νοῦς of Anaxagoras, the ἀνάγκη of Demokritos, the actuating form of fire of Herakleitos, the moving ether of Aristotle. The links which bind together ancient and modern physical thought are strong and enduring, and since they have lasted during the rise and fall of many nations, and during the most profound changes in the mode and tone of thought, it is not unlikely that they will endure as long as the chain itself.

G. F. RODWELL

THE DIATHERMACY OF FLAME

I HAVE just read Mr. Ericsson's paper on "The Sun's Radiant Heat" in NATURE, October 3, p. 458, and find that he has made some experiments on the diathermacy of flame closely resembling those which I made in 1869, and described in chap. viii. of "The Fuel of the Sun" published January 1870. Although the object of our investigations was identical and the method of proceeding very similar, the results obtained are so contradictory that one of us must be quite wrong, and therefore I think the subject demands discussion.

Referring the reader to the engraving illustrating Mr. Ericsson's paper, I may easily describe my apparatus. Like Mr. Ericsson's, there was a gas-pipe from the side of which projected a row of burners, each provided with a separate stop-cock. My burners, however, differed from his in being perpendicular to the main pipe which was always used in a horizontal position. My blackened bulb thermometer was similarly fixed at one end of a chamber or vessel, the other end of which was open to receive the radiations from the flames. This, however, was much simpler than Mr. Ericsson's. It had not the double chamber with intervening wall, nor was it surrounded by water, but was simply a thin tube of tin plate *polished inside* to prevent absorption of radiant heat. The thermometer was insulated from metallic contact with this tube, and thus could only receive heat from it by radiation, which the polishing reduced to a minimum. The sectional form and opening of the tube was made to correspond nearly with that of the presented side of the gas flames, but was somewhat larger.

At first I used Bunsen-burner flames, then flat flames like those figured by Mr. Ericsson, afterwards simple jets formed by the gas issuing from a small pin-hole, the jets being far enough apart to be quite independent; finally a row of such jets so near to each other that they came in contact, coalesced fully, and formed one sheet of flame, the edge of which was presented to the mouth of the polished tube containing the thermometer.

Guided by results obtained in a previous series of photometric experiments on the transparency of flames to their own special radiations, and by the first experiments I made on diathermacy, I relied on the arrangement last described, viz. the coalescing jets. The reason for this will presently appear.

My mode of proceeding differed in another respect from Mr. Ericsson's. Instead of lighting one jet at one end and then another and another in succession towards the thermometer, I always worked with an odd number of flames, and began with the middle jet, then lighted one on each side, next one on each side of those three, then one on each side of those five, and so on. My flames were thus maintained at a constant mean distance from the thermometer.

By means of a well-constructed experimental gas meter, with micrometic regulator, and a minute alarum clock, the supply of gas was accurately adjusted, so that each additional jet, or pair of jets, should consume an exactly equal differential increase of gas. The results obtained were as follows:—

Number of Jets	Consumption of gas in cubic feet per hour	Highest reading of Thermometer
1	1·0	19°·0 Cent.
3	1·5	23°·0 ,,
5	2·0	27°·0 ,,
7	2·5	31°·0 ,,
9	3·0	35°·5 ,,
11	3·5	39°·0 ,,
13	4·0	43°·5 ,,
15	4·5	48°·0 ,,
17	5·0	53°·0 ,,

Here, then, is a serious discrepancy. I get an increase of 4° by the first addition of two flames, and by eight of such additional pairs obtain an increase of 34°, instead of the 32° due to theoretical diathermacy. These 2° of excess (being due to the latter end of the series) I attributed to the increased temperature of my apparatus.

Mr. Ericsson obtained an increase of only 7°·9 instead of 17°·6, the theoretical requirement.

Without any disposition to underrate the value and importance of Mr. Ericsson's researches, I think that in this matter he has been deceived by overlooking some important sources of fallacy.

1. He tells us nothing about the quantity of gas consumed. His jets all issue from the same main pipe, which he describes as supplied with "gas at ordinary pressure." Now with such a supply the quantity of gas burning from each jet would steadily diminish as he turned on the additional jets. On turning the second jet the first would diminish; when the third was turned the supply to both first and second would be reduced; and so on, to an extent depending upon rates of sectional area of the supply pipe to that of the jet holes. If Mr. Ericsson's drawing is made to scale, the error due to this was of great magnitude.

A second source of error is described in Mr. Ericsson's own words; he says, "It will be observed that the prolongation of the axis of the conical vessel upwards passes through the central portion of the flames at the point of maximum thickness and intensity." Now the point of maximum thickness of a flame is just that part which is hollow, and consists of a central core of unburnt gas with an outer coating of true flame, and the central portion of such a flat flame as Mr. Ericsson represents includes much of the blue portion of the flame, consisting of hydrocarbon not yet in full combustion. Mr. Ericsson, therefore, was not experimenting upon the diathermacy of ten flames, but upon the diathermacy of ten discs consisting of a mixture of flame proper and unburnt hydrocarbon. Now Tyndall has demonstrated the remarkably high resisting or absorbing power of such hydrocarbon in reference to the radiations from a flame produced by hydrocarbon combustion. The flame itself might therefore be perfectly diathermous, and yet, when examined in this manner, exhibit a considerable degree of athermacy.

