bleached are dipped. They are stirred about with a glass rod from time to time, and after about ten minutes they are taken out of the bath, strongly colored of a violet brown hue by an abundant deposit of oxide of manganese. They are then dipped as quickly as possible in a bath of water, acidulated with sulphurous acid, and again stirred and turned over with a glass rod, and after two or three minutes the materials or thread, originally of yellow or gray color, are already white. These operations are repeated twice more, and the result is a brilliant white, whilst the fibres are in no way injured. The materials operated upon were cotton fabrics, dirty as they came direct from the loom, as well as skeins of linen thread of a dark slate-color, which, by existing processes, would have taken many days to bleach.

Simple and Economic Process for obtaining Soda from Common Salt.

From the London Chemical News, No. 347.

Mr. Walter Weldon has taken out patents for a process described as follows: The new process consists in placing within a vessel capable of resisting the required pressure, an equivalent of common salt, and another of carbonate of magnesia, with a small quantity of water, and then pumping into the vessel the carbonic acid formed by causing atmospheric air to traverse coal in a state of ignition. The carbonate thus becomes bicarbonate of magnesia, which dissolves in the water, and then decomposes the chloride of sodium, chloride of magnesium, which remains in solution, and bicarbonate of soda, which precipitates, being formed. The whole process lasts but a quarter of an hour at most, and the cost is only that of the coal used in forming the carbonic acid. A moderate heat drives off the second atom of carbonic acid from the bicarbonate of soda, changing it into carbonate, and the magnesia may be recovered from the chloride by evaporating the solution containing it to dryness, and raising the residue to a temperature below redness.

On the Combustion of Gas for Economic Purposes. By Dr. Letheby.

From the London Chemical News, No. 344.

(Continued from page 249.)

The temperature of different combustibles is shown on the diagram below, and you will notice that the highest temperature produced by the various constituents of coal gas is that of acetylene, or the vapor of benzole when burned in oxygen, the heat of which exceeds 17,000° Fahr. The lowest temperature of all the constituents is about 12,700° Fahr., the temperature of burning carbonic oxide.

On the same diagram I have tabulated the thermotic power of a great number of substances. It is expressed in the number of pounds of water raised 1° Fahr. by a pound of the substance, and when the body is capable of being converted into gas or vapor, I have also expressed it in the cubic foot at common temperature and pressures.

Hydrogen, you perceive, is the most powerful thermotic agent, and carbonic oxide is the weakest. A pound of the first of these gases will raise 62,030 lbs. of water 1°, whereas a pound of the latter will only heat about 4325 lbs. of water to that extent. Examined by the cubic foot, and considering that for every pound of water raised 1°, about 48 cubic feet of air are raised to the same extent, we may say the chief constituents of coal gas have this thermotic power—

Pounds of Water and Cubic Feet of Air raised 1° Fahr. by a Cubic Foot of the Gas burning in Air.

Cubic foot of—		Lbs. water raised 1° Fahr.	Cub. ft. air raised 1° Fahr.
Hydrogen	heats.	329	15,837
Marsh gas	"	996	47,946
Olefiant gas	"	1585	76,299
Propylene	"	2376	114,378
Butylene	"	3168	152,502
Acetylene	"	1251	60,220
Benzole vapor	"	3860	185,814
Carbonic oxide gas	"	320	15,403
Common coal gas	"	650	31,290
Cannel coal gas	"	760	36,585

From this we can determine the practical thermotic power of any of these agents. A cubic foot of common gas will heat 65 gallons of water 1°, or 6·5 gallons 10°, or 3·25 gallons 20°; so that a bath containing 250 gallons of water would require about 77 cubic feet of common gas, or 66 of cannel, to raise its temperature from 55° to 75°. In practice, however, this is rarely attained, because of the faulty construction of the heating apparatus. I find, indeed, that a bath in my own house, made by Phillips, of Skinner Street, takes nearly twice this proportion of gas to heat it, and being in a closed room the atmosphere is almost poisoned before the bath is ready; and the circulation of the hot water is so imperfect that the top layer becomes boiling hot before the bottom of the water is warm. This is a subject which requires attention, for it is open to much improvement.

