On the Colour of a Hydrogen Flame

ACCEPTING, for the time being, the experiments of Mr. Barrett as sufficient proof that a pure hydrogen flame does not exhibit a blue colour, my "elaborate theory" must, I suppose, seek refuge under the actinic power of the electric light.

Mr. Murphy refers this actinism to the fact "that the electric light is *bluer* than solar light," the blue rays of the sun's light having been abstracted by absorption. This is a bare fact, and deals solely with the relative proportions of the different coloured rays which reach us from the two sources—it conveys no clue to the reason *why* the blue rays have an entity in the first instance.

I would not have it understood that I consider *all* the high refrangible rays to be due to secondary waves; but I think it possible that some, at least, of those emitted from sources of a very high temperature may owe their existence to this cause. Considering for the moment the electric light, we have a centre of the most intense commotion sending off waves in all directions—a condition necessary, and at the same time eminently favourable, for the production of secondary waves.

With respect to Mr. Barrett's experiments, I intend to repeat them as soon as I can command the time. The absence of the higher refrangible rays in a hydrogen flame does not, however, affect the mechanical possibility of the existence of secondary waves; although it would be reasonable to expect their presence in a pure oxy-hydrogen flame, the amplitude of the disturbed particles being necessarily very great. A. G. MEEZE

Hartley Institution, Southampton, April 15.

Another Aurora

A MAGNIFICENT aurora, scarcely inferior to that of February 4, was observed here on the evening of the 10th inst., between 8^h 30^m and 9^h 30^m.

The display was at its greatest beauty about 9^h 0^m, when the creamy-white streamers attained an altitude of at least 60° above the N. horizon, and formed a fine contrast with a pale rose-pink background. The streamers appeared to proceed from behind a dense mass of stratus cloud which, although a moderate breeze was blowing from the S.W., remained almost stationary and unaltered during the display. The N. horizon was lighted up with a glow as intense as the early twilight on an evening in June.

With a small direct-vision spectroscope by Browning, I could see the line in the green near F, but no others. It was remarkably bright and sharply defined.

Bedford, April 12

THOS. GWYN E. ELGER

Brilliant Meteor

YESTERDAY afternoon, whilst standing on the lawn of the Observatory with my back to the sun, which was brightly shining, I saw a splendid meteor fall in the south-east. The sky at the time was of an intense blue and cloudless, with the exception of a few cirri in the north and north-west, and the meteor as seen against it presented the appearance of polished silver. The flight of the meteor was almost vertical at an altitude of about 30°, its extent was about 10°, and the trail which seemed to hang in the air and fade away like the trail of a rocket, was at the instant of explosion probably 3° in length. There was no report accompanying its disruption, or it would certainly have been heard, the neighbourhood being very still at the time.

Immediately on its disappearance I looked at my watch, it was 4^h 36^s P.M. G.M.T.

Had the fall occurred after dark I have no doubt but that the meteor would have exhibited a magnificent spectacle, for its brilliancy far exceeded that of the moon as seen by daylight.

During the aurora on the evening of the 10th I observed at 9.16 P.M. a peculiar well-defined patch or short band of bright red light, the position of which, as seen from here, was N.N.E. altitude 40° to 45°. Perhaps other observers may have noticed it, and their observations will give data which may serve to assist in determining the true height of the auroral discharge.

The magnetic disturbance on the 10th commenced abruptly at 2 P.M., and was greatest during the hours of daylight, so it is extremely probable, the sky being but partially clouded, that if the aurora was visible before night, some observers may have seen it. I cannot say I have ever seen it myself in the daytime, although I have repeatedly seen cirrus clouds assuming a form very similar to auroral streamers. However, on looking at the

magnets and finding them undisturbed at the time, I have concluded that no aurora was taking place.

Kew Observatory, April 13

G. MATHUS WHIPPLE

Tide Gauges

THE subject of the tides is now one in which much interest is taken by the committee of the British Association, and it would be a great boon to many who are in a position to give attention to it, if some of your readers would supply a description of a self-registering gauge for recording the heights, which should do its work effectively and not very expensively. Many plans are suggested; the difficulty is to know which is the best.

Vicarage, Fleetwood, April 11

JAMES PEARSON

NOTES ON THE RAINFALL OF 1871

THE following are a few particulars of the rainfall of the past year, deduced from daily observations with Glaisher's (Hall's improved) rain gauge* at Fulwell,† near Twickenham, Middlesex, the place of observation being in lat. 51° 26' 0" N. long. 0° 20' 53" W.

