Aug. 12. 16h. 10m. to 17h. 10m. Moon occults κ Piscium (mag. 5).
13. 20h. Venus at greatest brilliancy.
15. Venus. Illuminated portion of disc = 0·280.
15. Mars. ,, ,, ,, = 0·932.
18. Saturn. Outer minor axis of outer ring = 18″·35.
18. 12h. 42m. to 13h. 24m. Moon occults ι Tauri (mag. 4·7).
18. 14h. 47m. to 15h. 39m. Moon occults 105 Tauri (mag. 5·8).
19. Mercury at greatest elongation (18° 32′ W.).
20. 22h. Venus in conjunction with moon. (Venus 1° 49′ S.).
22. Jupiter 26′ S. of β Scorpii.
23. Expected return to perihelion of De Vico-Swift's comet (1844–1894).
27. 10h. 26m. Minimum of Algol (β Persei).

NEW VARIABLE IN HERCULIS.—Prof. W. Ceraski, of the Moscow Observatory, communicates to the *Astronomische Nachrichten* (Bd. 153, No. 3650) the discovery of a new variable by Mdme. Ceraski on photographs taken by M. S. Blajko. The star's position is as follows:—

R.A. h. m. s.		Decl. ° ′ ″		Epoch.
18 30 54·8	...	+ 25 55 49	...	(1855·0)
18 32 44·1	...	+ 25 57 54	...	(1900·0)

The star is not found in the B.D. At maximum the star is slightly brighter than 9th magnitude, decreasing to a minimum of about 12th magnitude. At present its brightness is increasing.

NEW STAR IN AQUILA.—A telegram from Prof. Pickering, Cambridge, Mass., dated 1900 July 9, states that the *Nova* of the 8th magnitude found by Mrs. Fleming in April 1899 is now a nebula of 12 magnitude. Its position is

R.A. h. m. s.		Decl. °
19 15 16	...	−0 19

A further statement is made in the *Astronomische Nachrichten* (Bd. 153, No. 3651) that the measures are from the photographs.

METEORITIC THEORY OF THE GEGENSCHEIN.—In the *Astronomical Journal*, No 483 (vol. xxi. pp. 17–21), Mr. F. R. Moulton puts forward a mathematical analysis of the conditions which would appertain if the *Gegenschein* were due to the presence of a more or less condensed region of meteorites. The idea of the problem appears to have been suggested by remarks of Prof. Barnard (who has made consistent observations of the phenomenon during the last sixteen years) to the author.

Discovered by Brorsen about the middle of this century, very few systematic observations are recorded until those of Barnard, who has made careful determinations both of its position and shape. He comes to the conclusion that it is always exactly opposite the sun, or as nearly so as can be determined. Other observers have stated varying positions, but in the case of so difficult an object it is advisable to consider the more systematic records as having greatest truth.

After citing the well-known reasons for considering that interplanetary space is densely occupied by meteoric particles, moving with widely varying velocities in all directions, he supposes that a great multitude will at any time be situated at the opposition point, and that a considerable proportion of these would be under such initial conditions as to remain there for some time. Then the meteors being very small compared with the earth, they are treated as infinitesimal bodies, disturbing neither the earth nor each other. He also neglects the eccentricity of the earth's orbit. Then referring the motion of one meteor to rectangular axes with the origin at the centre of gravity of the sun and the earth, he traces the conditions for stability for a certain time. Then by slightly varying the conditions, he finds the nature of the movement of the infinitesimal body with special reference to the circumstances under which it will make periodic oscillations around certain points. The result of successive integration suggests that meteors passing near one of these selected points with the assumed conditions of motion would be subject to forces directed nearly to this point, and would have a tendency to revolve round it. Although after a few revolutions they might escape, the average result would be a condensation with respect to space, if not with respect to time. The difficult point now to determine is whether a sufficient number would be captured to become visible. If the meteors are revolving round the sun at a distance of about 900,000 miles greater than the earth's mean distance, they will be moving slower than the earth, which will gradually overtake them in longitude. As they approach opposition they will be retarded and drawn in towards the sun, their motion being thereby accelerated. The net result of these actions will be to bring the meteors into the plane of the ecliptic, thus causing the condensation at opposition, and explaining the tendency to an oscillation in latitude which has been observed.

