Gas-Consumer's Guide

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THE

GAS-CONSUMER'S GUIDE:

A HAND-BOOK OF INSTRUCTION

ON

THE PROPER MANAGEMENT AND ECONOMICAL USE OF GAS.

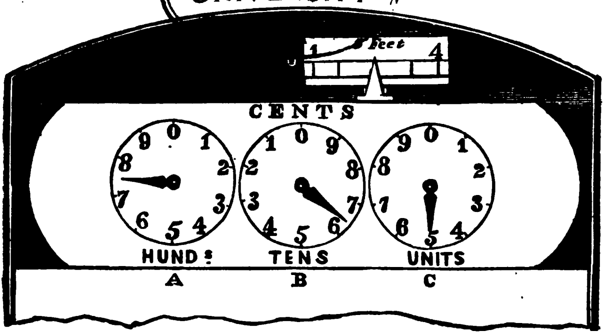
WITH

A FULL DESCRIPTION OF GAS-METERS,

AND

DIRECTIONS FOR ASCERTAINING THE CONSUMPTION BY METER.

ON VENTILATION, ETC.



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THE GAS-CONSUMER'S GUIDE.

CHAPTER I.

BRIEF HISTORY OF ARTIFICIAL LIGHT.

THAT light and heat were first produced simultaneously by burning the branches of trees, etc., is apparent, from the means employed by savage tribes to obtain fire.

Then, afterwards, splinters of resinous wood probably supplied the means of artificial light (as for this purpose they are even now employed in many parts of the civilized world); and for the same object, torches and similar devices followed.

The employment of the lamp can be dated back to a very early period; it being generally believed that it is an invention of the Egyptians, who not only used them for common illuminating purposes, but also placed them in the tombs of the dead, as emblems of mortality.

The progress toward the realization of the lamp may, however, have been so gradual and simultaneous by different nations, as to preclude the merit of invention to any one of them.

The ancient Greeks are known to have been accustomed to the use of lamps, which we have every reason to believe were fed by vegetable oil.

It is very probable that the earliest, or most primitive lamps, were not made of any set form, but that the fat or oil was placed in any convenient vessel, and burned by means of a bundle of rushes or dried moss.

Long after the ancients were far advanced in the arts and manufactures, they continued the use of these rude and simple lights, little or no attention seemingly having been devoted by them to this subject. However elaborate the design of the vessel for holding the oil, the simple wick dipping into it completed the arrangement, which was defective in principle, limited in utility, expensive in result, and not unfrequently sent forth volumes of smoke with a very small amount of light.

The candle is a scientific production of great antiquity; and, in addition to its means of lighting, has often been applied as a rude indicator of time. Perhaps one of the most curious offices it has fulfilled, was formerly, when sales by auction, in England (called "candle auctions"), were decided by its durability. The property or article was offered for sale at the same moment that an inch of candle was lighted; the bystanders bid as long as it continued burning, and the commodity was adjudged to the last bidder previous to its extinction.

The lighting of streets, now so generally adopted, was unknown to the ancient Greeks and Romans, who, when returning from their nocturnal revels, had torches or lanterns carried before them by their slaves. But public illuminations on particular occasions are, however, very ancient: Egypt and Greece had them; Rome was lighted up on the occasion of some games exhibited under Caligula; the Jews illuminated the Holy City for eight days at the dedication of the Temple; and Constantinople was hung with festal lamps on Easter Eve.

London seems to have been the first city which permanently adopted this improvement; for in 1414 the citizens were ordered to hang out lanterns to light the streets; and in 1417 (according to Stowe), Sir Henry Barton, being Mayor of London, ordered "lanthorns with lights to be hanged out in the streets in the winter evenings between All Hallowtide and Candlemas"; and it was the duty of the watchmen to see the order duly enforced.

These were the first attempts to illuminate streets; but we can judge of the dreary state of London from the fact that the steeple of old Bow Church, before the Great Fire, was so constructed that on its top there was a lantern, intended to direct travellers and market people who came from the north; and in Barbican was a tower with light for the same object.

In those times, whenever a large light was required, such as at the entrance of churches on the occasion of religious processions, beacons were used for the purpose. These were iron cages, or, as now termed, fire-baskets, which were generally attached to the walls, and supplied with wood and tarred rope. They were also made to be portable, being placed on the top of a wooden frame, with a ladder to supply the fuel, and carried, on festal occasions, wherever they might be required.

In 1668, when some regulations were made for improving the streets of London, the inhabitants were reminded to hang out their lanterns at the usual hour for "the peace and safety of the city."

In 1679, we find the Lord Mayor complaining of the neglect of the inhabitants of the city in not hanging and keeping out their lights at the accustomed hours, "according to the good and ancient usage and acts of Council in that behalf."

In 1690, the order was renewed, with an exception in favor of those who should agree to make use of lamps of any sort, to be placed at such distances in the streets as should be approved of by the Justices of the Peace.

In the year 1716, the Common Council of the city of London passed an act, "That every housekeeper whose house fronts the street should set or hang out one or more lights, with sufficient cotton wicks, that shall continue to burn from six o'clock at night till eleven o'clock the same night, on penalty of one shilling, to be enforced by distress or otherwise."

In 1736 and 1739, lighting the streets with lamps was partially adopted; but as this did not extend to the whole town, and many street robberies were committed, an Act of Parliament was passed in 1744 for completely lighting the cities of London and Westminster. Birmingham was first lighted by lamps in 1733, so that in this improvement it preceded London.

The streets of Paris were first lighted in 1524, when a mandate was issued requiring the inhabitants to keep lights burning from nine in the evening, in those windows which fronted the street, in order to guard against incendiaries and robbers; and in 1558, large vases, supplied with pitch and other combustible matter, were placed at the corners of the streets, to serve the purpose of illumination.

In 1662, an Italian abbé of the name of Laudati obtained an exclusive privilege to let out torches and lanterns for hire; for this purpose he erected booths in several parts of Paris, where men and boys were in waiting ready to attend either carriages or foot-passengers. These link-men and boys were paid by time; and to avoid disputes, each of them carried an hour-glass.

The reverberating or reflecting lamps were introduced into Paris in 1766. These were suspended over the centre of the road by chains or cords, which extended from house to house, and were raised or lowered, for the purpose of lighting or trimming, by means of a pulley and cord or chain.

At the commencement of the present century, the parochial or district street lighting was so defective, that in first-class streets in London every house had its lantern with iron frame attached to the railings at the entrance; and when well-to-do people went out on foot they were accompanied by a servant carrying a hand-lantern to light the way; whilst the entrances of theatres and such like places were thronged with link-boys, with their general salutation of "Link, yer honor," ready to accompany coaches, sedan-chairs, or foot passengers. And to show the importance of these light bearers, all the principal houses had extinguishers for the torches at their entrances, many of which, with the frames of the lanterns before mentioned, are still in existence at the west end of London.

At that period people seemed to care little about quantity of light; perhaps, never having experienced its utility, they did not know its worth. The rows of lamps at the entrances of houses in the principal streets only served to make darkness visible; but whilst the better class of streets were thus badly illuminated, the others were next to total darkness; a dingy lamp here and there was supposed to light, but answered really no useful purpose.

Everything connected with street lighting was just as preposterously large as the lights were ridiculously small, two of which, according to the evidence of Mr. Accum before a committee of the House of Commons, only gave the light of one penny tallow candle. The lamp-lighter carried an immense torch, which illuminated more than all the lamps in a large street combined. The diminutive jets were enclosed in colossal glasses, and the watchman of the time carried a lantern of gigantic dimensions, and yet so small was its light, that to be assured of the identity of an individual he was obliged to hold it close to the person's face. At that period the streets of London were infested with footpads, who carried on their depredations in the most daring manner, and often with extreme violence. Robberies were of most frequent occurrence, and the ladders of the lamp-lighters who went to trim the lamps at midnight were often "borrowed" for the purpose of committing burglaries.

But whilst this dreariness existed in the streets, the interior of dwellings was little better. It is true Mr. Argand had previously invented his beautiful lamp-burner; but it was far from being perfect, was very expensive, and after all only a slight advance in lighting when compared with gas.

Coal, from which gas is almost universally obtained, was first used in London by brewers, dyers, and other businesses which required large fires, about the year 1306; but the smoke therefrom becoming very offensive to the resident nobility and gentry, combined with the opposition from the medical profession, who pronounced it to be poisonous, a royal decree was in consequence issued, prohibiting the use of coal under severe penalties. But in time, as wood fuel became scarce, and the trade of the city increased, prejudice gave way to utility, and gradually the use of coal was tolerated.

The first patents, or as then termed exclusive privileges, in conjunction with coal, were granted about 1589. These consisted in forging iron, melting glass, boiling soap, and melting lead with coal. Amongst the products for which patents were granted may be enumerated the making of charcoal (coke), pitch, tar, and oil, the latter being described as a cure for "rheumatick, scorbulatic, and other cases."

Gas was first obtained from coal by Dr. Hales, in 1726, who employed it as a source of amusement for his friends; by filling a bladder with it, and puncturing a small hole therein, he lighted the issuing gas. However, it was regarded only as a philosophical toy, without any view to utility. Subsequently, Dr. Clayton, Dr. Watson, and other scientific men, at various periods, turned their attention to the subject; but the true discoverer of the practical application of coal-gas for lighting purposes was Mr. Murdock, a Scotchman, who, in the year 1792, while at Redruth, in Cornwall, made a series of experiments on the quantity and qualities of the gases produced by distillation from different mineral and vegetable substances. That gentleman first lighted his house and offices by gas in 1792; and in 1798, by the same means, he lighted part of the Soho Works, at Birmingham; and in 1802, a magnificent public display of gas illumination was made by him at that establishment.

Mr. Murdock, and a few others who entered into competition with him, then commenced the construction of gas-works for supplying large manufactories, such as cotton-mills, etc., to which they seemed to confine themselves; but the views of Mr. Winsor, who entered the field at the period as a propagator of gas lighting, were much more gigantic and comprehensive, for he proposed the necessity of lighting streets, shops, dwellings, heating apartments, and cooking by gas, and the establishment of a company for the full development of the new art.

For this purpose Mr. Winsor gave public lectures demonstrating the utility and practicability of gas, showing the various operations and the vast superiority of that over all other means of artificial light. The opposition against the innovation was great in the extreme; but at length, after struggling with indomitable perseverance for some years, he ultimately succeeded in establishing the first gas company in the world for the production of gas as an article of commerce—the "chartered" of London—and was originally empowered as "*The* Gas Light and Coke Company," which commenced business in 1813.

But the prejudice against it was very great. Napoleon ridiculed it, and said, "C'est une grande folie." Sir Walter Scott gravely informed his friends that he thought London would be in flames from one end to the other if this visionary idea was attempted to be carried out. Mr. Clegg gives an account of the horrors of the lamp-lighters when they first beheld the burning gas, and how he was obliged to light the lamps himself for some time, on account of the fears of the people. Even such men as Sir Humphry Davy and Sir Joseph Banks were unable for many years after this to overcome the prejudices which existed in their own minds concerning it; and they thought the scheme a wild and dangerous one. The public, however, soon became reconciled to it; and in 1814, the oil-lamps were removed from the streets of St. Margaret, Westminster, and gas-lights were put in their places. This was the first parish that entered into a contract to have the streets lighted with gas.

Paris was first lighted by gas in 1820, and although previously strong prejudices existed against the project, yet, when carried out, it produced a corresponding enthusiasm; and, to give an instance, a French author of the period, in writing to a friend describing the new light, said, "Where gas-light exists, there is no night; where gas-light is, there is continuous day."