The orifice, or receiving surface of the gauge, which is placed horizontally, is 8.00 inches in diameter (50.26 in area), the height of the same above the ground being one foot, and, as determined by spirit levelling from Ordnance B.M., 47 feet above mean sea-level.

The results of the observations have been calculated in the imperial system, and metric equivalents are placed in brackets, the use of which (brackets), for the sake of distinction, has been avoided in all other formulæ; they have, in each instance, been calculated to two or three places of decimals, but are here given, so far as is practicable, in whole numbers; the nearest integer, in each instance, having been taken; *they have further been calculated upon the hypothesis that the rainfall was equally distributed.*

In the following table:—

α = depth of rainfall in inches	} Total fall per month. Equivalents per acre.
β = depth in centimetres	
γ = number of gallons	
δ = number of hectolitres	

	α	β	γ	δ
January	2.03	5.156	45,675	2,074
February	1.00	2.540	22,500	1,022
March	1.08	2.743	24,300	1,103
April	3.52	8.941	79,200	3,596
May	0.62	1.575	13,950	633
June	3.21	8.153	72,225	3,279
July	3.00	7.620	67,500	3,065
August	0.93	2.362	20,925	950
September	4.20	10.668	94,500	4,291
October	1.10	2.794	24,750	1,124
November	0.54	1.372	12,150	552
December	1.19	3.023	26,775	1,216

The total depth during the year was 22.42 in., or 56.947 centimetres.

The rainfall on a square mile during the year was $22,500 \times 640 \times 22.42 = 322,848,000$ gallons ($\div 22.024 = 14,658,918$ hectolitres), or $640 \times 4840 \times 9 \times 22.42 \div 12 = 52,086,144$ cubic feet ($\div 35.31658 = 1,474,835$ cubic metres).

A cubic inch of distilled water at a temperature of 62° Fahr. (16.66 C.) is a standard of weight; this quantity has been determined to weigh 252.458 grains, of which 437.5 make one ounce Av. ;‡ therefore, a cubic foot weighs

* Vide *Scientific Opinion*, Vol. iii., pp. 429, 440 (May 18, 1870).

† Although the observations refer especially to this locality, they will probably be scarcely the less interesting.

‡ *Practical Meteorology*, by John Drew, Ph.D., sec. 127, p. 190.

$\frac{252'458 \times 1728}{437'5} = 997'137$ oz. Av.; hence we may assume that the entire weight of water which fell on one square mile was $\frac{52,086,144 \times 997'137}{35,840} = 1,449,136$ tons,

($\div .984 = 1,472,699$ milliers). Some idea of this enormous quantity will be afforded by the following illustrations.

The Thames at London Bridge is, at low water, nearly 700 feet wide,* and from 12 to 13 (say 12'5) feet deep. We will, for the sake of argument, assume the sectional area throughout to be $700 \times 12'5 = 8,750$ square feet. The amount of rainfall on a square mile was equivalent to a volume of water corresponding in sectional area to

the Thames at London Bridge, and extending $\frac{52,086,144}{8,750 \times 5280} = 1'127$ miles in length; in other words, it would extend from London Bridge, past Cannon Street (Railway), Southwark and Blackfriars (Railway and Road) Bridges, to about Somerset House, or nearly to Waterloo Bridge.

The same quantity of water would equal the contents of a river or canal having an uniform width of 20 feet, and depth of 5 feet—the sectional area being 100 feet—extending nearly 99 miles, or 159 kilometres in length.

The cubic contents of a sphere are $\frac{8}{3}$ of that of a cylinder of the same diameter and altitude. But the altitude being equal to the diameter, and $\frac{8}{3}$ of 7854 being 5236, the contents may be expressed as I have arranged it in the following formula. Calling Δ the diameter, and x the cubic contents required, we have

$$\Delta^3 \times 5236 = x,$$

or the reverse, calling C the cubic contents and x the diameter required.

$$\sqrt[3]{\frac{x}{5236}} = x.$$

By these formulæ I have determined that the rainfall on a square mile—under the conditions mentioned in paragraph 3—was equivalent to a globe of water 463 ft. in diameter (approximate), a height exceeding that of the top of the cross surmounting the dome above the pavement of the churchyard of St. Paul's Cathedral (370 ft.†) by 93 ft.

The same quantity of water was equivalent to the following:—

A circular column of water 144 ft. in diameter (corresponding to that of the dome of St. Paul's Cathedral—interior surface‡), rising to a height of 3,198 ft.; in other words, it would be upwards of $8\frac{1}{2}$ times the height of the cross before-mentioned.

