ment of these faculæ in parts of the sun where there are no spots at all.

Those who are familiar with this class of observations will remember that it is much easier to see the faculæ near the sun's limb than in the centre of the sun. Also it is easier to get a photograph of the faculæ using a collodion or a dry plate which works very far up in the blue, than it is with a collodion or a dry plate which works in the green or the blue-green; this latter fact proves to us quite conclusively, as it was pointed out a good many years ago now,[1] that the difference between the light at the top of a dome, so to speak, or the bottom, or between the top of the cumulus and the base of the pore, is a difference chiefly of that kind of light which writes its record by means of the absorption of the blue end of the spectrum.

The reason that we see the sun red at sunrise and sunset frequently is not that there is anything different in our air at that moment, but because we are looking at the sun through a greater thickness of the air; and the redness of the sun is the balance left after our atmosphere has done all it can in the way of absorbing the blue. We do not expect to get the sun red at midday. Of course a London fog will do anything; but I am talking of our ordinary atmosphere; and the fact that we do not get the sun red in the middle of the day is one of the same kind as the other one that we do not so easily see the faculæ on the centre of the sun as we do at the edge of it. There is absorption going on between the top of a facula and the bottom of a pore; and, as you know, to get that out in its greatest vigour and quantity we must take the greatest possible thickness of atmosphere. We see in a moment that the only way to have a considerable thickness of solar atmosphere to work this for is to make observations near the sun's limb.

These faculæ exist on an enormous scale. It is quite common to see reaches of them tens of thousands of miles long, lasting for days, and perhaps weeks; we get in that fact an indication of the enormous amount of energy which may still be changing places in the solar atmosphere, even though we do not get other phenomena which appear to us to be more important. By "other phenomena" of course I mean the spots.

J. NORMAN LOCKYER

(*To be continued.*)

BARK BREAD

MOST travellers in Norway have probably had more than sufficient opportunities of becoming acquainted with the so-called "Fladbröd," flat bread, of the country. Few, however, among them who have partaken of this dry and insipid food may possibly be aware that in many districts, more especially in Hardanger, the chief ingredient in its composition is the bark of trees. This substitution of an indigestible product for *boná fide* flour is not necessarily a proof of the scarcity of cereals, but is to be ascribed rather to an opinion prevalent among the peasant women that the bark of young pine branches, or twigs of the elm, are capable of being made into a thinner paste than unadulterated barley or rye-meal, of which the Norse housewife, who prides herself on the lightness of her "Fladbröd," puts in only enough to make the compound hold together.

The absence of any nutritive property in bark bread, whether made with elm or pine bark, and the positive injury it may do the digestive organs, has of late attracted much notice among Norwegian physiologists, and the editor of *Naturen*, with a view of calling the attention of the public to the subject, has, with the author's permission, reprinted some remarks by Dr. Schübeler on the history and character of the bark bread of Scandinavia. From this source we learn that the oldest reference to the use of bark bread in Norway occurs in a poem, ascribed to the Skald Sighvat, who lived in the first half of the eleventh century. In the year 1300 the annals of Gothland record a season of dearth, in which men were forced to eat the bark and leaf-buds of trees, while then, and during the later periods of the Middle Ages, the frequent failure of the crops in all parts of Scandinavia led to the systematic use of the bones and roe of fishes, as well as the bark of trees as a substitute for genuine flour; and so extensively was the latter substance used that Pastor Herman Ruge, who in 1762 wrote a treatise on the preservation of woods, has drawn attention to the almost complete disappearance of the elm in the Bohus district, which he ascribes to the universal practice in bygone times of stripping the bark for the preparation of bread.

In Nordland and Finmark the root of *Struthiopteris germanica* and other ferns, as well as the leaves of various species of Rumex, have been largely used with barley-meal in making ordinary bread as well as "Fladbröd." In Finland the national "pettuleipa" (bark bread), which was in former times almost the only breadstuff of the country, still ranks as an ordinary article of food in Kajana, and in the forest-regions of Oesterbotten, and Tavastland. Here it is usually made of the inner layers of the pine-bark, ground to a meal, which is mixed with a small quantity of rye-flour to give the requisite tenacity to the dough. The Finlanders of an older generation showed marvellous ingenuity in composing breadstuffs, in which scarcely a trace of any cereal could be detected in the mixture of bark, berries, seeds, bulbs, and roots of wild plants, which they seem to have accepted as a perfectly legitimate substitute for corn-bread. In the interior of Sweden, according to Prof. Säve, the *best* bread of the peasants consisted till the middle of this century of pease, oats, and barley-meal in equal proportions, while in the ordinary daily bread the husks, chaff, and spikes of the oats were all ground down together. In bad seasons even this was unattainable by the Dalekarlian labourer, who had to content himself with pine-bark bread.

