

$$\begin{aligned}
 &+ (y_3 - y_6) \{y_1 (y_1 - y_3) + y_2 (y_3 - y_2) + (y_4 - y_3 + y_2) (y_2 - y_1)\} \\
 &= (y_1 - y_4) (y_3 - y_6) (y_2 - y_1) + (y_3 - y_6) (y_1 - y_4) (y_1 - y_2) \\
 &= 0, \text{ which proves the truth of the theorem in question.}
 \end{aligned}$$

$$\text{If } y_4 - y_3 + y_2 = y_6 - y_1$$

$$y_5 - y_6 + y_1 = y_3 - y_2$$

$x_4 = x_5$, $y_4 = y_5$, the points 4 and 5 coincide, and by reference to the figure it will easily be seen that it is useless to coincide this case.

The equation of condition

$$y_1 - y_2 + y_3 - y_4 + y_5 - y_6 = 0$$

has been found upon the supposition, that $x_1 = 0$, $x_2 = 0$, which simplifies the expressions. But it is easy to show by the transformation of coordinates that if the above equation be true, with such limitations, it is also true in the more general case, the only limitation required being, that the axis x be parallel to the axis of the parabola; and then, however the circumscribed hexagon be situated

$$y_1 - y_2 + y_3 - y_4 + y_5 - y_6 = 0.$$

In the *Phil. Mag. and Annals*, N.S., 1829, vol. vi. p. 249, I gave a direct proof from the equation to the parabola $y^2 = px$ of Pascal's celebrated property of the inscribed hexagon, and I showed that the proof might be extended to the general equation of the conic sections $y^2 = p'x + q'x^2$, by substituting for the coordinates x and y of any point

$$x \frac{p'^2}{p'} \text{ and } \frac{p'y}{p' + q'x} \text{ respectively.}$$

By such substitutions all the preceding expressions which are true for the parabola $y^2 = px$ may be extended to the conic sections generally, which are included under the equation $y^2 = p'x + q'x^2$. Thus the equation of condition

$$y_1 - y_2 + y_3 - y_4 + y_5 - y_6 = 0 \text{ becomes}$$

$$\frac{y_1}{p' + q'x_1} - \frac{y_2}{p' + q'x_2} + \frac{y_3}{p' + q'x_3} - \frac{y_4}{p' + q'x_4} + \frac{y_5}{p' + q'x_5} - \frac{y_6}{p' + q'x_6} = 0.$$

XIV. *Experimental Researches on Combustion and Flame.*

By DAVID WALDIE*.

[Illustrated by Plate I.]

THE subject of combustion has long engaged the attention of the most distinguished chemists, and the results of their inquiries are incorporated more or less in the various

* Communicated by the Author.

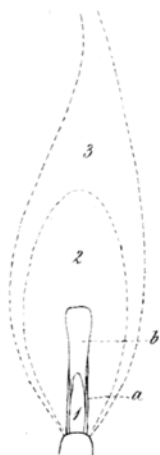


Fig. 1.



Fig. 7.



Fig. 2.



Fig. 3.

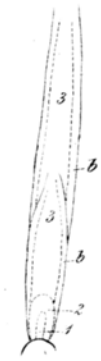


Fig. 4.

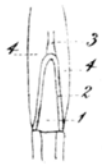


Fig. 5.



Fig. 6.

*Structures of Flames; illustrative of M^r Waldie's
Researches on Combustion & Flame.*

treatises on chemistry; an excellent account of them may be found in Ure's Chemical Dictionary, under the article Combustion. The subject however is not exhausted, and there are still some questions which by a new method of investigation may I think now be decided, and several phænomena hitherto unaccounted for which may now be explained.

The principal or essential circumstance in combustion is the fact of combination between two substances of opposite electrical energies. One of these, as being the apparent source of the heat and light, is called the combustible; the other, as absolutely necessary to the phænomena, the supporter of combustion. This has given rise to the division of bodies into these two classes, supposed by some to be remarkably distinguished from each other by their part in the process as they are in their place on the electro-chemical scale. Others again have contended that there is no essential distinction between the two classes of bodies with respect to this phænomenon; that in fact both are equally entitled to the name of combustible, and that the heat and light evolved are simply indications of energetic chemical action between any two substances: in proof of this various instances have been adduced, such as the combustion which takes place between iron or copper filings and sulphur, between potassium and cyanogen or sulphuretted hydrogen, between vapour of anhydrous sulphuric acid and dry baryta, as noticed by Bussy, magnesia and sulphuric acid, &c. in all of which we have all the phænomena of combustion, without the presence of any of those substances exclusively called supporters of combustion, or in some of these cases without either combustibles or supporters.

