"Philosophical Transactions" for 1862, the memoir on the rigidity of the earth is fully printed, and immediately following it is another designated "dynamical problems regarding elastic spheroidal shells and spheroids of incompressible liquid." The conclusions arrived at in the first are essentially and admittedly dependent on the investigations presented in the second. Not long after they were published I gave my best attention to the study of both, and it soon appeared to me that the problems treated in the second could have no physical bearing on the question of the earth's structure. The very title of this memoir partly reveals its character in this respect. In order to apply the results obtained in this memoir to the earth, it is supposed to be a spheroidal homogeneous elastic shell filled with incompressible fluid; whereas in such an inquiry the earth can scarcely be supposed to be otherwise than a heterogeneous solid envelope containing a fluid whose properties are not inconsistent with those of fluids coming under our notice. Under this form I have treated the hypothesis in the "Philosophical Transactions" for 1851, and also in subsequent publications.

Incompressibility is not a property of any known fluid; and Neumann, when referring in his comprehensive treatise on geology to the influence of pressure in promoting the density of the interior parts of the earth, expresses what is very generally admitted among philosophical geologists as well as physical inquirers, when he says that "fluid bodies are endowed with *far more* compressibility than solids."* Hypotheses are often indispensable in physical inquiries where we are proceeding from the known to the unknown, but there are two conditions to which they should conform; first, they should be capable of verification by a comparison of the results to which they lead with those of observation, and secondly, they should not contradict established physical laws or the known properties of matter, unless the contradiction is specially explained and fully accounted for. The second of these conditions is clearly violated when the internal fluid of the earth is supposed to differ from all known fluids by being supposed to be incompressible. And this violation is especially flagrant when the solid matter enclosing the incompressible fluid is supposed to be at the same time elastic and therefore compressible, and when, moreover, the line of reasoning adopted as to the earth's internal structure pointedly depends upon these assumptions as to the properties of its fluid and solid portions. Sir William Thomson endeavours to prove, by a process of *reductio ad absurdum*, that the interior of the earth is for the most part or altogether solid; in other words, he supposes the interior to be fluid, and then tries to show that the tidal actions produced in this fluid by the sun and moon must cause oscillations in the crust which have not been observed. He may justly claim to have proved that the earth does not consist of an elastic solid envelope enclosing a mass of the ideal substance called an incompressible liquid, but he has not proved the point which he intended to establish, namely, the absence of an interior fluid nucleus endowed with the properties commonly attributed to fluids. He also supposes throughout his investigations, in the same manner as was supposed by Mr. Hopkins, that the transition from the solidity of the shell to the fluidity of the nucleus is not gradual but abrupt. Those who maintain the validity of the hypothesis of the interior fluidity of the earth are far from holding this opinion. On the contrary, all observations hitherto made on the materials of the earth lead to the conclusion that the solid shell is so constituted as to present first a superficial coating whose mechanical properties we can partly ascertain by direct experiment; secondly, a mass whose density and rigidity probably increase with the depth from the outer surface; thirdly, an interior coating in which the effects of pressure are resisted by those of temperature, and where an imperfectly fluid and pasty mass is in contact at one side with the solid shell, and on the other with the more perfect fluid. This mass should be manifestly much more yielding and compressible than the perfectly solidified shell; for if compression tends to increase the rigidity of solid matter, the middle division of the shell, as just described, should be more rigid than its superficial portion, and very much more rigid than the interior pasty mass. The work performed by small changes of shape in the fluid nucleus due to the action of exterior disturbing bodies should thus be expended partly in producing small variations of density among the compressible strata of which it is composed, and partly in changing the shape of the yielding matter of the inner surface of the shell. The deformations of a shell consisting of homogeneous elastic matter, such as steel acted upon by exterior forces, must be the resultants of all the elementary deformations among its particles summed up or integrated. It would behave somewhat like a vibrating bell; but such is not the behaviour to be expected in a mass of discontinuous and heterogeneous materials. Vibratory motions in such bodies are for the most part extinguished by interferences, or their amplitudes are at least very much reduced.

