General Catalogue," two authorities supplying him with excellent positions of a large number of stars.

THE COMET OF 1533.—In the catalogues of the orbits of comets we find two sets of elements for this comet, both deduced from the observations of Apian between July 18 and 25, which are contained in his rare work, *Astronomicum Cæsareum.* The first orbit is by Douwes, who assigned *retrograde* motion, but in the *Berliner Jahrbuch* for 1800, Olbers gives another orbit, equally satisfactory as regards representing Apian's observations, in which the heliocentric motion is *direct*, and he appeared to think it was not possible to decide which of the two is to be preferred. In addition to Apian's account of this comet we have a brief one by Gemma Frisius, who states that after having been seen about the beginning of July in 5° (or rather, as Pingré corrects him, in 15°) of the sign Gemini, near the star Capella, with 24° of latitude and 48° north declination, it passed by a westerly motion, or contrary to the order of the signs, to the constellation Cassiopea, which it traversed, finally disappearing in Cygnus. Fracastor has also left us an account of the comet's track, though there is some ambiguity about it. Since Olbers calculated the orbit the Chinese observations have been published, in the first instance by M. Edouard Biot, in the additions to the *Connaissance des Temps* for 1846, and more recently in Mr. Williams' work upon Cometary Observations in China, and it would appear that the comet moved to the vicinity of π Cygni, and was last seen on Sept. 16. If we compare the elements of Douwes and Olbers with the track thus roughly defined, we see that the retrograde orbit of Douwes is hardly probable, and that possibly a modification of the direct orbit of Olbers would be found to sufficiently represent the path of the comet, according to Apian, Gemma, and the Chinese Annals.

OCCULTATION OF VENUS.—Mr. R. Meldola, of the Royal Society Eclipse Expedition, writes that the occultation of May 2 was partially observed by Prof. Tacchini and himself from the P. and O. steamer *Peshawur* in the Arabian Sea. The moon was obscured by clouds at the time of immersion; the last contact took place at 16h. 15m. 6s. local mean time. Ship's position furnished by Capt. White—long. 77° 3′ E., lat. 6° 48′ 18″ N.

OUR BOTANICAL COLUMN

PHENOMENA OF PLANT-LIFE.—The expansive power of growing vegetable tissue is something marvellous, if the experiments undertaken by Mr. Clark, president of the State Agricultural College of Massachusetts, are perfectly trustworthy. If his appliance for measuring the force exerted by a growing pumpkin was not at fault, the greatest weight lifted by the pumpkin in the course of its development was nearly two-and-a-half tons. Apparently the greatest care was taken to arrive at the truth, and we have no reason to doubt the accuracy of the statements contained in Mr. Clark's paper which was presented to the Massachusetts Board of Agriculture. But in our ignorance of the phenomena of plant life we should like to see the observations repeated. At the end of the experiment alluded to the soil was carefully washed from the roots of the pumpkin vine, and the entire system of roots spread out upon the floor of a large room and carefully measured. In addition to the main root, roots were formed at each joint or node. The total length of root developed was calculated to be over fifteen miles; and the time the plant was growing, four months. During the greater part of the time, of course, the rate of growth was relatively slow, but the maximum rate was computed at not less than one thousand feet of root per day.

With another plant of the same species, *Cucurbita maxima*, an experiment was instituted to ascertain the pressure exerted by the rising sap. For this purpose the plant was cut off near the ground, after it had attained a length of twelve feet, and a mercurial gauge attached to the part left in the ground. The maximum force with which the root of the pumpkin exuded the water absorbed by it was equal to a column of water 48·51 feet in height.

Some experiments to determine the channels through which the crude sap rises, and on the diffusion of the elaborated sap, gave interesting results. Mr. Clark says: "We find that the crude sap imbibed by the root-hairs from the surface of the particles of the soil seems to be taken up in a dry state; that is, it appears to be absorbed molecule by molecule, no fluid water being visible, and carried in this form through all the cellulose membranes between the earth and leaf, by which it is to be digested or exhaled. We do not say this is literally true, but it accords very nearly with what is constantly to be seen in some species of plants. The circulation of the sap in a poplar tree is very dry compared with that of the blood of any animal. Not a drop of moisture will ever flow from the wood of an aspen, so far as we have observed." It was found that an exceedingly small proportion of sap-wood sufficed to convey the necessary supply of crude sap to the foliage, but none would ascend through the bark.

