thermometer with a reservoir of iron or glass inclosed by a non-conducting material. In the sides of the reservoir tubes of glass or platinum are introduced, extending deep into the mass of mercury. In these tubes the reactions between weighed amounts of various substances take place, and the heat given off to the surrounding mass of mercury causes a corresponding rise in the thermometer tube. The second apparatus devised for measuring the heat ensuing from the combustion of gases, is much more complicated, being modelled after Dulong's classical calorimeter, but altered in a variety of ways so as to ensure the utmost accuracy in the results. It is to these instruments, or modifications of the same, that we owe a large proportion of the data serving as a basis for our present knowledge of thermo-chemistry. Among the long series of observations carried out by their means, the most important were the series of experiments on combustions in oxygen gas; on the action of gases on each other, and on liquid or solid bodies; on the influence of dimorphism on the heat evolved by combustion, as in the case of red and vitreous phosphorus, where there is a difference of 16 per cent. in the number of units of heat resulting from oxidation; on the influence of polymerism, in which it was shown that the amount of heat evolved decreases with the increase of density in the vapour resulting from combination with oxygen; on the property of metameric bodies to yield different degrees of heat; on the relative diminution in the heat evolved by the combustion of a compound body, compared with that due to the combustion of its various constituents; on the combination of bases with acids, in which it was shown that the amount of heat evolved by the union of equivalent quantities of different acids with a given base is nearly always the same; on the heat evolved by metallic precipitations; on the heat developed by the solution of salts and gases; on the heat evolved by the absorption of gases in porous bodies, especially in connection with the condensation of hydrogen by means of palladium or platinum; on the phenomena of heat resulting from the mixture of liquids; on the development of heat in connection with the compression of liquids; on the specific and latent heat of a number of bodies; on the heat developed by the electrolysis of various compounds, and on the development of heat in electric conductors, and in electric action generally. Closely allied to some of the above researches were studies on the changes in volume consequent upon solution; on the dissociation of crystals; on the chemical effect of light; on electrolysis; and on the influence of pressure on solubility, in which connection he ascertained that the solubility of certain salts was increased when submitted to a pressure of from thirty to sixty atmospheres. Of the labour attendant upon the observation and recording of so extensive a series of experiments, it is difficult to form an adequate idea. As a monument of the patient, painstaking, conscientious collation of valuable physical constants, they rank among the achievements of modern physical chemistry, while too much praise cannot be accorded to the address and ingenuity with which the mechanical difficulties of so wide and varied a range of experiment were successfully met and overcome.

The results obtained by Favre alone or in connection with Silbermann, united with those due to the classical contemporaneous researches of Andrews, form practically the basis of modern thermochemistry, the introduction of their methods of exact measurement having much the same influence as Lavoisier's introduction of the chemical balance. Under the impetus given by their investigations, Berthelot in Paris, and especially Thomsen in Copenhagen, have during the last decade rapidly perfected and elaborated this subject, until at the present day there are few branches of chemical physics based on so numerous and varied experimental data.

The labours of Prof. Favre were recognised in France by his nomination to the Legion of Honour, and by his election as a Corresponding Member of the Academy of Sciences in the Section of Chemistry.

ARAGO

WE recently gave some account of the inauguration of a statue to Arago at Perpignan. We now give an illustration of that statue, with some extracts from the interesting address delivered by Dr. Janssen, who was present at the ceremony as representative of the Paris Academy of Sciences. After speaking of Arago's visit to Spain, and his election as a member of the Academy, Dr. Janssen went on to say:—

The young physicist was not long in surpassing the hopes which they (the Academicians) had placed in him. Within two years of his election he had laid before the Academy many very important memoirs, and a noble discovery which gave birth to a beautiful chapter of optics, the discovery of chromatic polarisation, as it is now called. He observed that polarised light acquired certain entirely new properties when made to pass through properly prepared crystalline plates. The brilliant phenomena of colours to which polarised light could give birth in these circumstances had a great theoretical bearing, and in the hands of Arago they became the bases of the most ingenious and important applications, the principle one being the invention of a polariscope which disclosed the least traces of polarised light, and which Arago was able to employ in determining the gaseous nature of the sun's dazzling surface.