The first attempts to introduce gas into this country were made at Baltimore, in 1816. The company first organized, which is the oldest in this country, constructed works for the manufacture of tar-gas, but was unsuccessful; and it was not until about 1821 that gas was successfully introduced. Boston next introduced it in 1822, and continues to work under its first charter. New York followed, commencing operations in 1823, but did not get into successful operation until 1827. Philadelphia introduced it in 1835; and it has, since its first introduction, been gradually extending over the whole world. It may now be said to be universal in the cities and towns of Europe; and is making rapid progress in North America. It is used in all the principal cities of the United States and of Canada, and it is spreading rapidly in the smaller towns. Its introduction into South America and into Asia has been more recent, and its progress there, as might have been expected, is much slower. It has also been introduced into the principal towns in Australia and Tasmania.

CHAPTER II.

ADVANTAGES OF GAS.

NOTWITHSTANDING the opposition which has existed against the employment of this indispensable article, the inexplicable conflagrations unjustly laid to its charge, and but too often the work of the incendiary; the rare and unfrequent accidents which have unfortunately occurred, not by its use, but by its abuse; and the partial and unjustifiable attacks made against its usefulness by interested persons; notwithstanding the full amount of this wholesale prejudice, gas has made such rapid and universal advances as to prove incontestably its immense superiority over all other means of artificial illumination. And can any one doubt that the same voice which first bade light to be, has summoned gas to the service of man, and pronounced the light from it to be good?

A few observations on the advantages, safety, economy, cleanliness, brilliancy, salubrity, and utility of gas, may not be considered out of place here.

Advantages.—The superiority of coal-gas, as compared with every other material for producing light, has been too long acknowledged to require arguments or illustrations. The superiority of gas consists, not merely in the relative cheapness of the light obtained from it, as that compared with tallow, wax, sperm-oil, kerosene, camphene, etc.; there are other circumstances connected with its use, which are of far greater importance, namely: its convenience, cleanliness, brilliancy, manageability, and safety.

Gas requires no preparation by the consumer; it is lighted in a moment, can be increased or diminished at pleasure, and retires with the rapidity of thought. It saves labor and time, as compared with oil and other lamps, and where candles are used. The *odor*, so peculiar to coal-gas, has often been urged as an objection to its use; a stronger ground of objection would exist if it was free from odor; its presence, in an unburnt state, is thereby infallibly detected, and thus fair warning is given that something requires remedying.

Safety.—Gas is beyond all comparison safer than any other means of artificial illumination. It puts aside the necessity of movable lights, and as candles or lamps were a continuous source of trouble, by which both life and property have been endangered, and too frequently destroyed, the stationary, steady, and brilliant light from gas must be more desirable. But no better argument is required than the daily accidents from explosions of camphene and kerosene lamps, resulting, as they so often do, in the most horrible of deaths, to prove the superior safety of gas. It may, however, be mentioned that many insurance companies in Europe insure premises thus lighted at a much lower premium than those illumined by other means.

Economy.—Gas is the best and most economical mode of obtaining artificial light as yet brought into use, though hardly known at the beginning of the present century. It requires no labor, no provision, nor store; it is a good servant, comes momentarily when demanded, and is extinguished as readily when no longer required.

The cost of gas varies somewhat in different localities, and at different periods, according to the fluctuations in the price of coal, the cost of labor, the quantity manufactured, and the character of district supplied.

The present cost per one thousand cubic feet (1870) in New York, is $3.00 and $3.50; in Boston, $3.00; in Cincinnati, $2.50; in Buffalo, $3.50; in Detroit, $3.50; in Rochester, $3.00; in Milwaukee, $4.50; in Erie, $4.00. The average cost to private consumers will average throughout the country abont $3.50 per one thousand cubic feet.

The actual cost of production, with coal and labor at present prices, cannot much exceed, if any, $1.50 per one thousand cubic feet. In addition to the first cost, however, in justice to the gas companies, must be added the *leakage* and *loss* from bad customers, which should not increase the cost to more than $1.75 per thousand cubic feet, leaving a *pretty wide* margin of profit to the gas companies.

But suppose that the average cost of production and service should reach $2.00, or even $2.25, our gas should be supplied at *an average* cost of not more than $3.00, instead of $3.50, per one thousand cubic feet, as at present. One ton of coal should produce about 9,000 cubic feet of gas, about 1 chaldron of coke, and about 11 gallons of tar, and 9 of ammoniacal liquor.

Cleanliness.—Gas is by far much cleaner than any other artificial light. Much unpleasantness and pollution have always accompanied the use of the oil or kerosene lamp, the tallow, sperm, or wax candle, or, in fact, any other method of illumination. Sometimes there is a deficiency of oil, or defect in the lamp; the least draught of air will disarrange the burning of the candle; grease and dirt will besmear the person and dress; but by the use of gas, the evening's vocations or pleasures are enjoyed without any of these interruptions or annoyances.

Brilliancy.—The light from gas is more congenial than that from candles and lamps; its position, when properly placed, is above the line of vision, so that the eyelid serves to protect the eye from its direct rays. Some people have pretended that it is injurious to the sight; but a stronger contradiction to such statement cannot be given than that many public and private institutions and offices are almost exclusively lighted in the daytime by these means, giving every opportunity for complaint, if any cause existed; but, on the contrary, from experience, it is more agreeable than any other artificial light, and once used and properly purified is never abandoned. There is a further advantage, that it can be increased or decreased at pleasure, thus preventing the straining of the eyes, which is so injurious where there is an insufficiency or excess of light.

Salubrity.—In order to show the advantage of well-purified coal-gas over all other materials for illumination, as regards the injury done to the atmosphere of the room in which their combustion is going on, Dr. Frankland has given the following table, which exhibits the amount of carbonic acid evolved by a number of illuminating agents burnt in such quantity as to give a light, for ten hours, equal to that of 20 sperm candles, each burning 120 grains per hour:—

Tallow	evolves	10.1	cubic feet	carbonic	acid.
Wax	"	8.3	"	"	"
Spermaceti	"	8.3	"	"	"
Sperm oil	"	6.4	"	"	"

Common gas evolves	5.0 cubic feet carbonic acid.			
Medium gas "	4.0	"	"	"
Best gas "	3.0	"	"	"

When a given amount of light is obtained, gas is thus shown to be more salubrious than any other illumination; it is identical in its nature with the lamp or the candle, which is demonstrated by blowing out the one or the other, when the gas, combined with vapor, is perceptible to the sight, and emits a similar smell to that supplied from the company's works when unconsumed; indeed the odor is more disagreeable, caused by the cotton forming the wick.

Some people think that as gas in its fluid state emits an offensive odor, that the same must exist when inflamed; this, however, is not the case, for gas when properly purified gives no more obnoxious odor during combustion than lamps or candles, but as just illustrated with these, when allowed to escape unconsumed, the inconvenience exists. Still we must regard it as providentially ordained that gas possesses this obnoxious quality, as it is a notice or forewarning of a required attention, which being immediately adopted, the possibility of danger and nuisance is avoided.

Utility.—Gas may now be burnt in private houses without the slightest effluvia or escape of the pipes, joints, or fittings, and, if properly purified, may be burnt in any kind of room, however highly ornamented by gilding and otherwise, without being in any way prejudicial.

Gas has large claims for throwing out a genial warmth throughout apartments; it is also extensively employed in the cooking or preparing of food, and is daily being introduced into the culinary department of private families. Roasting by gas surpasses all other ways. Boiling, steaming, stewing, etc., are all fulfilled with much less trouble and cost, and more cleanliness and perfection, than by charcoal or the common stove.

Baths are heated by gas at a very insignificant cost. Drying-rooms in laundries are kept at a good uniform temperature with a couple of burners, so applying a remedy on this point for the uncertainty of climate, and the breakfast-table no longer requires a coal fire. A simple apparatus at the cost of a few dollars is a substitute for the kitchen range or house fire; this can, by means of a flexible tube, be placed anywhere, and a given quantity of boiling water, sufficient for the wants of the breakfast of any family, can be procured in one-fifth the time of the house fire, at less than one-third the cost, and a twentieth part of the trouble.

Indeed there are few branches of industry where heat is required that gas cannot be used with advantage, and new applications of it are continually being made. Its benefits are such as a means of illumination, which any one who has left the obscurity of candle, or lamp, for its *light*, can fully appreciate, and the wonder is how people can be without it.

But gas has fulfilled another most important service: in our large cities, it has rendered life and property more secure; and those numerous localities, which at night were the haunts of violence and crime, are now comparatively safe; and the lonely traveller (whose purse and person were so frequently in danger from an attack of the highway robber, or footpad) can now pursue his path in comfort and safety, knowing that those gentlemen of the road "prefer darkness rather than light, because their deeds are evil." Some may say this change is due to the advanced civilization of society, and undoubtedly it is so; but gas has contributed largely to that change. The greatly improved illumination of our streets has tended to prevent crime; it has afforded great facilities for persons to assemble at nightly scientific, literary, musical, and other meetings; it has thus facilitated the reunion of society of every grade, and therefore it may be truthfully said that gas has certainly assisted largely in attaining this advancement in civilization.

CHAPTER III.

MANUFACTURE OF GAS.

Gas is a term which is applied to all permanent invisible fluids. The air we breathe is composed of two gases —oxygen and nitrogen; there are innumerable other gases, possessing very different and opposite natures, which, by the science of chemistry, we are taught to understand, produce, and combine.

Gases exist in various ways; some are natural productions, as those arising from the decay of vegetable or animal matter, those issuing from volcanoes, the atmosphere, etc. Others are obtained by chemical manipulation, one of which processes is called destructive distillation; that is, by submitting materials to a great heat, gas is expelled, and the original nature of the material destroyed; thus when coal, tallow, oil, and a large number of other substances are submitted to this process, gas, such as used for lighting, is produced.

Vapor, as steam, will convey to the mind the idea of the volume of gas; but this, by a diminution of temperature, becomes liquid, whereas gases of every kind are permanent under all ordinary circumstances. We are enabled better to understand their volume by observing smoke when issuing from a fireplace, chimney, or elsewhere, which is a mixture of several gases in combination with vapor and small particles of solid matter commonly called soot. In these pages, when the word gas is applied, it will be understood in its general acceptation to be that for lighting; and whenever other kinds are intended, they will be expressed.

We observe in the ordinary house-fire how, by the action of the incandescent fuel, the gas is expelled from the coal, sometimes in vigorous small jets suddenly igniting, producing a brilliant light, and as suddenly extinguished, leaving a stream of impure gas or smoke. The flame of the fire is due to the ignition of gas, and the volume of smoke ascending the chimney consists principally of this, but either being combined with an excess of vapor, or there being an insufficiency of air intermixed therewith, it does not ignite, and so passes off to be distributed in the atmosphere.

Although there are many materials from which gas can be produced, yet coal is almost universally employed for the purpose, on account of its price, the facility with which it is distilled, the quantity and quality of the gas derived therefrom, and the value of the residues after that is expelled.

Illuminating gas is produced by the decomposition of organic substances, of which coal is the cheapest and most convenient.

Under a destructive distillation at a high heat, wood, resins, fats, oils, peats, and many other substances yield lighting gas.

In some places (as at Wilmington, N. C., at one time), the whole supply of gas has been made from *pine wood*, which does not, however, afford a gas of a high illuminating power.