The quantity of sap that flowed from different trees during the season varied greatly in diverse species. Thus the entire flow from the bitter-nut was less than the product of the sugar-maple for a single day; but the iron-wood and the birches surpass the maple in the rapidity and amount of their flowing. A paper-birch, fifteen inches in diameter, bled in less than two months over one thousand four hundred and eighty-six pounds of sap; the maximum flow, on the 5th of May, amounting to sixty-three pounds and four ounces. The grape bleeds comparatively little as compared with many other things. A very large proportion of the trees experimented upon did not show any tendency to bleed in spring. We might extract many other interesting details from Mr. Clark's paper, had we sufficient space for them.

PHYSICS IN GERMANY

(*From a German Correspondent.*)

HERR STEFAN, of Vienna, has published a paper on a series of researches on adhesion. It is well known that two plane plates which are placed upon one another adhere together so firmly that they can only be separated by a certain amount of force. This phenomenon has hitherto been considered as caused by adhesion (*i.e.* by the action of molecular forces between the particles in contact between the two plates), and it was tried to determine the magnitude of this adhesion statically.

The improbability of this conception already follows from the fact that in the case in question no immediate contact of the two plates takes place, but that between them there is a layer of air of considerable thickness. If two glass plates are employed for this experiment, they do not show Newton's coloured rings; these can only be produced with plates that are perfectly plane and with the application of considerable pressure. If, therefore, molecular forces were active in this case between the particles of the two plates, then the molecular sphere of action would have to be very much larger than is generally adopted according to other experiments. The phenomenon becomes still more striking if the experiment is made under water. In that case an attraction in the two plates can still be perceived, even if they are a millimetre apart. Herr Stefan used for his experiments two plates of glass, of which one was suspended from a balance in such a manner that its inferior plane was horizontal. The balance was then brought to equilibrium. The second plate was also placed horizontally under the other one. Three little pieces of wire were then placed upon it, and the upper plate was then let down so far as to rest upon these pieces of wire. By varying the thicknesses of the wires the distance of the two plates could be brought to any desired magnitude. To tear away the upper plate from the under one, it was necessary to place a certain over-weight into the other scale of the balance.

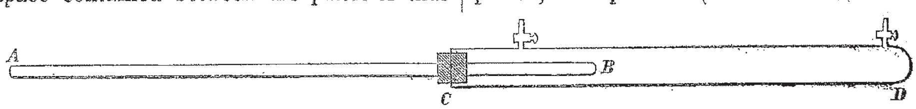
It was found that the separation of the two plates can be accomplished by any force, however small, only the time in which the distance of the plates is increased by a certain fraction through the action of such a force, is all the greater, the smaller this force is. This time is still greater if the two plates are in water or in another liquid, instead of in air. To give an idea of this we may mention that the distance of two plates, of 155 millimetres diameter, under water, which originally was 0·1 mm., was increased in consequence of the continuous pull of 1 gramme by 0·01 mm. only in $1\frac{1}{2}$ minutes, by 0·1 mm. only in 7 minutes.

Herr Stefan in his experiments measured the time that passed while the original distance of the plates increased by a certain fraction. First, the law was established for the motion of the plates in liquids as well as in air, that the times stand in the reverse proportion to the separating force. With the same overweight they are the longer, the smaller the original distance of the plates, but this in a far greater than a simple proportion; they increase nearly in square proportion if the distance of plates decreases in a simple one. For different sized plates the times in question stand in the proportion of the fourth powers of the semi-diameters of the plates; for different liquids in the same proportions as the times which elapse, while equal volumes of these liquids flow through a capillary tube, under equal pressure.

It results clearly that with this phenomenon there rests a problem of hydrodynamics and not of molecular forces. The phenomenon can be explained in the following manner:—When the separating force begins to act, the distance of the plates is increased by an infinitely small part. The space contained between the plates is thus enlarged, the liquid therein contained is dilated, and consequently its hydrostatic pressure decreased. The over-pressure of the exterior liquid acts against the separating force. No equilibrium is, however, attained, because the decrease of hydrostatic pressure between the plates causes an inflow of the exterior liquid and thus a decrease of the difference of pressure. The distance of plates may be again increased by the separating force, and then the same process is repeated in a continuous manner.