Gentlemen, it was a great and glorious epoch for our Academy. The discoveries regarding light and the principles which regulated its phenomena succeeded each other almost regularly. Malus, Arago, and Fresnel were at the head of this great scientific movement in France. After Malus, who in 1808 discovered polarisation by reflexion, and a little later assigned its laws, Arago published this series of his beautiful works on chromatic polarisation, on circular polarisation, and the photometer; he adduced in favour of the wave theory the capital fact of the retarding influence of a thin metal plate in this system of two interfering rays of light. Finally Fresnel appeared on the scene, and this genius, so simple, yet so profound, connected these discoveries without an effort, and attached them again to the principle of undulations, of which he showed the fruitfulness, and which in his hands received its final definite triumph. Arago then has taken his place in this aristocracy, but posterity owes to him a still greater obligation. Thanks to his perspicacity in divining merit, thanks to the natural generosity of his disposition, exempt as it was from all jealousy, Fresnel, an obscure provincial engineer, was found out, encouraged, and called to Paris, where he had a situation. Arago formed a friendship for him which was never dimmed by a cloud and he missed no opportunity of supporting his works and the interests of his fame. Between such rivals in glory, a sentiment so pure and noble is one of the finest spectacles which the human mind can offer us. Truly, gentlemen, posterity should delight to allow a moral share to Arago in the grand scientific monument which it has received from the genius of Fresnel.

"The movement which produced these remarkable discoveries in light began to slacken when there came to us from Denmark in 1820, the announcement of a scientific fact of a very different character but of immense importance, and which threw back on electricity almost all the activity of the scientific world. Every one knows Œrsted and the discovery of the action of the current on the magnetised needle. The relations which ought to unite magnetism and electricity had long been foreseen, but the common bond had always eluded those who attempted to seize it. Now the bridge was thrown, and

two distinct sciences, in appearance so different, were resolved into one, and all the facts which they comprehended were connected by one identical principle. If the theoretical consequences of Œrsted's discovery were considerable, those which had regard to economic and industrial applications were incalculable, and were to cause a veritable revolution in the relations of mankind. But if this grand discovery opened out such vast horizons and disclosed a new world, it required the concourse of genius to effect the conquest. France has still the best part of this honour, thanks to Ampère and Arago.

Within a week Œrsted's experiments had been repeated before the Academy. Already Ampère brought before it his discovery of the reflex action of the currents, and he

Arago.

had laid the foundation of that magnificent chapter of electro-dynamics, one of the finest, most profound, and most perfect of which the science of all times can boast. A week later and it was Arago's turn, he having discovered the attractive action of the current in iron filings, a discovery of which he made good use as we shall soon see.

Arago then, as he himself informed us, showed his experiments to Ampère, and these two great physicists for a brief period united their efforts. The object pursued was the magnetisation of steel by the current. From the first, Ampère guided by his new views on the constitution of the magnetism in the magnet, saw at once the conditions of success. He indicated that in order to obtain a steady and powerful magnetisation, it is necessary to roll up in screw-form a part of the wire conductor and at that point to place the needle; and his theory is so sure, so precise, that he assigned the position of the poles in the magnet so as to give in the spiral the force or the current and the direction of the screw. The prediction has been entirely confirmed by experience.

These leading experiments thus established the principle of the electro-magnet, on which has been based for the most part the mode of action in electric-telegraphy.

But all the world knows that this admirable mechanism by which the properties of the magnet are associated with those of electricity, has since received almost numberless applications in science and industry. We might cite by the thousand these magneto-electric motors, these clocks which disseminate in every town the time which the electric wire draws up to a central regulator, these checks on the railway which arrest a train so efficiently in the presence of a danger signal, &c.

And now, gentlemen, a still greater future seems reserved for the electro-magnet. This marvellous facility of developing at a distance by means of a simple electrical-conducting wire a magnetic power capable of raising enormous weights occupies the engineers of the present day, and it seems that the time is not far distant when the telegraphic wire will transport afar mechanical force even as it now transmits human speech.