DILATANCY[1]

THE principal object of this lecture was to show experimental evidence of a hitherto unrecognised fact of fundamental importance in mechanical philosophy. This newly-recognised property peculiar to granular masses (named by the author "Dilatancy") would be rendered clear by the experiments. But it was not from these experiments that it had been discovered. This discovery was the result of an endeavour to conceive the mechanical properties a medium must possess in order to act the part of the all-pervading ether—transmitting waves such as light, but not such as sound, allowing free motion of bodies, causing distant bodies to gravitate, and causing forces like cohesion, elasticity, and friction between adjacent molecules, together with electricity and magnetism.

As the result of this endeavour, it appeared that the simplest conceivable medium, a mass of rigid granules in contact with each other, would answer not only one but all of these requirements, provided such shape or fit could be given to the grains that, while these rigidly preserved their shape, the medium should possess the apparently paradoxical or anti-sponge-like property of swelling in bulk when its shape was altered.

This required that the grains should so interlock that, when any change in the shape of the mass occurred, the interstices between the grains should increase. Having recognised this property as a necessity of the ether, the next question became, What must be the shape and fit of the grains so that the mass might possess this unique property? At first it seemed that there must be something special and intricate in this structure. It would obviously be possessed by grains shaped to fit into each other's interstices: this was illustrated by a model of bricks arranged to bond as in a wall; when the pile was distorted, interstices appeared. Subsequent consideration revealed this striking fact—that any shape of grains resulted in a medium possessing this property of dilatancy so long as the medium was continuous, or so long as precautions were taken to prevent rearrangement of the grains, commencing at the outside. All that was wanted was a mass of smooth hard grains, each grain being held by the adjacent grains, and the grains on the outside being so controlled as to prevent rearrangement. This was illustrated by a model of a pile of shot, which, when in closest order, could not have its shape changed without opening the order and increasing the interstices. The pile being brought from closest to most open order by simply distorting its shape, the outside balls being forced, those in the interior were constrained to follow, showing that in no case could a rearrangement start in the interior.

Considering the generality of this conclusion, it was necessary to explain how it was that dilatancy was not a property of ordinary atomic or molecular matter. This was owing to the elasticity, cohesion, and friction which rendered molecules in-

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[1] In 1872; see "Solar Physics," p. 404.

[1] Abstract of a Lecture delivered at the Royal Institution of Great Britain, on Friday evening, February 12, 1886. By Prof. Osborne Reynolds, LL.D., F.R.S.

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capable of acting the part of independent grains whose only property was to keep their shape. This was not inconsistent with dilatancy in ether, for these physical properties were possessed by the molecules of matter in consequence of the presence of the ether, and hence it was not logical that the atoms of ether should possess these properties.

If evidence of dilatancy were to be obtained from tangible matter, it was to be sought on the most commonplace, and what had hitherto been the least interesting, form, that of hard, separate grains—corn, sand, shot, &c.

That an important geometrical and mechanical property of a material system should have lain hid for thousands of years, even in sand and corn, was such a striking thought that it required no small faith in mechanical principles to undertake the search for it; and, though finding nothing but what was in accordance with previous conclusions, the evidence obtained of this long-hidden property was as much a matter of surprise to the lecturer as it could be to any of the audience.

To render the dilatancy of a mass of grains evident, it was necessary to accomplish two things: (1) the outside grains must be controlled so that they could not rearrange, and this without preventing change of shape or change of bulk; (2) it was necessary to adopt means of measuring the change of bulk or volume of the mass or of the interstices between the grains as its shape was changed. A very simple means—a thin india-rubber bag—was found to answer both these purposes to perfection. The outside grains indented themselves into the india-rubber, which prevented their changing their places, while the impervious character of the bag allowed of a continuous measure of the volume of its contents by measuring the quantity of air or water necessary to fill the interstices.

In these experiments neither the bag nor the fluid had anything to do with the dilatancy of the contents considered as forming part of a continuous medium, the bag merely controlling the outside members as they would be controlled by the surrounding grains, and the fluid merely measuring or limiting the volume.

India-rubber football cases were then shown full of dry sand, shot, corn, and glass marbles, shaken down into their densest form. The bags could not be distorted, as by squeezing between two plates, without enlarging the interstices between the grains, and hence the volume of the bag. Such increase of bulk was not, owing to the change of shape, evident to the eye; but by connecting the mouth of the bag to a pressure-gauge, it appeared as the squeezing began, the pressure of the air within the interstices began to diminish, and as the squeezing went on diminished as much as 6 inches of mercury, which showed that the interstices had increased a third. These experiments were introduced mainly to prevent the impression that the character of the fluid within the interstices had anything to do with dilatancy. Water affords a more definite measure of volume than air. This was shown. A bag holding six pints of sand full of water without air, connected by a tube with the bottom of a vessel of water, drew, on being squeezed, about a pint of water from the vessel into the bag. This was the maximum dilation; for further squeezing the water ran back into the vessel, and then again, for still further squeezing, was drawn back again, showing that, as the change of form proceeded, the medium passed through maximum and minimum dilations.