If the conclusions deduced by M. Perrey of Dijon from his voluminous labours so often referred to by Mr. Mallet in his Reports on Earthquakes, be correct, some connection between these disturbances and the phases of the moon seems to be established which may be due to such comparatively feeble vibratory actions. Sir William Thomson's conclusions rightly interpreted show that the constitution of the fluid nucleus and the nature of the materials of the shell must be essentially different from what he supposes in order to establish these conclusions. A person who never saw a railway train might as justly reason as to the impossibility of travelling in it at high rates of speed, by demonstrating that the shocks experienced by perfectly rigid carriages connected without any compressible arrangements would be too great for travellers to endure, if not too great for the permanent integrity of the carriages themselves. In assuming the incompressibility of the fluid nucleus for the purposes of his indirect demonstration of the rigidity of the earth, Sir William Thomson makes a *petitio principii* nearly as vital as shocks incident to influence of buffers in reasoning on the the omission of the railway carriages.

I am at a loss to know where any warrant was found for affixing the property of incompressibility to the supposed fluid nucleus of the earth; and those who maintain the hypothesis of the interior fluidity of the earth are entitled to repudiate an assumption fastened on that hypothesis not only in opposition to evidence derived from experiments on fluids, but in direct contradiction to the arguments employed by them in discussing the question of the earth's structure.

HENRY HENNESSY

* Lehrbuch der Geologie, i. p. 268, 2nd edition.

THE LANDSLIPS AT NORTHWICH

IN the "Notes" of the number of NATURE, for Jan. 25, I find one referring to the landslips at Northwich in Cheshire, by mistake called Nantwich. As the description given of these landslips and their cause is scarcely accurate, your readers may like to see a short account of them.

Northwich is the great centre of the Cheshire salt trade. The manufacture is principally carried on now at Northwich and Winsford, both towns lying in the valley of the River Weaver, though formerly Nantwich was engaged in this trade, and Middlewich still continues so to be. The position of the latter is indicated by its name, it lying between Northwich and Nantwich. The salt is found lying in two beds, called the upper and lower rock salt. The first bed is met with in the neighbourhood of Northwich at the depth of about forty yards, and

is twenty-five yards thick. Although brine springs had been known and worked as early as the time of the Norman Conquest or earlier, yet the bed of rock salt was only discovered in 1670 when searching for coal at Marbury, about a mile to the north of Northwich. During the last 200 years this rock salt has been worked, or to speak more correctly, for more than a century the upper bed was worked, when an agent of the Duke of Bridgewater sank lower still, and, after passing through about ten yards of hard clay and stone, with small veins of rock salt running through it, the lower bed of rock salt was discovered. This lower bed is between thirty and forty yards thick, but only about five yards of the purest of it is "got." This good portion lies at a depth of from 100 to 110 yards, according to the locality. In the neighbourhood of Winsford both beds are met with at a much greater depth. The whole of the rock salt obtained is got now from the lower bed, and last year it reached nearly 150,000 tons, probably the largest quantity ever obtained in one year. It may as well be said that this mining of rock salt has had nothing whatever to do with the subsidences spoken of, though the wording of the note would lead readers to expect the contrary. At present there is no danger to be expected from the lower bed of rock salt. The whole danger arises from the upper bed, as will be seen from the following account:—The salt trade of Cheshire is a very extensive one, and during the year 1871 upwards of 1,250,000 tons of white salt have been sent from the various works in that county. The whole of this immense quantity has been manufactured from a natural brine which is found in and around Northwich and Winsford, as well as in several other smaller places. This brine is produced by fresh water finding its way to the surface of the upper bed of rock salt, technically called the Rock Head. The fresh water dissolves the rock salt, and becomes saturated with salt. The ordinary proportion of pure salt in the brine is 25 per cent. To obtain the quantity of salt above mentioned, it would be necessary to pump 5,000,000 tons of brine. The pumping of brine is incessantly going on, and as a natural consequence the bed of rock salt is being gradually dissolved and pumped up. As the surface of the salt is eaten away, the land above it subsides. This subsidence is not spread over the whole surface, but seems to follow depressions in it, thus forming underground valleys with streams of brine running to the great centres of pumping. Wherever a stream of brine runs, there the subsidence occurs, and in many localities the sinking is very rapid and serious, but fortunately is almost always gradual and continuous. An immense lake, more than half a mile in length, and nearly as much in breadth, has been formed along the course of a small brook that ran into the river Weaver, and this lake is extending continually. Besides this gradual continuous sinking, which affects the town of Northwich very seriously, causing the removal and rebuilding of houses or the raising of them by screw-jacks in the American fashion, the raising of the streets and so on, there is a sudden sinking of large patches of ground, leaving large deep cavities such as described in your Note. These latter are more terrifying and dangerous. They are in the majority of cases caused by the falling-in of old disused mines in the upper bed of rock salt. These old mines were worked so as to leave but a thin crust of rock salt between the superincumbent layers of earth and the mines. The roof of the mine is supported by pillars of rock salt at intervals. Of course the weakest and most dangerous point is the old filled-up shaft. As most of these mines have been disused for nearly a century, the position of the old shafts is unknown. When the brine has eaten away the layer of rock salt left as a roof, the whole of the earth lying above falls into the mine, and an enormous crater-like hole, some 100 feet or more in depth, is formed, which in process of time becomes filled up with water, the mine itself being choked with earthy matter. In the immediate neighbourhood of Northwich there are a great number of these rock pit holes, as they are called, and it is nothing very unusual for one to fall in.