Works for the production of gas from resins, fats, and oils, were at one time common, but have been generally abandoned on account of the greater cost of the gas produced, as compared with that obtained from coal, in the ordinary manner. Some interest has been aroused by the gas-producing properties of peat, and one or two of the London companies have been experimenting with peat from the estates of the Earl of Caithness, in the north of Scotland, with encouraging results; and it may be that peat-gas will come into extensive use. Kerosene oil is distilled at a moderate heat from the highly hydrogenous boghead coal, and it is probable that the vast subterranean collections of oil in and near our coal-fields have formed, by the action of internal heat, upon the beds of coal themselves. At various places, not far from the oil-wells, natural gas is obtained in abundance from the ground; Fredonia, in the State of New York, being lighted throughout by natural gas, which is also employed for illuminating one of the lighthouses on the southern shore of Lake Erie. This gas we may suppose has been generated at a higher temperature from the coal or coal-oil, from near deposits, of which the gas is obtained.

A simple way to demonstrate the manufacture of gas is to fill the bowl of a common tobacco-pipe with powdered coal, which is then covered with a layer of plastic clay, being pressed tightly round the edge of it, so as to close it hermetically; the bowl being then inserted into the midst of an ordinary fire, after a short time gas will issue from the end of the pipe, which can be ignited, and will continue to burn till all is expelled, leaving the residue of coke in the bowl. This is a rude gas-works in miniature, without the purifying apparatus.

In the gas manufactory, the tobacco-pipe bowl is replaced by large cast-iron or earthen vessels called retorts; these are imbedded in ovens, and exposed to the action of a furnace, and so kept continually red-hot; they are partially filled with coal, and hermetically closed, when the heat decomposes the coal, and expels the gas, which passes from the retort through several vessels for condensing the vapors in combination, and extracting impurities, which would be injurious to health and comfort if allowed to remain. When the gas is purified, it passes to the gasometer, ready for distribution.

On burning the ordinary lamp or candle, a precisely similar operation of distillation, or decomposition of the materials, and production of gas or vapor, takes place. The oil or melted tallow ascends to the wick by capillary attraction; it then comes in contact with the lower part of the flame, is decomposed by the heat, and converted into gas, which immediately supplies the flame, producing light and heat. In the house fire, or in lamps or candles, the gas is consumed as soon as produced; but in gas-works, after production, it has to be stored and kept ready for the time it may be required, then to be conveyed sometimes through a distance of several miles of pipes before it is burned.

Gas-consumers have generally a very vague idea of the quality of gas; defects of every denomination which exist on their premises, whereby the supply or light is rendered inadequate, is often attributed to the badness of the gas, and, as will be shown in the chapter on burners and glasses, frequently one-half or two-thirds of the light that might be derived is lost; the consumer then complains of the high price, or the "bad gas," little imagining this to be the result of his own mismanagement; yet such is the fact. But gas, like every other article in commerce, varies in quality, depending on the description of coal from which it is produced or distilled, and the manner of operation.

Many people imagine, when a flame gives forth smoke, that it arises from the bad quality of the gas, whereas the very reverse is the case. This smoke is the illuminating constituent—indeed the source of light; and if it be allowed to escape unconsumed, it is not the fault of the gas, but the manner it is employed.

This is easily demonstrated with an ordinary oil lamp; if the cotton of this be properly trimmed, and the glass chimney suitably adjusted, the flame is clear and bright; but on removing the glass, or allowing an excess of wick, the flame becomes dull, and emits smoke in abundance. Or with an ordinary tallow candle, if left unsnuffed, it becomes smoky, and gives but little light. In like manner, gas being improperly used, an excess of smoke and diminished light must be expected.

The means of preventing smoke consist in having suitable burners or glasses, and not permitting a superabundance of gas to issue; for if the flame of an argand or other burner be allowed to pass certain bounds, the annoyance in question, and waste, are the consequences; but when adjusted to the proper limits, the flame is clear and bright, emitting little, if any, smoke.

In defining the quality of gas, there are two distinct considerations: the first, its power of giving light; the second, its freedom from impurities. Gas may be of good illuminating power, yet so contaminated with impurities as to be insupportable; or it may be perfectly free from these, yet very deficient as an illuminating agent. Therefore when speaking of good gas, it should be free from impurities, and rich in illuminating qualities.

Gas, as it leaves the retorts, is totally unfit for combustion as a light-giving agent. It burns with a lurid smoky flame, and is heavily charged with sulphur and ammonia, both of which must, according to law, be removed. At present there is no known process for removing these which does not also remove some of the light-giving materials.

Formerly, in England, the quality of gas was not so much considered as at present, and was entirely dependent on the company supplying; but of late years, the gas companies of nearly all the towns and cities of Great Britain are bound to supply gas of a specified illuminating power, and free from impurities. In many places, responsible inspectors or chemical examiners are appointed for the purpose of testing the quality of the gas; and it is to be regretted this is not more general, as it would tend to establish that confidence between the consumers and companies which is desirable for both parties.

The English law on this subject is as follows: "The quality of the common gas supplied by any gas company shall be, with respect to its illuminating power, at a distance as near as may be of one thousand yards from the works, such as to produce from an argand burner having fifteen holes and a seven-inch chimney, consuming five feet of gas an hour, a light equal in intensity to the light produced by not less than twelve sperm candles of six to the pound, each burning one hundred and twenty grains an hour; and the quality of cannel gas supplied by any gas company shall, with respect to its illuminating power at the distance aforesaid, be such as to produce from a bat's-wing or fish-tail burner, consuming five feet of gas per hour, a light equal in intensity to twenty such sperm candles; and each such gas shall, with respect to its purity, be so far free from ammonia and sulphuretted hydrogen that it shall not discolor either turmeric paper, or paper imbued with acetate, or carbonate of lead, when these tests are exposed to a current of gas, issuing for one minute under a pressure of five-tenths of an inch of water, and shall not contain more than twenty grains of sulphur in any form in one hundred cubic feet of gas."

According to this law, it will be seen that the general conditions stipulated in defining the quality of gas, are: that an argand burner having fifteen holes, and consuming five cubic feet per hour of the gas supplied, shall give at least the same light as *twelve* sperm candles, each consuming 120 grains per hour; that the gas shall be free from ammonia, sulphuretted hydrogen, and that it shall contain the minimum quantity of sulphur that can be practically effected.

In this country, the illuminating power of gas as compared with the English standard is somewhat higher, ranging from 14 to 16 candle power.

The manner of comparing the relative light from the gas and candles is of the greatest simplicity; and to make this understood, it must first be stated that the rays of flame, when intercepted by a solid substance, produce a shadow, and the *density* of this shadow is in direct proportion to the *intensity* of the light. So, if on a table covered with a white cloth, or a large sheet of white paper, two lighted candles be placed, one at each end, and exactly midway between them a pencil or similar object be fixed perpendicularly on the table, then a shadow will be shown from each light; and should they be exactly of the same *density*, then the lights would be equal.

Now if at one end of a long table, provided as before, we place the twelve candles lighted, and at the other end the gas-burner attached to a meter, so as to show accurately the quantity consumed per hour, and if a pencil be fixed in a perpendicular position exactly midway between the two lights under examination, then on the flame of the gas being regulated until the shadows are alike in density, or the two lights equal in intensity, an observation of the meter will give the quantity of gas required to produce the light equal to the candles. In practice, there is a much simpler way to arrive at the result, but it would be too lengthy to describe, and would answer no purpose.

In addition to the illuminating power, there is the other important requisition in gas—that is, its purity, or freedom from pernicious qualities; and although in all large towns and cities there are qualified managers and engineers who carefully superintend the operation of purification, there are, however, other places which have not this advantage, and for which the following observations are intended.

Impure gas is beneficial to no one, and is alike prejudicial to the works supplying as to the consumer. It brings discredit, prevents the full development of the business of a company, and when it occurs can only be through ignorance, carelessness, or accident. When gas is impure, it gives forth a very disagreeable odor during its combustion; it changes the colors of ornamental furniture hangings and paper; it tarnishes plate, as well as several of the metals; it speedily deposits a cloudy tinge on gas chimneys; but above all it is unwholesome, and exceedingly disagreeable to persons who breathe the atmosphere in which it is consumed.

A gas company has been known to sustain a heavy loss of business occasioned from supplying impure gas. A large street in the city was composed principally of silversmiths' and jewellers' shops. Gas had been tried by a few of these establishments, but its impurities speedily tarnished the plate, etc., to such a serious extent, which compelled its use being discontinued; but years afterwards, when a proper system of purification was applied, in a short time every shop adopted it.

Many have been and are the annoyances experienced in some places by impure gas being supplied, and persons, after having incurred considerable expense in fittings, etc., to obtain this light, have been much disappointed on that account, and have eventually abandoned it.

The ordinary impurities in gas are few, and the operation of detecting them is simple. All that is required for the purpose are three small books of test papers, namely, turmeric, blue litmus, and acetate of lead, which may be had of most operative chemists for a mere trifle; with these the consumer can himself test the purity of the gas supplied to him, as will be now described.

The ordinary impurities are ammonia, sulphuretted hydrogen, carbonic acid, and sometimes in small quantities a compound of sulphur and carbon, all of which, of course, exist in a gaseous state in combination.

To detect the presence of ammonia, take a leaf of turmeric paper, which has a peculiar yellow color, and hold it within about a quarter of an inch of a fishtail or bat's-wing burner, and let the gas impinge upon it for about half a minute. Should the paper remain unchanged in color, the gas is free from this impurity; but should it change from its yellow color to brown, then the presence of ammonia is established, and according to the deepness of the color so will the quantity be indicated. But in the event of the test being applied for a protracted period, even when the gas is moderately pure, the presence of ammonia will be shown. However, a slight quantity of this is acknowledged to be actually indispensable, and by no means injurious.

The next impurity, sulphuretted hydrogen, is much more pernicious than the former. To detect this, take a leaf of the acetate of lead paper, act as before, and if, after being exposed to the gas for half a minute, the test paper retains its original whiteness, then this impurity does not exist; but should it become brown, sulphuretted hydrogen is present.

Carbonic acid is injurious on account of its deteriorating the illuminating power of the gas with which it is combined; for, according to good authority, the presence of one per cent. of this impurity in gas diminishes its light nearly one-tenth part. To detect this, take a leaf of the blue litmus paper, and act as before, when the presence of carbonic acid will change the color of the test to red; on the contrary, if the gas be pure, it will retain its blue color.

The last impurity, the compound of sulphur and carbon, has been considered by a chemist of great ability to be of little importance. This, however, is by no means the general opinion; but as the method of detecting its presence is too complicated for the general reader, it will not be entered into here. When this exists, it is readily perceived by a peculiar disagreeable, suffocating, sulphurous odor given off when gas containing it is burned in a close apartment.

In making these trials, only a small quantity of gas escapes, being about the twentieth part of a cubic foot at each operation, so that not the slightest inconvenience beyond the odor for a few minutes is to be apprehended. Should the gas not be sufficiently pure to withstand these tests, and the consumer be annoyed in consequence, upon a proper representation of the complaint being made to the company supplying, undoubtedly they would devote themselves to correct the evil; but at the same time the consumer should guard against any unnecessary complaints.

Connected with the manufacture of gas is its distribution to the streets and houses. For this object it has to be expelled with a certain degree of force, technically called "pressure." Some conception of this may be formed by the reader breathing in the gentlest manner possible, which is about equivalent to the pressure with which gas is consumed under the most favorable circumstances; and by blowing with a slight force is equivalent to the greatest pressure existing in the main pipes of gas companies. It is therefore evident the fears sometimes expressed of the "gas bursting the pipes" have not the slightest foundation.

Although this pressure is of such little power, it is indicated by instruments for the purpose, on a scale divided into inches and tenths of inches. The first instance may be equal to two or three-tenths' pressure, and when blowing with slight force will be about equivalent to from three to five inches' pressure — a degree of force which very seldom exists outside a gas-works. These observations on pressure will be found of some importance in a future chapter, when treating on burners, glasses, etc.

