restored by raising it to a white heat, and then placing it under the rapid action of a steam hammer. Chernoff also describes and explains the case of a "burned" ingot of steel, which he treated in the above manner, and restored to its proper condition. Osborn states that steel has a remarkable property of remaining in a pasty condition through a considerable range of temperature below its melting point; and that bar-iron acquires a largely crystalline structure when exposed for a long time to heat considerably below fusion.

Professor Gore, in 1869, and subsequently Professor Barrett, in 1873, drew attention to certain anomalies that occurred in the expansion and contraction of iron wire; and in 1877 Professor Norris published the results of his experiments on the same subject, which appear to confirm Chernoff's theory in a remarkable manner. In cooling a strained iron wire from redness, it was found that the contraction due to cooling was, at a certain point, and for a limited period, changed into an action of elongation. In good iron wire this irregularity could not be detected, but in hard wire and steel it was very apparent. The wire has to be raised to a very high temperature before the temporary elongation during cooling, can be seen; and it does not take place if the wire is heated just beyond the temperature at which it occurs. Professor Norris' researches have led him to the following conclusions: (1) That in steel, and in iron containing free carbon, there is a contraction, or shortening, which is excited by heat, and which proceeds simultaneously with the dynamical expansion, and masks its true amount. This is divisible into high and low temperature contraction. (2) That similarly there is a cooling expansion, or crystallization, which comes in during the dynamical contraction, and masks its true amount. (3) That these effects, due to crystallization, and decrystallization, are the causes of the so-called "kicks," or temporary contractions and expansions, which occur during the heating and cooling respectively of the steel. (4) That the low temperature, contraction, and cooling expansion, are due to decrystallization and crystallization, which occur during the acts of heating and cooling; while the "kicks" themselves are simply the thermal effects associated with these changes, and are proportionate to their extent. (5) That protracted annealing, *i. e.*, extremely slow cooling, brings about molecular separation of the carbon and iron. Steel in such a state contracts greatly when high temperatures are reached, producing the effects of contraction, which are seen at the ends of the heating, and which are due to the condensation produced by the recombination of the carbon and iron. Steel in this state is less susceptible to cooling expansion (or crystallization), and, therefore, to low temperature contraction on subsequent heating. It would seem that the "kicks" observed by Professor Norris probably occur somewhere in the region of Chernoff's temperatures, *a* and *b*, where a change in the molecular structure of steel appears to take place, according to his theory. At any rate it is plain that molecular changes of some kind do occur, and manifest themselves by altering the bulk of the metal.

It has already been stated that Müller has demonstrated the presence of hydrogen, nitrogen, and carbonic oxide in the pores of Bessemer and Siemens-Martin steel. Edison, at the recent meeting of the American Association for the Advancement of Science, at Saratoga, has extended the observations of Döbereiner, St. Clair-Deville, Troost, Faraday, and Graham; and has not only applied the facts ascertained to explain the destruction of refractory metals, such as platinum and iridium, under long-continued high temperatures, but has discovered the means of overcoming those defects, which have proved a serious hindrance to the extension of electric lighting. Edison noticed that the effect of incandescence on wires was to produce, all over their surface, innumerable fine cracks. When the incandescence was maintained for twenty minutes, these fissures became so enlarged as to be visible to the naked eye; and, when still further continued for several hours, the cracks united and the wires fell to pieces. A number of experiments have led him to the conclusion that the cracking of the surface of the metal is due entirely to the occluded gases imprisoned within its pores, which become expanded, and are driven out under the action of heat. By heating spirals of platinum wire gradually, by means of a transmitted electric current of periodically increasing strength, and within an exhausted chamber, the gaseous substances contained within the metal were gradually withdrawn; and by allowing the metal, in the interval between each increase of temperature, to cool down *in vacuo*, a series of expirations from the surface took place, alternating with a closing up and welding together again of the minute fissures through which the gentle heating, *in vacuo*, had enabled the gases to escape. By continuing this simple operation, it has been found possible to change completely the physical character of metals, increasing their hardness and density to an extraordinary degree, and raising their points of fusion so high that they are perfectly unaffected at temperatures at which most substances would be melted and even volatilized. A spiral of ordinary platinum at a white heat softens and loses its elastic and rigid character; but platinum, after having been treated in the manner above described, becomes as rigid as steel, and as homogeneous as glass, and retains these properties when glowing under the most intense incandescence. The metal so transformed cannot be annealed by any known process.