The latter explanation seems now to be admitted so far by chemists in general, but yet it occurred to me that its truth was susceptible of still better demonstration, and that instead of searching for particular instances of combustion it might be supported by a much more general proposition: that in fact if this were the true explanation, it should follow as a general rule, that if what is commonly called a combustible burn in a supporter, a supporter ought also to burn in a combustible. This accordingly on trial I found to be the case.

The apparatus employed for these experiments consisted of a wide-mouthed flask (about 8 or 9 inches long) having cemented to it a cap of tinned iron, pierced with four holes: to two of these two brass sockets were soldered, made to fit the ends of two flexible tubes proceeding from two gas-holders; to the two other holes were attached small pieces of tube, over one of which a piece of sheet caoutchouc was

tied, through which a slender platinum or iron wire could be passed to try the temperature of different parts of the flame, and to the other was fixed a bladder in order to allow of expansion. The flask was filled by being immersed in a trough of water; the water was then displaced by inserting one of the flexible tubes into one of the sockets, and causing gas to flow into it from a connected gas-holder, the water escaping by the other socket; the tube was then removed, corks inserted in the sockets, and the flask placed on a retort stand, with its mouth downwards and the bladder hanging flaccid: the tube was then replaced in the socket so as to supply more gas if necessary. Now when the flask was filled with one of the common supporters, such as oxygen, and one of the common combustible gases was to be burnt in it, the method requires no explanation. When again the oxygen was to be burnt in hydrogen the cork was removed from the socket, and the gas set fire to, being made to flow gently from the flask, in order to prevent the combustion from getting inwards; the oxygen then being made to flow with a proper degree of force from a small brass jet fixed on the end of another flexible tube, communicating with another gas-holder containing oxygen, was passed steadily through the burning hydrogen into the flask, and the end of the flexible tube pushed home into the socket; the hydrogen burning outside the flask was now extinguished, and the oxygen found burning within.

When again the gas was not confinable in a common gas-holder with water, such as nitrous acid vapour, it was prepared in a wide-mouthed flask; and when this was believed to be full, a jet of hydrogen burning from a brass nozzle fixed to the turned-up extremity of a glass tube connected with a flexible tube was let down into it: or, for instance with chlorine, a jar was filled with this gas over the water-trough, and a jet let down as before, a tin plate being fixed to the tube so as to cover the jar and allow the jet to descend to near the bottom. If again these gases were to be burnt the materials were placed in a small flask, to which was fixed a tube having a brass piece to fit the socket of the flask, and a jet placed on its extremity.

By means of such apparatus oxygen was made to burn in atmospheres of hydrogen, olefiant gas, coal gas, sulphuretted hydrogen and carbonic oxide; nitrous oxide was burnt in hydrogen and coal gas; nitrous acid vapour in hydrogen; chlorine in hydrogen, and mixtures of these with nitrogen or carbonic acid, common air for instance, in the same gases.

By these experiments, oxygen, atmospheric air, nitrous oxide, nitrous acid and chlorine are shown to be not only

really but also apparently as much combustibles as hydrogen or coal gas, and these again are exhibited in the form of supporters of combustion. In fact this distinction arises simply from the accidental circumstance of oxygen being contained in our atmosphere, and of hydro-carbonaceous substances being emitted from other bodies into it: there is really no distinction between the two, the phænomena of combustion proceeding from *the act of combination* of the two oppositely electrical substances.

I did not succeed in making iodine vapour burn in hydrogen, nor the reverse; the affinity for each other seems not sufficiently strong. Nitric oxide does not burn in hydrogen, nor *vice versâ*; a circumstance remarkable enough, as the two constituents of this gas are in respect to their density in precisely similar circumstances to a simple mixture of the two; no more however than might have been expected from the circumstance that a mixture of the two does not detonate but burns with flame in contact with the air. It is said in some works on chemistry, that the products of this combustion are water and pure nitrogen: this I suppose must have been a conclusion made beforehand, on the supposition that the nitric oxide is decomposed completely: it would appear rather that the oxygen for the combustion of the hydrogen is supplied from the air, and that the nitric oxide is either not decomposed, or at least only partially, as I find copious nitrous acid fumes produced, whether the experiment is performed by burning them together in a jar even with excess of hydrogen, or by burning the mixture from a jet either in oxygen, or oxygen in it.

