collision may occur, viz. the instantaneous transmission of a finite amount of momentum from one part of the system to another, provided we have discontinuity in the *tendency to compression* in the different parts of the system.

The author has endeavoured, in former communications to the Royal Society, to show that when the velocity in a fluid diminishes in the direction to which the motion tends, the slower particles will offer a resistance to the motion of the faster particles, which the received theory fails to take into account. The foregoing speculation goes to prove that the circumstance of the surfaces of contact of contiguous elements of the fluid having the same velocity, constitutes no objection to the reality of such resistance.

IV. "On the Tides of Bombay and Kurrachee." By William Parkes, M.Inst. C.E. Communicated by G. B. Airy, Astronomer Royal. Received May 5, 1865.

(Abstract.)

The object of this paper is to exhibit the phenomena of diurnal inequality in the tides on the coasts of India, and describe the mode adopted by the author for obtaining formulæ based on astronomical elements for predicting them. It is accompanied by the following records of observations given in a diagram form :—

Kurrachee,	1857–8,	December to March.
,,	1865,	March to August.
,,	1867,	The whole year.
Bombay	1867,	February to May.

The height and times predicted by the author for 1867, and published by the India Office, are given on the diagrams for that year, so that they may be compared with actual observation.

The continuous curves of the height of the water taken at Bombay, at every ten minutes for the four months above named, are also given.

By the rotation of the earth every meridian-line is brought twice a day under the influences which ultimately result in the well-known semidiurnal tidal movements—once when in the position nearest to the attracting body, and once when in that furthest from it. But the actual point in that meridian which is in the centre of those influences will be alternately north and south of the equator, to the extent of the declination of the attracting body. This alternation of the position of the centre of attraction from the northern to the southern hemisphere produces a diurnal tide, and that diurnal tide produces a diurnal inequality in the semidiurnal tide

The character of the diurnal tide and the highly complex conditions under which its constantly varying solar and lunar component parts are combined are then traced. Being entirely dependent on the declinations of the sun and moon, the solar element vanishes twice a year, and the lunar element twice a month, each reappearing after the solar or lunar equinox, with its times of high and low water reversed.

The diurnal tide produces a diurnal inequality in height and time of high and low water, affecting simultaneously respectively high-water time and low-water height, and high-water height and low-water time. In particular cases, the actual values of height and time of diurnal tide may be directly deduced from the values of diurnal inequality. From these it was found that diurnal tide follows the moon's movements at a much shorter interval than semidiurnal, the retard of the former being from two to three hours only, while that of the latter is from thirty-four to thirty-six hours.

The mode adopted for identifying the varying values of diurnal inequality with their physical causes was then explained. A hypothetical series of diurnal tides, based on the varying values of the declination of the sun and moon, was calculated, the necessary local constants being deduced from the particular cases in which their values could be directly obtained. These hypothetical diurnal tides being combined with a series of semidiurnal tides deduced from the diagram of observations, the diurnal inequalities so obtained were compared with the actual diurnal inequalities. It was then found that a further element was wanting, which was approximately and provisionally obtained by the introduction of a second empirical diurnal lunar tide of twelve inches maximum half-range at Bombay, and six inches at Kurrachee. This tide was assumed, like the first and principal diurnal tide, to be dependent on the moon's declination, but to vanish at intervals of two or three days, before the moon crossed the equator. The author expresses an opinion that this empirical correction might probably be superseded by one more consistent with physical causes, if more extended and more correct observations were subjected to investigation.

Lastly, the comparison of calculated heights and times with the records of observations for four months at Bombay and eight months at Kurrachee were given. This showed that three calculated tides out of four were correct within three inches in height and fifteen minutes in time, the errors of the remainder ranging up to nine inches in height, and thirty minutes in time.

Since receiving the observations made at Bombay and Kurrachee in the year 1867 the author has subjected them to another process for obtaining the actual times and heights of diurnal tide, which has been more successful than that described in the paper.

The only data made use of were the diurnal inequalities in *height* at high and low water, the range of semidiurnal tide and the diurnal ine-

quality in time, which were necessary to the previous process, being now altogether disregarded.

The diurnal inequalities in height were obtained by measuring the widths of the brown spaces where they were crossed by the vertical lines representing noon on successive days. The two daily values thus obtained are respectively the sine and cosine of an angle which represents the difference in time between semidiurnal and diurnal tide. Dividing the low-water by the high-water value gives the cotangent of that angle, and thence the angle itself. Thus the time of actual diurnal tide (first in relation to the time of semidiurnal low water, and then in relation to solar time) was obtained.

The actual range of diurnal tide was obtained by adding together the squares of the high-water and low-water values (sine and cosine), and taking the square root of the sum.

With these two series of results as ordinates, curves were drawn representing times and ranges of actual diurnal tide, which were thus presented in a convenient form for comparison with the diurnal tide which had been previously calculated.

The comparison confirmed the previous conclusion that the tide based on the simple declination theory was insufficient, and the empirical correction which had been adopted seemed to provide an approximation to the required addition to it, both in time and height. But it appeared that a better coincidence in time would have been obtained by assuming the diurnal tide at Kurrachee to be forty minutes earlier. This supposition was tested by treating the observations of 1865 in a similar manner, and also by recalculating a portion of the tides of 1867 with the earlier diurnal tide. In both cases the supposition was confirmed, a better agreement being obtained.

On treating the Bombay observations in the same manner, a fair general coincidence with the calculated diurnal tides was found to exist; but it was further found, on comparing together the Kurrachee and Bombay curves of actual diurnal tide (thus for the first time recorded for the same period), that the times were nearly identical at the two ports, and the range at Bombay about one-tenth greater than that at Kurrachee.

The tables for the four months over which the Bombay observations extend were recalculated with the diurnal tides which had been calculated for Kurrachee (but made forty minutes earlier, and increased in range by one-tenth), and the result was quite as good as that shown by the original tables. This fact would seem to point to the possibility that the diurnal tide is a vertical undulation, acting simultaneously, or nearly so, over a large area.