through the same slit upon the photographic plate. The further galvanometer can have a much lower resistance, and consequently greater delicacy, than the nearer one, so that, while the line photographed on the moving sensitised plate from the nearer galvanometer might represent a range of temperature of, say, 1500 degrees, the line traced by the mirror of the further galvanometer should represent only one-tenth of this. The angular deflection of the nearer mirror would not exceed the limits of the sensitised plate, while the mirror of the delicate galvanometer might traverse a far larger range. Both galvanometers would be connected "in parallel" with the same thermo-junction; and obviously any portion of the extended range which it was desirable to reflect on the sensitised plate could easily be caught by a suitable adjustment of the mirror on the further galvanometer. If, therefore, the thermo-junction is plunged into a mass of metal cooling from say an initial temperature of 1500 degrees, the whole of the cooling curve could be traced by the mirror of the less delicate galvanometer, while only the portion greatly magnified would be recorded by the mirror of the more delicate galvanometer. The first curve derived from the less delicate galvanometer would serve as a "calibration curve" for that afforded by the other galvanometer.

By means of diagrams exhibited on the walls of the theatre, a large number of cooling curves for electro-iron were shown, care being taken that the iron was exceedingly pure. The points of recalescence were well shown on these curves, which may be studied with interest in the *Transactions* of the Institution, as bearing on the question of allotropy of iron, which has already been fully discussed in a former report. The cooling-curve of an aluminium-copper alloy was also given. This was the alloy containing 6 per cent. of copper, used by Mr. Yarrow in the construction of torpedo boats for the French Government. Two freezing points were shown, one due to the main mass, and the other at a lower point due to the copper associated with the aluminium. The pyrometric examination of iron-aluminium alloys was also treated at some length, but it would be difficult to give results without reproducing the curves and the diagram shown.

One feature that may be noticed, however, was that the freezing point of iron alloyed with, say, one per cent. of aluminium, is but little lower than that of iron itself; that is to say, the melting point of nearly pure iron is only slightly lowered by a small addition of aluminium. Osmond had already shown that aluminium does not produce any considerable lowering of the freezing point of cast-iron; and the usually accepted idea that cast-iron or steel containing aluminium is very fusible, must be due to the fluidity of the metal when it is melted.

Another interesting point was that the samples of alloys used in these experiments were kept for some months before being analysed, and it was found that during this time those which contained from 40 to 60 per cent. of aluminium had spontaneously disintegrated, and had fallen to powder. The powder was not oxidised, but consisted of clean metallic grains, probably resulting from chemical changes which had gradually taken place in the solid alloy. Whether the iron and aluminium were in a state of solution or were chemically combined when molten, there can be little doubt that they are so combined in the metallic powder, as attempts to re-melt this powder have proved unsuccessful, which points to the formation of an infusible compound.

Some experiments made by Mr. Thomas Wrightson to ascertain whether the welding of iron is attended with a fall of temperature, as is the case in the regelation of ice, were next described. The welding was done by means of electricity and observations were taken by means of the pyrometer formerly described. The results have been communicated to the Royal Society, and tend to show that the welding of iron and the regelation of ice are analogous phenomena, a point of no small theoretical importance.

In his last report the author had called attention to the fact that M. André Le Chatélier had suggested that the prejudicial action of an element is due to its forming a fusible compound with the metallic mass in which it is hidden; while, on the other hand, the presence of an element which forms an infusible compound with the mass, promotes the formation of a fine grain and imparts strength. The author did not wish it to be supposed, however, that the action of the added element is due solely to its infusibility, or to its power of forming a fusible compound with a portion of the mass which contains it; for cases are numerous in which such an explanation does not apply. In this connection a suggestion made long ago by Raoult Pictet (*Comptes rendus*, vol. lxxxviii. 1879, pp. 855 and 1315), well deserved consideration. He urged that there must be a connection between the melting-points of metals and the periodic law of Mendeléeff; for he showed that for all metals there is a simple relation between their atomic weight, the amplitude of the movement of their molecules under the influence of heat, and their melting-point. Pure metals with high melting-points—such as platinum, iron, copper, and gold—are comparatively strong; and, conversely, metals with low melting-points—zinc, lead, cadmium, bismuth, and tin—are relatively weak. Metals with high melting-points must necessarily be coherent and tenacious, because much heat is required to drive their molecules apart in reducing them to the liquid mobile state in which the molecules have very small coherence; and therefore at ordinary temperatures much force must be applied to overcome the cohesion of the molecules and break the mass. Conversely, in metals with low melting-points a small elevation of temperature will overcome the molecular cohesion, and render them liquid—that is, will melt them. Such metals will be weak, the author continued, because if little heat is required to melt the metal, less force will be needed to tear it apart. Hence melting-point and tenacity are clearly connected. The absolute temperature of the melting-point of a metal must be closely connected with its atomic volume, because the former is inversely proportional to the rate at which the amplitude of the oscillations of the molecules increases with temperature; and the rate of increase of amplitude at any given temperature is obtained by multiplying the ordinary thermal coefficient of linear expansion by the cube root of the atomic volume.