I had made but very few of these experiments until I perceived that there was a great variety in the appearance of the flames. The jet of hydrogen for instance, in passing from air to oxygen was observed to shrink in size, and become brighter and denser; the jet of oxygen in hydrogen was observed also to be much smaller than that of hydrogen in oxygen. The flame of hydrogen in chlorine, nitrous oxide, or nitrous acid was much larger than in air; the flame of these gases in hydrogen again was small and concentrated. In all these cases the gases were made to issue from the same jet, with as nearly as possible equal degrees of velocity.

Before making any observations on the causes of these differences, it will be necessary to take some notice of the structure of flame. This has been studied chiefly in the flame of a common candle or jet of coal gas. It consists then, according to observations already made, of, 1st, a dark central portion consisting of unmixed, unconsumed gas; 2ndly, a dense

very luminous white portion surmounting the dark portion which penetrates further up its centre than its circumference; this consists of solid particles of charcoal burning at a white heat; 3rdly, a blue cap arising from the bottom and surrounding the dark portion, extending moreover some way up the sides of the white part, this being supposed to be composed of the gas burning in an undecomposed state; 4thly, an envelope of a light blue colour, of a pinkish or lilac shade, consisting of the proper combustible mixture, this being the hottest part of the flame: this part is thinnest at the bottom, increasing in thickness to the top where, of course, the heat is most intense; and, 5thly, another envelope of a yellowish brown colour, chiefly covering the upper part, and consisting of unconsumed matter or products of combustion. These two latter are not well seen in the flame of coal gas, on account of the great size and brightness of the luminous white portion.

The explanation of these appearances is obvious enough: the gas issuing from the jet spreads out into the atmosphere, till it mixes with a sufficient quantity of oxygen to form a combustible mixture; as it ascends, however, it becomes strongly heated by the surrounding flame, deposits solid charcoal, the combustion of which forms the white part of the flame.

When a jet of coal gas or olefiant gas burns in oxygen the parts of the flame are all the same, but differing considerably in appearance; the dark portion, the white portion, and the blue cap 1, *b*, *a*, (Plate I.) fig. 1, are greatly diminished in size, looking as it were compressed, the white being however more brilliant. The light blue portion again, 2, is greatly enlarged, the shell of flame becoming much thicker, and the heat is much greater, easily fusing a small platinum wire. The yellow tail, 3, also is now perfectly visible. The whole flame is also much smaller than in air. These changes are due simply to the more perfect combustion produced by the oxygen being undiluted, so that the greater part of the gas at once undergoes perfect combustion; the diminution of size of this as well as of flames in general, in oxygen compared with air, arising from the circumstance, that in the latter the gas requires to penetrate or diffuse itself over a much larger space before it meets with a sufficient quantity of air to produce full combination.

In flame again, where there is no solid matter deposited, as in that of hydrogen, the appearances are much simpler; in this case (burning in oxygen) it consists of a dark central portion of unmixed gas, 1, of a light lilac blue envelope of ex-

plosive mixture, 2, and of the external envelope and tail of unconsumed matter or products of combustion, 3, often of a greenish colour.

Olefiant gas issuing with the same degree of force and from the same jet as hydrogen burns with a much larger flame: this is easily explained, as it requires 15 times its volume of air to burn it, whereas hydrogen requires only $2\frac{1}{2}$ times. This shows the influence of quantity on the size of flames. But hydrogen requires only its own bulk of chlorine or of nitrous oxide for combustion, yet its flame in these gases is much larger than it is in air; these burn on the other hand with a very small flame in hydrogen. The only cause to which this can be attributed appears to me to be the difference of their diffusibility. From Mr. Graham's researches we now know the law of the diffusibility of gases,—that it varies inversely as the square root of their density; so that hydrogen, a light gas, diffuses itself much more rapidly through chlorine, than chlorine, a heavy gas, does through hydrogen.

These then are the two causes by which I would explain the different appearances of different flames, and they are confirmed by all the experiments I have made. Probably they are not the only causes, but they are the primary ones, particularly with the simple gases. A great number of experiments were made to ascertain, if possible, the exact proportional effect of these two causes, but with the apparatus I was in possession of, it was a hopeless task. The only way in which I could regulate the jet of gas was by the degree of opening of the stop-cock by which the water was supplied to the gas-holder, a very imperfect method where accuracy is required. With some of the gases produced in the method already described there was not even this resource. The peculiarities of size, &c. which I notice here, are, however, so great and decided, as to leave no doubt about them, allowing freely for inaccuracy of the apparatus.