It appears to the committee that the expulsion of the gases contained in the body of the metals may have the effect of bringing the ultimate atoms closer together, increasing thereby the force of their cohesion, and consequently resisting more strongly any rearrangement that would be necessary in annealing. It would appear also that the existence of gases in the pores of metals is an attribute of their normal states; and that the expulsion of the gases increases hardness and necessarily raises the melting point on account of the stronger cohesion of the atoms. May it not be that the sudden contraction in hardening steel has the effect of expelling occluded gases; that subsequent tempering, by raising the temperature, has the effect of permitting a fresh absorption; and that the iridescent colors which accompany tempering are due to the change of surface caused by the infiltration of gases? Another view is that the mere heating of steel to the proper temperature for hardening is sufficient to expel a portion of the gases, which are kept out by sudden cooling, and are slowly re-absorbed in tempering. Graham states that platinum at a low red heat will absorb four times its volume of hydrogen, and that palladium condenses more than 600 times its volume of hydrogen at a temperature below that of boiling water. May not steel, therefore, possess analogous properties with respect to some of the gases constituting the air? May it not absorb these more freely as the temperature of tempering rises, and so gradually become restored to its original softness?

VI.—DIRECTIONS IN WHICH FURTHER INVESTIGATIONS APPEAR TO BE NEEDED.

(1) To investigate whether Edison's theory can be applied

to the explanation of the hardening and tempering of steel; and to ascertain by experiment whether absorption and expulsion of gases take place. (2) To determine by analysis whether any chemical difference exists between the outer and inner layers of a piece of hardened steel, which before hardening was of homogeneous structure. (3) To ascertain whether there is any connection between Chernoff's theory and Norris' observations on the contraction and expansion of wires. Signed on behalf of the committee, 5th Nov., 1879, W. ANDERSON, Chairman and Reporter.

APPENDIX.

List of Works Consulted.—Percy, "Metallurgy of Iron and Steel;" Chernoff, "Remarks on the Manufacture of Steel and the Mode of Working it," 1868; Barba, "Etude sur l'emploi de l'acier dans les constructions," 1874; Camus, "L'art de tremper les fers et les aciers," 1846; Osborn, "Metallurgy of Iron and Steel," 1869; Jullien, "Théorie de la Trempe," 1865; Jullien, "Résumé de mes recherches sur l'acieration," 1868; Caron, "Recherches sur la composition chimique des aciers," (Mémoires des savants étrangers, publiés par l'Académie Royale de Belgique, 1865); Gruner, "Traité de Métallurgie," article viii., 1878; Various Specifications for the Supply of Steel to the French Navy, 1879; Gore, "On a Momentary Molecular Change in Iron Wire" (Proceedings of the Royal Society, No. 108, 1869); Norris, "On Certain Molecular Changes which Occur in Iron and Steel During the Separate Acts of Heating and Cooling" (Proceedings of the Royal Society, No. 180, 1877); Baumhauer, "On Diamond" (*Annalen der Physik und Chemie*, neue Folge, vol. i., p. 467, 1877); Overzier, "On the Flotation of Solid Iron in Fluid Iron" (Poggendorff's *Annalen*, 1870, vol. cxxix., p. 651); Akerman, "On Hardening Iron and Steel: its Causes and Effects," Iron and Steel Institute, 1879; Tyndall, "Heat as a Mode of Motion," 1870, on Fusing Points of Substances as affected by Pressure; Edison, "The Action of Heat on Metals *in vacuo*," American Association for the Advancement of Science, 1879 (*Nature*, Oct. 2, 1879). Proceedings of the Institution of Civil Engineers, as under: Douglas Galton, on Chilled Iron Wheels (vol. liii., pp. 35, 87); Siemens and Fernie, discussion on Fox's paper on Pennsylvania Railway (vol. xxxix., pp. 100, 110); Hackney, on the Manufacture of Steel (vol. xlii., p. 1); Siemens and Riley, discussion on Price Williams' paper on Railways (vol. xlii., pp. 198, 203); Euverte, on the Effects of Phosphorus and Manganese upon the Mechanical Properties of Steel (vol. xlix., p. 360); Mannermann, Studies on the Cementation Steel Process (vol. lvi., p. 361); Müller, on the Gases inclosed in Iron and Steel (vol. lvi., p. 360); Boyd, "Experiments Relative to Steel Boilers," Proc. Inst. Mech., E., 1878, p. 217. *Mechanics' Magazine*, as under: Tempering of Steel, rules by a "Clever Workman," 1855, p. 515; R. Burn, on Tempering in Oil (1857, p. 110; M. Gaudin, on Heating Iron with Boron, Phosphate of Iron, and Peroxide of Manganese (1865, p. 389); Anonymous Article on Tempering (1867, p. 119); ditto (1870, p. 184); W. L. Austin, on "Hardening and Tempering," 1879 (M.S.)