Herr Stefan has therefore given the name of *apparent adhesion* to this phenomenon. He has tried to deduce theoretically all the different laws to which the different experiments have led him; he has succeeded in finding an equation which expresses these laws, and which at the same time permits the deduction of the co-efficients of interior friction of the liquids experimented with, directly from the experiments. The values of the coefficients obtained in this manner correspond almost exactly with those obtained by the experiments of Poisseville, Maxwell, and O. E. Meyer. But as Herr Stefan thinks the theoretical solution of the problem only an approximate one, we reserve further details on the subject.

If we rub a wet cloth quickly over a glass tube, closed at both ends, it is caused to vibrate longitudinally. If at the same time it gives its lowest longitudinal note (as we will suppose for the sake of simplicity), then the end planes of the tube strike quite periodically against the air enclosed in it, and cause the same to vibrate. These vibrations are isochronous with those of the tube itself. They proceed from both ends of the tube towards one another, and, as a consequence, standing waves are formed in the enclosed air column. If into such a tube lycopodium or silicic acid has been placed, these powders (as also Herr Kundt has discovered



a few years ago) collect at the node points of the standing waves and form figures of a very peculiar kind. As the length of these standing waves depends solely on the height of the generating sound and of the velocity of the waves in the gas, with which the tube is filled, the proportion of this wave-length to the wave-length in the glass gives the relative velocity of sound in air, with that in the glass as unity. Herren Kundt and Lehmann at Strasburg have lately tried to produce longitudinal vibrations and the figures just mentioned in a liquid, enclosed in a cylindrical tube, in a similar manner. It was found that in a column of water standing waves and figures can be produced almost as easily as in a column of air. The apparatus which was used for this purpose consisted of a glass tube, A B, closed at one end, B, which was placed firmly into a wider glass tube, C D, by means of an india-rubber stopper. The latter glass tube was closed at end D, and had two lateral outlets with stopcocks, so as to be easily filled with water. The powder which is placed in the tube C D must be sufficiently heavy and of a certain degree of fineness; it is best to use for this purpose finely divided iron (*Ferrum limatum*). The column of liquid must be free of even the smallest air-bubble. If the liquid used, for instance water, contains a gas absorbed, it must be first freed from it by continual boiling. In order to make the apparatus sound it is necessary only to rub a wet cloth quickly over the protruding part of the tube A B.

The figures in this column of liquid may serve for the determination of the velocity of sound in the liquid. If the end A of the sounding tube is closed by a cork, and if then over this end another tube is attached, which contains lycopodium, then, by the figures which occur in the liquid, and by those which occur in the tube with air, the wave-length of the same sound is obtained both in liquid and in air. The proportion of both gives the relative velocity of sound in the liquid with reference to that in air as unity. This relative velocity multiplied by the absolute velocity in air at the same temperature, gives the absolute velocity of sound in the liquid at the temperature in question. It was interesting to compare the results of this method of determining the velocity of sound in water, with the values required by the ordinary theory of the velocity of sound. According to the theory based on the experimentally determined elasticity of water, the velocity of sound at 8° Celsius is 1,437 metres. Colladon and Sturm, by their experiments in the Lake of Geneva, found the same to be 1,435 metres at 8° C. Although the remarkable coincidence of these values is only accidental, it is nevertheless proved that experiments such as those of Colladon and Sturm do not give figures that are very far from the theoretical values. The experiments of Kundt and Lehmann show that the diameter and thickness of the glass of the tube, which is used for the determination of the velocity of sound according to the method above described, greatly affect the value of the velocity of sound in water. In a tube of 2·2 mm. thickness of side, and 28·7 mm. diameter, the velocity at 18° C. was 1040·4 metres (the mean of two experiments which coincided very closely); in another one of 5 mm. thickness of side and 14 mm. diameter, the velocity was found 1382·2 metres at 22·2° C. As it would be very difficult to avoid unevenness in the sides of the tube, it does not seem probable that when using tubes the above value of 1,435 metres could be completely reached. These experiments, proving the influence of the thickness of the sides and diameter of a tube upon the velocity of sound in water, contradict the hypothesis of Wertheim, according to which a column of liquid, which is sounding or conducting sound, behaves like a firm rod. S.W.