and the coast of Cuba,—only a week after the 'Reindeer' had been dismasted about five hundred miles to the north-eastward. There was a light breeze from the north-east at the time, and the sky was about half covered with nimbus clouds, moving slowly. Just after a light squall had passed by, the first appearance of a water-spout was indicated by the formation of a whirlwind, gradually increasing in size. It was cylindrical in shape below, spreading out above, and rotating in a direction with the hands of a watch. When within about a hundred yards of the vessel, its angular altitude was about 35°, which would indicate a height of only two hundred and fifty feet or less. It was moving to the south-west at the rate of about eight miles an hour. At the base it was transparent; and descending currents seemed to be plainly visible, causing the water at the surface to fly in all directions. A heavy shower of rain accompanied the spout, and the phenomena lasted, in all, about ten minutes.

"Although the study of such reports has already greatly increased our knowledge of the origin and nature of these interesting and often destructive phenomena, much yet remains to be done before we can hope to be able fully to understand the laws by which they are governed. That portion of the North Atlantic from the northern coast of Cuba to the 40th parallel, and from the Atlantic coast of the United States to the Bermudas, is pre-eminently a region where water-spouts are liable to occur, owing largely to the warm, moist air which hangs over the Gulf Stream, and the cool, dry air brought over it by the north-westerly winds from off the coast.

"Among desirable observations to be made, referring to water-spouts, special attention is called to the temperature of the air and water, the reading of the barometer, direction and force of the wind, and the changes which take place in each while the spout lasts; also the direction of rotation of the whirl, and an estimate of its size, character, and changes of form, with, if possible, sketches, however rough, of its appearance at the various stages of its formation and progress."

SCIENTIFIC NEWS IN WASHINGTON.

The Flow of Solids: Solids are not liquefied by Pressure.—The Law of Probabilities: a Discussion of the Doctrine of Philosophical Necessity.—Dynamite Shells: the Progress made by the Ordnance Department of the Army with Experiments with Nitro-Glycerine.

The Flow of Solids.

Mr. WILLIAM HALLOCK of the United States Geological Survey, whose paper upon a new method of making alloys was presented to the Philosophical Society a few weeks ago, read another address upon a somewhat related subject at the meeting of the same body March 17. The question whether solids, he said in substance, possessed any of the properties of liquids, or what conditions will impart such properties to them, is one of ever-increasing importance, to the student alike of molecular physics in general, or of the earth's crust in particular.

The temperature rises as we penetrate the earth: hence, if no other influence affect the substances, the earth has a liquid centre with a thin solid crust. Astronomical and mechanical facts seem to demand a considerable rigidity. Thomson has even demanded a rigidity equal to that of glass or steel. Geological phenomena require a considerable liquid-like motion. With rising temperature, as we penetrate the earth's crust, we also have rising pressure, which probably increases the rigidity of the materials. Cannot we satisfy the demands of both geology and astronomy, and also of mechanics?

In the glaciers we have the grandest examples of the flow of solids. Henri Tresca proved that lead and some other substances would flow, and follow the laws of flowing liquids. W. Spring has extended the list. Monsson actually liquefied ice by pressure. These observations have led many to advocate the idea of a liquefaction by pressure. Others having in view the results of Bunsen, Hopkins, Amazat, and others, maintain that the melting-point is raised by pressure.

Solids can be made to flow: hence that property cannot be used to distinguish solids from liquids. The essential difference between a solid and a liquid is that the relative ease of re-arrangement of the molecules in liquids is very easy, in solids very difficult. Rigidity may be briefly defined as the difficulty of re-arranging the molecules of the body in question. Can rigidity be reduced by pressure? *A priori*, it seems scarcely likely that forcing the molecules nearer together can give them greater freedom of motion. Generally rigidity is inversely as the intermolecular distances. Ice is abnormal, and cannot be taken as evidence *pro* or *con*. Lead, copper, iron, steel, are all hardened by compression. All metals are harder, more rigid, in the drawn, rolled, or hammered state than cast or annealed. The rigidity of a steel pin was raised from 95,000 to 110,000 pounds per square inch by pressure.

