

ON THE REDUCTION OF LIGHT DUE TO THE PRESENCE OF CARBONIC ACID IN ILLUMINATING GAS.

(Read before the American Association for the Advancement of Science, Troy Meeting.)

By FRED. E. STIMPSON.

[THE experiments here detailed were made by Prof. William B. Rogers, in 1863, and a meagre abstract appears in the Reports of the British Association, at its Bath meeting, 1864, p. 40. The details have never before been published.—F. E. S.]

It is a familiar fact that carbonic acid gas is incapable of burning, and that a flame of any kind plunged in an atmosphere containing a large amount of it, is immediately extinguished. Its presence, therefore, in considerable quantity, in ordinary illuminating gas, might be expected to impair its illuminating power. But in the small proportion of one or two per cent., in which, at some manufacturing, it is allowed to remain in the gas, the evil is so inconspicuous as to have led to the belief that a more complete removal of the impurity is practically of no importance.

The opinion has even been advanced, that in such small quantities, its action is merely that of diluent, serving, when present in such gas, to facilitate the combustion, to the extent, at least, of compensating for the loss of light it might otherwise occasion.

These reasons in favor of an incomplete removal of the carbonic acid are moreover strengthened by the fact, that in separating the last portions of this impurity by the dry lime, or other purifying process, we at the same time arrest a small portion of the illuminating ingredients of the gas, and thus run the risk of weakening, instead of strengthening its illuminating power.

These vague and uncertain impressions as to the action of small quantities of carbonic acid, and as to the economy of its removal, suggest the importance of a thorough experimental investigation on the subject, and have led me to make the series of observations which follow; offering, I believe, the first conclusive results thus far published on this interesting question in the science and economy of gas lighting.

Mode of conducting the experiments.—1. The carbonic acid was evolved from Bi. Carb. Ammonia, by the action of dilute sulphuric acid, using the common form of self-regulating apparatus, and passing the gas through water in a wash bottle properly connected with the exit pipe.

2. The mixture of carbonic acid and gas was made in a diaphragm gas-holder, from which it was afterward delivered to the burner in the photometric experiments. To effect this mixture, gas was turned on to one side of the diaphragm, and the other compartment, as far as possible, emptied. The carbonic acid was then turned in upon the latter until a sufficient volume was introduced, then this compartment was filled with gas, the first gas admitted being expelled in corresponding quantity from the other side. The whole being closed in, the vessel was repeatedly inverted and turned from side to side, with the view of thoroughly incorporating the contents, and when this was thought to be effected, and before connecting the holder with the photometrical apparatus, a portion of the mixture was taken out for analysis.

3. The percentage of carbonic acid in the mixture was determined in a graduated tube over mercury. In the first experiment the tube was filled by displacement through mercury. Afterwards it was found more convenient, and quite as accurate, to fill by displacement with a long inserted tube in air.

The absorbent was a ball or rod of caustic potassa (the latter being the more prompt), fixed upon the end of a long wire.

4. The illuminating power was determined by passing successively the common gas and the mixture through the same dry meter, at equal or nearly equal rates (5 feet per hour), and burning them from the same 15-hole argand burner, and comparing their respective lights with a third light, also burning 5 feet per hour, at the other end of a photometric bar, 150 in. long.

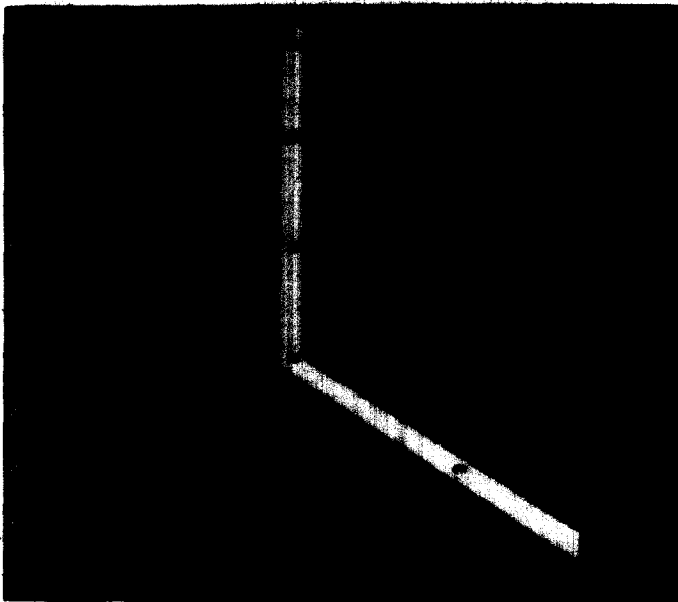
These two results were then reduced to equality of delivery.

EXPERIMENTS.				CO ₂	Ill.
				2·6 p. c.	Power.
(1.)	Boston Gas, containing about	“	by determination	24·	·203
	Mixture	“	“	26·6	·152
	“	“	“	16·25	·400
	“	“	“	8·75	·667
(2.)	Boston Gas,	“	“	2·5	1·000
	Mixture	“	“	12·5	·609
	“	“	“	29·	·084
	“	“	“	58·5	·060
(3.)	Boston Gas,	“	“	2·50	1·000
	Mixture	“	“	24·	·193
	“	“	“	12·	·619
(4.)	Boston Gas,	“	“	2·8	1·000
	Mixture	“	“	4·6	·903
	“	“	“	4·4	·936
(5.)	Boston Gas,	“	“	2·4	1·000
	Mixture	“	“	3·3?	·921
	“	“	“	5·8	·854

NOTE.—From the above we obtain the following table: Allowing 2.6 per cent. to produce a loss of $2.6 \times .0364 = .094$ loss of light.