Instead of being exactly opposite the earth, the point of condensation will be nearly opposite the centre of gravity of the earth and moon, and consequently the *Gegenschein* should have a monthly oscillation in longitude of the nature indicated by the observations of Douglass, but much less in extent. The oscillation in latitude would, however, be monthly also, instead of yearly, as the observations tend to indicate.

A phenomenon, observed so far by Barnard alone, is the series of marked changes to which the *Gegenschein* is subjected in short periods of time, being large and round in September and the beginning of October, becoming slightly elongated by the 4th or 5th, very much elongated by the 10th or 11th, and showing merely as a swelling on the zodiacal band by the 18th. Although this is not directly explicable, the shape of the *Gegenschein* will depend on the thickness of the zodiacal disc of meteorites, and if the opposition point should pass through a dense portion of the swarm it is readily conceivable that a change of form would ensue. The distance of the opposition point works out at 930,240 miles from the earth. The period of oscillation would be 183·304 days. It is thus suggested as possible that meteors may move for long periods of time in the vicinity of the opposition point, in sufficient numbers to cause the faint glow of the *Gegenschein* by reflecting the light of the sun. Reference is finally made to a paper by M. Hugo Glydén in the *Bulletin Astronomique*, Tome 1, where similar views are enunciated.

METEOR OF JULY 17.—A bright meteor was seen in many parts of the north of England on the evening of Tuesday, July 17, shortly before nine o'clock. A few particulars concerning the phenomena are given by correspondents in the *Yorkshire Post*. An observer at Menston-in-Wharfedale saw the meteor at a point about N.N.W. from that place, and about forty degrees above the horizon. At Wiseton, Notts, it was seen at 8.47, and at Bramhope at 8.48. At Armley, a hissing noise was heard, and the meteor seen to disappear close by.

THE GREAT EARTHQUAKE OF JUNE 12, 1897.

THE investigation of the great earthquake of June 12, 1897, being the most extensive of which there is historic record, has naturally led to important additions to our knowledge. A detailed report of this earthquake, by Mr. R. D. Oldham, has been published by the Indian Government,[1] and its investigation suggested a line of further research, the results of which have been published in the *Philosophical Transactions* of the Royal Society.[2] The principal results described in these bulky publications are here given in the form of an abstract.

The known extent of the principal seismic area was about 1,200,000 square miles, a figure which will surprise many after the statement that this was the greatest earthquake of which there is historic record. One of the results of this earthquake was, however, a re-examination of the records of the great Lisbon earthquake of 1755, which has shown that the statements regarding it, copied from one text-book to another, are grossly exaggerated. The statement that it was felt in the lead mines of Derbyshire is shown, by reference to the original record, to be an error, the shock that was felt being clearly an independent, local, though possibly sympathetic, shock. Apart from this, there is but one doubtful record of its having been felt so far north as England, though its effects were visible, both in England and in Holland, in disturbances of the water in ponds. The accounts of its having been felt in Iceland and America refer to the sea-waves, which may travel to regions far beyond the utmost limit at which the shock could be felt. Omitting these records, taking only those which refer to the sensible shock, and rounding off the seismic area to an elliptical form, it

1 "Report on the great earthquake of June 12, 1897." By R. D. Oldham. *Memoirs* of the Geological Survey of India, vol. xxix. 1899, pp. xxx + 379 + xviii; 44 plates, 3 maps, 51 woodcuts in text.

