Its telescopic appearance at the beginning of the month is that of a moon seven days old. At the end of the month it will be seen as a thin crescent resembling the Moon when four days old. During this period the diameter of the disc increases by one-half. Venus may be easily picked up before sunset if its position be roughly known. It will be at about the same altitude at the time of sunset throughout the month, but will move a little towards the south. It sets in Cape Town at 8.35 p.m. on the 1st, and at 8.11 p.m. on the 31st. The corresponding times for Johannesburg are 8.19 and 7.53; for Durban, 7.57 and 7.32.

Neptune.

Neptune appears as a star of the 8th magnitude. It is now in the constellation Leo, just over the border from Cancer. Its position for the 14th is R.A. 9 hrs. 20 min. 45 sec.; Decl. 15° 48′ North. Its motion is direct.

Saturn.

Saturn is well placed for observation, as it rises before sunset. Its meridian passage occurs in Cape Town at midnight on April 30, and at 10 p.m. on May 29. Subtract from these times 38 minutes for Johannesburg, and 50 minutes for Durban. The planet is in Virgo about six degrees from Spica. The beautiful ring system of Saturn is plainly visible in small telescopes, as is also Titan, the largest and brightest of Saturn's ten satellites.

Jupiter.

Jupiter is in the southern extremity of Ophiuchus, and about ten degrees from Antares, which it greatly outshines. This planet is at its greatest brightness (—2.1). It rises in Cape Town at 8.12 p.m. on the 1st, and at 6.1 p.m. on the 31st. The corresponding times for Johannesburg are 7.52 and 5.40; for Durban, 7.32 and 5.20.

The phenomena of the eclipses, occultations and shadow transits of Jupiter's four major satellites may be observed with small telescopes. A list is given of those which occur during the month between 6 p.m. and midnight.

JUPITER'S SATELLITES.

Day of Month.	Satellite.	Phenomenon.	S.A.S. Time.
2	II	Sh. c.	9 41
4	II	Em.	7 42
5	III	Sh. c.	6 18
	III	Sh. f.	8 38
	I	Sh. c.	9 39
	I	Sh. f.	11 51
6	I	E. c.	7 0
	I	Em.	9 52
7	I	Sh. f.	6 19
11	II	E. c.	6 26
	II	Em.	10 0
12	III	Sh. c.	10 16
	I	Sh. c.	11 33
13	I	E. c.	8 53
	I	Em.	11 37
14	I	Sh. c.	6 1
	I	Sh. f.	8 13
15	I	Em.	6 3
18	II	E. c.	9 2
20	II	Sh. f.	6 29
	I	E. c.	10 47
21	I	Sh. c.	55
	I	Sh. f.	10 7
22	I	Em.	7 47
23	III	Em.	8 1
25	II	E. c.	11 38
27	II	Sh. c.	6 40
	II	Sh. f.	9 4
28	I	Sh. c.	9 49
29	I	E. c.	7 9
	I	Em.	9 31
30	I	Sh. f.	6 30
	III	E. c.	8 22
	III	Em.	11 18

The above times are for any place in South Africa.

E., eclipse; Em., occultation emersion; Sh., shadow transit; c., commences; f., finishes.

Mars.

Mars is in the constellation Capricornus. It rises in Cape Town at 11.33 p.m. on the 1st, and at 10.51 p.m. on the 31st. The corresponding times for Johannesburg are 11.13 and 10.27; for Durban 10.53 and 10.8.

Mars comes 21 million miles nearer to the Earth during the month. Its distance from us on the 31st is about 68 million miles. The stellar magnitude of Mars is + 0.1 on the 1st, and — 0.6 on the 31st; that is, its brightness is nearly doubled during the month.

Uranus.

Uranus is a morning object. It is placed in the constellation Pisces near the border of Aquarius. This planet may be glimpsed with the naked eye, being about the 6th magnitude. Its position for the 14th is R.A. 23 hrs. 27 min. 19 sec.; Decl. 4° 20′ 47″ South.

Reid's Comet.

A new comet was discovered by Mr. W. Reid, the Director of the Comet Section, on March 25, at 8.30 p.m. The comet was then in the constellation Fornax, R.A. 2 hrs. 38 min. 15 sec.; Decl. 36° 18′ South.

The comet was past perihelion at discovery, and is rapidly moving away from both Sun and Earth.