A NEW METALLIC COMPOUND.*

By GRANVILLE COLE, Ph.D.

THE paper which I am about to read this evening affords me the privilege of appearing for the first time before a meeting of the members of the Society of Arts, and I hope you will grant me your indulgence for any shortcomings which may attend this my first appearance as a public lecturer in England.

The subject of the paper is the discovery of a metallic compound, which I shall prove to you is new, and I shall endeavor further to set forth a few facts, attested by experiments, in respect of its nature. I am duly impressed with the very technical character of my subject, and the tendency there must be, in dealing with it, toward a certain dryness in my remarks. But, while I trust that many of the data will appeal with special interest to engineers and other practical men, I still hope to arrest your attention by showing you to how many artistic and industrial purposes this new metallic compound may be put. In the first place, it will be right to give a brief account of the

I.—DISCOVERY OF THE METAL.

Nearly a year ago, Mr. J. Berger Spence discovered that the sulphides of metals, combined with molten sulphur, formed a liquid. This liquid, on cooling, became a solid homogeneous mass, possessing great tenacity and having a peculiar dark gray—almost black—color. Nearly every metallic sulphide which is known combines, as experiments have proved, with an excess of sulphur, and, curiously enough, nearly all these combinations have the same properties. The combination, of which I have specimens here for inspection, consists of an ore of iron pyrites, containing both lead and zinc sulphides.

II.—CHEMICAL COMPOSITION.

Examining the metal from a chemical point of view, I may state, briefly, that it is a chemical compound belonging to that class known as thiates, or sulphur sulphides.

Dr. Hodgkinson, chemical demonstrator at the Science Schools, South Kensington, has kindly sent me the following facts. I cannot do better than quote his letter on the subject:

"It appears to be the easiest thing in the world to obtain a homogeneous casting with it. Specific gravities of portion sent gave 3.3743 to 3.7036 (reduced to 0° C.).

"When finely powdered, it is acted upon slowly by concentrated HCl and NO₂H in the cold; in large lumps, little or no action takes place. As yet I have not been able to determine the expansion equivalent accurately; it would appear, however, to be small. The fracture is not conchoidal, as might perhaps have been expected, but somewhat like that of cast iron.

"I have not had time to try many 'utilization experiments' on the substance, but I have no doubt it would be exceedingly useful in the laboratory, even, for instance, for making the air-tight connections between glass tubes by means of caoutchouc, and a water or mercury jacket, where rigidity is no disadvantage; the fusing point is so convenient, about 340°, that it may be run into the outer tube on to the caoutchouc, which it grips on cooling, like a vice, and makes perfectly tight.

"I don't know what you may call the material, but should think, as it seems to be more than a mere mixture, 'ferric thiate' would not be a bad or inappropriate name."

III.—PROPERTIES OF THE METAL.

I propose, this evening, to illustrate by experiments such

* A paper recently read before the Society of Arts, London.

as are possible at a lecture, some of the properties of the metal. I will begin by giving you a short summary of its peculiarities, and its advantages over those of other metals or metallic compounds.

1. It has a comparatively low melting point, viz., 320° Fahr., or rather more than 100° above the temperature of boiling water. Here, then, we have in its favor the small amount of fuel needful to supply the necessary heat for reducing the metal to a condition for use.

2. It expands on cooling, a property not shared by the majority of other metals or metallic compounds. I believe that type metal and bismuth are two exceptions. Later on, I think I shall convince you that, for an operation like the joining of gas and water pipes, this expanding property is one of great importance.