Again, with regard to the boiling power of gas, although in good practice a cubic foot of gas should boil off about 4712 grains of water, or about 22 times its own weight, yet this is not often attained, for in an open vessel we rarely evaporate more than 2866 grains of water, or about 13 times its weight.

But the heat of the burning gas is more surely applied to the warming of rooms; for, as you will see by the table, a cubic foot of common gas will heat an apartment containing 3129 cubic feet of air 10°, and the same quantity of cannel gas will heat 3658 cubic feet to the same extent. Other illuminating agents will, however, light for light, heat the atmosphere, and vitiate it to a larger extent. This is seen in the table which I brought under your notice at the last lecture.

TABLE *of the Combustion, Temperature, and Explosive power of Gases.*

	Per lb. substance.			Pounds of water heated 1° Fahr.			Temperature of combustion.				Explosive power.		Mechanical power per lb.
							Open flame.		Closed vessel.				
	Ox. used.	CO_2 produced.	Air vitiated.	Per lb. substance.	Per cub. ft. substance.	Per lb. ox. used.	With ox.	With air.	With ox.	With air.	With ox.	With air.	Tons raised 1 ft. high.
	Cub. ft.	Cub. ft.	Cub. ft.	Lbs.	Lbs.	Lbs.	Deg.	Deg.	Deg.	Deg.	At.	At.	Tons.
Hydrogen . .	93·4	0·0	467	62030	329	7754	14510	5744	19035	7852	25·6	12·5	21390
Marsh gas . .	47·2	23·6	826	23513	996	5878	14130	4762	18351	6680	37·0	14·0	8108
Olefiant gas . .	40·5	27·0	878	21344	1585	6225	16535	5217	21344	7200	42·9	15·1	7360
Propylene . .	40·5	27·0	878	21327	2376	6220	16522	5239	21327	7177	67·3	22·5	7360
Butylene . .	40·5	27·0	878	21327	3168	6220	16522	5232	21327	7177	85·8	30·2	7360
Acetylene . .	36·3	29·1	909	18197	1251	5914	17146	5142	22006	7009	37·9	17·6	6275
Benzole . .	36·3	29·1	909	18197	3860	5915	17146	5142	22006	7009	113·7	52·8	6275
Carbonic oxide .	6·7	13·5	371	4325	320	7569	12719	5358	16173	7225	21·8	11·7	1490
Bisulph. carbon .	14·9	5·0	689	6120	1239	4845	15280	4314	20031	5917	30·2	11·6	2110
Sulph. hydrogen .	16·7	0·0	630	7444	671	5271	13688	4388	17542	6026	28·3	12·7	2567
Cyanogen . .	14·5	14·5	435	6712	925	5142	13488	5028	17645	6167	35·6	17·8	2314
Common coal gas .	37·5	17·6	618	21060	650	6816	14320	5228	18101	7001	29·2	14·6	7262
Cannel gas . .	31·0	22·0	698	20140	760	6503	14826	5121	19046	7186	38·8	18·0	6945
Wood spirit . .	25·3	11·8	422	9547	819	6363	11435	4641	14902	6347	40·3	15·3	3290
Alcohol . . .	24·6	16·4	533	12929	1597	6195	13305	4831	17223	6629	46·4	16·2	4455
Ether . . .	30·9	20·4	664	16249	3217	6158	14874	5150	19225	6958	58·6	19·0	5603
Camphene . .	38·9	27·8	880	19573	7134	5942	16271	5026	20953	6922	47·6	16·0	6750
Spermaceti . .	37·0	25·2	815	17589	. .	6088	14599	4413	. .	. .	. .	. .	6065
Wax . . .	37·7	25·6	829	15809	. .	4995	12921	4122	. .	. .	. .	. .	5451
Stearic acid . .	34·6	24·0	783	17050	. .	6061	15885	4818	. .	. .	. .	. .	5880
Stearine . . .	34·4	14·2	527	18001	. .	6143	15815	5095	. .	. .	. .	. .	6207
Paraffin . . .	40·5	27·0	878	21327	. .	6220	16522	5239	. .	. .	. .	. .	7354
Paraffin oil . .	40·5	27·0	878	21327	. .	6220	16522	5239	. .	. .	. .	. .	7354
Rape oil . . .	38·7	24·3	801	17752	. .	6123	15830	5087	. .	. .	. .	. .	6121
Sperm oil . .	38·7	24·3	801	17230	. .	6088	15363	4937	. .	. .	. .	. .	5941
Carbon . . .	31·0	31·5	943	14544	. .	5447	18329	3026	. .	. .	. .	. .	5015

Heating and Vitiating Effects of Different Illuminating Agents when burning so as to give the Light of 12 Sperm Candles.