A few examples may be given in illustration of these remarks. The diffusibility of oxygen to hydrogen is as 1 to 4, or the inverse of the square root of their respective specific gravities (sp. gr. of hydrogen = 1). The difference of size however of their flames is not so great as might be supposed from this compared with chlorine: to account for this it is to be kept in mind that the oxygen requires twice its volume of hydrogen for combustion, so that it must spread further through the hydrogen than it would otherwise require to do, and thus make its flame larger; the flame of hydrogen in oxygen being smaller than it otherwise would be from the same reason. Let us *suppose* it set down in this way:

Vols.	Sp. gr.	Diffusi- bility.	Inverse of quantity.
1	16· oxygen	1	$\times 2 = 2.$
2	1· hydrogen	4	$\times 1 = 4.$

Now let carbonic oxide be treated in the same way.

Vols.	Sp. gr.	Diffus.	Inv. of quant.
1	16· oxygen	3·75	$\times 2 = 7·5$
2	14·12 carbonic oxide	4·	$\times 1 = 4·$

In this case the flame of oxygen should be larger than that of carbonic oxide (that is, when burning in each other), because their diffusibility is nearly equal, and the larger quantity of carbonic oxide is required. On trial I found that it was so in fact; the only instance I have seen with unmixed gases where the oxygen flame is larger than that of the other substance. In the same way the flames of oxygen and sulphuretted hydrogen approximate to each other in size.

The flames of chlorine and hydrogen in each other ought to depend on their diffusibility alone, as their combining proportion is equal volumes. Not having the chlorine in the gas-holder I could not ascertain its size well; but from the trials I have made it is very small, similar to that of oxygen. So also is that of nitrous oxide, and nitrous acid has also a small flame. The flame of hydrogen in these gases is very large, of a greenish or yellowish colour, darkish in centre, 1, (fig. 2) brightest and hottest about the middle of the outer part, 2, but very diffused in its appearance.

The flame of oxygen in hydrogen consists of a dark unmixed central narrow portion, 1, (fig. 3) surrounded by a lilac blue flame of small size, 2, and then by a dark yellowish envelope and tail, 3. The heat is concentrated in the blue portion, where the platinum wire fuses and sparkles brilliantly, the heat being compressed into so small a space.

The flame of oxygen in olefiant gas is a very beautiful and instructive example. It is necessary to premise, that as the oxygen is the least diffusible of the two gases, and as it requires only one third of its volume of olefiant gas to form a proper combustible mixture, both of these circumstances conspire to make its flame small. In this, therefore, we have a small light blue flame, darkish in centre; in this blue flame is the strongest heat which fuses the platinum wire, 1 and 2, fig. 4; surrounding this and stretching far above it was a dull strong yellow flame, *b*, red at the edges and dark in the centre, 3, evidently consisting of solid red hot charcoal, a very large quantity of which was separated as smoke, and adhered to the sides of the flask.

Gases were also mixed with nitrogen and carbonic acid. When a pure gas was burnt in such a mixture it had its flame much enlarged, as it had to expand itself further till it met with a sufficient supply of the other, on account of its dilution. Thus hydrogen, as already noted, burns with a larger flame in air than in oxygen, and oxygen with a very large flame in hydrogen diluted with twice its bulk of nitrogen or carbonic acid. When mixed with the gas which was to issue from the jet an opposite effect was produced; thus the mixture of nitrogen or carbonic acid with hydrogen burnt with a smaller flame in oxygen than pure hydrogen did, and air burnt with a much smaller flame in hydrogen than oxygen did—there being less gas issuing—and of course sooner meeting with a sufficiency of hydrogen. In this case the flame of air was such as represented in fig. 5, burning from a wide hole in a piece of a tobacco pipe: 1, dark; 2, blue very distinct; 3, dark reddish tail; 4, greenish envelope.

Carbonic acid was employed in these experiments, in order that its effects might be compared with those of nitrogen, on the supposition that, on account of its greater density, a jet of gas burning in it would be expanded or diffused to a greater degree than in a similar mixture of nitrogen; this accordingly was found to be the case. The greater degree of contraction which should be supposed to take place when the mixed gases were made to issue from the jet was not demonstrated so clearly by the experiments; in some instances it seemed sufficiently apparent, in others it was doubtful. Experiments with more accurate apparatus would be necessary to establish the proportional effect of such mixtures.

