On Webster's Method of Preparing Oxygen Gas from a Mixture of Nitrate of Soda and Oxide of Zinc. By JOHN HENRY PEPPER, Esq., F. C. S., A. Inst. C. E., Professor of Chemistry, and Hon. Director of the Polytechnic Institution.

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The statement, that large quantities of oxygen gas could be quickly and easily procured from a mixture of one part, by weight, of nitrate of soda, and two parts of crude oxide of zinc, obtained from the (so-called) galvanizing zinc-pots or baths of Birmingham and other places, appeared so doubtful, that, prior to the introduction of the new process at the Polytechnic, I was induced to visit Mr. Webster and his co-patentee, Mr. John H. Porter, at Bent's wharf, Cannon Row, Westminster, in order to investigate practically the working of this new mode of making oxygen gas.

The apparatus, arranged for the manufacture of oxygen and other products, consists of a circular, portable, iron, fire-brick lined furnace, containing an inner, strong, cast-iron vessel, 10 inches in diameter, furnished with a cover and iron tube; into this is placed a second cylindrical iron pot or retort, of 7 ins. diameter, open at the top, and provided with an orifice at the base, temporarily stopped with a piece of sheet iron, so that, when the materials used are exhausted, the inner pot can be removed, and the contents easily knocked out with an iron bar; and as the product left after the disengagement of the gas is not allowed to fuse, and only becomes slightly coherent or pasty, this cylindrical form of retort, open top and bottom, and placed in an outer vessel of iron, which can be properly closed by a luted cover, answers remarkably well, and may be used by any intelligent workman. In connexion with the outer iron vessel is a 1½-inch iron pipe luted into a stoneware tube, forming part of, and leading to the bottom of a 30-gallon stoneware vessel, containing half a gallon of water (5 lbs.), and eight movable stoneware, colander-like shelves; upon these are placed 48 lbs. of residue, which have been taken out of the retort after a former experiment, *i. e.*, when the oxygen has been obtained from it. This residue, or *caput mortuum*, consisting (as will be noticed more particularly in another part of this paper) of oxide of zinc, caustic soda, nitre, nitrite and nitrate of soda, &c., is moistened with half a gallon of water, and carefully placed on the shelves, which are fitted in one after the other, commencing at the bottom of the vessel. The purifier, thus arranged, is furnished with a lid dropping into a water-joint, and the whole connected with a sheet iron gasometer, painted inside and out, and having a sectional area of 28·2744 feet, making the cubical contents per vertical inch 2·3562 c. i.

As the success of the process, so far as the maximum of oxygen is concerned, depends greatly on the thorough dryness of the materials used, 12 lbs. of nitrate of soda were dried on a hot plate forming the top of the circular iron furnace, and 24 lbs. of oxide of zinc were made red-hot in the retort; the loss of weight by this method of drying was very slight, and did not exceed an ounce or so in either case.

Ten pounds of the dry and warm nitrate of soda, and 20 lbs. of the dry and warm oxide of zinc, were then roughly mixed together in an iron tray, and dropped through an iron funnel into the inner red-hot retort, which could be easily lifted in or out of the exterior one by means of a chain and little crane attached to the furnace.

The cover, provided with a hole at the top, was then luted on with a mixture of Stourbridge clay and sand, and in about a minute or so the nitrate of soda gave off oxygen, colored with the orange-red fumes of nitrous acid: the top aperture was now closed, and the connexion with the purifier and gasometer opened at 1.30 P. M.

The following columns show the rate at which the gas was made, although it is right to state that the gas comes over frequently much faster:—

Time.	Vertical Inches, equal to 2.3562 Cubic Feet.									
1.30										
1.35	.	.	.	.	.	.	.	.	.	1.50
1.40	.	.	.	.	.	.	.	.	.	1.90
1.50	.	.	.	.	.	.	.	.	.	2.30
2.00	.	.	.	.	.	.	.	.	.	3.00
2.10	.	.	.	.	.	.	.	.	.	4.30
2.30	.	.	.	.	.	.	.	.	.	6.75
2.40	.	.	.	.	.	.	.	.	.	8.50
2.50	.	.	.	.	.	.	.	.	.	9.75
3.00	.	.	.	.	.	.	.	.	.	11.00
3.10	.	.	.	.	.	.	.	.	.	12.00
3.20	.	.	.	.	.	.	.	.	.	13.00
3.30	.	.	.	.	.	.	.	.	.	13.30
3.45	.	.	.	.	.	.	.	.	.	14.00
4.00	.	.	.	.	.	.	.	.	.	14.30

$$2.3562 \times 14 \text{ vertical inches} = 32.968 \text{ cub. feet.}$$

Directly the gas ceased to come over, the valve in connexion with the gasometer was turned off, and the inner retort being lifted out with the contents (the residue or *caput mortuum* already mentioned), and weighed, was found to have lost 5.5 lbs. After knocking out the residue, the retort was again quickly charged, at 4h. 5m. P. M., with a fresh mixture of 10 lbs. nitrate of soda, and 20 lbs. of oxide of zinc, which gave off the whole of the gas by 6h. 30m. P. M.