2 "On the propagation of earthquake motion to great distances." By R. D. Oldham. *Phil. Trans.*, Series A, 1900, pp. 135–174.

is found to cover not more than 1,000,000 square miles; while if the shock of June 12, 1897, is treated in a similar manner, we obtain a total seismic area of over 1,750,000 square miles.

Owing to the paucity of good records, the course of the isoseists could not be traced in detail. The outermost isoseist was, however, determined with approximate accuracy for about half of its circumference. The seismic area presents a peculiarity in that there is a detached area in the alluvium about Ahmedabad over which the shock was felt, though it was unfelt over a tract of about one hundred miles separating this alluvial area from the furthest limit at which the shock was felt on rock. It is also reported to have been felt at Burhanpur, on the border of the Tapti valley alluvium, though it was felt nowhere else in the neighbourhood. Outside the area over which it was felt there are records, in India, of the passage of the earthquake wave as indicated by the swinging of lamps, &c.

Apart from the records in India, there is good evidence that it was felt in Italy; the observers at Catania, Leghorn and Spinea di Mestre all record having felt a slight shock at the exact time when the instruments throughout Italy recorded the advent of the first phase of the disturbance due to this earthquake. Had there been only a single record, it might have been attributed to a distinct local shock; but these three separate records, all agreeing with each other in time, and also with the advent of the first tremors, which, having a period of about ·5 second, might have been sensible, leaves little possibility of doubt that the Indian earthquake was actually felt. The observers are, however, to be complimented on their acuteness of observation.

The epifocal area is of a peculiar shape. Situated in Western Assam and North-eastern Bengal, it is bounded on the south by a straight line running about E.S.E. for some 200 miles; on the north it is bounded by a nearly symmetrical double sigmoid curve, the maximum breadth being not less than 50 miles, and possibly as much as twice this amount. Over the whole of this area of not less than 6000 square miles, the intensity of the shock was in excess of 10 degrees of the Rossi-Forel scale, and alterations of level have taken place; while for a year and more afterwards earthquake shocks—some severe, but most feeble and local—were very frequent. The changes of level were not only shown by faults, one of which was traced for a distance of over 12 miles, and had in places a measured throw of over 30 feet, and by differential changes of level, whereby streams were dammed up into lakelets, but also by a remeasurement of some of the triangles of the great Trigonometrical Survey. As the whole of the triangles reobserved lay within the epifocal area, it is not possible to say what amount of actual change has taken place; but changes of position of one hill relative to another were determined, which reach as much as 24 feet in a vertical, and 12 feet in a horizontal, direction.

The results of the triangulation, as published by the Trigonometrical Survey of India, indicate an increase in the horizontal distances between the stations; but in the geological report it is shown that this is probably due to a shortening, by compression, of that side which was assumed as an unaltered base-line. The true nature of the focus is regarded as a thrust plane, from which minor faults branched off, and in places appeared as such, while elsewhere they died out before reaching the surface and merely caused those changes of level which, where other circumstances were favourable, led to the formation of lakes. No less than thirty of these were observed, the largest having a length of 1½ miles and a breadth of ⅝ mile, and the smallest a few yards across; the depth varied from 1 to over 20 feet.

Within this epifocal area the violence was everywhere great, though subject to great local increase in the neighbourhood of the fault planes which extended upwards to the surface. Not only were upright stones broken, but sound hardwood trees of a diameter of 6 to 7 inches were snapped across by the violence of the motion they were subjected to; no masonry building was left standing, and the hill sides were scarred by landslips. In many places it was noticed that stones lying on the ground had been projected into and through the air.

The acceleration necessary to cause the fracture of standing monoliths, or sound hardwood trees, must have been great—much greater than the measured accelerations, as determined by West's formula from overturned tombstones, which range up to 32 feet per sec. per sec. It is doubtful, however, whether West's formula is applicable to cases where the height of the overturned column is less than three or four times its diameter; in the earthquake of 1897 all the high accelerations were obtained in places where there must have been a large vertical component in the wave motion, and the overthrow of squat pillars is regarded as a modified form of projection. It is improbable that accelerations of over 6 feet per sec. per sec. can occur, except in the vicinity of the epicentre, where there is a considerable vertical component in the wave motion, and the excessive accelerations which have been supposed to have been measured in the case of other earthquakes must be regarded with suspicion.

