from the thirty-seven years' observations now available.

The principal results for the magnetic elements in 1910 were :—

Mean declination	... ...	15° 41·2′ West.
Mean horizontal force	... ..	0·18532 (C.G.S. units.)
Mean dip (with 3-inch needles)	...	66° 52′ 37″.

There were no days of "great," and only six of "lesser," magnetic disturbances.

The mean temperature for 1910, 49·7°, was 0·1° above the 1841–95 average, but the sunshine recorder showed a deficiency; July provided only about half the average number of hours of bright sunshine, and May was the only month when the amount was appreciably above the average. The rainfall, 25·93 inches, was 1·81 inches in excess of the 1841–95 average, and the number of "rainy days" was 175.

In the time department, the performance of chronometers is reported as satisfactory, and that of chronometer watches as exceptionally good. The increase of electrical devices on board ships having made the question of the magnetic disturbance of chronometers an urgent one, special experiments are being carried out with strong magnetic fields at the observatory.

THE HARD AND SOFT STATE OF METALS.

DR. G. T. BEILBY, F.R.S., delivered the second annual May lecture of the Institute of Metals on Friday, May 12, taking for his subject "The Hard and Soft States in Metals."

In the course of his lecture Dr. Beilby said that the hardening effect of cold working on ductile metals, and the softening effect of reheating, must have been known to the earliest workers in metals. To the general mind, the phenomena were sufficiently explained as being due to the "compacting" effect of hammering and the "opening up" effect of heat. The advent of scientific methods of inquiry led to the exposure of this fallacy, and to the discovery of new points of difference in a metal in the two states. The discovery that the polishing of all substances, even of those so hard or brittle as antimony or calespar, involves the transient liquefaction of a thin layer on the surface, led to the study of this subject from an entirely new point of view. In a pure ductile metal which has been slowly cooled from the molten state, the structure of the solid is completely crystalline, and the metal is in its softest condition. Any permanent deformation of the mass, whether by hammering, by rolling, or by wire drawing, hardens and stiffens it. The microscopic examination of the hardened metal shows that its original crystalline structure has been broken up and replaced by a new type of structure. If the hardened metal is raised to a sufficient temperature, the softness is completely restored *and the crystalline structure is also restored.* In the ductile metals the greatest degree of softness is always associated with well-developed crystallisation.

The composite character of the hardened structure, which in some cases resembles a bed of broken and distorted strata concreted or cemented together by a matrix, can only be explained by the presence of two constituents, namely, the broken-down remains of crystals and an amorphous or glass-like form of the metal by which the mass is so firmly cemented together that it has become vastly more rigid and mechanically stable than the crystalline structure. This amorphous or vitreous form of the metal stands in the same relation to the crystalline form as glass does to the crystalline silicates of which it is composed, or as the clear, vitreous "barley sugar" does to the ordinary crystals of the breakfast table.

The pure ductile metals cannot be obtained in the vitreous state by cooling, because their molecules retain sufficient mobility to enable them to marshal themselves in crystalline formation for a range of about 800° below the solidifying point. All the facts show, however, that when liquefaction is produced by mechanically induced flow the solidification is so rapid that the solid which results is in the vitreous condition.

Microscopic analysis of the surface skin produced by polishing a plate of calcite shows that the disturbance due to polishing has penetrated to a depth of one thousandth of a millimetre, and that the subsequent healing over of the disturbance has been so perfect that it can only be explained by the assumption that the transient liquefaction of a layer some thousands of molecules in thickness has occurred. It is evident that the conditions necessary to bring about liquefaction and solidification at the outer surface must equally exist within the substance at all surfaces of slip or shear, and the microstructure of the hardened metal confirms this view.

The direct bearing of these researches on the obscure subject of molecular structure in solids was pointed out, and a "pulsation cell" hypothesis of the three states of matter was outlined.

Prof. Quincke's "foam-cell" theory of solidification was referred to, and was applied to the explanation of certain observations made by Prof. Carpenter some years ago. In view of the possible bearing of this theory on questions of foundry practice, it was suggested that the Institute of Metals might offer a prize for the best research on the subject.