The gas amounted to 14.3 vertical inches—

$$14.3 \times 2.3562 = 33.69 \text{ cubic feet,}$$

and the loss of weight of the materials used was again found to be 5.5 lbs. The residue in the purifier having now been used for these two charges, was taken out, and it weighed 2 lbs. heavier than before, in consequence of its having absorbed nitric acid. The residue was then digested with the whole of the weak nitric acid which had been absorbed by the half-gallon of water placed at the bottom of the purifier (the whole weight of the acid being about 11 lbs.), and when perfectly dried and warm it weighed 48 lbs. It was then placed in the retort and lost 4 lbs., producing (according to Mr. Webster, who watched the operation to the end) 28 cubic feet of gas—thus showing that when 50 lbs. of refuse material out of the retort are used to purify the gas from 20 lbs. of nitrate of soda, the nitric acid obtained during the process is retained, partly by the solid substance, and

partly by the water in the purifier, and that, if the whole is then mixed, digested, dried, and subsequently heated in the retort, it will give out almost as much gas (28 cubic feet) as 10 lbs. of fresh nitrate of soda (33 cubic feet).

The 50 lbs. of residue were procured after heating a mixture of 20 lbs. of nitrate of soda and 40 lbs. crude oxide of zinc; so that the quantity of gas obtained by this plan from 20 lbs. of nitrate of soda, and using the nitric acid, amounts to—

1st charge of 10 lbs. nitrate of soda and 20 lbs. crude oxide of zinc, .	Cubic feet.
2d ditto, ditto,	32·986
3d. Material out of purifier, after being used to absorb the nitric acid produced from Nos. 1 and 2,	33·69
	28·00
Total cubic feet,	94·676

Theoretically, and supposing the 20 lbs. of nitrate of soda were chemically pure, and decomposed into oxygen and nitrogen, leaving a residue of soda, the loss should be 12·82 lbs.; the loss was, however, $5\cdot5 \times 2 = 11$ lbs. The nitrate of soda used was the ordinary commercial article, and contains $2\frac{1}{4}$ per cent. of chloride of sodium.

The gas obtained from the nitrate of soda and oxide of zinc was analyzed by the phosphorous method, and also by the usual hydrogen mixture fired by the electric spark in Ure's syphen eudiometer, and gave, as the mean of several experiments, 59 volumes per cent. of oxygen gas, and 41 volumes per cent. of nitrogen.

94·676 cubic feet of gas, therefore, contain—

	lbs.	oz.
55·858 cubic feet of oxygen* =	4	11
38·818 cubic feet of nitrogen =	2	13
Nitric acid and loss	3	8
	11	0

The nitric acid appears to be formed during the first stage of the process, when the materials thrown into the red-hot retort are comparatively cold, and evolve nitrous acid NO_3 , and oxygen; these gases, in the presence of the moisture of the purifier, form nitric acid, and it is very likely that when a second and smaller red-hot iron vessel, containing oxide of zinc, or, still better, oxide of copper, is connected with the first iron retort, any acid produced during the process would be decomposed perfectly by the second red-hot surface, and, even if nitrate of zinc or copper were formed, it would be ultimately decomposed into nitrogen, oxygen, and oxide of copper. The experiment again, twice repeated, afforded nearly the same results:—

Experiments.	Nitrate of Soda.	Oxide of Zinc.	Loss.	Cubic feet of Gas.
No. 1,	10 lbs.	20 lbs.	5·25	37
No. 2,	10 "	20 "	5·25	32
2	20 lbs.	40 lbs.	10·50	69

In order to ascertain how often the same 20 lbs. of oxide of zinc could be used with separate additions of 10 lb. charges of nitrate of

* Weight of a cubic foot of oxygen, at a temperature of 60°, barometer 30 inches, Grains.
 Weight of a cubic foot of nitrogen, at same temperature and pressure, 590·8
 517·7

soda, three experiments were tried, as tabulated below, it being understood that the second 10 lbs. was not added until the first had evolved its gas, and so on with the third 10 lbs.