These experiments were made on the idea that from them we should get an explanation of the fact, that carbonic acid is more deleterious to combustion than nitrogen, or “exerts a positive influence in checking combustion, as appears from the fact, that a candle cannot burn in a gaseous mixture composed of four measures of atmospheric air and one of carbonic acid.” (Turner’s *Elements*, sixth edit.). On examining the effect of nitrogen on the combustion of a jet of coal gas, it was found that by successive additions of it to air the flame became more and more expanded, the tube of flame becoming wider and longer, and the white part diminishing or disappearing altogether when the nitrogen was in considerable excess; when beyond a certain proportion, it would not burn at all, obviously from the cooling effect produced by excessive diffusion. It was therefore concluded, that this effect depended on the density of the gases, and accordingly on trial the following results were obtained.

Combustion of coal gas in mixtures of

	Permitted.	Prevented.	Sp. gr. <i>Hydrog.</i> = 1.
1 Oxygen...	7	8 Nitrogen.....	14·12
1 Do. ...	3	4 Muriatic acid ...	18·42
1 Do. ...	$2\frac{1}{2}$	3 Carb. acid	22·12
1 Do. ...	2	$2\frac{1}{2}$ Fluosilic acid ...	52·72

Now we observe that their power of preventing combustion is just in the order of their density. Sulphurous acid was also tried, but it was found to hold about the same place that muriatic acid did, which it should not do, as it is denser than carbonic acid, its sp. gr. being 32·1 (hydrog. = 1). It appears, however, that it is decomposed when there is more than a certain proportion of oxygen present to invigorate the combustion; as on inspecting the flame the external blue shell of flame, where the principal combustion takes place, was found to be enlarged and considerably stronger in colour, and a red streaky appearance was also observed in the flame, precisely similar to that observed in the flame of sulphuretted hydrogen, from separation, I believe, of particles of sulphur; this being in accordance with the fact, that hydrogen and carbon at a temperature of ignition decompose sulphurous acid.

Sir Humphry Davy tried the effect of various mixtures of gases in preventing the explosion of oxygen and hydrogen, a table of which he has given. To many of these this explanation does not apply, as the greater part of those he employed were combustible gases; and there is most probably in that circumstance other causes affecting the result, only to be avoided by employing incombustible gases. He has noticed, however, that a wax taper is extinguished in air containing $\frac{1}{10}$ th of silico-fluoric and $\frac{1}{6}$ th muriatic acid gas; also that a larger quantity of steam is necessary to prevent the explosion of oxygen and hydrogen than of nitrogen. This latter fact is usually connected by chemical writers with the heat necessary to maintain steam in the state of gas, but it appears rather to be one instance among the others following the general law; that, *of incombustible gases which remain undecomposed the power of preventing combustion is in the order of their density*: what the exact ratio is I cannot at present say, but beginning with steam, which has a sp. gr. = 9. (Hydrog. = 1), we have the gases increasing in this power in the order already given in the table, namely, nitrogen, muriatic acid, carbonic acid, and fluosilicic acid. The vapour of anhydrous sulphuric acid, sp. gr. = 40·1, should stand between the carbonic and fluosilicic acids, if no decom-

position takes place; this I have not yet tried. *This effect of density in cooling the flame depends on the excessive diffusion of the flame in the denser gas.*

The effect of diffusibility on a flame burning in another gas is obvious enough, for it is visible; but when the gases are mixed together in one vessel its influence is not so easily perceived. It appears to me, however, that in this case it operates in a similar manner: in passing an electric spark through an explosive mixture, or applying a heated body to it, the combination and combustion take place amongst the particles immediately in contact with the exciting cause, and are thence propagated to the rest of the mixture; when the gases are pure, this takes place so rapidly as to appear instantaneous; but if they be diluted with another gas, the progress of the flame may be easily seen. In a mixture which does not explode by the electric spark, I conceive that the particles of the combustible mixture immediately subject to the influence of the spark do combine, but that being diffused to too great a degree, either from excessive dilution or from excessive diffusibility in a denser gas, the temperature is reduced so much that it does not cause combination of the rest of the mixture. This idea seems to be confirmed by the fact (Turner's Elements, sixth edit., p. 252), that "An explosive mixture diluted with air to too great a degree to explode by electricity, is made to unite silently by a succession of electric sparks," namely, from new particles of the mixture coming to be subjected immediately to the action of the spark. This view is likewise supported by other considerations.

In the table I have given fluosilicic acid does not seem to be so powerful as it should be, but this probably depends on impurity. These experiments would require to be repeated on a larger scale, as mine were performed with a jar capable of containing only about 4 oz. of water, and a still smaller trough, with 6 or 7lbs. of mercury.