Or, with regard to specific gravity:—

A circular column of lead (cast)§ of the same diameter (144 ft.—a cubic foot being taken as 710 lbs., or 11,360 oz.) containing 4,571,921 cubic ft., and rising to a height of 278 ft.

A circular column of granite (Aberdeen) of the same diameter, a cubic foot being taken as 2,690 oz.,|| containing 19,307,443 cubic feet, and rising to a height of 1,184 ft.

But perhaps the most remarkable illustration will be afforded by comparing the weight of this quantity of water to a corresponding weight contained in, say, a number of railway coal waggons. Railway coal waggons are constructed to carry, on an average, from eight to ten tons. Let us assume it as the former of the two, and the average length of a number of waggons as 16 feet

each from buffer to buffer. It would require no less than 181,142 such waggons to carry a corresponding weight of coal (or 3,623 heavy trains of fifty waggons each) which would, when close coupled, *i.e.*, buffer to buffer, extend over a distance of nearly 549 miles (883 kilometres) represented very nearly by the distance from London (Euston Station) to Aberdeen *via* Rugby, Stafford, Crewe, Carlisle, Glasgow, and Perth (London and North Western and Caledonian Railways). An express train, travelling at a uniform speed of sixty miles per hour, would take upwards of nine hours to run this distance, in other words, to pass this number of waggons; or, if I may indulge in another illustration, this number of waggons would, if travelling at a uniform rate of twenty-five miles per hour—which is about the average rate of goods trains—be nearly twenty-two hours in passing any given point, such, for instance, as a station. (Aberdeen is upwards of 130 miles N.N.E. of Edinburgh by the Caledonian Railway—Eastern route from London.)

Such a means of illustration as the one I have here set forth may not be considered in all respects strictly scientific; it has nevertheless this advantage, it enables us to comprehend something of the truth and magnitude of the subject—although dealing with hypotheses—where mere abstract figures would fail to produce anything like a similar result.

JOHN JAMES HALL

ON CERTAIN PHENOMENA ASSOCIATED WITH A HYDROGEN FLAME

PHENOMENA of much interest and possibly of future usefulness are associated with the combustion of ordinary hydrogen.

I. To study these phenomena free from disturbing causes three things should be attended to, although the effects to be described can be obtained without any special precaution.

(a) The gas must be stored and purified in the ordinary way, namely, by passing into a gas-holder through a solution of potash, and then through a solution of perchloride of mercury or nitrate of silver.

(b) From the holder the gas must be led through red or black india-rubber tubing to a platinum, or better, a steatite jet.

(c) And then the gas should be burnt in a perfectly dark room, and amid calm and dustless air.

II. In this way the flame gives a faint reddish brown colour, invisible in bright daylight. Issuing from a narrow jet in a dark room, a stream of luminosity, more than six times the length of the flame, is seen to stretch upward from the burning hydrogen. This weird appearance is probably caused by the swifter flow of the particles of gas in the centre of the tube. The central particles as they shoot upward are protected awhile by their neighbours; metaphorically, they are hindered from entering the fiery ordeal which dooms them finally to a watery grave. Dr. Tyndall has shown that the radiation from burning hydrogen is hugely ultra-red, and moreover, that it has not the quality of the radiation from an elementary body like hydrogen, but practically is found to be the radiation from molecules of incandescent steam. So that, except at its base, a hydrogen flame is a hollow stream of glowing water raised to a prodigious heat.

III. Bringing the flame into contact with solid bodies, in many cases *phosphorescent* effects are produced. Thus allowing the flame to play for a moment on sand paper and then promptly extinguishing the gas, a vivid green, phosphorescence remains for some seconds. The appearance is a beautiful one, as a luminous and perfect section of the hollow flame is depicted. Similar phosphorescence is produced by the flame on white writing paper,

* I quote this from a paper "On the Rainfall of Devonshire," by W. Pengelly, Esq., F.R.S., *Scientific Opinion*, Vol. i. p. 137. (From the Transactions of the Devonshire Association for the Advancement of Science, 1868.) The depth is confirmed in the *Encyclopædia Britannica*, Vol. xxi. p. 163.

† *Encyclopædia Britannica*, vol. xiii. p. 670.

‡ From the Cathedral authorities.

§ "Sprague's Pocket Tables (Architects and Surveyors)," p. 9.

|| *Ibid.*