	Lbs. water raised 1° Fahr.	Oxygen consumed, cu. ft.	Carb. acid produced, cu. ft.	Air vitiated, cu. ft.
Cannel gas	1920	3·30	2·01	50·2
Common gas	2786	5·45	3·21	80·2
Sperm oil	2335	4·75	3·33	83·3
Benzole	2326	4·46	3·54	88·5
Paraffin	3619	6·81	4·50	112·5
Camphene	3251	6·65	4·77	119·2
Sperm candles	3517	7·57	5·77	131·7
Wax	3831	8·41	5·90	149·5
Stearic	3747	8·82	6·25	156·2
Tallow	5054	12·00	8·73	218·3

The vitiating effect is calculated on the actual loss of oxygen, and on the power which 4 per cent. of carbonic acid has on the vital qualities of the atmosphere; and, though the results indicate that there should be less discomfort in a room lighted with coal gas than with any other illuminating agent, yet common experience is altogether in the opposite direction. The explanation of this is to be found not only in the fact that gas is used more lavishly than other agents, but also that in burning it produces a larger proportion of aqueous vapor, which, becoming diffused into the surrounding atmosphere, occasions great discomfort. Professor Tyndall has shown that the molecules of aqueous vapor are endowed with a remarkable power of absorbing the radiant heat of burning gas, and by thus becoming warm they create a sense of oppression. And again, when the warm atmosphere of a room is overcharged with moisture, it checks the action of vaporous or insensible perspiration, and this also causes distress. In all cases, therefore, where gas is largely used in rooms, provision should be made for the quick removal of the products of combustion.

When the heat of gas is required for warming a room, its radiant power should be increased by allowing it to ignite some solid substance, for the radiant heat of a non-luminous flame is very insignificant. I have here a Bunsen's burner, which gives with this gas the highest temperature of combustion, but the amount of heat which radiates from it is very small—smaller, indeed, than is the case when the gas is burnt in the ordinary way, when every atom of ignited carbon becomes a centre of radiation. The proportion of radiant heat from the same flame under different circumstances is very variable. From Bunsen's burner it is only 12, from the same gas burnt as a luminous flame it is 30, and with a spiral platinum in it it is 85. The introduction of solid matter into a non-luminous flame of high temperature changes its character altogether, and from the heat of convection it becomes heat of radiation. No doubt the quality of the vibrations is greatly changed, and they pass from the large and comparatively slow undulations of obscure heat to the small and quick vibrations of light; and the more this is affected, the greater and greater becomes the intensity of the radiant heat. Prof. Tyndall found that the following were the quantities of radiant heat from a platinum spiral, at different degrees of luminosity:

		Degress of heat radiated.
Platinum spiral,	feebly red	19
" "	dull red	25
" "	full red	62
" "	orange red	88
" "	yellow red	158
" "	yellow white	200
" "	blue white	276
" "	intense white	440

So that, when we wish to economize the radiant heat of burning gas, it is best to use it with some solid body, as fragments of pumice or pieces of asbestos.

The last point to which I would refer is the available or convertible motive power of burning gas.

The calculations of Dr. Mayer of Heilbron, and the experimental inquiries of Mr. Joule of Manchester, show that the mechanical power of heat is 772 lbs. raised a foot high for the heat necessary to raise the temperature of a pound of water 1° Fahr. A cubic foot of hydrogen in burning has, therefore, the mechanical power of ($329 \times 772 =$) 253,988 lbs.; and the same quantity of common gas has the power of ($650 \times 772 =$) 501,800 lbs.; while the power of a cubic foot of cannel gas is ($760 \times 772 =$) 586,720 lbs., raised a foot high. But if the same quantity of these gases is exploded with air or oxygen in a closed chamber, the mechanical power is somewhat different. I have here tabulated the expansive force of such a mode of combustion, and I may say that the calculations are deduced from the temperatures of combustion and from the volumes of the products, allowance having been made for the specific heats of the several products. It would seem, therefore, that the explosive powers of the several constituents of coal gas, when mixed with their proper proportions of air or oxygen, are as follows:

Explosive Power of Mixed Gases.