Opportunity was taken to review the various formula for deducting the accleration and velocity of movement of the wave-particle; these have been all collected in an appendix and discussed. One result of the discussion is in a manner reactionary, for the one quantity which it was believed could be determined with real accuracy, the velocity as deduced from projection, is shown not to be due to wave motion at all. The velocities deduced from observed projections are shown to lead to impossible results if combined either with the deduced acclerations or with any conceivable amplitude or period, and the conclusion is come to that the projection of solid objects was due, not to molecular wave motion, but to a molar displacement of the ground, resulting in permanent changes of level.

Instances of the rotation of objects, both within and without the epicentre, were numerous. As many as possible of these were carefully measured to determine, not only the angular rotation, but also the direction and amount of displacement of the centre of gravity. From a careful examination of the data, it is shown that none of the attempts to explain rotation by simple rectilinear motion are in accordance with the observed facts, and that it is necessary to accept the explanation of vorticose motion. This vorticose motion does not, however, take the form of angular rotation as has been assumed by some investigators, but the whole ground either moves in a more or less circular track, or is subject to a more or less rectilinear to-and-fro motion, whose direction changes continually in azimuth.

Over a large alluvial area the river channels were narrowed, railway lines bent into sharp curves, and bridges compressed and destroyed, much as in the Japanese earthquake of 1891. This compression is shown to have been due, in all cases, to displacement of the superficial alluvium, and not to any general compression. Over this same alluvial area fissures and sand vents were opened in myriads. With regard to the fissures, it is shown that Mallet's explanation of their formation by unsupported masses of clay being thrown off from free surfaces by their own inertia is incomplete, and that they were formed in places where no such action could have taken place. It is suggested that in such cases the fissures were due to the visible surface undulations which were noticed by many observers. The sand vents were formed in such numbers that large areas were temporarily flooded by the volumes of water which issued from them with such force that it rose in solid columns to a height of 3 feet and more from the ground, while splashes and spouts are said to have reached 18 or 20 feet in height. It is noteworthy that in several cases these sand vents are said to have been formed *after* the passage of the shock, and flowed for a period of half an hour or, according to some, several hours. This is attributed to the settling of clay beds on to underlying quicksands, which supported the overlying beds as long as these were continuous, but would not do so after they had been broken up by the earthquake.

Earthquake sounds were very loud and conspicuous, but the data available do not allow of much advance in this difficult branch of seismology. In some cases explosive sounds of short duration were heard after the earthquake had passed, and the connection of these with the "Barisal guns," "mistpœffers," "marina" and other similar phenomena is discussed, all being regarded as probably in the main seismic.

The most important results obtained are probably those connected with the rate of propagation. Numerous time observations in India yield a time curve with double curvature like that of Schmidt's "hodograph," but the curvature is too slight to accord with it, and the true time curve is shown to be most probably a straight line indicating a uniform rate of propagation of 3·0 km. per sec. Turning from the observed rate of propagation of the sensible shock to the distant records, it is shown that the records of the Italian seismographs exhibit three principal phases of motion, after each of which there is a marked diminution of movement. The first of these gives an average rate of propagation of 9 6 km. per sec., the second of 5·6 km. per sec., and the third, the phase of long period undulation, accompanied by marked tilting of the ground, a rate of transmission of 3·0 km. per sec. The agreement of this with the observed rate of transmission of the sensible shock is held to indicate that both are due to a form of wave motion which was propagated at a uniform rate along the surface of the earth. The first two phases, it is suggested, are due to wave motion transmitted through the interior of the earth, and as in the presumably isotropic, or nearly so, material of the interior of the earth a separation of condensational and distortional waves could take place, which Knott and Rudzki have shown to be impossible in the rocks of which the surface of the earth is composed, it is suggested that these two phases are due to the arrival of the condensational and distortional waves respectively, travelling by brachisto-chronic paths through the interior of the earth.

