The first nitrogen would be too heavy, if it contained residual oxygen. But on this hypothesis something like 1 per cent. would be required. I could detect none whatever by means of alkaline pyrogallate. It may be remarked the density of this nitrogen agrees closely with that recently obtained by Leduc, using the same method of preparation.

On the other hand, can the ammonia-made nitrogen be too light from the presence of impurity? There are not many gases lighter than nitrogen, and the absence of hydrogen, ammonia, and water seems to be fully secured. On the whole it seemed the more probable supposition that the impurity was hydrogen, which in this degree of dilution escaped the action of the copper oxide. But a special experiment appears to exclude this explanation.

Into nitrogen prepared by the first method, but before its passage into the furnace tubes, one or two thousandths by volume of hydrogen were introduced. To effect this in a uniform manner the gas was made to bubble through a small hydrogen generator, which could be set in action under its own electromotive force by closing an external contact. The rate of hydrogen production was determined by a suitable galvanometer enclosed in the circuit. But the introduction of hydrogen had not the smallest effect upon the density, showing that the copper oxide was capable of performing the part desired of it.

Is it possible that the difference is independent of impurity, the nitrogen itself being to some extent in a different (dissociated) state?

I ought to have mentioned that during the fillings of the globe, the rate of passage of gas was very uniform, and about $\frac{2}{3}$ litre per hour. RAYLEIGH.

Terling Place, Witham, September 24.

## Recent Spectroscopic Determinations.

IN the September number of the *Philosophical Magazine* Mr. Michelson has published determinations, by a most interesting method, of very close double and multiple lines. In any attempt to interpret his results, it is neccesary to bear in mind the profound modifications which the internal motions of a gas—the rectilinear motions of the molecules between their encounters, as well as the motions going on within each molecule—had undergone within the Geisler's tubes upon which he experimented.

In a gas under ordinary circumstances the rectilinear journeys of the molecules take place indifferently in all directions, and where this is the case it follows from the well-known relation between the surface of a sphere and that of its circumscribing cylinder, that the effect of the velocities which happen to lie between $\nu$ and $\nu + \delta\nu$ is to substitute for each line of the spectrum of the gas a band of uniform intensity and without nebulous edges, the width of which can be calculated. This width, for example, is ·04 of an Ångström or Rowland unit (the tenthetmetre), in the yellow part of the spectrum and for velocities of the molecules which lie in the neighbourhood of two kilometres per second, which is about the average velocity of molecules of hydrogen at atmospheric temperatures. Hence with all the velocities that prevail among the molecules, the effect of the rectilinear motions under ordinary circumstances is that each line will be symmetrically widened and rendered nebulous. To this effect Mr. Michelson calls attention.

But in the residual gas of a Geisler's tube through which electricity is passing, the case is altogether different. Here the rectilinear motions of the molecules are not alike in all directions, but preponderate in some: a state of things which must at least double the lines, and may introduce greater complications.

Moreover, different lines may be differently affected, since the behaviour of the gas varies according to its position between the electrodes; as is evidenced by the observed differences in the form and colouring of the striæ, &c., in the several parts of a Geisler's tube.

We must also be on our guard in another respect, when we attempt to interpret the results, since the distribution of the heat energy of a gas between the rectilinear motions of its molecules and the motions within the molecules, which in the case of ordinary gas is a fixed ratio, is certainly largely departed from in gas through which electricity is passing. Until the laws of the new distribution are understood, the temperature of the gas, judged of by its behaviour to neighbouring bodies, will give us little information.

It is to such events as are referred to above, or others which like them may arise from the special circumstances under which the vapour of sodium was in Mr. Michelson's experiments, that we must apparently turn for an explanation of the doubling of the constituents of the principal pair of sodium lines which he has detected; since he found that "the width of the lines, their distances apart, and their relative intensities vary rapidly with changes in temperature and pressure."

The method of investigation which Mr. Michelson has so successfully applied appears to be by far the most searching means yet discovered of experimentally investigating the intricate and obscure phenomena which present themselves in Geisler's tubes, and we seem justified in hoping for great results from it.

G. JOHNSTONE STONEY.

9, Palmerston Park, Dublin, September 22.

## Printing Mathematical Symbols.

EVERYONE who has had to correct printers' proofs of mathematical formulæ must be painfully alive to the pitfalls into which the non-mathematical compositor continually blunders. To such as know the extreme difficulty of getting such formulæ properly set up, there have doubtless occurred from time to time suggestions for such simplifications of notation as shall render the composition less liable to derangement. One most sensible step of the kind I allude to is the introduction by Sir G. Stokes of the solidus notation for quotients, whereby

$$\frac{dy}{dx} \text{ is now written } dy/dx.$$

The immediate purpose of this letter is not to propound any wholesale scheme of reform, but to advocate one other simple step, and to induce some of my *confrères* to give the world their own suggestions.

Exponentials are a continual stumbling-block to the compositor, and to the printer's reader, who, when he comes to an expression like

$$A\epsilon^{-ax},$$

does his best to make it look a little straighter and turns it into

$$A\epsilon - ax,$$

or into

$$A_{\epsilon} - ax,$$

or perhaps worse.

The reform I advocate is to write the thing as follows:—

$$A\ exp[-ax],$$

the square brackets being possibly omitted in all cases when their omission would occasion no confusion. One gain in this notation is the reduction of the whole of the symbols to one level, so not breaking the line of type.

Another useful reform, though one on which I fear the probability of agreement is less likely, is the use of the Continental notation for inverse trigonometrical functions, writing, for example,

$$\text{arc}\tan x,$$

instead of

$$\tan^{-1} x$$

for the angle whose tangent is $x$. Our notation is not only liable to continual misprinting, but is very confusing to Continental readers, who again and again read the latter expression as meaning

$$(\tan x)^{-1}, \text{ or } \cot\text{an}\ x.$$

I have even seen it reprinted in a German technical journal as

$$\tan - 1x.$$

SILVANUS P. THOMPSON.

Technical College, Finsbury, September 22.

## A so-called Thunderbolt.

DURING a short storm in Liverpool this summer, I noticed one flash as peculiarly sharp and noisy, and subsequently in the correct bearing from my house the ground was reported as having been struck by a thunderbolt. I examined the place, which was on the greensward of a lake, where the ground was penetrated by a number of fairly clean-cut almost vertical holes down which a walking-stick could be thrust. People sheltering near the lake reported a ball of fire and a great splash up of the