	Mixed with air. (Ats.)	Mixed with ox. (Ats.)
Hydrogen	12·5	25·6
Marsh gas	14·0	37·0
Olefiant gas	15·1	42·9
Propylene gas	22·5	67·3
Butylene gas	30·2	85·8
Carbonic oxide	11·7	21·8
Common gas	14·6	29·2
Cannel gas	18·0	38·8

These are the theoretical pressures exerted upon the sides of the containing vessel when these several gases are exploded with their proper proportions of air or oxygen; but as the explosion is never instantaneous, but proceeds from particle to particle, and therefore occupies time, and as the walls of a vessel always cool the products of the exploded gas to a great degree, this theoretical value is never obtained in practice, the highest pressure in the exploding chamber of a gas engine being only 75 lbs. on the square inch, or five atmospheres. The power of this has been determined experimentally by Mr. Evans, who informs me that, with a cubic foot of a mixture of 9 air and 1 gas, he has propelled a wooden shot (3 inches by 4) 50 yards; and he ascertained that the same effect was produced with an ounce of gunpowder. The motive power, therefore, of the exploding mixed gas is considerable.

In the gas engines of Lenoir it has been found that the best proportions of air and gas are eight volumes of air to one of common gas; theoretically the best proportion for London (13-candle) gas is 5·6 volumes of air to 1 gas. A larger portion of air is required for cannel gas, as 11 to 1; but in practice it is found that cannel gas does not produce so good an effect as common gas. The time of the explosion is about the twenty-seventh part of a second, and the temperature of it is about 2474° Fahr. instead of from 5228° to 7000°, the calculated temperatures for open and closed chambers.

The machines which are used for practically employing this power are all modifications of the original engine of Lenoir. They consist of a cylinder with a double-action piston, receiving the mixed gas alternately on either side of the piston. The arrangement is such that, in the movement of the piston, the air and gas, in proper proportions, (8 to 1,) are drawn into the cylinder by a suitable side valve, and when the piston has made half a stroke it shuts off the valve; at that moment the mixed gas is fired in the cylinder by means of an electric spark from a Ruhmkorff's coil passing between the points of two wires in the cylinder. One of these wires is insulated by traversing a rod of porcelain fixed in the cylinder, and, being in connexion with a make-and-break contrivance, called a distributor, attached to the fly-wheel of the engine, it receives the charge of electricity, and so fires the mixed gas at the right moment. The expansion caused by the explosion and heat of combustion drives the piston through the rest of the stroke, and it generally ends with a good deal of unutilzied pressure. In one case I find that the indicator recorded an initial pressure of 75 lbs. on the inch at the moment of explosion, and a final pressure of 25 lbs. The loss of power in this case must have been considerable, for not only is there the loss of the difference (12·5 lbs.) between the calculated pressure, 37·5 lbs., (75 ÷ 2,) and the real, (25,) but there is also the total loss of the unavailable final pressure. A part of this loss is no doubt due to leakage, and to the cooling effect of the walls of the cylinder; for the temperature has been observed to fall from 2474° Fahr., at the moment of explosion, to 1438° at the end of the stroke, the calculated temperature being 2156°. Iudeed, the management of the temperature is one of the difficulties of the engine, for the cylinder has to be cooled by a stream of water. Improvements will no doubt be made in the construction of the engines, and especially in the utilization of the residual power, and this must be done by shutting off the valve and firing the gas earlier in the stroke. This has already been done to some extent in America with engines of half horse power, as with cylinders of 4⅝-inch diameter by 8¾-inch stroke; and this with 185 revolutions, or 370 explosions, in a minute, raises 16,280 lbs. 1 foot high in a minute. In France and in this country much larger engines are made, as from 1 to 3 horse power.