This suggestion is followed up in the second paper. The published records of distant earthquakes were looked up, and those selected of which the time and place of origin were known within a limit of error of 1 minute of time and 1 minute of arc respectively. Further, on account of the known impossibility of separation of the two simple forms of elastic wave motion in the surface crust of the earth, only those records were considered which came from a distance of not less than 20° of arc from the epicentre.

Seven distinct earthquakes were found of which the published records satisfied all these conditions, and as in some of them there was more than one shock, they constituted eleven distinct shocks. From the published records were extracted (1) the time of commencement of the record; (2) the time of any sudden increase of movement, when recorded; and (3) the time of maximum displacement. Tabulating these, it is found that each earthquake exhibits a three-phase character in the record; and, further, that if the times are plotted and a curve drawn through them, the time curves of the first two phases show precisely that curvature which Prof. Rudzki's investigations show to be characteristic of wave motion propagated along brachistochronic paths through the earth, where the rate of propagation increases with the depth. Continuing these curves by extrapolation to the origin, they give rates of propagation fairly concordant with the rates of propagation of condensational and distortional waves as experimentally determined for ordinary rock. As a subsidiary part of this investigation, it is shown that the "preliminary tremors" of earthquakes coming from Japan to Europe reach a depth of about ·45 of the radius from the surface, attain there a maximum velocity of 14·5 km. per sec. for the condensational, and 8·8 km. per sec. for the distortional wave, and traverse a medium which has, at that point, a bulk modulus of 17 times, and a rigidity of about 21·5 times that of granite.

The records of the third phase show some irregularity, but the time curve is a straight line, pointing to a uniform rate of transmission along the surface. There is, however, some indication that in the case of the greatest earthquakes it is higher than in the case of lesser ones; in other words, that the rate of transmission is in some way dependent on the magnitude of the earthquake, hence, probably, on the size of the wave. From this it is concluded that the propagation of these surface undulations is, in part at least, gravitational.

EXPLORATIONS OF THE "ALBATROSS" IN THE PACIFIC.[1]

WE left San Francisco in August of last year, and in latitude 31° 10′ N., and longitude 125° W., we made our first sounding in 1955 fathoms, about 320 miles from Point Conception, the nearest land. We occupied 26 stations until we reached the northern edge of the plateau from which rise the Marquesas Islands, having run from station No. 1, a distance of 3800 miles, in a straight line.

At station No. 2 the depth had increased to 2368 fathoms, the nearest land, Guadeloupe Island, being about 450 miles, and Point Conception nearly 500 miles, distant. The depth gradually increased to 2628, 2740, 2810, 2881, 3003 and 3088 fathoms, the last in lat. 16° 38′ N., long. 130° 14′ W., the deepest sounding we obtained thus far in the unexplored part of the Pacific through which we were passing. From that point the depths varied from 2883 to 2690 and 2776, diminishing to 2583, and gradually passing to 2440, 2463 and 2475 fathoms until off the Marquesas, in lat. 7° 58′ S., long. 139° 08′ W., the depth became 2287 fathoms. It then passed to 1929, 1802 and 1040 fathoms in lat. 8° 41′ S., long. 139° 46′ W., Nukuhiva Island being about 20 miles distant. Between Nukuhiva and Houa-Houna (Ua-Huka) Islands we obtained 830 fathoms, and 5 miles south of Nukuhiva 687 fathoms. When leaving Nukuhiva for the Paumotus we sounded in 1284 fathoms about 9 miles south of that island. These soundings seem to show that this part of the Marquesas rises from a plateau having a depth of 2000 fathoms and about 50 miles in width, as at station No. 29 we sounded in 1932 fathoms.