Pure Gas	Per cent. CO_2 .	Ill. Power = 1000.	Loss.	Per cent. loss Ill. Pow. for each per cent. CO_2
	2.6 =	.906	.094	...
	3.3 ? (4.3)	.840	.160	5
	5.8	.779	.221	4
	4.5	.820	.180	2
	8.75	.604	.396	$4\frac{1}{2}$
	12.	.563	.437	$3\frac{1}{2}$
	12.5	.554	.446	$3\frac{1}{2}$
	16.25	.363	.637	$3\frac{3}{4}$
	24.	.183	.817	$3\frac{1}{2}$
	24.	.175	.825	$3\frac{1}{2}$
	26.61	.137	.863	$3\frac{1}{4}$
	29.	.076	.924	$3\frac{1}{8}$
	58.5	.000	1.000	...

I have put these results in the form of a curve, and, for the purpose of comparison, have added a curve representing the loss due



to the addition of atmospheric air, taken from Audoin and Bérard's Experiments. *Annales de Chimie, &c.*, 1862.—F. E. S.

In the next experiments the gas was passed through hydrated lime, according to the ordinary method of the dry lime process.

(6.) Boston Gas, Carbonic Acid (undetermined)	1.000
The same purified through Lime, "	1.060
(7.) Boston Gas, Carbonic Acid, 2.2 per cent.....	1.000
The same partially Purified,	1.030

The difference between experiment 6 and 7 may have been partly due to the presence of a larger amount of carbonic acid in the former case. This small effect on the illuminating power of the 2 per cent. of carbonic acid taken out is in striking contrast with that observed in the former case, where 2 per cent. was added, and leads to the suspicion that the lime removes some of the illuminating ingredients at the same time that it abstracts carbonic acid.*

(8.) The lime was removed and replaced by broken fragments of pumice-stone, boiled down in solution of potassa (13°) until the water was nearly all evaporated.		
Partially purified gas, carbonic acid	0.3 per cent.	1.070
Boston Gas, " "	2.7 "	1.000
" " purified " "	0. "	1.055
(9.) " " " "	2.7	1.000
" " purified " "	0.5	1.073
(10.) Boston Gas	2.58	1.000
Purified so that it did not act on baryta water while passing through for 5 minutes.....	0.	1.061
The same partially purified	1.61	1.035

These results not being altogether satisfactory, further experiments were made upon gas manufactured by the Charlestown Gas Light Company, in the office adjoining their works.

This gas was purified by the dry lime process, and being nearly free from carbonic acid, was well suited for determining the effect of small additions of this impurity on the illuminating power. Observations with the absorption-tube, made at intervals during

* Indeed, both in these and next two experiments with potassa, the purifying material was colored slightly green by the absorption of some other ingredient than carbonic acid.

It was found, also, that the lime and potassa soon ceased to act upon the acid, and, on opening the purifier, this loss of action was accounted for by finding the purifying material quite *dry*. Its action could be restored again, for a time, by re moistening it. That this inaction does not occur so soon when the crude and sulphurous gas is acted upon in the ordinary dry lime process, I think, is quite clear, for I have frequently determined the carbonic acid in gas purified by that process, and have found, almost without exception, that when the sulphuretted hydrogen was taken out, I could discover but faint traces of carbonic acid. And it has been equally true, that when sulphuretted hydrogen was present, carbonic acid was also present.—F. E. S.

the continuance of the experiments, gave the percentage of carbonic acid in the gas 0·3, 0·3, 0·2, 0·2.

The following table gives the results obtained by these experiments: pure gas being 1·000.

Per cent. Carb. Acid in gas.	Ill. Power.	Loss of Ill. Power.	Loss per cent. Ill. for per cent. C O ₂ .
1·0	1·000		
1·9	·900	·100	5·2
2·1	·888	·116	5·5
2·2	·878	·122	5·5
3·1	·814	·186	6·
4·2	·769	·231	5·5
6·6	·707	·293	4·4
6·7	·710	·290	4·3
9·7	·555	·444	4·5
9·7	·618	·318	3·9

From these results, it would seem that at least 10 per cent. of the light was destroyed by the addition of 2 per cent. of carbonic acid; and it is but reasonable to expect that if we could take out that 2 per cent. without removing any illuminating ingredient, there would be a corresponding gain.

LIST OF OBSERVATIONS ON THE POLARIZATION OF THE CORONA.

By PROF. EDWARD C. PICKERING.

IN the observations of the eclipse, on the 22d December of last year, one of the principal questions to be determined will be the constitution of the corona. As both the spectroscope and polariscope will be used for this purpose, and it seems desirable to collect what has already been done with these instruments. The observations with the spectroscope are well known, being confined to the eclipses of 1868 and 1869. In the former, nothing unusual was seen in the corona spectrum, and it was supposed to be the same as that of the sun. The observations of last year, however, especially those of Prof. Young, showed no dark lines, but at least one bright one. The observations with the polariscope are more scattered, but the following list includes the most important. I have endeavored to give, where possible, the exact words (or the most literal translation) of each observer's report, with the place of its publication, and in some cases a short criticism.

This question appears to have been first suggested by Arago in