The rock miners, as they are called, were at work in the lower mine last year when one of these sudden subsidences occurred. They knew nothing of it. I have been myself under this hole, and it was a fearful one to look at when it first went in. There is no communication between the upper and lower beds, and the miners have about thirty yards of hard clayey stone and rock salt between them and the upper old mines. The subsidence more particularly alluded to in your Notes is not in the immediate neighbourhood of Northwich, but rather midway between Northwich and Winsford, near Marton Hall. It is rather difficult to know what is its cause, as there is no record of any mines ever being worked in that neighbourhood. The general belief is that the rock salt, which undoubtedly underlies the whole neighbourhood, has been gradually dissolved, and that a sinking has commenced as at Northwich; then that, owing to some peculiarity of the particular overlying strata—probably to their sandy nature, as quicksands are known to exist about Northwich—the earthy and sandy matter of the immediately overlying strata has been carried away by the brine streams till a large hollow has been formed. This has continued till the superincumbent mass could not be borne up any longer, and thus suddenly fell in, filling up the lower cavity, but opening a large crater-like pit from the surface.

A Government inspector has been to the neighbourhood, and his report is expected very shortly.

The whole neighbourhood of Northwich is well worthy of more attention than it has received, and it is surprising that our geologists have not been able to give a better account of the rock salt formation than has yet been done.

THOS. WARD

NOTES

WE are glad to be able to state that the severe sentence passed upon M. E. Reclus has been changed, in consequence of the representations of the scientific men of this and other countries, into the comparatively mild one of exile from France.

WE understand that the Chair of Anatomy in the new German University of Strasburg has been offered to, and declined by, Prof. Gegenbaur, who has done so much to raise the scientific reputation of the University of Jena. A similar offer has also been made to Gegenbaur's distinguished colleague, Haeckel, the result of which is not yet announced.

THE Master and Senior Fellows of St. John's College, Cambridge, have elected Mr. J. B. Bradbury, M.D., of Downing College, Linacre Lecturer in Medicine in the room of Dr. Paget, who has been elected Regius Professor of Physic.

THE Royal Commission on Scientific Instruction and the Advancement of Science recommenced their sittings yesterday.

THE two Smith's Prizes of the University of Cambridge have been this year awarded to the First and Second Wranglers respectively.

WE regret to learn that the Australian Eclipse Expedition has proved a failure, through the unfavourable state of the weather at the point of observation.

IT is with great regret we have to record the death on Wednesday, January 31, at Torquay, of Dr. G. E. Day, F.R.S., late Chandos Professor of Medicine in the University of St. Andrew, at the age of 56. Our columns have borne frequent evidence of the extent of Dr. Day's acquirements in many branches of