3. It claims to resist atmospheric or climatic influences, as compared with bronze and marble. I noticed only a few days ago how the statues in bronze, on the Holborn viaduct, had been affected by our London fogs. And I have evidence to produce in the direction of showing the imperviousness of the metal to such degrading influences.

4. As compared with other metals or metallic compounds, its resistance to acids, used commercially, to alkalis and to water, is certainly superior.

5. A smooth surface of this metal or metallic compound, now known commercially as Spence's metal, takes a very high polish. I will illustrate this to you by casting some of this molten metal on to a surface of glass.

IV.—ITS USES TO ART.

It may, perhaps, be interesting to my hearers to learn the manner in which Mr. Spence first thought of utilizing this metal for works of art. In order to obtain a perfectly smooth surface, he had been running molten metal on to a piece of glass, as I have just done. But before doing so, he had chanced to touch the glass, and had left the marks of the pores of the skin of his fingers upon it. On removing the metal, these marks were found to be reproduced, and so indelibly that they did not disappear on polishing the surface metal. This led Mr. Spence to try to cast the metal in a mould; and although at present no artistic work of high order has yet been reproduced, yet I venture to think that enough has been done to justify the expectation that, in a short time, standard works of both ancient and modern art may be successfully and usefully reproduced. Various colors, such as the green patina of bronze, the dark blue hue of steel, and the appearance of silver and gold, have already been obtained. Experiments are now in progress, which give promise of enabling those who adopt this metallic compound for such uses, to reproduce metallic works in their original colors.

I have here a casting that was made from a nickel-plate engraving; every line, however minute, has been reproduced in Spence's metal. Experiments are now being carried on to test the adaptability of the metal for printing and stereotyping purposes, but they are not complete, so I refrain from giving you any facts about them.

Besides this, experimental castings have been made of various medallions and busts, notably this large bust of her Majesty the Queen. The metal in this case has not subsequently been treated in any way beyond being polished with a cloth. The metal can be cast into almost any material used for moulds.

Mr. Spence has succeeded in obtaining casts from metal moulds, plaster moulds, and even from gelatine moulds. These last are probably the first metallic castings produced from gelatine moulds. Spence's metal, being almost a non-conductor of heat, cools so rapidly in the gelatine mould that it yields a perfect impression before the form of the mould is destroyed, and if the gelatine be allowed to remain on the metal till cold, it remodels itself ready for the next casting. It is, therefore, hoped that an additional process has been secured, by which the most undercut objects may be reproduced successfully and easily.

The advantages which Spence's metal possesses over other materials used for artistic productions may be summarized under three heads, viz.: 1. Cheapness. 2. Facility of working. 3. Resistance to climatic influences.

Cheapness.—As compared with lead, which is one of the cheapest of metals, it is one-third the weight; and, whereas, the average cost of lead for the last ten years has been nearly £18 a ton, Spence's metal only costs £15. A ton of Spence's metal being three times the amount in bulk of that of a ton of lead, it is available for three times the amount of work. It may, therefore, be considered to be nearly a quarter of the price of lead, and, consequently, very considerably less than that of bronze.

Facility of Working.—Its melting point being very low, it can be very easily prepared for pouring into a mould, and its property of expanding, when cooling, causes it to take such a perfect impression that the cast requires very little chasing after. In respect of a gelatine mould, which can cover a considerable surface of work without joints, such as one has to make in plaster piece moulding, the metal cast obtained from such a mould would require no chasing whatever.

Resistance to the Atmosphere.—With regard to its resistance to climatic influences, experiments have been conducted in this direction with complete success. A polished surface of the metal has been exposed for six months in all weathers without showing the least change.

Mr. Wood, the secretary of this society, has had a medallion, which I sent him a month ago, exposed to all the recent fogs and frosts, on the outside of this building. You can judge and see for yourselves how well it has stood this test.

Not to confine myself to this test alone, I have here another medallion of this metal, which Mr. Wood tells me has been left for the same period in aqua-regia, one of the strongest acids known. You see how little effect the acid has had on the surface of the metal. I believe that no work of art in any other substance would bear this test without suffering. I will here endeavor to show you the effect the same acid has on marble or bronze. I venture to think that if Spence's metal has resisted this acid for a month, it ought certainly to be able to resist the climate of London for a much longer period. I, therefore, beg to submit that this metal, if skilled labor is brought to bear on it, ought to be of a great value for decorative purposes, both internal and external.