Two experiments were described bearing directly upon the question, and are convincing, although they gave unwelcome results to those who made them. The first was conducted under the direction of the Ordnance Department, and is given in full in the report on 'Tests of Metals, etc., for 1884,' pp. 252–285. A mixture of four parts wax and one part tallow was used as a 'straining liquid' in 'tangential' test. It was demonstrated that that mixture would not transmit pressure through a hole $\frac{3}{16}$ of an inch in diameter and $2\frac{1}{2}$ inches long, when the pressure at one end was 100,000 pounds per square inch, and at the other 30,000 pounds per square inch, or less; whereas 2,000 pounds was sufficient to overcome all friction, and force it through, when there was no back pressure: that is, the wax and tallow were rigid enough, under pressure, to maintain a difference of 70,000 pounds per square inch (100,000—30,000) at the two ends of that hole.

The second experiment was also made with the testing-machine of the Ordnance Department at Watertown, Mass. (see *American Journal of Science*, iii. 34, 1887, p. 280). In that experiment silver coins on top of paraffine and beeswax in the holder, instead of sinking through a liquid under 6,000 atmospheres, were pressed so hard against the top of the holder that their impression in the steel was easily seen and felt. The paraffine and wax were rigid enough to impress silver into steel.

Such facts lead us to believe that pressure increases rigidity; and, when we remember that the pressure at the centre of the earth is millions of atmospheres, a demand for the rigidity of steel seems trifling. What is the rigidity of steel? Simply a rigidity capable of resisting 30,000 to 100,000 pounds per square inch. But distinguished geologists have made the fatal mistake of using 'the rigidity of steel' and 'absolute rigidity' as synonymous and equivalent terms. Nothing is more misleading.

Upheavals and depressions, and other geological phenomena, are most beautiful examples of viscous flow of solids. The forces causing a glacier to flow are trifling as compared with those generated in the earth's crust by shrinking; and undoubtedly to cause any body to flow, we only need sufficient force and time.

Can pressure impart to solids the ability to change crystallographically, mineralogically, chemically? Prismatic sulphur naturally changes to octahedral, and in many other cases changes take place under ordinary conditions of pressure and temperature. We should scarcely expect pressure pure and simple to cause a re-orientation of the axes of the two crystal fragments, even if it could perfectly weld them together. Nor should we expect pressure, without heat, to impart the ability to complete the fusion of a lump of barium sulphate in sodium carbonate, even after the process had been well started by heat. Under the extremely complex conditions, it is difficult to generalize. A welding-together is not only theoretically but practically possible between two chemically clean surfaces that fit, but any operation which requires an increase of freedom in the molecules would scarcely be assisted by pressure. Cohesion and adhesion I believe to be identical, and molecular rather than molar.

The bearing of these ideas, if good, upon geological phenomena, is somewhat thus: by the action of pressure and time we might find a sandstone, or such material, compacted, and rendered coherent or even continuous, the most plastic constituents yielding most, and the most viscous retaining their shape most perfectly. Some constituents might even appear to have been fused and filled in between the rest. Certain crystallographic changes might take place, but more than the slightest chemical effect of the constituents upon each other is not to be expected. The case becomes infinitely complex, and a subject for conjecture only, if the temperature is high. An indisputable fact in this connection is that many more experiments are needed, and that they should be of such a character that each effect can be ascribed to its proper cause, and that causes and effects shall not be treated collectively, as at present.

On Probabilities.

A year ago, or more, Mr. M. H. Doolittle presented a paper to the Mathematical Section of the Philosophical Society, on the doctrine of probabilities. It gave rise to an interesting discussion at the time, which led him, at the last meeting of the section, to return to the consideration of the subject. Referring to an important change of opinion by John Stuart Mill, as shown in the eighth edition of his 'System of Logic,' and set forth in the introductory paragraphs of the chapter on 'The Calculation of Chances,' Mr. Doolittle showed that the two antagonistic schools started with two different definitions of the doctrine of chances, — one, to which he belongs, accepting the latest definition by Mill, which he adopts from Laplace; and the other, that given by Mill in the first edition of his 'Logic.'

"Probability," says Laplace, "has reference partly to our ignorance, partly to our knowledge. We know that among three or more events, one, and only one, must happen; but there is nothing leading us to believe that any one of them will happen rather than the other. In this state of indecision it is impossible for us to pronounce with certainty on their occurrence. It is, however, probable that any one of these events, selected at pleasure, will not take place; because we perceive several cases, all equally possible, which exclude its occurrence, and only one which favors it."