When lighting by gas was first introduced, consumers were supplied by contract, that is, a certain sum per annum was charged for each of the various classes of burners, to be lighted from sunset to a specified hour. This system was accompanied with serious loss to companies, who, having no means of shutting off the supply at the hour stipulated, the gas was left entirely at the discretion of the consumer, and the result was continued and serious loss. A much better system was adopted in France, where it was the custom to attach a tap to the supply-pipe of every house, which was opened and shut by an *employé* of the company precisely at the time contracted for, thus avoiding part of the loss occasioned by the less scrupulous class of the community. The system now universally adopted is to supply gas only by meter, which is alike advantageous to companies and consumers, and is the only equitable way that it can be employed.

CHAPTER IV.

CONSIDERATIONS ON ADOPTING GAS LIGHTING.

Many obstacles at one time existed against the adoption of gas as a means of illumination. It was very expensive, and the prices of fittings and apparatus connected with its introduction were costly. Companies frequently required advances before they would supply; and they sometimes insisted on the incoming tenant paying the gas debt of his predecessor, although the persons were totally unacquainted with each other. The consumer often paid a high price for the supply-pipe, and had in most cases to purchase the meter. All these impediments prevented many who had the desire to burn gas from carrying it into effect.

These obstacles—at least in New York, Philadelphia, and Boston, and we believe generally throughout the country—have been removed. The cost of gas-fittings is reduced very considerably; no charges are now made by many companies either for supply-pipes or meter; nor is a deposit now required from any responsible person. In other respects, consumers have many advantages which were never conceived some years ago; and by these concessions companies have advanced materially their own interests, in giving every facility for purchasing and consuming their production, and extending their operations.

When the decision is made to adopt this light, it is of importance to employ a skilful man as gas-fitter, for perhaps their are few branches of business where there exist comparatively so many incompetent tradesmen; and it consequently happens that, in endeavoring to purchase at the cheapest rate, the very reverse is the case; and the householder has to contend with much annoyance and trouble before he can comfortably enjoy the admission of gas into his dwelling.

It has been observed by an authority on this point: "There is economy in employing the most intelligent and experienced workmen, although their charges, in the first instance, may be the highest. When gas-fittings are judiciously arranged, and constructed of good materials, they constitute the most durable portions of the fixtures of a house. If, on the contrary, they are put up by a blundering fitter, who professes to work cheaper than his neighbors, it is probable that frequent repairs will be required; that there will be a deficiency of gas in some parts of the house; or what is still more disagreeable, that there will be an escape of gas, or an obstruction (by the condensation of vapor) in those parts of the pipes which pass between the ceilings and floors. In these, as in all other matters, there needs only the exercise of a little common sense to insure success; the expense of altering and rearranging gas-fittings constructed by unskilful workmen very often amounts to more than half their original cost."

Although the gas-fitter is supposed to be able to fulfil all the necessary arrangements in the introduction of gas to the premises, still the consumer should be in a position to insist on some material points for his convenience, safety, and economy. The following suggestions are therefore offered for his guidance, both on the introduction and general use of gas :—

The company's service-pipe conveying the gas from the street to the house, in this country, is always of iron, and should be continued (necessarily at the expense of the consumer) to the locality where the meter is placed ; and the main tap, or valve, fixed on the end of the iron pipe, just at the entrance to the meter.

The main tap, or valve, for shutting off the gas from the premises, should always be placed in a position easy of access, for the purpose of turning on and off every night, or for any sudden emergency ; and it is imperative that the pipes should be so placed as to accomplish this object.

A locality of moderate temperature should be carefully selected for the position of the meter ; for if a wet meter were exposed to frosty weather, the water would be liable to freeze ; and if to a warm situation, it would evaporate, and afterwards be condensed in the pipes, and so obstruct the passage of the gas, or cause that disagreeable effect called "jumping lights." It is true the dry meter avoids this ; but there is the important question of measurement to be considered ; for as gas expands by heat, it follows that if the meter be placed in a very warm situation, the gas, during its passage, would increase in volume, and the consumer in consequence would have to pay more than actually necessary.

All places of public resort should be supplied by at least two meters, which ought to communicate with each other, so that in the event of one of them failing—a frequent occurrence with the wet meter, caused by the evaporation of water—the other continues the supply, which, although perhaps inadequate to the wants of the establishment, yet avoids the alarm and confusion attending a total extinction of light; and the defect can afterwards be easily remedied at leisure.

The meter once fixed, the consumer should not allow it to be removed without first giving notice to the company; but supposing, by extraordinary circumstances, the gas-fitter cannot obtain light otherwise than by displacing it, the consumer is then bound without delay to inform the company of such a change; also when it is refixed; and thus prevent annoyance and disagreements which might otherwise occur.

When price is not a consideration, the pipes, in exposed positions, or between floorings, or outside buildings, should be always of iron, and if galvanized, or coated with zinc, would be preferred.

In manufactories of every kind, iron pipe should be exclusively used throughout; and these may even be employed for the pendants, brackets, etc., being exceedingly strong, and of the greatest durability.

When iron pipes are buried in the walls, it is imperative that they should be galvanized and varnished internally, otherwise there are probabilities of continuous stoppages in the supply, by deposits of rust, etc.; and to remedy this the paper hangings, plastering, and painting are necessarily seriously injured. The softer metals, or composition pipes, would in one sense be better for the purpose, but they are likely to be destroyed by the action of the lime in the mortar. Where it is a question of economy, composition pipes (composed of lead, tin, and antimony) can be advantageously used for the interior of dwellings, shops, etc.; they are very durable; are more sightly than those of iron; but they should not be buried in the mortar.

All outside lights, such as lanterns, should have a tap inside and within reach, so as to shut off or regulate the supply; great loss has occurred for want of care on this point, through gas escaping, when the consumer has complained, with apparent reason, saying he "had not consumed any more gas than before"; but here it must be remembered that the meter indicates the *quantity which* PASSES, without any reference as to how it is employed; and gas, like every other commodity, when delivered to the consumer, requires him to exercise every care to prevent it being wasted or lost; and, if he permits this, it must necessarily be at his cost.

In all cases where goods are kept in the highest part of an apartment or store, as in shops or libraries, etc., it is of the greatest importance to insure good ventilation in the ceiling, so as to carry off the heated air and vapor formed by the combustion of the gas. The lower part of a room may be only at a moderate temperature, whereas above the level of top of door, and near the ceiling, the heat will be almost insupportable; so that, in consequence of the absence of proper ventilation, goods are often spoiled and the gas condemned.

Whenever there is an odor of escape of gas, emanating from the street, cellar, drain, cistern, sewer, or anywhere in the immediate neighborhood of the consumer's premises, written notices should be sent without delay to the company, who, regarding their own interest, would immediately attend to it, and thus prevent annoyances or accident.

Whenever there are signs of an escape in the interior of a building, there is no occasion for alarm, but immediate and prompt care must be employed. Lights of any kind should be avoided, the main tap turned off, the doors and upper parts of the windows opened (as gas, by its lightness, ascends and escapes very readily at the highest part of an apartment), then by proper supervision a tap may probably be discovered to be left turned on; or if there are any sliding or hydraulic lights (to which we shall refer hereafter), they should be supplied with water; or if the pipes are exposed, and within the reach of children, a small puncture may have been made, which can be temporarily repaired with a little grease, white lead, or soap placed upon it, and afterwards should be substantially done as soon as possible. The defect being remedied, the doors and windows should be left open for a short time, when the lights can be used.

But if the evil be not discovered, the consumer should, under no circumstances, attempt to find it by means of a lighted candle, but send for his gas-fitter, who is experienced in the matter, is responsible for the result, and thus avoid all risk. The odor of escaping gas, whether on the premises of the consumer or not, should never be neglected, otherwise it becomes unhealthy, and sometimes very serious. A few years ago a poor woman was found suffocated in her bed, from the gas which had escaped from the main in the street having passed through the ground, and so entered her cottage, and causing the disaster.

In lighting burners, particularly in gas or cooking stoves, care should be taken to apply the light immediately the gas is turned on, otherwise it is sometimes forgotten, and there is an accumulation of it in the apartment, which causes unnecessary nuisance. When this precaution with the stove is not attended to, often a disagreeable report occurs when lighting, which, however, frightens more than harms.

Accidents from explosions of gas are exceedingly rare; and one great preventive is to shut off the main tap at night; for these accidents have happened through people turning the small tap to extinguish the light, when, by the slightest mischance imaginable, they have inadvertently turned it on again, and the gas escaping during the whole of the night, it fills the apartment, and the greatest danger, on the approach of a light, is the serious consequence. If a similar occurrence happened during the day, the odor would cause it to be detected long before it became perilous. Hence the necessity of turning off the supply of gas at night.

Many erroneous impressions exist as regard explosions; but these can only occur when a large quantity of gas is allowed to escape and intermix with the air in an apartment, or other enclosed place, when, on the approach of a light, an accident might happen; however, the smell always gives ample timely notice, unless, as in the case just mentioned, the gas has been permitted to issue for several hours together.

Gas-lights should never be placed in cellars, or similar confined places, without ventilation by an opening in the highest part for the escape of the gas, should it, by accident, be left turned on; and another lower down, for the admission of air. It is always better there should be provided a tap on the outside, in addition to those inside, and thus avoid the chance of accident.

In large establishments, where it may be necessary to have a few lights burning during the whole of the night, as at the entrance of buildings, these should be supplied by a separate small meter, so that the gas exists only on that part of the premises where required.

In places where the gas is not turned off regularly, the main tap is liable to become set or bound in such a manner as to render it utterly useless. From this cause conflagrations have occurred, arising from an escape igniting, and at the all-important moment when it was desirable to shut the tap, it was found impossible. Therefore they should be seen to from time to time; and if found difficult of action, the attention of the gas-fitter called thereto. Gas taps of every denomination should be what is termed "stopped"—that is, when the key is turned to the extreme point in one direction, the gas is full on; and when in the opposite, it is shut completely off.

GAS-FITTINGS, PENDANTS, BRACKETS, ETC.

The present fashion of light and elegant designs for gasaliers and other apparatus for the display of gas-lighting, is a strong inducement for the further development of that art; and the amount of excellence attained by the manufacturers of these articles is calculated to suit the tastes of the most wealthy and capricious, as well as the most economical and unpretending.

The forms of gasaliers, brackets, pendants, and lustres, are so varied, that their selection is entirely a matter of taste. Cheapness in this case is not incompatible with usefulness and durability. For passages, staircases, bedrooms, etc., very little ornament is required—the less the better. In the most conspicuous parts of a house, the dimensions of the rooms, the style in which they are furnished, and the purposes to which they are applied, all deserve consideration. The colors of the walls and ceilings, and furniture of a room, have much to do with lighting it effectively.

These are of the utmost importance, and should be carefully considered, so that the colors which reflect light and harmonize in their various combinations, may be chosen in preference to others. The difference in the quantity of light required for rooms of equal dimensions, one of which shall have dark-colored walls and draperies, and the other, those which are bright and cheerful, will be as two to one.

In choosing gas-fittings, it is better to see the articles themselves than to order them from drawings, otherwise there may be some mistake or disappointment as to sizes and relative proportions. To this may be added, the drawings of ornamental apparatus like those in question, are very deceptive; a good drawing will often set off a very bad design.

When a gas-fitter is employed, it is best to have the work done by contract, and care must be taken that the sizes, quantities, and situation of the various kinds of tubing are distinctly specified. No respectable tradesman, who properly understands his business, will object to this. It is more satisfactory to all parties to know beforehand what is to be done, and how much is to be paid.