The most striking evidence of dilatancy is obtained from the fact that, since dilatant material cannot change its shape without increasing in volume, by preventing change of volume all change of shape is prevented. By closing the communication between the bag and the vessel of water, and thus preventing further increase of volume, further change of shape was instantly prevented. Starting with the sand at its densest, and the communication closed, a pinch of 200 lbs. was put on the planes without producing the smallest apparent change in the spherical shape of the bag.

Communication with the pressure-gauge was then opened, which showed that, so far from the water in the bag being at a greater pressure than the atmosphere, it was less by 20 inches of mercury, so that a little more pressure on the planes and a vacuum would have been formed. On opening communication with the water the bag instantly responded by change of shape, and again instantly stopped when the supply was cut off.

That the thickness of the envelope was of no importance so long as it was impervious to air, was shown by using india-rubber balloons, so thin that the sand could be seen through them; one of these, which was soft and yielding when the water was in excess, became hard like a cannon-ball when the excess of water was drawn off, maintaining any shape it had when the bag was closed, supporting 200 lbs.

In this way a cast was taken from a mould, into which the bag was shaken with water in excess till it took the form of the mould; the excess of water was then drawn off, and the mould removed, leaving an image which preserved its shape loaded with 200 lbs.

The firmness and softness of the sand by the sea was shown to be due to these causes; as the tide falls it leaves the sand apparently dry, but in reality full of water, the surface of which is kept up to the surface of the fine sand by capillary attraction. This saturated sand cannot yield to the tread without dilating, and cannot dilate until it has had time to draw more water, the first effect of the foot being to draw down the capillary surface, leaving the sand apparently dry round the foot. This was shown by experiment.

The lecturer then indicated how the property of dilatancy in a continuous medium would render it capable of causing an attraction between bodies at a distance, like gravitation, and cohesion, and elastic forces between bodies close together; how the ability of the grains to rearrange at a free surface would allow bodies to move freely in the medium which, if in a state of agitation by transverse waves in all directions, would transmit waves like those of light, but not like sound, and which if consisting of grains of two different sizes or shape, would give rise to phenomena resembling those of electricity.

In conclusion, it was remarked that, promising as this dilatant hypothesis of ether was, it could not be taken as proved until it had been worked out in detail. This would take long, and in the meantime it was put forward to add interest to the property of dilatancy, to the discovery of which it had led. The property of dilatancy once recognised was, however, independent of any hypothesis, and seemed to have opened up a new field for philosophical and mathematical research quite independent of the ether.

SOCIETIES AND ACADEMIES

LONDON

Royal Microscopical Society, February 10.—The President, Rev. Dr. Dallinger, F.R.S., in the chair.—The President referred to the loss sustained by the death of Mr. P. H. Lealand, to whom microscopists were so largely indebted for the optical productions which were so well known and appreciated.—The Report of the Council was read and adopted.—Dr. Dallinger then gave his annual address, in which he detailed the results of his later researches into the life-history of minute septic organisms as carried on by means of the improved lenses constructed for him by Messrs. Powell and Lealand. Four forms were selected for study. Each of these septic organisms terminate a long series of fissions with what is practically a generative act of fusion. The two last of a long chain of self-divided forms fuse into one, become quite still, and at length the investing sac bursts, and a countless host of germs is poured forth. The growth of these germs into forms like the parent was continuously watched, showing gradual enlargement, and ultimate, but as to time somewhat uncertain, appearance of the nucleus, and the somewhat sudden appearance of the flagella or thread-like motor organs, the latter being found in each instance to arise in the nucleus. Very soon after the adult stage is reached the act of self-division commences, and is kept up for hours in succession. The delicate plexus-like structure becomes aggregated at one end of the nucleus, leaving the rest perfectly clear, except that a faint beading is seen in the middle line, with two or three finer threads from it to the plexus. Then occurs the commencement of partition of the nucleus, followed by a slight indication of division of the body-substance. Quickly afterwards the nucleus becomes completely cleft, and the body-substance follows suit. Then the plexus-like condition is again diffused equally over the whole nucleus. When the generative condition is approached by the last generation of a long series of dividing forms, it is remarkable that the organism becomes amœboid, showing how far-reaching is the amœboid state. In this condition, when two such forms touch one another they coalesce and fuse into each other almost as though two globules of mercury had touched, until nucleus reaches nucleus and the two melt into one, and the blended bodies become a globular sac, which ultimately emits an enormous number of germs. Previous to the blending it is now made out that all

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