"To a calculation of chances, then," says Mill, "according to Laplace, two things are necessary: we know that of several events some one will certainly happen, and no more than one; and we must not know, or have any reason to expect, that it will be one of these events rather than another." Mr. Mill then expounds the doctrine formerly held by himself, to the effect that these are not the only requisites, and that Laplace has overlooked, in the general theoretical statement, a necessary part of foundation of the doctrine of chances, — the knowledge that one or the other of the events must happen, but the possession of no grounds for conjecturing which. "We must remember," explains Mill, "that the probability of an event is not a quality of the event itself, but a mere name for the degree of ground which we or some one else have for expecting it."

Having read these passages, Mr. Doolittle took up briefly the discussion of the doctrine of philosophical necessity, and referred to Edwards on 'The Freedom of the Will' as exceedingly able in the presentation of this doctrine, and one of the first, if not the very first, American book that became famous throughout the world. On the other side, he quoted from Adam Clarke's 'Commentary on the Bible' as one of the ablest opponents of philosophical necessity. Dr. Clarke's argument is, that, since there are events in the future which are uncertain, it is impossible for them to be known as certain, so that divine foreknowledge is only a knowledge of probabilities, and does not include the certain knowledge of uncertain things. Mr. Doolittle then asked his audience whether, whatever they might think of Adam Clarke's Deity, any one would claim to be a Deity of that sort himself, and argued, that, in any case, it is proper for us to base our theory of probability on human intellectual conditions, and not on divine intellectual conditions. He then said that the doctrine of probability is not peculiar in this respect. Metaphysicians say that all our knowledge is based upon our states of consciousness. We know only our states of consciousness, and although we cannot say that any probabilities exist in the nature of things, still we may presume that probabilities having a scientific basis, have in some manner their counterparts in the external world, just as we presume that other states of consciousness have their counterparts in the external world.

With regard to such probabilities, Mr. Doolittle said Mill was right in his first edition. But there still are probabilities of less scientific character that may nevertheless be made the subject of mathematical computation.

This paper was discussed for an hour by leading members of the section. Professor Harkness of the Naval Observatory accepted the definition of probabilities given by Mill in his first edition, as did also several other gentlemen connected with that institution. The gentlemen connected with the Coast Survey, on the other hand, generally accepted Mill's latest definition adopted from Laplace.

Dynamite Guns.

Among the appendixes to the 'Annual Report of the Chief of Ordnance,' soon to be published, is one prepared by Maj. George W. McKee, on 'The Present Status of Dynamite as an Explosive for Shells.' Prefacing it with a brief history of the discovery and use of nitro-glycerine, he says, —

"The Nobel's explosive gelatine, or blasting dynamite, has been used in this country by United States officers to the entire demonstration of the fact that this high explosive, contained in a shell as a bursting charge, might be fired from a gun. The ordinary blasting dynamite made by the company (some of it experimentally modified with about 3 per cent of camphor) was used, and enough shells were thrown from the bores of the old mutilated guns used in the experiment to demonstrate the fact that dynamite could be projected in shells from an 8-inch rifle gun with a 40-pound charge of powder. The great chemist Nobel never, perhaps, thought of applying his invention to this delicate test; but his powerful and wonderful gelatine, made only to be detonated in mines and the like, stood in several instances the tremendous initial shock of the gunpowder, and, by the aid of the rectangular diaphragms devised by Captain Whipple of the Ordnance Department, stood, what is thought to be equally dangerous, the heat developed by the angular velocity. If the gelatine had been especially undertaken by these chemists for a military and not an industrial agent, and enough time and means had been at hand to perfect the diaphragm, it is believed all of the shells would then have become, as they will be in future, high-explosive batteries, projected with as much safety as though they had been charged with black gunpowder."