Prof. Roberts-Austen here pointed out that the recent work of Dewar and Fleming (*Philosophical Magazine*, vol. xxxiv. 1892, p. 326) bears directly on this question. They employed very low temperatures, and show that at the absolute zero of temperature pure metals would probably offer no resistance to the passage of an electric current, but that the electrical resistance of alloys does not diminish so rapidly with the lowering of temperature as in the case of pure metals. Prof. Dewar (*Proceedings* of the Royal Institution, vol. xiv. part 2, 1895, p. 1) has shown, moreover, that the tenacity of pure metals and alloys is greatly increased by extreme cold—that is, by the closer approximation of their molecules; and this affords additional evidence that metals become stronger at temperatures which are further and further removed from their melting-points.

The discussion on this paper was of a somewhat brief nature, the reading of the report and the appendices, together with the carrying out of certain experiments and illustrations, taking a considerable time. Mr. Wrightson also explained at some length his welding experiments, which, as stated, have been placed before the Royal Society.

Prof. Goodman, of Leeds, gave some interesting particulars of the work upon which he has been engaged during the last two years in connection with anti-friction alloys. He had discovered that these substances must always contain a metal of high atomic volume, and there seemed to be a direct connection between the efficiency of the anti-friction of alloy and the atomic volume of one of its constituents. If the atomic volume of the alloy were small, then the friction was enormously increased, but with high atomic volume it was reduced. He had produced an anti-friction metal which would withstand a pressure of two tons to the square inch when running at 550 revolutions per minute, the temperature being 140°; that was a very remarkable result for a white metal. The alloy used had a higher atomic volume than bismuth, but he was not at liberty then to state the nature of the substance. He wished, however, to impress the necessity of absolute purity, or that if there were any impurities, they should be of high atomic volume.

Mr. Blount, in referring to the author's remarks on the electrolysis of glass, and the fact that potassium would not follow sodium and lithium, said he would be glad of an explanation why gold, which had a lower atomic volume than sodium, should not have traversed the "galleries" left in the glass by the sodium.

The summer meeting of the Institution will be held in Glasgow, commencing Tuesday, July 30.

THE ROYAL COMMISSION ON TUBERCULOSIS.

IN July 1890, a Royal Commission was appointed to inquire and report "what is the effect, if any, of food derived from tuberculous animals on human health, and if prejudicial, what are the circumstances and conditions with regard to the tuberculosis in the animal which produces that effect upon man. Lord Basing was the chairman, and the other commissioners were: Prof. G. T. Brown, Sir George Buchanan, Dr. G. F. Payne, and Prof. Burdon Sanderson. After the death of Lord Basing, in October last, the commission was reorganised with Sir George Buchanan as chairman. The report of this commission, upon the evidence and experimental inquiries received since the appointment of the original commission five years ago, was presented to Parliament last week. The general results of the inquiries instituted by the commissions in connection with the matter referred to them, will be found in the subjoined summary appended to the report :—

"We have obtained ample evidence that food derived from tuberculous animals can produce tuberculosis in healthy animals. The proportion of animals contracting tuberculosis after experimental use of such food is different in one and another class of animals; both carnivora and herbivora are susceptible, and the proportion is high in pigs. In the absence of direct experiments on human subjects we infer that man also can acquire tuberculosis by feeding upon materials derived from tuberculous food animals. The actual amount of tuberculous disease among certain classes of food animals is so large as to afford to man frequent occasions for contracting tuberculous disease through his food. As to the proportion of tuberculosis acquired by man through his food or through other means we can form no definite opinion, but we think it probable that an appreciable part of the tuberculosis that affects man is obtained through his food. The circumstances and conditions with regard to the tuberculosis in the food animal which lead to the production of tuberculosis in man are, ultimately, the presence of active tuberculous matter in the food taken from the animal and consumed by the man in a raw or insufficiently cooked state. Tuberculous disease is observed most frequently in cattle and in swine. It is found far more frequently in cattle (full grown) than in calves, and with much greater frequency in cows kept in town cowhouses than in cattle bred for the express purpose of slaughter. Tuberculous matter is but seldom found in the meat substance of the carcase; it is principally found in the organs, membranes, and glands. There is reason to believe that tuberculous matter, when present in meat sold to the public, is more commonly due to the contamination of the surface of the meat with material derived from other diseased parts than to disease of the meat itself. The same matter is found in the milk of cows when the udder has become invaded by tuberculous disease, and seldom or never when the udder is not diseased. Tuberculous matter in milk is exceptionally active in its operation upon animals fed either with the milk or with dairy produce derived from it. No doubt the largest part of the tuberculosis which man obtains through his food is by means of milk containing tuberculous matter. The recognition of tuberculous disease during the life of an animal is not wholly unattended with difficulty. Happily, however, it can in most cases be detected with certainty in the udders of milch cows. Provided every part that is the seat of tuberculous matter be avoided and destroyed, and provided care be taken to save from contamination by such matter the actual meat substance of a tuberculous animal, a great deal of meat from animals affected by tuberculosis may be eaten without risk to the consumer. Ordinary processes of cooking applied to meat which has got contaminated on its surface are probably sufficient to destroy the harmful quality. They would not avail to render wholesome any piece of meat that contained tuberculous matter in its deeper parts. In regard to milk, we are aware of the preference by English people for drinking cows' milk raw—a practice attended by danger on account of possible contamination by pathogenic organisms. The boiling of milk, even for a moment, would probably be sufficient to remove the very dangerous quality of tuberculous milk. We note that your Majesty's gracious commands do not extend to inquiry or report on administrative procedures available for reducing the amount of tuberculous material in the food supplied by animals to man, and we have regarded such questions as being beyond our province."

