no powers and resources to fall back upon, to approach mechanism to mind? Is not photography in its infancy, as painting was in the times of Thotmes III.? Even the old masters, I understand, are going out of fashion.

What I mean to infer is this; the minuteness and accuracy of photography, when projected, must affect the artistic impressions of nature presented to us as signs of things, the meaning of which (signs) we learn inductively by a process of self-education. The mind will oscillate between the beauty and perfection of now the one and now the other, until, for each individual will, the point of rest shall be decided. Sight and mind are under the law of development, and man invents improved mechanism, and finally the fittest instrument will survive.

THE RATE OF EXPLOSIONS IN GASES.*

1. THE results obtained with hydrogen and oxygen, with hydrogen and nitrous oxide, and with marsh gas and oxygen, in exact proportions for complete combustion, were in close accordance with the mean results of Berthelot. For ethylene, acetylene, and cyanogen my numbers differed appreciably, but in no case differed by more than seven per cent., from the rates observed by Berthelot:

TABLE II.—*Velocity of Explosion in Metres per Second.*

	Berthelot.	Dixon.
Hydrogen and oxygen, H_2+O	2810	2821
Hydrogen and nitrous oxide, H_2+N_2O ...	2284	2305
Marsh gas and oxygen, CH_4+O_4	2287	2322
Ethylene and oxygen, $C_2H_4+O_6$	2210	2364
Acetylene and oxygen, $C_2H_2+O_5$	2482	2391
Cyanogen and oxygen, $C_2N_2+O_4$	2195	2321

The general agreement between these measurements left no room for doubt about the substantial accuracy of Berthelot's experiments. The formula he gives does therefore express, with a close degree of approximation, the rates of explosion of many gaseous mixtures.

2. The formula fails for the explosion of carbonic oxide with oxygen or nitrous oxide. This was to be expected if—in the detonation of carbonic oxide in a long tube—the oxidation is effected indirectly by means of steam, as it is in the ordinary combustion of the gas. Measurements of the rate of explosion of carbonic oxide and oxygen in a long tube showed that the rate increased as steam was added to the dry mixture, until a maximum velocity was attained when between five and six per cent. of steam was present.

3. When electrolytic gas was mixed with an excess of either hydrogen or oxygen, the rate of explosion was found to be altered; the addition of hydrogen increasing the velocity, the addition of oxygen diminishing it. The addition of an inert gas, nitrogen, incapable of taking part in the chemical change, produced the same effect as the addition of oxygen—one of the reacting substances—only the retarding effect of nitrogen was less marked than that of an equal volume of oxygen. The retardation of the explosion-wave caused by the addition of an inert gas to electrolytic gas evidently, therefore, depends upon the volume and the density of the gas added. In the following table the retarding effect of oxygen and nitrogen on the explosion of electrolytic gas is compared:—

TABLE III.—*Rate of Explosion of Electrolytic Gas with Excess of Oxygen and Hydrogen.*

Volume of oxygen added to H_2+O	O_1	O_3	O_5	O_7
Rate	2328	1927	1690	1281
Volume of nitrogen added to H_2+O	N_1	N_3	N_5	N_7
Rate	2426	2055	1822	—

* Concluded from page 652.

I think it a fair inference from these facts to conclude, when the addition of a gas to an explosive mixture retards the rate of explosion by an amount proportional to its volume and density, that such added gas is inert as far as the propagation of the wave is concerned, and that any change which it may undergo takes place after the wave-front has passed by—in other words, is a *secondary* change.

This principle has been applied to determine whether, in the combustion of gaseous carbon, the oxidation to carbonic acid is effected in one or two stages—an important question, on which there is little experimental evidence. If, for instance, in the combustion of a hydro-carbon, or of cyanogen, the carbon is first burnt to carbonic oxide, which subsequently is burnt to carbonic acid, the rate of the explosion-wave should correspond with the carbonic oxide reaction, in this case the primary reaction; whereas, if the carbon of these gases burns to carbonic acid directly, in one stage, then the rate of the explosion-wave should correspond with the complete reaction.

Now, if we adopt Berthelot's formula as a working hypothesis, we can calculate the theoretical rates of explosion of marsh gas, ethylene, or cyanogen—(1) on the supposition that the carbon burns directly to CO_2; and (2) on the supposition that the carbon burns first to CO, and the further oxidation is a subsequent or secondary reaction. On the first supposition, if 100 represents the rate of explosion of these three gases burning to carbonic oxide, the addition of the oxygen required to burn the gases to carbonic acid should *increase* the rate of explosion:—

	Marsh Gas.	Ethylene.	Cyanogen.
Calculated rate of explosion when burnt to CO_2	104	103	107

Whereas if these gases really burn first to carbonic oxide, and the extra oxygen is inert in propagating the explosion-wave, then the addition of this inert oxygen would diminish the rate of explosion:—

	Marsh Gas.	Ethylene.	Cyanogen.
Calculated rate of explosion when burnt to CO with inert oxygen present	92	88	87

The experiments show that if 100 be taken as the rate of explosion when the oxygen is only sufficient to burn the carbon to carbonic oxide, the following are the rates found when oxygen is added sufficient to burn the carbon to carbonic acid.

	Marsh Gas.	Ethylene.	Cyanogen.
Rates found	94	92	84

The results are, therefore, in favour of the view that in the explosion of these gases the carbon is first burnt to carbonic oxide.

But stronger evidence on this point is obtained by comparing the explosion rate of these gases (1) when fired with oxygen sufficient to burn the carbon in them to carbonic acid; and (2) when nitrogen is substituted for the oxygen in excess of that required to burn the carbon to carbonic oxide. We have seen that oxygen added to electrolytic gas hinders the explosion more than nitrogen. In precisely the same way, oxygen added to a mixture of equal volumes of cyanogen and oxygen hinders the explosion more than the same volume of nitrogen. The conclusion we must come to is, that the oxygen added to