Nitrate of Soda.	Oxide of Zinc.	Residue.	Loss.	Gas. Cubic feet.	Nitric Acid in solid contents of purifier 56 lbs.	Nitric Acid absorbed by water in purifier.
10	20	25.5	4.5	49.47	2 lbs.	3lb. + water 5
10	—	30 0	5.5	47.12	increase in	total 8lbs.
10	—	36.25	3.75	47.12	weight.	Sp. gr. 1.136
30	20	36.25	13.75	143.71	2 lbs.	8lbs. s.g. 1.136

These experiments were performed between 1 P. M. and 10 P. M., and it is evident that there is a great increase of gas, and a reduced proportion of nitric acid. It may be noticed as a proof the rapidity with which oxygen is prepared by this process, that with a small apparatus only capable of containing the three charges above mentioned, it produced 143.71 cubic feet of gas (containing 59 per cent. of oxygen) in nine hours, or nearly 16 cubic feet per hour.

If the apparatus had been large enough to contain more materials, there is no doubt that the same 20 lbs. of oxide of zinc would have done with one or two more separate 10 lb. charges of nitrate of soda.

The oxide of zinc probably acts mechanically (like oxide of manganese with chlorate of potash), and also chemically, as a carrier of nitric acid. When the nitrate of soda is heated, it gives off nitric acid, which is probably taken up by the oxide of zinc, and again decomposed (as the temperature rises) into oxygen and nitrogen; and, as before stated, if a second small red-hot vessel, containing oxide of copper or zinc, was attached to the retort, the whole of the nitric acid would probably be decomposed, and an increased proportion of oxygen obtained.

In order to form some notion of the value of the gas as a means of increasing artificial light, a peculiar shaped Bude Light burner, consuming coal-gas instead of oil, was experimented with.

The burner, with oxygen admitted to the centre of the flame, consumed, according to an experimental meter made by Brown and Bischoff, 4.2 cubic feet of coal gas, and 5.3 cubic feet of the oxygen gas per hour, and produced a light equal to 36.7 Parliamentary candles, consuming 120 grains per hour.

The same quantity of coal gas, per hour, burnt in a 36-hole Argand burner, with a chimney $9\frac{1}{2}$ inches high, gave a light equal to 10.1 candles.

The light obtained from the coal gas and oxygen was exceedingly bright and white, both gas and candle-light looking yellow by the side of it.

The cost of the coal gas alone, to produce the same light, would be about equal to that of the extra oxygen used; but the purity of the light, and the saving of gas burners and fittings, by using oxygen and coal gas, increase the value of the combined arrangement.

To ascertain the composition of the residuum, weighing 36 lbs. 4 oz. (left in the retort after the three experiments, in which the same oxide of zinc was used three times), it was digested with plenty of water, and the insoluble oxide of zinc separated by a calico filter, and this, when washed and dried, weighed 23 lbs. 12 oz.

The filtrate and washings, evaporated to dryness in an iron vessel, weighed 15 lbs. 4 oz., and a portion of this analyzed gave the following results:—

Insoluble matter, nearly all oxide of zinc	4.20
Oxide of zinc soluble in the soda	4.40
Water	15.00
Soda	37.00
Chloride of sodium	5.54
Nitrite of soda	5.15
Nitrate of soda	28.31
Loss	.40
	<hr/>
	100.00

The 36 lbs. 4 oz. would, therefore, contain, according to this analysis (stating it in round numbers, and omitting fractions):—

23 lbs. 12 oz. of oxide of zinc and alkali, less 10 oz. water	lbs. oz.	
	23	2
15 lbs. 4 oz. consisting of oxide of zinc	lbs. oz.	
“ soda	1	5
“ water	5	10½
“ chloride of sodium	2	4
“ nitrite of soda	0	13
“ nitrate of soda	0	12½
Loss	4	5
	<hr/>	
	15	4
Less water	2	4
	<hr/>	
	13	0 = 13 0
Loss	0	2
	<hr/>	
	36	4
13 lbs. 12 oz. gaseous matter lost by the 30 nitrate of soda, consisted of 143.71 cubic feet of gas, containing—		
83.36 cubic feet of oxygen gas	7	0½
60.36 “ nitrogen gas	4	7
10 lbs. nitric acid, sp. gr. 1.136, containing 19.128 per cent. dry acid, (Ure's table)	1	14½
Loss*	0	6
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	50	0

With respect to the cost of the oxygen gas prepared by Webster's process, it may be stated that, taking the commercial price of nitrate of soda to be £14 10s. per ton, and the crude oxide of zinc at £2 per ton, the value of 30 lbs. of nitrate of soda would be about 3s. 10d.,

* Probably not really a loss, but represented in the 2 lbs. of nitric acid absorbed by the solid matter in the purifier, which is, no doubt, of a higher quality than that absorbed by the 5 lbs. of water in the same purifier, and equal to 8 lbs., sp. gr. 1.136.

and that of the 20 lbs. oxide of zinc, 4d., making a total of 4s. 2d.; and the following table exhibits the probable value of the products:—

Materials— Cost of Materials.	Products.				
	Gas.	Soda.	Nitrate of Soda.	Nitric Acid.	Oxide of Zinc.
s. d. 30 lbs. Nt. Soda 3 10	143·71 cubic ft. containing	5 lbs. at 2d per lb. *	4 lbs. at 1½d. per lb. *	10 lbs. containing 2 lbs. stronger, at 6d. per lb.	20 lbs. at 4d.
20 lbs. Ox. Zinc 0 4	83·36 of oxygen.				
50 lbs. . . . 4 2	1s. 6d.	10d.	6d.	1s. 0d.	4d.