A most convenient apparatus, sometimes employed in dwellings where gas exists, is the hydraulic gasalier, which is constructed with chains and counterbalance weights, for the purpose of being raised or lowered at will. In this the gas is prevented from escaping by the intervention of a column of water in the tube, poured into the cup at top. This apparatus has the disadvantage that the water evaporates, or by a sudden jerk in raising or lowering it, the water is caused to overflow, when in consequence of the deficiency of water there is a probability of the gas escaping on the apparatus being drawn down, and if allowed to continue so for several hours, would become dangerous on a person entering the room with a light. Such accidents are exceedingly rare, and by a little care they can be prevented altogether. To avoid this inconvenience, the hydraulic gasalier should be attended to every two or three months, simply by raising it to the highest, and then pouring a small quantity of water into the cup at top until nearly full. If a teaspoonful of sweet oil be poured on to the water, it will prevent the evaporation, and the care required will be less frequent.

Whenever there is the odor of escape of gas in a house where hydraulic gasaliers exist, the attention of the occupants should be directed to them; but on no account to use a light when supplying water; for although the quantity of gas in the apartment may be small, yet as that ascends and floats in the upper part, the presence of a light there may probably be dangerous.

There are other kinds of sliding lights, called telescopic, which dispense with the water, chains, and counterbalance weights. In these one tube passes within another, similar to the instrument from which it is named, and a cork-tight joint prevents the gas escaping. These are much used for single-pendant lights.

In occupations where a portable light is required to replace the lamp or candle, an apparatus similar to a candlestick, to which the gas is conveyed by a flexible tube, supplies the want. With this the gas-light may be conveyed from one place to another with the greatest facility.

It is impossible to lay down any instructions as to the kind of apparatus to be employed; this will be ascertained, by those who may be desirous of using gas, observing the method adopted by their friends or acquaintance.

GAS STOVES AND GAS-COOKING APPARATUS.

Gas stoves, when properly constructed, are of the utmost importance for small offices or apartments having no fireplaces, where they can be employed with considerable advantage, both as regards comfort and economy, and in some instances supersede the ordinary stove.

These apparatus have, however, been frequently condemned, on account of the odor arising from them. This has sometimes been attributed to the peculiar action of the lighted gas upon the iron composing the stove; and, to remedy this, they have been constructed of porcelain, but without abating the nuisance. Sometimes an enormous chimney has been attached to carry away the products of combustion, but with no good result, whilst it has counteracted in a great measure the good effects of the heat derived from the stove, by allowing the principal part of the warm air to escape from the apartment.

It is well known that three or four lights can be burnt in a moderate-sized apartment without the slightest inconvenience of a disagreeable smell; and yet, a small quantity, not equal to one light in a gas stove as sometimes constructed, is often insupportable; therefore it cannot arise from the gas, but from the manner in which it is employed.

Until very recently, manufacturers of these stoves have followed one system of burner; that is, a large ring with a series of holes, producing detached flames or jets. Now there are two great objections to these circular burners. The first, when there is a slight excess of gas, they smoke imperceptibly, and serious complaint and dissatisfaction, with loss of gas, is the consequence; secondly, when they are turned down to a small blue flame, often for the purpose of preventing the odor, it is in reality increased, producing a most unhealthy compound, and causing a most disagreeable smell. On this account many have been compelled to abandon the method of heating apartments by gas.

The remedy for this evil is simple; for instead of the ring burner, if a large argand, with a talc or iron chimney, be employed, or if two or three fish-tail or bat-wing burners be substituted, with regulator attached to prevent the flame from rising too high and smoking, then the comforts of the gas stove can be appreciated; for there is neither smell nor smoke, and the air in an apartment can be kept at any moderate and continuous temperature at a very trifling cost.

The main points in constructing gas stoves are to have proper burners, with regulators; that they should be placed near the floor, so as to heat the air in the lower parts, which necessarily ascends and warms the upper part of the chamber; and every facility should be given for the free radiation of the heat: in short, the simplest gas stove is always the most effective.

Some gas stoves are constructed in such a manner that the flame of the gas acts on an incombustible fibrous material called "asbestos," which speedily becomes incandescent, and produces a lively, cheerful appearance.

Others are made to imitate in an admirable manner an ordinary coke fire. In these the coke is substituted by lumps of fire-clay intermixed with asbestos, of the size and form of coke; this being placed in an ordinary grate, the flame of the gas is caused to impinge upon the material, which quickly becomes incandescent, and assumes the appearance of a good coke fire. It must be observed that the heat from gas is not increased by these means, as people would suppose in witnessing the process, but the very agreeable and lively effect is a strong recommendation.

Small stoves or burners are frequently employed for continuously heating water, etc. An objection often complained of in these is the accumulation and deposit of soot. This inconvenience is prevented by employing the air, or atmospheric, or "Bunsen" burner, in which a portion of air intermixes with the gas in its passage to the orifices of the burner; the flame of this is of a blue color; there is neither soot nor smoke, and the heat derived is considerably more than that obtained from gas in the ordinary process of burning, inasmuch as the soot wasted in that method is consumed with the air-burner.

Gas-Cooking Apparatus, Baths, etc.—Of late years, gas-cooking apparatus have become very much in use, and have been introduced into private dwellings with very good result. The apparatus is admirably adapted for the French style of cooking, where stews are the prevailing dishes. Roasting by gas is allowed to be far superior to the process when conducted in the ordinary way; the juices of the meat are retained, the flavor is increased, and there is less loss. Boiling, baking, and frying are done with greater perfection than with the open fire, on account of the facilities with which the heat can be increased or decreased at pleasure.

Baths are also heated by gas in a most economical manner, they being, of course, constructed expressly for the purpose.

One of the recent and important applications of gas, is its adoption as an agent for producing motive power, being a substitute for steam, and on some accounts superseding that. In the gas engine, a portion of gas is intermixed with a given proportion of air, and on this compound being ignited by an electric spark, the motive power is obtained. This engine possesses several advantages; amongst them, are its portability; having no boiler, no danger is to be apprehended from explosions. Its management is of such simplicity, that any laboring man or lad can control it. Requiring no chimney, it can be fixed anywhere without the annoyance from smoke; and the cost of the power derived is stated to be exceedingly moderate.

The general management of gas is of the greatest simplicity, and it is only where downright negligence exists that any accident can occur; and although some cautions have been suggested in the foregoing instructions, this has been done with the hope of inspiring confidence and removing doubt, and with the view to prevent even the few chances of accident that may exist.

CHAPTER V.

BURNERS, FLAMES, GLASSES, REFLECTORS, ETC.

WHATEVER may be the quality of gas supplied by the company, the consumer, through want of knowledge of some simple facts connected with burners, flames, and glasses, may be occasioned much annoyance, disappointment, and expense; and, unfortunately, these evils are aggravated on account of gas-fitters being frequently unacquainted with the various contingencies which occur in burning gas.

It is an every-day occurrence for consumers to complain of the excessive cost and the deficiency of light on their premises. The first they invariably attribute to the inaccuracy of the meter, and the latter to the bad quality of the gas; and no doubt it would be a difficult task to convince the majority of those who thus complain that much of the fault rests with themselves. In fact many of the complaints made by gas-consumers may be traced to their own mismanagement, and the want of care and knowledge of gas-fitters. Bad burners are used, and small pipes expected to supply endless light, while half the lights are allowed to burn with ragged flames, and the gas hissing away, giving nothing like its proper light. Good burners, in connection with pipes of sufficient size, with the flow or pressure of the gas properly regulated, are the only means of getting the most satisfactory results.

If people would pay more attention to these seeming trifles, they would be more than paid for the trouble and expense.

The object of gas is to obtain light; and whenever this is effected at a greater cost than necessary, it is in every sense of the word a loss—just as palpable as permitting oil, or any other valuable commodity, to run to waste; therefore it is essential for us to consider the means requisite to avoid such loss.

For the purpose of obtaining the best results and economy from gas, there is no part connected therewith of more importance than the burners. If these are improperly constructed, or their flames unsuitably adjusted, the light derived from gas is reduced in a most extraordinary manner. Under such circumstances, the account of the consumer is much increased, and it is no exaggeration to state that a large proportion of consumers, through their own mismanagement, pay (considering the light obtained) twice as much as there is any occasion for; or, in other words, by proper burners and control, they could have their usual light for one-half the money paid.

The burner, technically speaking, is the point from whence the gas issues to be burned. Sometimes the flame is so called; this, however, is a misnomer; and in these pages the burner and flame are always considered distinct and separate from each other.

The flame of a bat-wing or fish-tail burner is seen to consist of two distinct parts,—one nearest the nipple, of a light blue color, sometimes nearly invisible, and a fringe of luminous flame above. The relative proportions of these two parts depend partly on the quality of the gas, but more on the construction of the burner. Small holes, or a narrow slit, will give more of the blue and less of the luminous part of the flame, all allowance being made for rate of burning and pressure.

"If you take a thirteen-candle gas, and burn it in an argand burner, you get the illuminating power of thirteen candles; if you burn the same quantity of gas in a bat-wing or fish-tail burner, you get only the illuminating power of *nine candles.* But if you put two bat-wing burners together, so as to have an agglomeration of the flame—not so large an expansion compared with the quantity of the flame—you get an illuminating power very nearly equal to twice thirteen. In other words, each one of these bat-wing burners, when the two flames are united into one, gives you very nearly as much illuminating power as an argand; showing that the real fact is, that the flame of a thin jet of gas greatly exposed to the atmosphere on both sides, loses its power of illumination, simply because there is such a large extent of atmosphere on both sides of this thin jet of escaping gas. This is thoroughly mixed up with the gas, and causes it to burn with a blue flame. Sometimes one-half or two-thirds of the whole area of the flame is blue. If you turn through a jet of gas a stream of atmospheric air, you will get a strong heat; but the illuminating power of the gas is gone. You have an enormous heat, which will melt platinum wire; but you have no light. So it is also where you have a jet of gas escaping from a burner, under conditions in which there will be a large amount of atmospheric air mixing with the gas."

There are four kinds of burners generally in usage, viz., the argand, bat-wing, fish-tail or union jet, and the single jet, each of which will be considered separately.

The argand burner was first invented by a French gentleman, from whom it derives its name, who adopted it in the last century for oil-lamps, making a most important improvement in them. As applied to gas, it consists of a ring pierced with small holes; from these the gas issues, and when burned forms a cylindrical flame, which is enclosed by a glass cylinder or chimney for the purpose of causing a draught or current of air to impinge on the interior and exterior of the flame.

These are generally defined by the number of holes they contain for the emission of the gas. As already stated, the standard indicated to test the quality of gas contains fifteen holes. This, however, appears to have been chosen as the medium, and is not by any means the most economical, and is far from being the most wasteful burner.

The annexed *figure* (1) represents an argand burner and flame under the most favorable conditions—the flame

Fig. 1.

being bright, clear, and uniform, slightly wavering at the top, the extremity of which is of a reddish color, having a tendency to emit smoke; and there is a total absence of those vertical streaks which indicate a separation between the various jets forming the flame, all of which points are indispensable to the economical consumption of gas with the argand burner.

The most important considerations for good burners are that the orifices for the egress of the gas should be perfectly regular in size, and sufficiently large, so as to permit it to issue with very feeble pressure or force. The passages to the interior and exterior of flame should be adjusted with great precision, so that sufficient air may be supplied, but avoiding any excess of that, which tends to cool the flame and diminish the light; and the glass chimney for gas of the quality ordinarily sold, should not be longer than seven or eight inches. In the event of this being exceeded, a sensible loss of light will be the result. With cannel coal-gas, longer chimneys may be employed with advantage.