THE GEOLOGICAL DEVELOPMENT OF AUSTRALIA.

BY the kindness of the Secretary of the Australasian Association for the Advancement of Science, we have been favoured with a complete account of the proceedings of the late meeting at Brisbane. The Hon. A. C. Gregory, C.M.G., the president of the meeting, took as the subject of his address "The Geographical History of the Australian Continent during its successive Phases of Geological Development." The subject afforded Mr. Gregory an opportunity for putting on record the knowledge he has gained from personal inspection of a larger proportion of Australian territory than has been explored by any other investigator. We are glad to be able to give the text of his address.

PRIMARY CONDITION AND FORM OF LAND.

In dealing with the geological history of Australia, it is convenient to refer to the groups of formation, as the scope of this address is insufficient for the separate consideration of the component members of each group which has taken prominent part in the geographical establishment of sea and land. Like all histories of remote events, the evidence of what was the primary condition and form of the land is necessarily of very limited character, but some evidence does remain for our guidance. The earliest indications of the existence of land within the limits of the present Australian continent consists in the fact that many of the more elevated summits are composed of "granite," which is certainly the oldest rock formation with which we are acquainted.

It is here necessary to state that the term granite is used to indicate ancient or continental granite, and that the granitoid rocks, which are so closely allied in lithological aspect as to pass under the same designation, but are really intrusive masses of more recent date, even as late as the Permo-carboniferous period will be termed intrusive granite. Now the higher portions of the granite ranges show no superincumbent strata, while sedimentary beds fold round their flanks in a manner which indicates that the edges of these strata were formed near the margin of an ancient sea, above which the more elevated masses of granite rose as islands. As an instance of this early existence of land, we find on the present east coast that the granite tract of New England is flanked by Devonian slates and marine beds of spirifer limestones in positions which indicate that their deposition was in an ocean of at least 2000 feet in depth, above which the granite mountains rose to an elevation of 2000 feet. Adopting similar evidence as a basis for the estimation of the area of land at this earlier date, it appears that there existed a chain of islands extending from Tasmania northerly along the line of the present great dividing range, between the eastern and western streams nearly to Cape York, a distance of about 2000 miles, and with a breadth seldom exceeding 100 miles. In Western Australia a much broader area of dry land existed in the form of a granite tableland, the western limit of which, commencing at Cape Leeuwin, extended north for 600 miles, with a straight coast-line rising 500 feet to 1000 feet above the ocean. This land had a breadth east and west of about 200 miles, but its eastern shores were comparatively low and irregular, with probably detached insular portions, more especially on the northern side, as the stratified rocks in which the West Australian gold mines are worked have an exceedingly irregular outline where they overlay the granite. Between these eastern islands and the western land, there probably existed some granite peaks which rose above the ocean, but the evidence is that they were not of important area, and principally located in the northern parts. The remainder of the present continent was covered by an ocean gradually increasing in depth from the western land to the central part, and great depth continued to the shores of the eastern islands.

SEDIMENTARY DEPOSITS

The next step in our history is that the natural decomposition of the granite, both terrestrial and marine, supplied material for sedimentary deposits; and we find a series of imperfectly stratified grit rocks, together with schists and slates, the former the results of the deposition of the coarser drifts, and the latter the more gradual deposit of the finer particles. These rocks, which are classed as Laurentian, Cambrian, and Silurian, did not extend far from the eastern islands, and are principally developed in Queensland to the north and in Victoria to the south, but, being of marine formation, they did not then materially affect the geographical configuration, though they are important features of the present time, and are the chief sources of our tin mines; and silver, lead, and copper also exist in sufficient quantity to afford prospect of future industrial success. There is also a marked characteristic in the abundant occurrence of fluor spar, which is an exceedingly rare mineral in the later formations,