Such, gentlemen, were the fruits of the momentary union of these two men, so great and yet so different.

Perpignan, to its great credit, pays this day to Arago, a portion of the debt of France. I desire to express here the hope that the city of Lyons will equally honour the memory of Ampère, the immortal founder of electro-dynamics, the geometric scholar, the philosopher who has pointed out the principle in galvanometry on which is based to-day the grand system of inter-oceanic telegraphy, the man, finally, whose candour equalled his genius, and whose slightest ideas are almost always marked with the stamp of keenness and profundity.

In order to conclude the grand series of Arago's discoveries, I ought to recall that of magnetism by rotation; it belongs to the year 1824. Humboldt tells us that Arago made it on the slope of the beautiful hill at Greenwich during some operations bearing on the measurement of magnetic intensity. Arago remarked that a magnetic needle attained repose sooner when it oscillated within its copper frame than when separated. This was but the first link in a chain of fertile truths which led Faraday to the great discovery of induction.

Gentlemen, it is impossible in sketching the life of Arago, not to recall the importance of his teaching and of the writings which he devoted to the diffusion of scientific learning. If his discoveries and his labours merit the recognition of posterity, his pen and his speech were the better part of the great influence which he exercised in his time. We know with what avidity his memoirs were read on their appearance. The collection of our *Annuaires du Bureau des Longitudes* preserves also the trace of an incident which shows the impatience of his readers. One year Arago, absorbed by some important work, allowed his *Annuaire* to appear without a summary. The press rebelled and made itself the echo of the public displeasure. They even went the length of contending that the *Bureau* had failed in the duties which were imposed by its regulations. There was nothing of the kind; but Arago understood to what an extent this sentiment was flattering to him, although expressed in an indirect and hardly courteous manner. He executed and published apart a memoir which was given gratuitously to all purchasers of the *Annuaire*. His biographic memoirs, his academic reports, his sessional lectures, his analysis of correspondence as permanent secretary were the object of an interest which is never disappointed. His admirable

career at the Observatory has left memories which are still living among us. Wherever Arago was to read or speak there was eagerness to hear him, and this eagerness was manifested by all classes and by men in all stages of education, from the scholar who was charmed to see with what art the master could, in treating a difficult subject, seize the side which would render it intelligible to all, to the artisan astonished at being able to understand and to receive clear, precise ideas on matters which he believed for him to be absolutely inaccessible. The cause of this success, gentlemen, lay in the harmony of mental and physical gifts, which I attempted to characterise at the beginning of this speech. They lay above all in that superior comprehension of subjects which he had developed by his labours and discoveries. He who has created in science, teaches very differently from the most educated professor who has never stirred the bowels of a subject in order to get at fresh truths. There are three degrees in the knowledge of truth; namely, those of student, teacher, and discoverer. In order to practise in a superior manner in one of these degrees, it is necessary to be raised to a stage which dominates it. As has been truly said, one does not thoroughly understand that which one is unable to teach. I say even that inventors alone can teach in a transcendent manner. That is not to say that all inventors are popular teachers. There are men of genius who like to hold themselves aloof, and whom it pleases to keep from others the truths of which they possessed themselves without effort; there are others, who although rich in the faculties of invention, have none of those which make the professor. But when all these gifts are united, and when to a zealous spirit are added the faculties of a superior mind, then we have one of these great popular teachers whose action extends over a whole epoch. Such was Arago, and such the real character of his greatness.

Gentlemen, Arago's writings shall not only have been of service to the generation which enjoyed them so eagerly. We inherit them and we shall not be their sole posterity. Among them, indeed, how many *chefs-d'œuvre* will always be consulted, in spite of the advance of science, on account of the perfection of their form and their rare historical ideas.

This speech would be incomplete if we did not add some touches to the grand and sympathetic figure. Arago, indeed, has not only served science by his discoveries, his labours, his writings, and his teaching; he has served it also by the protection and the encouragement which he delighted to lavish on the young philosophers of the future, on inventors of merit, and on all those who called upon him with any title. Just now I cited the case of Fresnel, but twenty other examples, many of them illustrious, could still be invoked.