V.—INDUSTRIAL USES.

I will endeavor now to point out to you the uses to which this metal may be applied for industrial purposes. And I propose to divide these purposes under three heads: 1. Gas and water works. 2. Chemical works. 3. Miscellaneous.

Gas and Water-works.—As practice is better than the theory, I will simply relate, as best I can, those experiments which have been tried at the South Metropolitan Gas-works. Ex-

periments, under the direction of Mr. Livesey, were made some weeks back; two pipes were joined by this metal in much less time than would have been taken had lead been employed. The pipes, after having been joined, were tested under pressure, but no leakage was found.

Method of Joining Pipes with Lead.—In order to show the especial advantages this metal has over lead, it will be as well here if I endeavor to tell you how gas or water-pipes are joined when lead is used. The pipes having been laid together, the joint is packed with yarn; clay is then laid round the exterior of the joint, and the molten lead is run in. Unfortunately, lead possesses the property of contracting on cooling. The leaden joint has, therefore, to be "calked," or as it is called in the north, staved. This calking, or staving, means wedging the lead into the joint, in order to obtain a perfectly tight join. This calking naturally occupies considerable time, and necessitates excavation, in order to enable the men to work all round the pipes.

Excavation and calking are both rendered unnecessary by the use of Spence's metal. The pipes have only to be laid together, and after the yarn has been forced into the joint and the clay placed, the liquid metal is run into the joint, the clay is removed, and the joint is finished. The metal does not splash in running into the mould, thus avoiding a great source of waste of material and danger to workmen.

Experiments were also tried to test the metal joints in the event of subsidence of the ground. Four lengths of nine-feet piping, six inch diameter, were joined with the metal and supported on trestles. After the metal had set, which it did in a few minutes, the center supports were knocked away, leaving only the two end ones. The thirty-six feet length of piping sank seven inches, without showing, even after pressure, a leakage.

These experiments were so satisfactory that the South Metropolitan Company have adopted the metal, and are now laying their pipes with it. Mr. Livesey, the chief engineer, in writing on the subject to Mr. Spence, says: "We have now only the test of time, and that, I think, we may take the risk of." Others of the London gas-works, and a very large number of provincial gas-works, are adopting it.

In the same way it will be useful for water-works. Mr. Hope, who undertook some experiments in Scotland, reports that at the Edinburgh water-works two pipes were joined and subjected to a pressure of 400 feet of water, which was as much as they could get on without the joint showing any leakage. This is the greatest pressure which we have as yet been able to put it to; so what it will actually bear I am not at present in a position to say.

From a sanitary point of view, as water has no action on the metal, it would be extremely valuable for cisterns, instead of iron or lead. Being almost a non-conductor of cold, pipes might be lined with it to prevent the water from freezing.

Uses to Chemical Works.—The metal being less acted upon by acids than other metals, it may also be of service to chemical manufactures. I refer especially to sulphuric acid, which is the most extensively used of all acids in commerce. Lead has, up to the present, been used for sulphuric acid tanks. I have myself tested the metal with sulphuric acid, and its action is almost imperceptible. The one objection to the use of this metal in this case is its low fusing point, but when acids have only to be used up to a certain temperature, say 200° Fahr., I venture to predict a large field for its use.

VI.—MISCELLANEOUS APPLICATIONS.

Besides the uses I have thus briefly and, I am afraid, somewhat imperfectly set before you, there are many others to which the metal may be applied, for instance, joining iron to stone or wood, the tensile strain of the metal being from 650 lb. to the square inch five minutes after setting. For joining railings to stone it would answer equally as well as lead, and cost very much less; also for coating the holds of ships. I have been told that an Act of Parliament has been passed by which builders are compelled, if the district surveyors desire to cover the walls of houses after they are built two feet out of the ground, with some material to prevent the damp from rising. It seems to me that Spence's metal is peculiarly adapted for this purpose.

I will illustrate to you some of the other uses to which this metal may be put. For hermetically sealing bottles; for covering cloth; for covering parcels that are being sent out to hot climates, thus obviating the use of lined boxes; for preserving fruit, or other articles of consumption; and I may state that experiments on a large scale are still being carried on at Mr. Spence's works, Belvedere, Kent.