Whenever the orifices for the emission of gas are too small, a greatly increased pressure is required to expel it, and the light derived is diminished just in proportion to that increased pressure. With burners constructed in this defective manner, the flame has a dull blue tinge, which increases in intensity according to the augmented pressure; the jets forming the flame are more or less detached, and a large portion of the lower part of this is of a deep blue color. If the pressure be great, and the orifices very small, a series of blue jets only are visible, for reasons already explained in reference to thin jets in contact, and being mixed with atmospheric air, which give no light, even although the full quantity for a good flame issues. Defective burners are very common, and by their usage the consumer frequently does not obtain more than one-half the available light to be derived from the gas.

To convey more forcibly to the reader the manner in which defective burners operate, we subjoin a series of experiments made with four different argands, all of the same size, and having 15 holes; but the holes in each burner respectively were of such dimensions as only to allow five feet per hour to pass under the various pressures indicated.

FIVE FEET OF GAS BURNED UNDER VARIOUS PRESSURES GAVE THE FOLLOWING RESULTS.

Gas issuing with pressure in tenths of inches.

1-10th	yielded	the light	of 12	candles.
5-10ths	"	"	6	"
10-10ths	"	"	2½	"
40-10ths	"	"	⅙	"

From these experiments we learn that the light to be obtained from a given quantity and quality of gas is entirely dependent on the burner from whence it issues to be consumed. The realization of the second experiment, when half the light is lost, is to be observed in practice in almost every street. The third experiment is rarely seen, and the fourth is mentioned merely as an illustration. This demonstrates very strongly the necessity of having proper burners; it also shows how, by negligence on this point, the consumer's gas account can be greatly increased in what appears a most mysterious manner.

The holes of argand burners may, however, be too large, in which case the flame smokes. Their size must be defined by the quality of gas they are intended to consume. With inferior gas, the holes are required to be large, whilst for that of superior quality they should be proportionably small. We will now refer to the varied light obtained by the adjustment of flames, which is another source of loss.

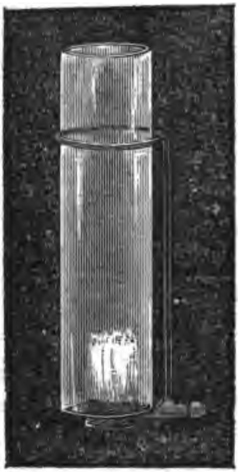


Fig. 2.

We would naturally suppose that, in proportion to the quantity of gas issuing from a burner, so would be the amount of light obtained; thus, if 5 feet give the light of 12 candles, that the flame being reduced so as to consume 2½ feet, would give the light of 6 candles. This, however, is far from being the case; for there is a particular point in the consumption of any class of burner where the maximum light is derived; and any deviation from this entails loss. As an example of this: if an argand flame consumes 5 feet per hour, and gives the light of 12 candles, and this be reduced so that only three-fourths of that quantity is burned (a flame very similar to *fig.* 2), then, instead of the light being equal to 9 candles, the theoretical proportion, it will be 6 candles only, causing a direct loss of 36 per cent. And if the flame be further reduced to consume 2½ feet, then, instead of the light being that of 6 candles (the due proportion according to the consumption), it will be 2¼ candles, being a loss of nearly 60 per cent. Lastly, if it be reduced to burn 1¼ feet per hour, a small blue ring of flame is all that is visible, without any available light.

Thus the cost of light from gas is very much increased by reducing the size of the flame. The knowledge of this fact is of importance to the consumer, who, in ignorance of it, in his desire to be economical, might obtain directly the opposite result. To give an instance of this, let us observe a shop window or other place having four good argand burners, as described, but their flames so checked or adjusted as to consume each 2½ feet per hour, about two-thirds the height of that represented in *fig.* 2, when the light from them conjointly would be only equal to 10 candles, obtained at a cost of 10 feet of gas per hour; whereas if these were replaced by one burner with the flame at the proper height, considerably more light would be had, at one-half the cost. Here, then, is one of many remarkable instances where consumers voluntarily increase their gas accounts by improper management.

It is therefore more economical to have one good gas-light than a number of small ones; besides, the brilliancy of the former contrasts strikingly against the dulness of the latter.

On the other hand, every care must be taken to prevent the gas passing off in waste; for whenever a flame becomes smoky, there is a considerable loss of gas, without any increased light. The inconvenience of having the ceilings blackened, with a probablity of goods stored in the upper part of the apartment being injured by the smoke, adds to the annoyance.

A great consideration with argand burners is that the flame, when slightly checked, should be perfectly regular and uniform in height. When this is not the case, it arises from some of the holes being obstructed, which may be easily cleared by means of a suitable broach, to be had of most fine-tool merchants; and should they be too small, with the same implement they may be enlarged. All irregular or pronged flames cause a serious loss of light; and the consumer should not hesitate to change any defective burners, as the cost is speedily realized by the economy, the brilliancy of the light, and avoiding smoke.

When a large quantity of light is required in enclosed places, as shops, warehouses, etc., argand burners are beyond comparison superior to all others; it is true they require more attention in cleaning glasses; there is also the expense of renewing the breakage of these; but the drawbacks are more than counterbalanced by the beauty and economy of the light, due attention, of course, being paid to its proper management.

The annexed *fig.* (3) represents an argand burner with two chimneys, the one within the other, the bottom of the outer being closed by a glass dish or saucer. In this the air to supply the flame passes down between the chimneys, in the direction of the arrows, and becoming heated in its passage, does not cool the flame, and a very large increase of light is the result. According to Dr. Frank-

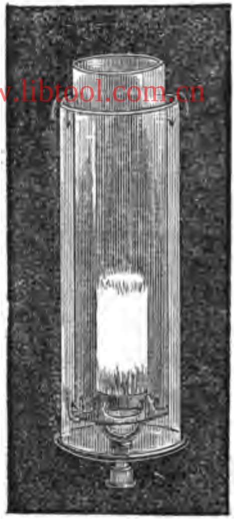


Fig. 3.

land, a high authority, for an equal amount of light, the saving of gas by the use of this hot-air burner is equal to 33 per cent.; and for an equal consumption of gas, the gain in light is equal to 62 per cent.

This class of burner is admirably adapted for private dwellings, offices, etc., on account of the diminished vitiated air, heat, and vapor, for the light derived; but although so highly recommended by Dr. Frankland, and other scientific gentlemen, from some unaccountable cause it has not been generally introduced to the notice of the public. This is the more to be regretted when we reflect on the innumerable absurdities which are produced from time to time, and have a large share of favor for a period, until their demerits become known.

Another economical class of argand burner has a perforated porcelain cup, on which the chimney reposes; the air to supply the flame passes through the pierced cup, and probably on account of it being limited in consequence, the light from the gas is increased. A precisely similar result is obtained by having a ring of perforated metal, or wire gauze, placed on the outer circle for the admission of air. Burners having cones, so as to cause the air to impinge upon the flame, are also considered economical.

A very suitable burner for lighthouses, signals, etc., is a modification of the argand called the Boccius burner. This consists of two or more concentric rings of flame, provided with a suitable chimney. In these each ring of jets should be adjusted by a separate tap, otherwise there is great difficulty in obtaining uniformity of flame.

The larger kinds of argand burners are the most economical. The advantage gained by employing a 30-hole argand instead of the standard is an increase of from 20 to 30 per cent. more light; for if the standard consumes 5 feet per hour, and gives the light of 12 candles, the 30-hole burner, consuming 7 feet per hour, will give the light of 22 candles. Therefore, whenever good light is desirable, the best results are obtained by employing the latter.

The argand is, however, not usually employed in dwellings, arising from its flame being susceptible to change in height with every variation of pressure in the company's main—at one time rising to a considerable length and smoking, at another requiring to be increased to give the desired light. Although the same irregularity exists with the other classes, it is not so evident as with the argand. This difficulty is easily overcome by attaching a good regulator to the premises, when the flames will be continuously uniform.

When only a small light is required, the argand is not well adapted; the bat-wing and fish-tail are then by far the most economical. As shown, when burning $1\frac{1}{4}$ feet per hour, this is useless; but the same quantity with the other burners will yield a very useful light.

THE BAT-WING BURNER

Is so called on account of its flame having the form of the wing of a bat. This burner consists of a metal, "lava," or "adamas" nib, with a hole pierced therein within a short distance of the top, across which is a slit from which

Fig. 4.

the gas issues in a thin flat flame. *Fig.* 4 represents a bat-wing flame under very favorable conditions, when producing the maximum of light from the gas. As seen, it is clear and bright, a small portion only of the lower part being tinged with blue; the two points are slightly reddened, and have a tendency to smoke. A flame like this wavers or flags. A perfectly steady bat-wing or fish-tail flame is never economical.

Following the law already mentioned, when the orifices of bat-wing burners are small, requiring a strong pressure to expel the gas, great loss of light is the result; the flame then becomes streaked with blue rays, the light therefrom is of a sombre hue, and when contrasted with a good burner and flame, the difference is so great that it is hardly possible to conceive that the two are supplied with the same gas.

Fig. 5.

Fig. 5 represents a flame under extreme circumstances, the orifice of the burner being very small, and the gas issuing with great pressure, producing a rough, uneven flame of a dull blue tinge, accompanied with a roaring noise. The loss of light under such conditions is very great, perhaps equal to three-fourths or four-fifths of that the gas would produce if properly consumed.

By an obstruction in the slit, the bat-wing flame becomes forked and uneven. This is also a cause of loss of light; however, they are easily cleaned by passing a piece of watch-spring or thin card through the slit; if the burner be made of "lava," or "adamas," a camel-hair pencil will clear it.

Bat-wing burners are the best adapted for all out-door lights. They require no glasses, nor are they affected, like the argand, by every breath of wind. They are also useful in enclosed places, where appearance is not a consideration, and are generally employed in the sunlight, hereafter mentioned.

Whenever economy in gas and a good light are desirable, the larger descriptions of bat-wing burners are always to be preferred, as reference to the following table of the light given by various kinds will demonstrate. The letters attached are for future observations.

						Candles.
A.	A bat-wing burner,	consuming	2 feet	per hour, gives	the light of	2¼
B.	"	"	2½	"	"	3½
C.	"	"	3½	"	"	6
D.	"	"	4½	"	"	10
E.	"	"	6	"	"	15½
F.	"	"	7½	"	"	22

The above may not be confirmed by every class of burners, but are a general average with gas of the quality supplied, the pressure being in all cases 4-10ths of an inch at the point of ignition.

THE FISH-TAIL BURNER.

This likewise takes its name from the appearance of the flame, and is formed by a nib of metal, etc., nearly pierced

Fig. 6.

to the top, where there are two holes, drilled at such an angle that each jet of gas in issuing impinges against the other, forming, when lighted, a sheet of flame at right angles with the holes. *Fig.* 6 represents such a burner and flame of the best description, yielding the maximum of light from gas.

The general observations respecting pressure, and the size of the orifice of argand and bat-wing burners, apply equally to these. When the pressure is excessive, it is indicated in the fish-tail by a roaring noise, with an alteration in the form of its flame; the result is that a large quantity of gas passes without giving light. In some respects this burner is the most defective, for it affords facilities for the gas to pass off imperceptibly in waste with any slight excess of pressure, whereas, with the other burners mentioned, notice would be given of this by the smoke arising therefrom. Fish-tail burners are very generally adopted for dwellings, on account of their being most suitable for glass moons or globes.

Fig. 7.

Fig. 7 is a sketch of this class of flame as ordinarily employed; but in this the gas is not burned in the most favorable manner, on account of the holes being too small, causing the flame to have a blue tinge, with a series of radiating blue streaks. By increasing the size of the holes for the emission of the gas, this is avoided, the flame becomes brighter, and economy is effected.