If we survey our *Comptes Rendus* we shall see the name of Arago constantly intervening, whether he deals with an important discovery, a meritorious work, or a remarkable invention. If the affirmations which he makes, or the praises which he believes to be merited encounter opposition, his speech then takes fire, he becomes excited and indignant, and overturns all obstacles. How many have had him as their all powerful advocate, who have subsequently forgotten it?

When Arago had to deliver a speech at the Academy on an important subject, it was quite an event. We know by tradition, for example, the impression caused at the sitting when Arago expounded the discovery of Daguerre, and the interest, the pleasure, the admiration which was produced in the hall on hearing this master of the mysteries of light, revealing the operations which allowed of the fixing of the figure in the camera-obscura. Among so many applications which his perspicacity foresaw for the admirable discovery, he was always struck by those which concerned astronomy.

Faye, one of Arago's students and our eminent co-worker, has sustained this idea and has signalised by many claims all the ways which can be devised for the application of photography to celestial phenomena.

Let us also recall the sittings when Arago explained the success of Grenelle's operations in the boring of wells, with which he was desirous of endowing the capital, and which we owe to his sagacity and to the perseverance by which he was able to triumph over general incredulity.

Finally among so many fruitful initiatives, let us remark in particular that which Arago took with regard to Vicat's pension. Arago proposed that a national pension should be given to the great engineer, to whom France owed so many fine works. There was only one almost forgotten precedent. Arago wished to create a brilliant one. This great spirit felt how much the institution of national pensions accorded to those who had wrought gloriously for the benefit of the country, and who in the struggle have forgotten themselves, would produce devotedness to the country. Let us apply generally, gentlemen, the example which is offered to us under the patronage of Arago. Let us give to the men, never very numerous, whose conspicuous services have received the recognition of the country, that proof of its justice. Then, even, though the recompense be materially modest, there will always be attached to it a special value, it will always excite the noblest emulation, because each reward that is thus offered in the name of the country becomes a medal.

Gentlemen, in the decline of his career, this great soul had worn out the body on which it had made such severe demands. His organs were no longer able to serve that powerful intelligence in realizing his scientific conceptions. Arago then gave a last proof of his generosity. Having conceived the project of a magnificent experiment on light, he went to the Academy, expounded his ideas, and invited the young philosophers to follow them out and to gather the glory of their realization. Thus it was that Foucault and Fizeau, aided by our eminent artist and colleague Bréguet, were brought to the works by which they have begun their great scientific reputation.

Shortly after, Arago, broken by disease, and feeling his end near, wished to bid a last farewell to that Academy which had held so great a place in his life, of which he was the organ for so many years, and where his voice, listened to, loved, and admired, had resounded for almost half a century. His death, on October 2, 1853, was a loss to the whole world.

VESBIUM

PROF. A. SCACCHI, who has been for some time engaged in chemical investigations on the lava which issued from Vesuvius during the year 1631, has recently made an interesting communication to the Royal Academy of Sciences at Naples with regard to the probable presence in these deposits of a new metal. The material which Prof. Scacchi has operated upon consists of delicate yellow incrustations found in the crevices of the lava, in company with atacamite and azzumite, and has been named by him *vesbine*, while the supposed new metal is termed *vesbium*. Both words are derived from the ancient name for Vesuvius mentioned by Galen in his work, "De Morbis Curandis" (Book v. Chap. 12). Vesbine is found to consist of silicates of copper, the alkalies, iron, aluminium, &c., together with small quantities of the salts of what receives the name vesbic acid. The latter is obtained in an impure state—containing traces of iron, aluminium, lead, and copper—by evaporating the solution of vesbine in hydrochloric acid to 170° C., extracting with water, treating the residue of silicic acid, and vesbiates with hydrochloric acid, filtering from silicic acid, evaporating again to 170°, and extracting with water. The dark green residue thus obtained formed the material for the series of investigations on which the discoverer