VII.—CONCLUSION.

I feel sure we have not yet come to the end of all the uses this Spence's metal may be put to, but I trust that I have shown you sufficient to induce you and others who may be interested in this discovery to make further investigations. If my paper is somewhat shorter than is usual, it is to some extent owing to my hesitation to make any statement which either Mr. Spence or I have not verified by actual experiment ourselves. I have already shown you a few of them, viz., casting on glass, casting an engraving, casting in metal moulds, casting in plaster moulds, casting in gelatine, resistance to atmospheric action, resistance to acids, resistance to acids as compared to bronze or marble, and uses in gas and water-works. In conclusion, I express a hope that I have established the proposition with which I started, and I trust you are satisfied that this Spence's metal is a discovery which has a prospect of much utility to the fine and industrial arts, and that I have been justified in bringing it before the attention of the members of the Society.

DISCUSSION.

The CHAIRMAN said Dr. Cole had certainly proved that there was in one way or other a very large field for the employment of this new metal. It was very curious to see how an invention first made with a particular object, sometimes took afterwards an entirely different direction. This material was first brought forward as affording admirable reproductions of works of art, and now they were informed that it could be used to preserve fruit, and possibly meat, and so it might solve the difficulty of bringing over American and Australian meat. This reminded him of an admirable invention for wood-carving, which made no way at first, but when troubles overtook France, and prevented the exportation of wooden heels for ladies' shoes, all the machines in London were immediately set to work profitably. So with Mr. Ransome's patent stone; it did not seem to take until it was turned to making large grindstones, for which it was admirably adapted. The same thing might occur in this case. This metal was already in profitable use for joining gas and water pipes, where it possessed considerable

advantages, not merely because lead required wedging in, in order to make a tight joint, but very often from the difficulty of getting at the under side of the joint, it was imperfectly accomplished; whereas this metal, from its fluidity, penetrated all round, and so made a good piece of work of it. It must not be too readily taken for granted that its power of resistance was proved; because, though it had been exposed for seven or eight months, that was really nothing in point of time; they had bronzes thousands of years old which were still perfect, though others, imperfectly made, such as some in that metropolis, which were not twenty years old, were already decaying. The last time he had looked at the paws of the noble lions in Trafalgar-square, he noticed they were full of holes; and if some means were not devised for preventing further decay, their ruin was certain. However, what they had already heard, said a good deal for the durability of this metal. It was quite certain they needed a material for the reproduction of works of art which should be cheap, hard, and durable. Sulphur itself had considerable power of resisting atmospheric influence, and many other reasons might be suggested why this compound might be expected to be durable; and if so, it would be a great boon for artistic purposes; but there were many other directions in which it would be useful, as, for instance, the joining of iron railings to stone copings. Probably owing to galvanic action, lead, which was generally used, had a very prejudicial effect on the stone. After the popular outbreak in Hyde-park, which led to new railings being put up, he noticed within a year that at every ten or twelve feet, where the iron bars were thicker than usual, the piece of stone had been driven forcibly out of the curb, which entailed a large expense in the repairs. Lead poisoning was another thing which naturally occurred to one, and if this could be used as a coating for pipes, or for the material of pipes, if not too brittle, it would have double the advantage of preventing the decomposition of the lead, and also the possibility of freezing.

The SECRETARY narrated the tests to which he had subjected the specimens sent him by Dr. Cole. When Dr. Cole first mentioned the compound to him, he said it was not liable to be affected by acids, and he (Mr. Wood) then suggested that if a couple of specimens were sent to him, he would himself test them, and relate the result to the meeting. One of these medallions he put on the roof of the Society's house about a month ago, and as they all knew, during the intervening period, they had had every possible description of bad weather. The time was not long, but if the material had been at all subject to atmospheric influences, it could hardly have failed to show some signs; at any rate the glassy surface would have been somewhat dimmed; but nothing of the kind was apparent. The other medallion he put into a basin with nitric and hydrochloric acid, about the strongest mixture of acids known to chemists. The surface of this had certainly been affected, and probably there were no substances except gutta-serena, or earthenware, which would have escaped. An iron hook, by which the medallion was intended to be hung, dissolved entirely in a few days. Dr. Cole also gave him a piece of the compound, with which he had experimented, and he found it exceedingly easy to work. You could take casts as easily as with wax. The only thing necessary was to get the right temperature. At anything under about 320° it was pasty, and if you went much beyond that temperature it became pasty again, but between 320° and 350° it was perfectly liquid, and could be poured into the very finest mould. He thought it rather a pity that a better name had not been devised for the material, as it was certainly not a metal.