On comparing the cost of this method with those of other sources of oxygen gas, it will be noticed that Webster's is the cheapest known process, if the products can all be realized. Monsieur Deville calculates the cost of oxygen, obtained from various substances, as follows:—

One cubic metre (equal to 35·317 cubic feet):	Fr.	s. d.
“ from chlorate of potash	10 00	= 8 4
“ “ oxide of manganese	4 87	= 4 0½
“ “ sulphuric acid	1·00	= 0 10
“ “ nitrate of soda, ox. of zinc	0	7½ 6-10
“ “ do. rejecting all products	1	9 7-10

The cheapness of Webster's process is so satisfactory, that it will probably be used at the Polytechnic, provided that the nitrogen mixed with the oxygen does not materially interfere with the brilliancy of the lime-light.

Additional Report on the above Process. By WILLIAM CROOKES.

By the kindness of the proprietors of the patent, I have been afforded an opportunity of critically examining every stage of the above process, and am, therefore, enabled, from personal observation and experiment, to endorse all the facts given by Mr. J. H. Pepper in this report. The gas is produced from materials of but trifling value, in large quantity, and by an operation requiring no skilled superintendence whatever. At first sight it would seem that the proportion of nitrogen present with the oxygen would tend to render the gas of only slight commercial value. A little consideration will, however, show that this is not necessarily the case. Although pure oxygen is invaluable in the laboratory, and at the lecture-table, its employment in an undiluted form would be impracticable in ordinary metallurgical operations on a large scale, as the intensity of its action would very soon rise to such a degree of violence as to reduce flux, fuel, metal, and furnace into one chaotic liquid mass. It is, indeed, very doubtful whether the mixed gas which is obtained in such abundance under this patent, is not as strong as could be employed in most manufacturing operations without serious damage to the furnaces and crucibles used.

* A chemical manufacturer would separate, by crystallization, the greater part of the nitrite, nitrates, and chloride of sodium from the caustic soda.

The only case in which it is likely a purer gas would be required, is in the metallurgy of the more refractory platinum metals. The intensity of the "lime-light" produced with this mixture is necessarily inferior to that obtained with pure oxygen, but it is abundantly sufficient for all ordinary purposes of illumination, and far better than could be anticipated from the composition of the gas. Indeed, it is only by comparing the two lights simultaneously, side by side, that the difference of intensity becomes apparent.

The Electric Lamp in Lighthouses.

From the London Athenæum, Nov. 1862.

For the last five or six years the maritime world has been waiting with some anxiety for the termination of certain experiments respecting the employment of the electric light as a beacon. These experiments are well nigh concluded, and the question whether the old oil-lamp is to be superseded by the electric lamp, will be speedily determined.

Early in 1857, experiments were made on the subject at Blackwall and Woolwich by Prof. Faraday and Prof. Holmes, and subsequently the latter was requested by the Elder Brethren of the Trinity House to prepare a plan for employing the new light. This plan was submitted to Prof. Faraday, who reported favorably upon it, and the result was that the Trinity Board sanctioned the establishment of an electrical apparatus in the South Foreland Upper Lighthouse. This apparatus consisted of an accumulation of powerful magnets and iron cores with surrounding coils, accurately arranged, so that when the associated cores were revolving, they sent all their currents into one common channel, from whence they were conveyed to the lantern by conducting wires, and there produced the electric light. There was no consumption of material or energy, other than that of the burning fuel required at the steam engines to produce motion.

A trial of the light began in the lighthouse on the 8th of December, 1858; but as the apparatus was imperfect in some points, and the results unsatisfactory, the lighting by the apparatus was suspended for awhile, that the defects might be remedied. The lighting was renewed in March, 1859, and during the following month it was carefully examined by Prof. Faraday. In his subsequent Report to the Trinity Board, after describing very fully the observations he made at sea, and the various experiments by which he tested the power of the light, he states his opinion that Prof. Holmes had practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned; that the light produced was powerful beyond any other that he had seen so applied, that its regularity in the lantern was great, and its management easy. Ten months after he had thus expressed his approval of the experiment, he again visited the light, and found it of the same character as when he had last seen it. It was gene-