Major McKee, in reviewing various experiments that have been conducted under the direction of the Ordnance Department, speaks of them as follows. Of the method exhibited by Mr. Snyder, he says, "He did fairly well with some of his firing at the Hook and on the Potomac, near Washington, D.C., and, as he is a man of inventive talent and an American, no one wishes him more success in his future experiments with dynamite than the men who were delegated by the government to supervise and report upon those he originally undertook." In the experiments with shells loaded with dynamite, conducted by Brevet Brig.-Gen. John C. Kelton, at Point Lobos, near San Francisco, Cal., in March, 1885, no specially camphorated or otherwise prepared explosive was used, but the shells were charged with the crude, blasting, industrial dynamite. Three rounds were fired from a 3-inch wrought-iron rifled gun, — shells with two hundred grams of dynamite, and a variable charge of projection. The target was a large rock at 157 yards distance. In the first two rounds the shell burst into innumerable pieces on striking the rock, but in the third it burst within the piece. Colonel Kelton considered this experiment as very satisfactory, since it demonstrated the possibility of employing dynamite in shells, as well as the great strength of this great explosive; and he estimates that for the effective use of these artifices, which, according to him, is to destroy ships, one-half the length of the projectile is the penetration needed, requiring 0.001 of a second, and he expects it will be successful.

After describing some experiments at Sandy Hook in 1883, Major McKee sums up the results as follows: —

"As detailed in the records, three shells were fired with fulminate-of-mercury fuzes. The fulminate was too sensitive to stand the shock, and it was found afterwards that the gelatine needed no detonator.

"Although the tests made were very few, it would nevertheless appear from them —

"(1) That the shells explode after clearing the muzzle, and therefore the detonation of the gelatine is due to some cause other than the shock of discharge, very possibly the heat generated by angular velocity.

"(2) This is corroborated by the fact that one shell passed through a 2-inch board target without explosion.

"(3) The gelatine used in these tests, not being camphorated, renders it highly probable that a certain percentage of camphor added would establish a compound which could be fired successfully in a specially constructed shell.

"(4) The gelatine does not require a fuze or detonator of any kind.

"(5) It is believed the shell which destroyed the 3.2-inch breech-loading gun broke from the shock of discharge, or admission of powder-gas, and thus detonated the gelatine."

In the summer of 1884 the Ordnance Board fired four cast-iron screw shells from an 8-inch muzzle-loading rifle, using forty pounds of powder in the gun, and from five to eight pounds of gelatine in the shells, at each discharge. The gun was mounted on a cradle, and directed at a target 383 feet distant. One of the shells burst at or near the muzzle with little comparative violence. The other three reached the target, penetrated about seven inches, and detonated from the shock. These trials led to the making of six steel shells, three of them being cast, and three forged. Analysis of the facts connected with these experiments shows —

"(1) That the 3-inch shells designed for gunpowder charge, when loaded with Hill's explosive gelatine, three months old, all cleared the gun without injuring it in the slightest.

"(2) That the shells, having to be charged through the fuze-holes with the dynamite, were necessarily packed loosely, thus subjecting the charge to the powerful action of angular velocity.

"(3) That in the trials made with the 3.2-inch gun, two Butler shells, charged with black gunpowder, broke up 'at or near the muzzle;' while of the two Butler shells charged with Nobel's gelatine, or dynamite, one broke up 'at or near the muzzle,' and the other reached the target and exploded on impact.

"(4) That in the trials made with the same 3.2-inch gun, using thin Hotchkiss shrapnel cases, charged with Nobel's dynamite or gelatine, all cleared the gun in safety (one reaching the target after passing through two-inch boards) with the exception of one, which the board reported on as follows: 'It either broke from the shock of discharge or admitted powder-gas.'

"(5) That *all* the trials with the 8-inch shells charged with *fresh* Nobel's dynamite or gelatine were successful, three of the shells detonating at the target, and one only exploding at or near the muzzle; that the gelatine used when the premature explosion took place was sixteen months on hand in this country after crossing the ocean, and therefore not such as was recommended by General Abbot, or contemplated by the board."

Major McKee's conclusions are as follows: that the United States officers undertaking the investigation of this subject were necessarily compelled to institute their inquiries *de novo*. All foreign information was so meagre, so unsatisfactory, and so shrouded in mystery, in accordance, doubtless, with the policy of the European governments, that it was seen, after careful investigation, that all trustworthy knowledge would have to be gleaned by Americans through experience. In obtaining this experience, devices have been experimented with, invented by Mr. Snyder, who presented several plans; Mr. C. P. Winslow, with a nitro-glycerine shell, in which the glycerine and combined nitric and sulphuric acids are placed in separate glass vessels within the shells; Mr. Garrick, with a mortar and projectile for nitro-glycerine; Mr. D. P. Hill, with an 8-inch explosive gelatine shell; Mr. Stevens, with a double shell for high explosives; Mr. Graydon, with a shell containing the dynamite in capsules; Mr. Taylor, who brought his own gun, and attempted to use dynamite as a propulsive charge; and Mr. Smolianoff, experiments with whose gun were made as late as last October.