Mr. LIVESLEY said he had had some experience in regard to joining gas-pipes, and he would state the result. Lead was most unsuitable for this purpose in some respects, though it was universally used. It was expensive; it required calking or setting up to make it tight, because it contracted in cooling; and, if you wanted to remove the pipes—which constantly happened, except in the very largest mains—from the increased consumption requiring larger pipes, the use of lead prevented your getting out the pipes without cutting them, which occasioned considerable loss. Various means had been tried for drawing pipes, but all had failed, and they always had to be cut. Another drawback was that lead, being valuable and easily disposed of, was constantly being stolen. Now, this new metal was free from all these disadvantages; the only thing which occurred to him, while listening to the paper, was that it seemed a shame to put so beautiful a substance to so base a use; for when he looked at those beautiful busts, it seemed a pity to use the same material for joining gas mains. However, it had many advantages for this purpose, not the least of which was its perfect soundness. The account given by Dr. Cole was quite accurate. The four pipes jointed in the Old Kent road, as described, and supported at the two ends, were exposed to the most severe test, and when he purposely broke one of the joints at the conclusion of the experiment to see what the effect was, he found the metal had taken a perfect impression of the cast iron. The South Metropolitan Gas Company were now using it instead of lead; the men had no difficulty in applying it; and the only test required was that of time, of which he had no fear. The only possible difficulty was that workmen, being accustomed to use a fierce fire to melt the lead, might make the metal too hot, and so burn the sulphur; but that could easily be guarded against. If required, it could be easily cut out with a chisel in order to remove the pipes; and another advantage was, that if from any cause it did not run quite round a large pipe and make a perfect joint, you could clean out the part which had not been filled, put a fresh piece of clay there, and fill it up with a little more metal, and thus the joint was made quite sound.

Mr. CRESSWELL wished to ask one or two questions, not with a view to throw a doubt on the utility of the invention, but rather to elicit valuable information. And first, he wished to compliment Dr. Cole on his paper, which had the rare merit, not only of brevity, but of being written in language so plain that any ordinary person could understand every word. Though brief and simple, it contained matter of considerable importance to the commercial interests of the country, because, if a substitute for lead had been discovered, it would be an immense advantage to every one, except, perhaps, those interested in lead mines. If, on the other hand, it would serve the purposes of art, he could not conceive a greater boon to the large class of struggling population, who were endeavoring, both male and female, to earn a living by the pursuit of art. He wished to know, in the first place, if this material, when used for jointing pipes, possessed any elasticity; because he was told that it was absolutely essential to the permanence of gas-pipes under the London streets, with heavy traffic passing over it continually, that there should be a certain give and take, or elasticity in the joints. If, when heavy pressure was brought to bear on these pipes, they gave way at the joint, the value of the joint was reduced to nil. In the ordinary way, you first calked the pipe, then filled it

with lead, and then calked the lead, and thus produced an elastic joint, which would yield to such an extent that you might bend the pipe without destroying the continuity of the joint. If, on the other hand, this metal was so brittle, that under any sudden pressure it gave way, it would be a formidable difficulty. The next question was this: He understood there was a project for bringing salt water to London from the sea, and one of the greatest difficulties, as he was informed, which the promoters would have to deal with, was to discover a joint for the pipes which would not be affected by salt water. If any means could be devised for cementing pipes which would allow of salt water being conveyed from Worthing to London, and remaining in the pipes for 48 hours or more, or even permanently, it would relieve the promoters of this enterprise of a great difficulty, and perhaps confer a great boon on the inhabitants of the metropolis.

CAPTAIN HEATHORN asked if there were any galvanic action between this metal and copper, and also if it had been left for some time at the bottom of the sea, to see if barnacles and such things would adhere to it?

Mr. WALLER asked if it would expand and contract in the same proportion as water-pipes, if used for hot water?