The quantity of gas used in the working of the engine is rather variable. In the American engine, already alluded to, it took 105 cubic feet of gas an hour to work an engine of half horse power, and a one horse engine in London takes about 185 cubic feet of London gas—say it is 200 cubic feet—per horse power. This is 1,980,000 lbs. a foot high; whereas the theoretical power of 200 feet is more than 100,000,000 of lbs.

The advantages of the engine are very great; for it takes up but little room, it is very clean, it works with great regularity, it requires little or no attention, and it costs nothing for fuel when it is not at work.

One thing I ought to mention in speaking of the explosive power of mixed gas, and that is the effect of using mixtures in improper proportions. Sir Humphrey Davy found, in his experiments with marsh gas, that there was but one proportion of air and gas which gave the maximum effect, and that was a mixture of 1 of gas and 7·5 of air, (theoretically it should be 1 to 9·5.) When the proportions are reduced in either direction the mixture becomes less and less explosive, until with 1 gas and 15 air, or with equal volumes of gas and air, the mixture ceases to explode.

In the case of coal gas, although the theoretical proportions for London gas are 1 of common gas* to 5·6 of air, and 1 of cannel gas to 7·4 of air, yet the best results are obtained with 1 of the former to 8 of air, and 1 of the latter to 11. On either side of this proportion the mixture rapidly becomes less and less explosive.

The effect of mixing other gases with explosive mixtures has been well studied by Davy and others. Taking, for example, an explosive mixture of 2 volumes of hydrogen and 1 of oxygen, it is found that 1

* *Average composition of London gas by volume.*

	Common gas.	Cannel gas.
Hydrogen	46·0	27·7
Light carburetted hydrogen	39·5	50·0
Olefiant, &c	3·8	13·0
Carbonic oxide	7·5	6·8
Carbonic acid	0·7	0·1
Aqueous vapor	2·0	2·0
Nitrogen	0·5	0·4
	100·0	100·0

of nitrogen to 6 of the gas, or 1 of carbonic acid to 7 of it, will stop its explosion.

Lastly, the temperature at which these gases are fixed is a matter of considerable importance. Davy found that he could not set fire to marsh gas, (the fire-damp,) or to an explosive mixture of it with air, by using the strongest heat of glowing charcoal. He even blew a mixture of the gas upon glowing charcoal until he got it at a maximum heat, without firing it; nor can it be fired by the sparks from flint and steel. Not so, however, with hydrogen, or olefiant gas, or carbonic oxide, all of which are fired by the sparks and by glowing charcoal—perhaps the igniting temperature is about 3900° Fahr., and the vapor of bisulphide of carbon is fired at as low a temperature as 300° Fahr. These facts are deserving of attention; for they show that gas leaking from the mains may be fired by a spark from a pick, or from the chipping of a hole in the pipe in laying a service.

And now, gentlemen, we have gone over the question of the phenomena of gaseous combustion, and of the manner in which gas is to be most profitably and most economically used for illuminating purposes. We have also examined the thermotic powers of coal gas, and I hope if I have the opportunity of meeting you again, I shall be able to bring under your notice one other question of interest to gas engineers, and that is the profitable utilization of the waste products of gas-works.

MISCELLANIES.

Effect of Forests on the Temperature of the Air.—The MM. Becquerel, in an elaborate memoir upon this subject, presented to the Academy of France, reach the conclusion that the temperature is higher away from the forest than within it, and higher within than immediately around it. The mean temperature of the trees appear to be that of the surrounding air; but changes take place much less rapidly in the trees, especially in the trunks. The phenomena of vegetation do not appear to influence the temperature, for the temperature of the leaves scarcely differs at any time from that of the air. A singular observation is that forests have the property of preserving tracts lying to leeward of them from hail. The windward edge of the forest is frequently attacked, but the hail becomes less and less as it penetrates the forest, soon ceases, and is not reproduced for some distance from the leeward edge.

Capillary Attractions.—This subject has attracted the particular attention of the distinguished chemist M. Chevreul, whose position as director of the government establishment for the manufacture of Gobelin tapestry has already led him to a number of very important investigations, especially those in reference to the harmony and contrast of colors. The phenomena of dyeing appear to have led him to his present researches, which were conducted in reference to the absorption