Following the law of other burners for the light produced, the larger descriptions of fish-tails are the most economical, as seen by the subjoined:—

						Candles.
A.	A fish-tail burner,	consuming	1¼	feet per hour,	gives the light of	1
B.	"	"	2½	"	"	2¾
C.	"	"	3½	"	"	6⅛
D.	"	"	4½	"	"	10
E.	"	"	5	"	"	12½
F.	"	"	7	"	"	18

The tables just referred to of the relative consumption of bat-wing and fish-tail burners, with the amount of light derived, are of the utmost importance to the gas-consumer; for we find on examination that bat-wing burner F, for a given quantity of gas consumed, gives nearly three times the light of A, and that E gives nearly twice the light of B. Again, with fish-tails, gas consumed with burner F gives more than three times the light than when consumed with burner A. Therefore, in order to employ gas advantageously, the larger size burners should always be adopted, even when only the limited light of two or three candles is required. The large burner, when turned down to the proper degree, furnishes that light at a much more economical rate than the smaller kinds.

Nevertheless, we see in daily practice establishments, such as hotels, illuminated by the smallest descriptions of burners, frequently arranged in clusters or bouquets. The light obtained from these is always of a dull nature, and most extravagant in price. To demonstrate this, we will take a case in point, a hotel, for instance, having a series of bouquets of fish-tail A, one hundred of which are distributed throughout the premises (by no means uncommon), giving the light of one hundred candles, at a cost of 125 feet per hour. Now, if, instead of these, only eight burners E were employed, then precisely the same quantity of light would be had at about one-third the cost. When consumers use these defective burners, they must necessarily expect to pay dearly for their carelessness or want of judgment.

THE CARCEL BURNER.

This is a simple burner, named from the resemblance of the flame to the celebrated carcel lamp, with a perforated disc at the lower part, and two orifices at the upper, where the flames unite and spread into one; each side of this united flame is supported by two curved levers or arms. It is thus made a steady burner. That it is noiseless, is at once evident on examination. In point of economy, it is said to be equal, if not *superior*, to the argand or fish-tail burners. The light from this burner is steady, soft, and mellow, and in these particulars is said to be almost without a rival.

THE SINGLE-JET BURNER.

This is a simple jet flame, similar to that of a candle, but is seldom used, except when only a very small flame is desired, as at counting-house desks for sealing, pipe-light burners, etc. With the richer descriptions of gas, such as produced in Scotland, it is very commonly employed, but only where a limited degree of light is required.

From the foregoing observations we learn:—

That according to the construction of burners, and the pressure with which the gas issues, so will be the amount of light derived. A proper burner will give the maximum of light, whereas an imperfect one diminishes it very materially; and it is even practicable, by bad burners and high pressure, to consume gas without it yielding any light whatever.

That when the flame of the argand is diminished, a greatly decreased light from the gas is the result; therefore it is essential that the full quantity of gas for which the burner is made should be consumed. One good light is much more economical than several bad ones.

That with all classes of burners the light obtained from the smallest sizes is always costly — in many instances the consumer, by using them, pays two or three times more for lighting his premises than would be necessary if proper burners were employed.

The best description of burners are of lava, and others called adamas. These, in appearance, resemble porcelain, and are constructed in a manner to produce the maximum of light from gas. Being incorrodible, they cannot be destroyed or obstructed by rust. They are of the greatest durability, and are cleaned from dust or dirt simply by a camel hair pencil. Whenever defective burners exist on premises, the consumer should not hesitate to replace them immediately, for the expense is speedily repaid by the economy effected and brilliancy of light obtained.

GLASSES, GLOBES, AND REFLECTORS.

With the argand burner the glass chimney is indispensable; otherwise, instead of the flame burning with that brightness and clearness peculiar to it, it would be dull, and yield a large portion of gas in an unconsumed state, which would pass off as smoke; but all additions, as globes, detract considerably from the light. No glasses of any description are ever used with bat-wing burners, on account of the flame having a tendency to distend itself with any increase of pressure, which would be liable to break them.

With fish-tail burners, glass globes or moons are commonly employed for the purpose of ornament. These are very desirable in private dwellings; but in shops they are frequently used without any consideration of appearance; on the contrary, their dusty state is often sufficient evidence of the neglect and carelessness with which they are regarded; in such places they should be dispensed with. Globes of every denomination present a serious obstruction to the diffusion of the light of gas; according to the best opinions, the light lost by them is as follows:—

Light obstructed	by a	clear glass globe	about	12	per cent.
"	"	clear globe engraved with flowers	"	24	"
"	"	globe of ordinary pattern	"	35	"
"	"	globe obscured all over	"	40	"
"	"	an opal globe	"	60	"
"	"	painted opal globes	"	64	"

Here, again, it will be observed that the consumer, in using these, voluntarily increases the price of light by employing the means to prevent its diffusion.

Where globes are necessary, the choice may be made between those which are entirely plain, or others where the upper half is obscured, leaving the under part plain, or those obscured all over and engraved; but the opal moon should only be used where economy is not a consideration, for, as shown, 60 per cent. of light is lost by its use.

REFLECTORS.

The purpose of the reflector is to throw back, or reflect, some of the rays of light which would be lost, or absorbed by surrounding objects. They are made of bright metal, porcelain, silvered glass, enamelled metal, etc. When placed in the upper part of shop windows, to throw the light on goods displayed, a good effect is produced. To attain the best results, they should be hidden as much as possible from the beholder.

Reflectors are used in many places as a source of attraction, by reflecting the light into the street; but possess the inconvenience of dazzling the eyes of persons who pass into their rays. They are useful in many places where the light is required to be concentrated in any particular spot; and for lighthouses, railway signals, etc., they are too well known to require any observation here.

CHAPTER VI.

THE PROPER POSITION OF GAS-LIGHTS.

THIS subject has received very little attention from those whom it most concerns, particularly as regards the position of lights in large buildings, such as churches, chapels, halls, theatres, etc., where it frequently appears that the system adopted is to distribute a given number of lights according to the area of the premises, without any consideration for the comfort or convenience of the congregation or auditory.

A common method of illuminating churches, chapels, and public halls, is to suspend a number of lights from the front of the galleries, whilst others are surmounted on pillars in the galleries and body of edifice. The consequence is that those persons seated at the furthest end from the pulpit, desk, or platform, have to sustain the full glare of a large number of flames or lights, which, in addition to rendering the speaker in comparative obscurity, after a short time has a tendency to produce drowsiness, causing some people involuntarily to close their eyes, to fall perhaps into a dose. Thus that which might be attributed to want of merit on the part of the speaker, is due to the defective arrangement of the gas-lights.

A similar objection exists in theatres, where often the lights are placed directly before the eyes of persons who occupy the best seats in the place; or perhaps a glaring chandelier is immediately in front of those in the upper part of the building. There are various other systems of lighting public edifices equally disagreeable as those mentioned, and unfortunately it is only in a very few instances where illumination in such places is properly carried into effect. In some cases the error of excess of light is committed, which is always fatiguing to the eyes of a large portion of the assembly, and is wasteful; should proper means of ventilation not be adopted, it then becomes unhealthy. In public buildings, where the degree of light necessary for persons to read with facility is exceeded, it becomes worse than useless.

It is well known that any one when seeking an object in a dark place with a lighted candle, in order to be enabled to see the better, the first impulse is to screen the flame from the eyes by the hand, otherwise its glare impedes the vision. Or when the sun shines on the eyes of an individual, in like manner he shades them, so as to be enabled to see any object or person at a distance off; and these simple operations ought to be imitated in gas-lighting, for objects are always seen to more advantage, or with greater facility, when the flame illuminating them is hidden from the spectator.

If a pulpit or lecture-table be illuminated by unscreened lights, the speaker is seen under considerable disadvantage; but if these be screened by suitable shades, so that the light falls on the individual, but is hidden from the assembly, the difference will be considerable. In the latter case every outline is well defined, every change of expression is observed with facility, and the eyes of the spectators are not fatigued. The same principle applies to the general lighting of churches, where the lights are arranged as already stated; but if they were so shaded that the light came only from the backs or above the heads of the people assembled, it would add much to their comfort and convenience.

Undoubtedly the best means of illuminating large public edifices, is the "sun-light."

It is difficult to conceive the beauty and agreeable glow of this description of illumination in large buildings, without having witnessed it. The apparatus is of the greatest simplicity and neatness; the light therefrom, on account of its position, surpasses all others, and, if the size and number of burners be properly considered, it is not expensive. A further recommendation is that it ventilates in an admirable manner the building where placed.

An error often committed in fixing these lights is to place them too high up; indeed, in some cases, the tube is dispensed with, the reflector being attached to the ceiling. This increases materially the cost of gas, inasmuch as the light is diminished very sensibly, in proportion to the increased distance of the flames illuminating. Therefore they should always be placed as low as consistent with general appearance, taking care that the reflector does not cast a shade on the persons assembled in the galleries or upper part of building.

The only objections that can be raised against this class of apparatus when properly arranged, are that the columns and galleries of buildings illuminated thereby cause shadows to be thrown, so that part of the building is in comparative obscurity. This, however, is counteracted by having a few lights fixed under the galleries, attached to the back of such columns, or wherever they may be desired.

Goods in shop windows are also displayed to much greater advantage when the lights illuminating them are hidden from the eye; and nothing is simpler to arrange than this. Most classes of merchandise are exhibited under the best conditions when the light descends from above, there being provided suitable reflectors to throw the light on the goods.

There are so many examples of lighting dwellings, that the consumer may judge for himself of the most suitable plan according to his taste. "Much of the economy and effect of gas-light, however, depends upon the arrangement of gas burners in relation to each other, to the surroundings of the furniture, height of ceilings, distance and angles of walls, hangings, etc.

"The general practice of disposing of burners in chandeliers in the centre of the rooms, although pleasing to the eye in its artistic effect, simply as an ornament to the room, is far from being the most philosophical manner to obtain the best effect from the light. Shadows have much to do in the effective and satisfactory lighting of any hall or room. Hence it is that a single light, or a centrepiece, or nucleus of lights as represented by a chandelier, is objectionable, because your shadow will appear in any part of the room opposite to the light, and is more or less inconvenient in proportion as it differs in that respect from daylight, which is so diffused as to avoid this evil, except in peculiar conditions.

"The proper and most efficient position for gas-burners, therefore, is at the different sides, or better, the different angles of the room. Then the intensity of the light will be more uniform in every part of the room.

"Brackets should not be used on one side of the room *only* when used, but should be disposed *vis-a-vis*, or as nearly so as possible."

One rule should, however, be imperatively laid down;

that is, in all sitting-rooms, reception or drawing-rooms, and even kitchens, when the light is suspended from the centre, if the apartment be sufficiently high, care should be taken to keep it above the level of the eyes of the occupants.

Of late years, great change has taken place in the construction of gas apparatus. They were formerly made in a very massive and costly manner; now they are light, elegant, and can be had at prices to suit all classes.

CHAPTER VII.

THE GAS-METER.

With the exception of the indicator of time, either known as clock, watch, etc., there is no mechanical instrument so much in use as the gas-meter, and perhaps, generally, there is none so little understood.

This want of knowledge of the instrument often causes much distrust and suspicion. All the extravagance of improper burning, accidental losses or escapes, errors in management of gas, are recorded, and brought to the account of the consumer by it, frequently producing much annoyance, which would be avoided were people better informed on the subject.

Some extraordinary circumstances occur daily in conjunction with the gas-meter, and we will merely relate three of them as examples, to illustrate how people may be deceived by their own acts.