Mr. SPENCE said the joints would be considerably affected by hot water if the temperature were very high. Ordinary boiling water would not affect it; but, as it melted at about 300°, if there were a steam pressure of about 40 lb. there would be such an increase of temperature that the joints would not stand. It did possess a certain degree of elasticity. In one case, 30 feet of pipes were connected with this metal at the joints, and deflected to the extent of eight inches, and, when the weight was removed, the pipes recovered their original position, showing that it was elastic to some extent. With regard to expansion and contraction, he was hardly yet in a position to speak. He would take this opportunity of stating that if ever this metal, as it was called, did take a place in art or industry, much of its success would be due to Dr. Cole, who had greatly assisted him in his experiments, and in elucidating the facts; and also to Mr. Livesey, who was the first to take it up in a practical way.

Mr. LIVESLEY said lead was certainly not elastic; if you were to join four lengths of 9 ft. together with it, calking it up in the ordinary way, and then knock out the central supports, the upper part of the joints would squeeze into a narrower compass, and the lower would be left open, and when the pipes were again brought to a straight line, the lead would not return to its original shape. Lead was not elastic in any sense whatever, and it was, therefore, a very bad thing for pipes where there was any settlement or change of position. This metal seemed to have the effect of making the four lengths into one continuous, perfect pipe, which had just the same strength in the joints as anywhere else. This was shown by the fact that when supported at the two ends it sagged evenly throughout, making a continuous curve, whereas if the joints had been made with lead, there would have been a number of straight lines, with angles at the joints.

Dr. COLE said he believed that salt water would have no action on the metal whatever. The same with regard to galvanic action, for which it has been tested. With regard to barnacles at the bottom of the sea, he regretted to say that no experiments had yet been made in that direction. He would conclude by another experiment, to show how quickly the metal set, namely, coating a pat of butter with it.

Whilst this experiment was being performed,

The CHAIRMAN proposed a cordial vote of thanks to Dr. Cole, which was carried unanimously.

GILDING METAL SURFACES.

A MONSIEUR P. A. DODÉ, of Rheims, has patented in France methods of gilding (both brilliant and dull or matte) wrought and cast iron and other metal surfaces by means of sulphide of gold, applied either by brush or bath. His process consists in covering the metal under treatment with a thin yet solid coating of gold, presenting a very rich metallic appearance, and produced without having recourse to burnishing or polishing.

FIRST OPERATION.

Product No. 1.—I dissolve a kilogramme* of pure alum in a sufficient but the smallest necessary quantity of water. When it is completely dissolved, I pour on to it a litre† of ammonia (alkali). The alum precipitates itself into the form of a very thick jelly, and I pour this precipitate on to a filter, in order to draw off as much liquid as possible. The alum is next put into a porcelain capsule, and I add 500 grammes‡ of nitric acid, which has the property of re-dissolving the alum.

Then I put, for dissolving, in another capsule 150 grammes of carbonate of cobalt, with 200 grammes of nitric acid, and I assist the dissolving by the moderate heat of a sand-bath. The dissolution being effected, I pour it upon the dissolved alum, and both being well mixed together, I assist the complete evaporation of the acids by placing the capsule upon a strongly-heated sand-bath. I collect and pound the produce and calcine it in a crucible by a strong heat before using it in the following composition:

Product No. 2.—I melt in a crucible exposed to a brisk fire the subjoined composition, thoroughly mixed:

	Kilos.	Grammes.
Product No. 1.		600
Orange oxide of lead.	3	200
Boric acid.		800
Finely powdered white glass. ..		200
	4	800

The melting being effected, I pour it into cold water, and afterwards dry and grind the product by the means employed for grinding enamels. Spirits of turpentine are used in the operation of grinding, which must be continued until a considerable degree of fineness is obtained, in order to facilitate the working. If the product be too thick, the quantity of turpentine necessary to reduce it may be added.

Product No. 3.—I dissolve in a porcelain capsule:

	Grammes.
Pure gold.	100
Muriatic acid.	200
Nitric acid.	100

* A kilogramme is equal to 2 lb. 3 oz. 4 drms.

† The French litre is a little less than the English quart.

‡ A gramme is equal to 15½ grains, or three-quarters of a scruple.