The following elements and ephemeris have been computed by Dr. J. K. E. Halm:—

$$\begin{aligned} T &= 1924 \text{ Feb. } 23.7835 \text{ M.T. Gr.} \\ \pi &= 11^\circ \ 58'.6 \\ \Omega &= 111 \ \ 18.3 \\ i &= 72 \ \ 48.5 \\ \log q &= 0.2334 \end{aligned}$$

Ephemeris.

	R.A.	Decl.	log r	log Δ
May 1.5 ...	4h. 34.1m.	—18° 3′	0.284	0.400
11.5 ...	58.2	—14 2	0.298	0.421
21.5 ...	5 20.2	—10 32	0.312	0.441
31.5 ...	40.4	— 7 31	0.327	0.461

HIS MAJESTY'S ASTRONOMER AT THE CAPE.

On the 30th July, 1923, Mr. Harold Spencer Jones, M.A., B.Sc., was appointed to the post of H.M. Astronomer at the Cape in succession to the late Mr. S. S. Hough.

Mr. Jones had a successful career at Cambridge, where in 1911 he was among the Wranglers (the position of Senior Wrangler no longer exists) in the Mathematical Tripos, Part II, with a *b** affixed to his name to indicate that he deserved special credit. In 1912 he was elected to the Isaac Newton Studentship. He was a Fellow of Jesus College. On the 1st July, 1913, he was appointed Chief Assistant at the Royal Observatory, Greenwich.

Mr. Jones's services since his appointment to Greenwich have been most varied and eventful. In 1914 he led the British expedition to Russia to observe the total eclipse of the sun on August 21st of that year. The observations were successful, and led to a considerable advance in our knowledge of the spectrum of the sun. From January 3rd, 1916, to December 2nd, 1918, he was on war service, being attached to the Optical Branch of the Inspection Department of Woolwich Arsenal. In 1922 he was again leading an eclipse expedition, but on this occasion the weather at Christmas Island on September 21st was unpropitious. Notwithstanding his long absence from the Observatory, he has made his mark in the discussion of the Greenwich observations, especially those made with the Cookson floating zenith telescope. In addition to these activities he is the author of many important papers on astronomical subjects, for example, "The Absorption of Light in Space"; "Proper Motions of the Brighter Stars"; "Latitude Variation"; "The Theory of Astronomical Interferometer Measurements." He also contributes the Astronomical Notes to the quarterly journal *Science Progress*, and since 1914 has been an editor of *The Observatory*. Last year he published *General Astronomy*, which is probably the best book on the subject in the English language.

No doubt Mr. Jones will find his varied experience of great benefit to him in the high office to which he has now been appointed.

VARIABLE STAR SECTION.

The following should be added to the list of observations given in the report of the Variable Star Section for 1922-1923 (printed on page 57):—

Mr. J. F. Skjellerup (up to April, 1923), 1,051 observations, bringing the total to 2,293.

ASTRONOMICAL NOTES.

1. Occultation of Regulus.

An occultation of the bright star Regulus (α Leonis) will occur in the early evening of May 12, 1924, and will be visible over the greater part of South Africa with the exception of the extreme south.

For Johannesburg the time of disappearance of the star behind the dark limb of the moon is 6 h. 34.1 m. p.m. (Standard Time of the Union of South Africa), and the point of disappearance is 149 degrees from the north point of the moon measured round by east. The reappearance at the bright limb takes place at 7 h. 52.2 m. p.m. at 264 degrees—*i.e.,* very near the most preceding point of the moon.

For Durban the time of disappearance at the dark limb is 6 h. 47.8 m. p.m. at 155 degrees, and of the reappearance at the bright limb 7 h. 58.0 m. p.m. at 256 degrees.

Cape Town is just outside the occultation zone, and the star misses the moon by just over one minute of arc. The time of nearest approach is 6 h. 56 m. p.m.

2. D'Arrest's Periodical Comet.

The story of the recovery of D'Arrest's periodical comet at its 1923 return is a very interesting one, and reflects great credit upon Mr. W. Reid, of the Astronomical Society of South Africa.