Between the Marquesas and the north-western extremity of the Paumotus we occupied nine stations, the greatest depth on that line being at station No. 31, in lat. 12° 20′ S., and long. 144° 15′ W. The depths varied between 2451 and 2527 fathoms, and diminished to 1208 fathoms off the west end of Ahii, and then to 706 fathoms when about 16 miles N.E. of Avatoru Pass in Rairoa Island.

Between Makatea and Tahiti we made eight soundings, beginning with 1363 fathoms, 2 miles off the southern end of Makatea, passing to 2238, 2363 (the greatest depth on that line), to 2224, 1930, 1585, 775, and finally 867 fathoms off Point Venus.

The deep basin developed by our soundings between lat. 24° 30′ N., and lat. 6° 25′ S., varying in depth from nearly 3100 fathoms to a little less than 2500 fathoms, is probably the western extension of a deep basin indicated by two soundings on the charts, to the eastward of our line, in longitudes 125° and 120° W., and latitudes 9° and 11° N., one of over 3100 fathoms, the other of more than 2550 fathoms, showing this part of the Pacific to be of considerable depth and to form a uniformly deep basin of great extent, continuing westward probably, judging from the soundings, for a long distance.

I would propose, in accordance with the practice adopted for naming such well-defined basins of the ocean, that this large depression of the Central Pacific, extending for nearly thirty degrees of latitude, be named Moser Basin.

The character of the bottom of this basin is most interesting. The haul of the trawl made at station No. 2, lat. 28° 23′ N., long. 126° 57′ W., brought up the bag full of red clay and manganese nodules with sharks' teeth and cetacean ear-bones; and at nearly all our stations we had indications of manganese nodules. At station No. 13, in 2690 fathoms, lat. 9° 57′ N., long. 137° 47′ W., we again obtained a fine trawl haul of manganese nodules and red clay; there must have been at least enough to fill a 40-gallon barrel.

The nodules of our first haul were either slabs from 6 to 18 inches in length and 4 to 6 inches in thickness, or small nodules ranging in size from that of a walnut to a lentil or less; while those brought up at station No. 13 consisted mainly of nodules looking like mammillated cannon-balls varying from 4½ to 6 inches in diameter, the largest being 6½ inches. We again brought up manganese nodules at the equator in about longitude 138° W., and subsequently—until within sight of Tahiti—we occasionally got manganese nodules.

As had been noticed by Sir John Murray in the *Challenger*, these manganese nodules occur in a part of the Pacific most distant from continental areas. Our experience has been similar to that of the *Challenger*, only I am inclined to think that these nodules range over a far greater area of the Central Pacific than had been supposed, and that this peculiar manganese-nodule bottom characterises a great portion of the deep parts of the Central Pacific where it cannot be affected by the deposits of globigerina, pteropods, or telluric ooze; in the region characterised also by red-clay deposits. For in the track of the great equatorial currents there occur deposits of globigerina ooze in over 2400 fathoms for a distance of over 300 miles in latitude.

We made a few hauls of the trawl on our way, but owing to the great distance we had to steam between San Francisco and the Marquesas (3800 miles) we could not, of course, spend much time either in trawling or in making tows at intermediate depths. Still the hauls we made with the trawl were most interesting, and confirmed what other deep-sea expeditions have realised: that at great depths, at considerable distances from land, and away from any great oceanic current, there is comparatively little animal life to be found.

The bottom temperatures of the deep (Moser) basin varied between 34·6° at 2628 and 2740 fathoms, to 35·2° at 2440

[1] Abridged from letters written to the Hon. George M. Bowers, U.S. Commissioner of Fish and Fisheries, Washington, D.C., by Mr. Alexander Agassiz, leader of the expedition of the U.S. Fish Commission Steamer *Albatross* to the Pacific.