HYDRO-ELECTRIC PLANTS IN NORWAY AND THEIR APPLICATION TO ELECTRO-CHEMICAL INDUSTRY.[1]

THE physical configuration of Norway is remarkably favourable for the utilisation of the large number of waterfalls to be found on the seaboard of the mountain chains which almost cover the country, and through the valleys of which the enormous quantity of water precipitated from the western and south-eastern sea breezes finds its way as rivers flowing down to the sea. In the winter the rainfall takes the form of snow, so that the volume of water brought down by the rivers is at its greatest from May to July, when the snows melt on the mountains. To make use of the water-power, storage is therefore necessary, and for this the nature of the country is peculiarly adapted, being covered with lakes that have very contracted outlets, and which can be easily converted by damming into storage reservoirs. Thus in the watershed of Skien the natural water-power of 50,000 horse-power has been increased to an available horse-power of 375,000, while the Mösvand reservoir has increased the water-power of the Rjukan factories from 30,000 to 250,000 horse-power, with a capital outlay of only some 85,000*l.*

The total water-power in Norway has been estimated at from five to seven million horse-power, but as much of the country has not been hydrographically surveyed, this is probably too low an estimate. The power stations can supply power at from 22*s.* to 44*s.* per e.h.p.-year, and in some cases even for less; and as the quantities available are as high as from 50,000 to 100,000 horse-power for a single fall, the conditions are ideal for the development of electrochemical and electrometallurgical industries. Many such industries have already reached an advanced stage of development. Thus nearly 180,000 horse-power will be utilised this year in the manufacture of nitrates of lime, soda, and ammonia from the air by the Birkeland-Eyde process and the Badische Analin und Sodafabrik Company's process; about 60,000 horse-power are employed in the manufacture of calcium carbide, and other electrochemical and electrometallurgical industries absorb at present some 20,000 horse-power. Now that a suitable electric furnace—the Grönwall—has been designed for the smelting of iron ore, a furnace that has yielded excellent results on a practical scale, electric iron and steel smelting is likely to develop largely in the near future, for Norway possesses extensive deposits of iron ore. Three plants, aggregating 16,000 horse-power, with provision for increasing to nearly 60,000, are now being erected at Hardanger, Arendal, and Tinfoss. Other ores, notably copper, nickel, zinc, will also possibly be electrically smelted at no distant date.

The second portion of the paper describes in some detail the various hydro-electric schemes now being developed in

[1] Summary of a paper read before the Faraday Society on May 2, by Mr. A. Scott-Hansen, of Christiania.

Norway. On the Glommen River, in the east, three falls are utilised. The uppermost, Kykkelsrud, yields about 40,000 horse-power, of which 10,000 kilowatts is transmitted at 60,000 volts (3-phase 50 periods) to Christiania, thirty-one miles away, and the remainder to Sarpsborg. At Sarpsborg occurs the lowest fall of the Glommen, and here there are two power stations—Hafslund, supplying 24,000 horse-power to calcium carbide works and for zinc smelting, and Borregaard, the output of 26,000 horse-power of which is utilised by the Kellner Partington Paper Pulp Company, Ltd., owning the largest works in Norway. The intermediate fall on the Glommen is at Vamma, where a dam is now in course of construction under considerable difficulties. This dam will have a height of 90 feet, and will be one of the largest in Europe. The power station will be in the centre of the river bed below the dam, and will yield some 70,000 to 80,000 horse-power.

A large number of the minor power stations in the south supply the towns with light and power. Among the smaller electrochemical works are the electro-iron and steel works at Arendal, the experimental nitrate works of the Badische Company at Christianssand, and nickel and aluminium factories near the same town. The nickel works refine nickel matte, and turn out about 400 tons of the pure metal per annum. At Gjössingfjord is Mr. Albert Hiorth's small experimental electro-steel works. At Vadheim, on the west coast, is a sodium factory, and at Trondhjem, in the north, carbide, ferro-chrome, and ferro-silicon are manufactured.

Another great power centre is in the Telemarken district in the south-east of Norway. The Svaelgfoss power station supplies 40,000 horse-power to the nitrate factory at Notodden at a voltage of 10,000, delivered without transformation. The four 10,000-horse-power machines—capable of developing 13,000 horse-power—are among the largest in the world. A power station now being constructed at Lienfoss will be able to furnish Notodden with a further 20,000 horse-power. The Tinfoss Works, also at Notodden, are intended to generate 15,000 horse-power, to be used mainly for iron and steel smelting.

The third of the great Norwegian falls is the celebrated Rjukanfoss waterfall on the Maaneely River. The Mösvand dam, above this fall, provides a reservoir of about 840 million cubic metres (tons) of water, and five miles below is another dam, forming the intake for the power station, situated 1000 feet below. A lower fall of about 1000 feet provides the power for a second station. Both of these power stations—the largest in Europe—will yield 140,000 horse-power, there being in each 10 units of 14,000 horse-power. The turbines, on account of the great height of the falls, are Pelton wheels. The construction of the dams, flumes, and power stations at Rjukanfoss was attended with great engineering difficulties, which are described in the paper. The power from these stations is transmitted through sixty copper and aluminium cables to Saaheim, where factories for the manufacture of nitrogenous products to employ from 2000 to 3000 persons are in course of erection.