In all these trials, Major McKee said, as to the practicability of using dynamite as a shell-explosive, that it was well understood by the officers undertaking them that the crude blasting compound of industry, which was the only available explosive attainable, was not the eventual product of chemistry which would satisfactorily answer this purpose. It was known that great improvements had been made in the dynamites of all kinds, especially in blasting dynamite, or gelatine of Nobel, and that these compounds presented in transportation by all modern conveyances, and in all mining and other industrial works, as much, if not greater, safety than the black war, sporting, and blasting gunpowders of commerce. With this status of dynamite apparent, it was seen that the time had arrived for military men in the United States to begin experiments with it as a shell-explosive, with some possibility of success. When it was demonstrated that the freshly prepared crude commercial dynamite might be fired in a shell from an 8-inch gun with a charge of forty pounds of black gunpowder, the only question that then remained was as to the stability and reliability of the compound through age. And when, after sixteen months' storage, it appeared to be more sensitive to shock, the Ordnance Board recommended that no more experiments be made with it until it was further camphorated, or otherwise treated by competent chemists. And it was ascertained further, in these few and inexpensive tests, that the heat developed by the angular velocity was a more potent factor in detonating the dynamite than was the shock of discharge. It has been seen, also, that, since the comparatively recent discovery of nitro-glycerine, its development has been rapid in the protean forms of dynamite. In Europe experiments are being constantly conducted to perfect this agent, and doubtless they will succeed. Even now they claim in France and Germany to have perfected melinite and helphonite, — compounds probably of nitro-glycerine and some of the ethers. In Russia they also announce some new improvements that are not known here. But in the near future there is every probability that the problem will be solved in this country.

ELECTRICAL SCIENCE.

Electrical Testing-Laboratories in Paris and Vienna.

THE Société Internationale des Electriciens has completed and opened a laboratory whose main purpose will, for the present, be the testing and calibrating of electrical apparatus. M. de Nevville will be the director. The following measurements will be made: resistance, capacity, electro-motive force, constants of batteries, of cables and wires, insulation resistance, efficiency of dynamos (provisionally of continuous-current machines), and co-efficients of induction. When the means allow, purely scientific researches will be carried on. The laboratory is built on a modest scale, and seems to lack a few pieces of apparatus that will probably be supplied: for example, there is no provision for measuring mechanical work, — a measurement necessary in many cases for the tests of dynamos and motors.

The laboratory in Vienna is an addition to the Technological Museum in that city. Herr Carl Schlenk will superintend the work, which will include very much the same kind of tests as are to be made in the Paris laboratory.

The establishment of these two laboratories is important. The applications of electricity have rapidly advanced, and have assumed a permanent character. The questions in many cases are not, 'Can electricity do this?' but, 'How cheaply can it be done?' and this last question can only be answered by measurements. As competition increases, and as that part of the public looking for investment becomes less satisfied with the mere running of a machine, and demands accurate measurement of its performance, the necessity of some reliable means of comparing measuring-instruments becomes necessary. In England the Central Institution of London has undertaken the work; in Austria, the Technological Museum at Vienna; in France, the International Society of Electricians. Our country has outstripped all others in the applications of electricity. Probably we will soon have some means of comparing electrical apparatus, and testing the value of the numerous appliances daily patented. Electrical progress has been retarded and discredited by worthless patents in which a great deal of money has been invested and lost, while a simple test, taking little time and made at little expense, would have shown them valueless.

DUJARDIN'S METHOD OF FORMING SECONDARY-BATTERY PLATES. — Several methods have been tried, and some are now commercially used, of obtaining a quick formation of 'active material' — peroxide of lead and spongy lead — for secondary-battery plates. The Planté process of reversing the current is employed by some makers, while others deposit the peroxide and lead on support plates from an alkaline solution of litharge, as in the Moutard batteries. Dujardin's process of obtaining a deposit is as follows: the lead plates are put into a solution of sulphuric acid and sodium nitrate in water (10 of water, 2 of sulphuric acid, 1 of sodium or potassium nitrate), and a current is sent through the cell. By the passage of the current, nitrate of lead is formed, the lead