The comet belongs to the Jupiter family, and has a period of about 6½ years. It is one of the faintest of the periodic comets. It was not observed at its 1917 return, and, as it made a close approach to Jupiter in 1920, the predicted positions for the comet for its return in 1923 were not considered to be very accurate. An intensive search was made from July to September 1923, at several observatories, but the comet could not be found; and as the comet was due to pass round the sun in September, it looked as though the comet was not going to be seen at this return. However, a very faint comet was found by Mr. Reid on November 10. Owing to bad weather this comet was nearly lost again, but was fortunately refound later on in the month, and then observed regularly. As soon as the necessary three observations of position had been secured, Dr. Halm, of the Cape Observatory, computed an orbit, and it was at once seen that the orbit was identical with that of D'Arrest's comet. The comet was observed visually at the Union Observatory from

November 29 to December 11, 1923, but it was extremely faint, and always difficult to observe.

After the identity of Reid's new comet with D'Arrest's periodic comet had been definitely established, the photographic plates taken at the Union Observatory during the earlier search for the comet were re-examined. The November and December observations were used to calculate the path over which the comet had moved. The result was that extremely faint impressions of the comet were found by Mr. H. E. Wood on plates he had taken on September 5 and 7, 1923, but nothing could be found on earlier plates. Although the comet was then within ten days of its perihelion passage, and should have been nearly at its brightest, it was actually several magnitudes fainter than when Mr. Reid discovered it two months after perihelion. There have been other cases than this where the brightness of a comet has unexpectedly increased after its perihelion passage.

But for Mr. Reid's fortunate discovery, the comet would very likely have entirely escaped observation at this return, as on four previous occasions. In future the comet will probably be known as D'Arrest-Reid.

Reviews.

"Mars," by Professor W. H. Pickering, of the Harvard Astronomical Station, Jamaica. Published by the Gorham Press, Boston, U.S.A. Price, 2 dollars 50 cents.

In this book of 172 pages Professor Pickering has gathered together the papers he has written on the planet Mars during the twenty-five years 1890-1914. The planet Mars is to many persons the most interesting body in the heavens chiefly because it exhibits phenomena that can hardly be explained, unless it is assumed that life in some form or other exists there. The most interesting question connected with the planet is associated with the origin of the "canals"; Professor Pickering deals very fully with this question, and comes to the conclusion that the "canals" have a natural origin, and that they are volcanic cracks filled with vegetation. He considers that the permanently dark areas on the planet are regions covered with vegetation, that the temporarily dark areas are marshes and the bright regions deserts. His opinion is that the permanent water area upon Mars, if any such region exists at all, is extremely limited in its dimensions.

"Stars of the Southern Skies," by M. A. Orr. Published by Longmans, Green and Co. Price, 3s. 6d. net.

This small book will be found to be full of interest for the amateur astronomers who live in the Southern Hemisphere. The two first chapters deal descriptively with the southern constellations and the history of their naming. Then follows a series of chapters dealing with the bright stars, the double and multiple stars, the variable stars, and the star clusters and nebulæ of the southern sky. A very interesting historical account is given of the remarkable star Eta Argûs. The classification of stars into different groups according to their spectrum is discussed, and the typical southern stars of each class are indicated. In her introduction the authoress states that "the Southern Hemisphere possesses the most beautiful part of the Milky Way, the two brightest stars of the sky, the finest coloured star cluster and the largest globular cluster, the brightest double star, the nearest of the stars, and the brightest of the large gaseous nebulæ. Let us add that the Southern Hemisphere has been less studied than the north, and therefore there is an even wider field for amateur workers." In the book the amateur astronomer will find several suggestions for useful work which he might do. As a frontispiece to the book there is a very clear star chart of the Southern Hemisphere.

"Celestial Objects for Common Telescopes," by T. W. Webb; edited by T. E. Espin. 2 vols. Published by Longmans, Green and Co. Price: Vol. 1, 8s. net; Vol. 2, 8s. net.

This standard work is now in its sixth edition, and has been brought thoroughly up to date with the assistance of various authorities. The two volumes, together with a good star atlas, should be in the possession of every owner of a telescope, as it is only with such guidance that the amateur astronomer can derive the greatest advantage from his instrument. The main portion of the work deals with the sky north of 31 degrees South declination, but, for the benefit of Southern astronomers, several appendices have been added dealing with Southern telescopic objects, so that the new edition is now practically a complete guide to the heavens. An extremely fine map of the Moon in four quadrants by Goodacre is inserted in a pocket in the cover of the volume, and there is also an independent Index Map of the Moon. Considering the special value of this work, the price at which it is sold is eminently reasonable.

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