The paper concludes with a description of the power plant at the Tysse falls, which consists of seven units, each of 4500 horse-power, and from which electric energy is transmitted at 12,000 volts to Odda, where it is used for the manufacture of calcium carbide and of cyanamide. Here again, on account of the steep, mountainous character of the country, great difficulties presented themselves, particularly in the drilling of tunnels 1320 feet above the fjord, and in fixing the flumes, some against a smooth precipice, with an inclination of 60°. The Tysse power station will eventually yield some 100,000 horse-power.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

BIRMINGHAM.—At the last meeting of the council the following resolution was passed:—"The council of the University has heard with great regret of the death of Prof. Whitcombe, who for twenty-three years was professor of mental diseases at Queen's College, Mason College, and the University, and desires to place on record its appreciation of the valuable services he has rendered to the University."

Dr. Helen M. Wodehouse has resigned her appointment as lecturer in philosophy on being elected to the principalship of the West Riding of Yorkshire Training College.

At the forthcoming degree congregation, official degrees are to be conferred on Prof. C. E. Martineau (M. Com.), professor of accounting, and on Miss S. M. Fry (M.A.), the warden of the Hall of Residence for Women Students.

BRISTOL.—Mr. Herbert Bolton, curator of the Bristol Museum of Natural History, has been appointed reader in palæontology in the University.

The thanks of the council have been accorded to the Local Committee on Agricultural Development for passing the following resolution:—"In view of the valuable research work now being done in the University of Bristol in the interests of the cheese industry, and also in the investigation of plant diseases, this meeting urges that a substantial grant for a given period of time be provided by the Development Commission, to enable the investigations to be proceeded with until practical results are arrived at."

CAMBRIDGE.—An offer to contribute 200*l.* a year for the next five years to the Geographical Education Fund has been made by the council of the Royal Geographical Society, which has further granted an additional 100*l.* for the year ending Michaelmas, 1912. A private benefactor has also offered 100*l.* for the ensuing academic year. It is proposed that these offers be gratefully accepted by the University.

A lecturer in historical and economic geography, a lecturer in regional and physical geography, and a lecturer in surveying and cartography, will be appointed by the General Board for five years from Michaelmas. The two latter will be known as the Royal Geographical Society's lecturers.

It is proposed to confer the degree of Doctor of Letters, *honoris causa*, upon Prof. Wilhelm Dorpfeld, principal secretary of the Imperial German Archæological Institute in Athens; and the degree of Master of Arts, *honoris causa*, upon Mr. John Watson.

OXFORD.—The following is the text of the speech delivered by Prof. Love in introducing Prof. H. L. Bergson for the degree of D.Sc. *honoris causa* on May 27:—"Adest Henricus Ludovicus Bergson, inter huius aetatis philosophos insignis, vir multis nominibus laudandus, doctrinae novae et singularis suasor, eiusdem variis in rebus probator, rationis sibi constantis et late patentis inventor, orationis vi lumine venustate pollens. Qui cum non solum mathematicam et scientiam naturalem, sed etiam litteras et philosophiam penitus hausisset, id consecutus est ut, si quis alius, ipsius scientiae rationes corrigere et quasi terminos statuere posset. Nova profecto eius est sententia, esse quaedam, velut durandi notionem, sine qua vita et libertas esse non possint, quae in scientiam physicam mathematicis fundamentis exstructam non cadant: nova etiam eius doctrina, esse quoddam cognitionis genus ipsi scientiae non obnoxium, quo usa mens ipsam veritatem capiat, et durandi, vivendi, mutationis, motuum naturam comprehendat. Hanc ad sententiam, cum multa alia, tum rationem Darwinianam exegit, qua de re magna controversia exorta est, cum multi multis in terris huic suffragentur, ii qui adhuc dissident eius acumen admirentur.

SHEFFIELD.—Mr. Llewellyn Lloyd, assistant curator of the Museum of Zoology, has been appointed entomologist to the Sleeping Sickness Commission of the British South Africa Company, and is leaving England at once for northern Rhodesia.

THE fourth holiday course and second nine months' training course in physical instruction for men and women at Silkeborg, Denmark, sanctioned by the Danish Board of Education, will commence respectively on July 31 and September 2. Particulars can be obtained from the principal, H. G. Junker, Silkeborg, Denmark.

A COURSE of three lectures on "The Evolution of Coasts" will be given by Prof. Albrecht Penck, director of the "Institut für Meereskunde," Berlin, at Burlington House, Piccadilly, London, W., at 5.30 p.m. on June 27, 28, and 29. The following is an outline syllabus:—development of English coastal scenery; formation of