These researches throw complete light on the action of the blowpipe: the jet of air thrown into the central cool part of the flame is in precisely the same circumstances, and has exactly the same appearance as a jet of air burning in the flask containing a carburetted hydrogen gas, except of course in being surrounded by a hot external flame, and therefore improved by this circumstance. In this case we see the two phenomena at once, the vapour burning in the air, and the air burning in the vapour. Hence also the reason why the flame of the blowpipe is so distinct when thrown through this

part of the flame, and so different when projected on the upper part, where the gas being already mixed with air it can act only as a mechanical agent.

This may be seen very well with sulphur. A crucible of moderate size was filled to about one third with sulphur, and placed on a charcoal fire till it boiled. A jet of oxygen flowing with a certain force was introduced within the upper part of the cavity of the crucible, entirely within the blue burning flame of the sulphur outside; a strong yellowish tapering flame was observed, darkish in centre, and red at edges and tail, of about one inch in length. The same experiment was repeated with the same circumstances, substituting air for oxygen; a very slender jet of blue flame was observed darkish at centre, and red at the tail, greatly smaller than that of the oxygen. These flames are of course expanded by the heat of the vapour to double their volume, but their relative size is in accordance with the principles already laid down.

The influence of quantity is also well seen when diluted gases are burnt from a jet. Thus 1 oxygen and 8 nitrogen or carbonic acid will not burn in the flask filled with hydrogen from the brass jet commonly used, nor even from the tobacco pipe, but will do so from the mouth of the flexible tube about one-fifth inch diameter, forming a thin blue hollow cone of flame, fig. 6; sometimes this cone was deficient at the top, and was extinguished when the gas was made to flow with greater velocity.

In these cases when the diluted gas issues from a small orifice the heat produced from the combustible mixture of the gases is so little that it is cooled by the velocity of the current; from a larger orifice it comes more slowly, and the small quantity of combustible mixture formed constitutes the thin shell of flame observed.

These then seem to be the primary causes regulating the size and appearance of flames, hitherto, so far as I am aware, unobserved or undescribed. Probably, however, these are not the only causes, particularly with compound gases. I have made a few observations on these, and have observed some peculiarities, in nitrous oxide for instance; to these however I shall not advert until they have been examined more particularly. One peculiarity in the flame of hydrogen must have been frequently observed, namely, a green jet inside of the usual dark central portion; and when the flame is full, a dark central part even in this. Having only unsupported conjecture to offer in explanation of this, I shall refrain from saying anything at present. There are

also peculiarities of colour and appearance of the external envelopes and tails so often referred to, which might be worth examining.

These remarks have, I trust, thrown some additional light on the nature of gaseous combustion and the influences affecting it. The inquiry seems to be worth the prosecuting, in order to obtain accurate results. For this purpose superior apparatus is required: one most essential instrument is a gas reservoir, from which gas can be expelled with any degree of force that may be required, and with considerable accuracy. The flask I may also remark, though it may do very well for most flames, does not suit well those which require a large and free supply of the atmospheric gas; thus olefiant gas will scarcely burn in the flask full of air: it shakes violently as if seeking for air, and then goes out; and this cannot be remedied by forcing in air, as the agitation thereby produced blows out the flame. By pursuing the investigation with greater accuracy, results may probably be obtained that may assist in elucidating the nature and affections of gaseous bodies. In the mean time I shall prosecute the inquiry as much as lies in my power, with the view of giving greater accuracy to the results already obtained, or making new observations connected with the subject.

Linlithgow, June 2, 1838.

XV. *Researches on Heat. Third Series.* § 1. *On the unequally Polarizable Nature of different Kinds of Heat.* § 2. *On the Depolarization of Heat.* § 3. *On the Refrangibility of Heat.* By JAMES D. FORBES, Esq., F.R.SS. L. & E., Professor of Natural Philosophy in the University of Edinburgh.*

[Illustrated by Plates II. & IV.]

§ 1. *On the unequally Polarizable Nature of different Kinds of Heat.*

IT has been my anxious wish to preserve these papers pure from even the appearance of controversy, and those who have paid attention to the recent history of our present subject must be aware that without making direct allusion to the doubts which have at different times been thrown upon my experiments, I have contented myself with adducing new facts and more convincing reasonings; and I have had the satisfaction to see that the general result of this course has been

* Read before the Royal Society of Edinburgh 16th of April 1838: abridged by the Author from the Transactions of that Society, vol. xiv.; and communicated by him.