There is still a third source of error in Mr. Ericsson's mode of proceeding, the magnitude of which I am not yet able to estimate, though some experiments made since publishing my first results lead me to suspect that it is sufficiently important to demand very careful elimination. I allude to the arrangement of a series of separated flat flames, with the broad surfaces presented to the thermometer.

What must we have between each of these separated flat flames? Obviously each flame is coated with a film of vapour, the product of the combustion of those portions of flame lying below it; these vapours, though rapidly rising, must form a layer of sensible thickness equal to an important fraction of the whole thickness of such thin flames. When operating with the whole eleven flames, there were twenty-one such films between the first flame and the thermometer. Now, we know from the experiments of Tyndall, that a large proportion of the rays of heat emitted from a hydrocarbon flame will be absorbed by such intervening strata of aqueous vapour, carbonic acid, and carbonic oxide. It is true that the middle or blue part of the flame, having less combustion going on below it, must have a thinner coating of such vapours than the upper part; and thus in Mr. Ericsson's arrangement this third source of error is diminished in the same proportion as the second is increased. It was these theoretical considerations, confirmed by results of preliminary experiments, that induced me to abandon the flat flames in favour of the simple round jets, and finally to adopt the continuous flame formed by the coalescent jets.

As I stated on the first publication of the results of these experiments on the diathermacy of flame, I do not regard them as sufficiently delicate to be finally and quantitatively conclusive; the means at my disposal rendered them less satisfactory than those I made on the transparency of flame. Still, I think they are not open to any such serious sources of error as those I have here pointed out.

I hope that Mr. Ericsson will not be offended by the candour of my criticism, nor by the egotism which is inevitable in an unaffected defence of one's own philosophical bairns.

My experiments, like those of Mr. Ericsson, were made with the direct object of throwing some light upon the great mystery of solar radiation; and the fact that we have arrived at such opposing conclusions will, I hope, lead to further investigation,

and finally to a settlement of the important fundamental physical question, whether the properties of flame, in reference to the absorption and transmission of heat and light, are, as I have ventured to suggest, diametrically opposite to those of gases and vapours—whether flames are specially transparent and diathermous to rays of their own emission, and resist the passage of heterogeneous rays; that a flame is thus not merely heated gas, but another and distinct form of matter, or rather is matter in a different state of activity.

If this be established, we shall be driven back upon "the wisdom of the ancients," and be forced to admit the classification of the four elements, "fire, air, earth, and water," or flame, gas, solid, and liquid; remembering, of course, that they used the term "element" with a different meaning to that of our modern acceptation. They described elementary or necessary conditions, not elementary constituents. It was the philosophy of material existence, not the composition of material substances, which chiefly occupied their attention. From this point of view their classification may, after all, prove to be correct.

I must reserve for another communication some remarks I proposed to make on the application of the above to Mr. Ericsson's researches on the radiation of the chromosphere.

W. MATTIEU WILLIAMS

SCIENTIFIC SERIALS

THE part of the *Transactions of the Linnean Society* just published, forming the 2nd part of vol. xxviii, consists of two elaborate botanical papers; "Memoir on the Spermogones and Pycnides of Crustaceous Lichens" by Dr. Lauder Lindsay; and "On the Hippocrateaceæ of South America" by Mr. Miers. Of the important features of the latter paper we gave a sketch on the occasion of its being read before the Society. It is illustrated by seventeen very beautiful plates executed by the author. The first is an extremely elaborate paper, illustrating the great variation in the spermogones and pycnides in the same species of lichen, and even in the same individual. For this purpose as many as twelve or even 20 specimens of the same species, preserved in various herbaria, are in some cases minutely described. This paper is also illustrated by eight coloured plates.

THE *American Naturalist* for August does not contain so many original articles as usual. The Rev. Samuel Lockwood describes a new Entozoon from the eel, belonging to Duvaine's type, the Acanthocephala or spiny-heads, but forming a new genus; the name proposed is *Koleops anguilla*. Dr. J. J. Woodward has a paper on the use of monochromatic sunlight, as an aid to high-power definition; and the Rev. H. J. Bruce describes some of the familiar birds of India. Among the shorter articles there are some very interesting notes.

The number for September opens with an interesting article by Mr. S. H. Scudder, the curious history of a butterfly. The American butterfly *Brenthis bellona* occurs in two different forms produced at different times of the year, in both cases the larva hibernates, but with one set when just out of the egg, with the other when half grown, the butterfly appearing in one case in May, in the other in September; and it seems impossible that these two parallel races of the same species can ever mingle. Prof. N. S. Shaler has a paper on the Geology of the Island of Aquidneck and the neighbouring parts of the shores of Narragenset Bay; and Dr. R. H. Ward sends a microscopical contribution entitled "The new Immersion Illuminator." Mr. C. V. Riley, who has paid great attention to the *Phylloxera* and other diseases of the vine, has some valuable remarks on the cause of the deterioration of some of the native grape-vines, which he has contributed to his report as Entomologist to the State of Missouri.

THE *Quarterly Journal of Science* for October commences with two meteorological articles, the Origin of the Great Cyclones, by Prof. T. B. Maury, and an anonymous paper on Weather Prophecies. The author of the former article considers it proved that cyclones are formed chiefly, if not exclusively, along the edges of the great atmospheric currents, the surface currents and the upper currents alike, the polar streams which descend into our valleys, and the aërial gulf streams which move invisibly over our heads. Capt. Oliver continues his series of papers on the Amorpholithic Monuments of Brittany, and in continuation of a previous series we have an article on Natural and Artificial Flight —an Aërial Ship. Mr. F. C. Danvers, on Paper in the International Exhibition, gives a slight sketch of the history of the manufacture of paper and of the various specimens to be seen in the Exhibition. The Physiological Position of Tobacco, by Mr. E. A. Axon is a powerful attack on the use of the weed as not only unnecessary and destitute of any beneficial results, but positively injurious.

THE first paper in the *American Journal of Science and Arts* for September is by Prof. J. W. Draper, "Researches in Actino-Chemistry," from which we have already reprinted an extract on the distribution of heat in the spectrum. Prof. Shepard concludes his account of the Corundum region of North Carolina and Georgia; and then follows a sketch of Barrande's account of the origin of Palæozoic species. Mr. A. A. Hayes has a long article on the red oxide of zinc of New Jersey. In Prof. O. C. Marsh's continuation of his preliminary description of new Tertiary Mammals are descriptions of a large number of new genera and species.

IN the *Geological Magazine* for October (No. 100), the Editor, Mr. Henry Woodward, gives us notes, illustrated with excellent figures, on some British Palæozoic Crustacea belonging to his order Merostomata. These notes include a full description of *Hemiaspis limuloides*, a species originally established by Mr. Woodward in 1865, and also shorter characters of three other species of the same genus, namely, *H. speratus* (Salt ms.), *H. horridus*, sp. n., and *H. Salweyi* (Salt). These Silurian forms are particularly interesting as they constitute a connecting link between the suborders Eurypterida and Xiphosura.—Of the latter group Mr. Woodward here notices some species of the genus *Bellinurus*, and describes a new form under the name of *B. Königianus*, also a new *Prestwichia*, *P. Birtwelli*, both from the Coal measures.—Mr. W. T. Aveline publishes a short note on the continuity and breaks between the various divisions of the Silurian strata in the Lake district, and Messrs. Davidson and King some remarks on the genera *Trimerella*, *Dinobolus*, and *Monomerella*. In this paper the authors propose the establishment of a new Brachiopod family, Trimerellidæ, allied to the Lingulidæ.—Dr. H. A. Nicholson describes a new genus of fossil tubicolar Annelides founded upon a division of the fossils hitherto referred by Palæontologists to *Tentaculites*. The so-called genus *Tentaculites*, according to Dr. Nicholson, includes forms belonging to the Pteropodous Mollusca and others which are true tubicolar Annelides, the former being free shells, the latter attached to other bodies. He proposes to retain the name *Tentaculites* for the Pteropods, and to establish a new genus, *Ortonia*, for the Annelides. He describes and figures a new species of the latter from the Cincinnati group of the Lower Silurian of Ohio under the name of *Ortonia conica*.—The concluding article in the number is a further instalment of Prof. Nordenskiöld's account of the Swedish Greenland Expedition of 1870.

SOCIETIES AND ACADEMIES

PHILADELPHIA

Academy of Natural Sciences, April 2.—Prof. Leidy made some remarks on specimens of fossils of extinct mammals from the Tertiary of Wyoming. One of these is an upper jaw fragment with two molars; the other a lower jaw fragment with a single molar. The upper molars have crowns composed of four lobes, of which the outer are like the corresponding ones in *Anchitherium*. Of the inner lobes, the front one is much the larger, and is prolonged outwardly in advance of the antero-external lobe. It is homologous with the antero-internal and antero-median lobes as existing in *Anchitherium* in a completely connate condition. The postero-internal lobe is the smallest of the crown. It is conical and conjoins that in front. A barely perceptible trace of a postero-median lobe is seen. A strong basal ridge incloses the crown, except externally, where it is feebly produced. The three upper molars occupied a space of 8 lines. The first molar is $2\frac{1}{2}$ lines fore and aft and $3\frac{1}{4}$ transversely; the second is $2\frac{3}{4}$ lines fore and aft, and the last one $2\frac{1}{4}$ lines. A question arises as to whether these teeth pertain to any of the animals previously indicated from lower jaw specimens with teeth. They are too large for the known species of *Hyopsodus* or *Microsyops*. They nearly accord in size with the lower molars of *Notharctus*, and perhaps belong to this genus. *Limnotherium* appears not to differ from this, as the number of teeth and their constitution are the same. The lower jaw fragment accompanying the upper one may belong to the same animal. The molar it contains, though resembling those of *Notharctus*,