A gentleman and his family, of Boston, being about to visit some friends for a short period in a distant part of the country, shut up their house, together with the furniture, leaving no one in charge of them. It was at first intended their absence should be but a few days, but was ultimately prolonged from time to time, and at the end of six months they returned to their home.

A short time after their arrival the gas company presented a very heavy account, and the gentleman, believing it an error, went for explanation, taking with him the receipt for payment to within a few days of his departure; he was, however, informed that it was for gas consumed *since.* He then exulted in the proof he could give of the house having been shut up — the absence of his family — consequently not requiring lights; but the officers of the company insisted on the accuracy of the meter, and on payment for the quantity indicated thereby.

The gentleman, not in the best of humors, went home protesting against the injustice, and stated the circumstances to his wife, who at first was equally astonished. She hesitated — reflected a moment. "Well," she said, "how silly! Now I recollect, just as we were leaving, I had forgotten my keys, which were left in the drawing-room. To find them I lighted the gas; in my hurry forgot to turn it off again, and *on returning I found it still burning.* It is my fault, and we must pay for it."

The gas had actually been burning day and night for six months, and of course indicated by the meter. The gentleman being satisfied with the explanation, paid the account.

We can draw two inferences from this: Firstly, if the lady had not been candid, the worst conclusions would have been entertained by the consumer; secondly, if she had been aware of the importance and fidelity of the meter, she would have given it more attention, and so saved the money.

Another instance occurred at a large wholesale warehouse, where gas was being consumed during the whole of the twenty-four hours daily; but in the day-time, as at night after business hours, only a small number of burners were used. However, the principal of the establishment found the consumption very excessive, and complained to the company. The meter was accordingly tested for his satisfaction, in the presence of his representative, and found correct. Subsequently, renewed and continuous complaints were made, when an officer of the company went to investigate the affair, and a simple observation of a few minutes convinced him that there was an important escape of gas somewhere; pursuing the inquiry, he found a defective pipe on the roof of a detached building, which at once accounted for the complaint and loss. The isolated position of the place where the defective pipe existed, prevented the escape of gas being detected by the smell; and the loss, being continuous, made it of very serious importance.

Had the principal, or the persons in his employ, understood the construction of the meter, they would have done precisely the same as the gas inspector — turned off all the taps on the premises, leaving the main tap open, and then have noticed the drum or dial, referred to when speaking of the index of meters, which shows the units of feet passing, and would have observed this to revolve; clearly proving that gas was *passing*, although none was *used*.

In the other case, a gas inspector in the course of his business having informed the proprietor of an establishment the amount of consumption — "That won't do," said the latter, "for I have been away all the quarter, and no one has used it." "But," said the inspector, "perhaps your servant has." "Not she," was the reply: "and I will not pay it; it is a cheat — a fraud, which I protest against."

The following quarter the inspector again called, when the same consumer blandly asked, "How much have I used this time?" "Nothing," was the reply. "Nothing!

look again." "No," was the rejoinder, "nothing." "Well," said the consumer, "I begin to imagine I can rely more on your *box* than on the word of my servant; for, thinking to detect you in error, I took away the key of the gas, so that it could *not* be used, and only replaced it when you came to the house. I am satisfied now."

These cases might be mentioned by hundreds. They are of daily occurrence, and the consumer, not being able to assign a reason for discrepancies, places the evil to the account of his meter. The amount of harsh language through circumstances like these is beyond description; and our task is to endeavor to explain and show the accuracy and justice of the instrument in question. But at the same time we do not pretend that it is impossible for a meter to err; it may have been wrongly constructed. This is, however, very unlikely, for upon its correctness rests the reputation of the manufacturer. If constructed erroneously, it is a witness against him at all times; to-morrow, or twenty years after, there it is, a proof. Hence the necessity for gas-meter manufacturers to employ every care and accuracy in these machines.

In this chapter we hope to be enabled to show that although gas is invisible, it is capable of being measured with the same accuracy and certainty as liquids—that its volume or bulk is just as palpable as water, or any other substance; and gas consumers should thoroughly understand this, in order to avoid those prejudices against the gas-meter which unfortunately too frequently exist.

There are two kinds of gas measures, the one called the "wet meter," on account of it requiring to be partially filled with water to render it effective; the other is called the "dry meter," because it requires no liquid,

6

being complete in itself. The wet meter being the first kind employed, merits priority of description.

DESCRIPTION OF WET METER.

The first wet gas-meter was patented by the late Samuel Clegg, of England, in the year 1815. This instrument was very far from being a practical machine, but subsequently was brought to a much higher state of perfection by John Malam and Samuel Crosley.

It is a remarkable fact that companies did not at first encourage the use of gas-meters; on the contrary, the majority actually opposed them, although for some years their operations were attended with serious loss, mainly caused by the extravagance or dishonesty of their consumers, many of whom, not content with lighting their premises most wastefully during the hours assigned to them, actually heated them day and night with the gas, often burning six or eight times the quantity for which they contracted and paid for. Other systems of fraud existed — by substituting larger burners, or placing extra lights without advising the company, and of course without payment; and all the personal surveillance of the companies' officers was not sufficient to counteract these evils.

At that time, when increase of business to gas companies only increased their loss, they resolved to try the use of meters — a wise decision, that has done immense service for the propagation of gas. This effected, they began to understand their interests; and reduced the price of gas by meter, and ultimately in many cases enforced the use of the instruments, so that the economical no longer paid for the extravagant; and the latter, who formerly burned without consideration, then began to understand the loss they had entailed on the companies.

Once the gas-meter perfected and manufactured, it was just as absurd to sell gas by contract as to supply oil or any other valuable commodity to the public indiscriminately, and leave this at their discretion.

The measurement of liquids is easily understood; for by their opaqueness they are visible, and by their weight they readily flow from one vessel to another, and it is thus a simple operation. But with gas or air (both of which are alike in bulk and measurement) the case is different; these are invisible, and so light that they require a peculiar manipulation to retain them, and prevent their loss. The operation of measuring them is, therefore, necessarily more complicated.

A decanter, or bottle, or any other vessel which we call in ordinary language *empty*, is in reality full of the air we breathe. This is made evident by hastily filling a decanter with water, when we observe the struggle between the air rushing out and the water going in; or in emptying the same hurriedly, the bubbles of air are observed to struggle to enter and replace the liquid coming out.

To illustrate in a more striking manner the bulk of air or gas, we will suppose two glass vessels, say tumblers, both of about the same depth, but the one so much larger in diameter than the other, as to permit the smaller to enter freely in it. The larger is filled with water, and the smaller inverted, held by the hand, and allowed gradually to descend until it reaches the bottom.

Whilst descending, the greater part of the water in the larger glass overflows, which is equal in bulk to the air contained in the smaller glass, and that part of it which is immersed; but it will be observed that water does not enter the inverted glass, the space therein being already occupied by the air.

If we now take a very similar apparatus, but the larger glass having in its centre a vertical pipe P, which rises above its edge, and is open throughout to the atmosphere at the bottom; on the larger glass being filled with water, the other inverted and allowed gradually to descend as before, then only a very small quantity of water overflows, this being merely equal to the bulk of the glass immersed; the water enters the smaller glass, expelling the air therefrom through the pipe P to the atmosphere; and when this reaches the bottom, it will be full of water. If again it be lifted gradually, air will enter, and when at the top, as represented in *fig*. 8, will be filled with air.

Fig. 8.

Here we have a very simple means of illustrating the measurement of air; for if the inverted glass be of the capacity of half a pint, each time it is raised from the bottom to the top, it receives that quantity of air from the atmosphere; and each time it is caused to descend, it expels the same. It is evident that if the pipe were in communication with gas, this would be measured with the same facility as the air.

The accompanying sketch (*fig.* 9) shows similar, but larger vessels. The inner vessel or bell, instead of being

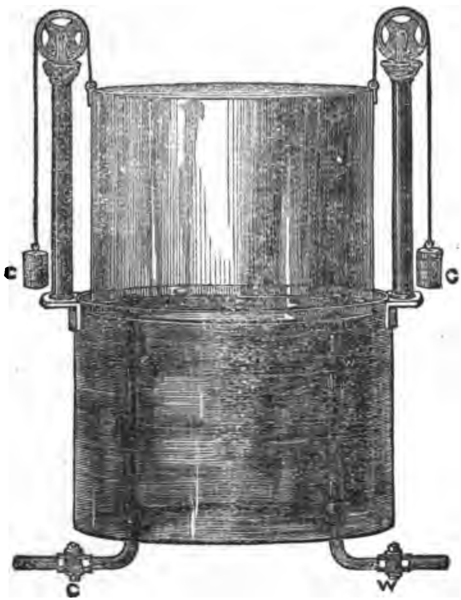


Fig. 9.

held by the hand, is now suspended to two columns, and nearly counterbalanced by cords and weights, *c c*, just leaving it sufficiently heavy to expel the air or gas when required. There are two pipes—the one, *w*, we will suppose to convey the gas from the company's works; the other pipe, c, to convey it to the consumers' premises. Each of which has its respective tap, *w* and *c*.

The tap *c* being shut, and tap *w* open, and in communication with the company's main, the gas, by the force or pressure with which it is expelled from the manufactory, enters through the pipe *w*, and pressing or forcing itself between the surface of the water and underneath the bell, causes this to rise—the force of the gas now doing that which was formerly done by the hand—until in the position of sketch, when the bell will be full of gas. Proper appliances are of course adapted to prevent the mouth of the vessel rising out of the water.

If now the tap *w* be shut, and tap *c* open, the weight of the bell (as before stated, not being entirely counterbalanced) will expel the gas to the burners of the consumers. So that if we suppose it to contain 6¼ gallons, or one cubic foot, each time in rising from the bottom to the top, it receives that quantity of gas from the company, and each time in descending it expels the same to the consumers' burners.

If to this apparatus we adapt a simple mechanism to cause the taps to open and shut, by the rising and descending of the bell, and another to indicate on a dial the number of times it had been filled and emptied, or in other words, the quantity delivered by the company, and received by the consumer, then we have a clear idea how gas can be measured by a self-acting instrument.

The tank and bell just described are similar to the immense gas-holders, or stores, in every gas-manufactory. The water in the tank serves three purposes: it prevents the gas escaping or intermixing with the atmosphere; it is the means of resistance for the gas to raise the bell or holder; lastly, it displaces or expels the gas.

To approach gradually in describing the meter, let us conceive that the supply of a liquid, as water, etc., in being measured, required to be delivered with the same uniformity as gas; and for the purpose, we may imagine a rude self-acting machine, as shown in *fig*. 10.

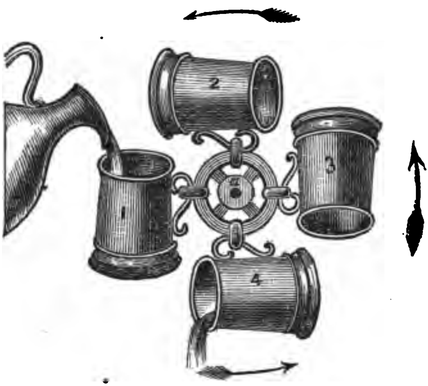


Fig. 10.

Here it will be observed there are four vessels of known capacity attached at right angles to each other, to axle *a*, with which they revolve. The axle is supported by, and revolves freely, in suitable bearings, which, for simplicity, are not shown. The vessels are filled successively by hand or otherwise, there being suitable mechanical means to prevent them moving, until each in succession is quite full. As seen in sketch, vessel No. 1 is being supplied with the liquid to be measured; and No. 4, which has been filled, is emptying itself. When No. 1 is full, by the action of the weight of the liquid contained therein, it suddenly descends, bringing No. 2 in the position to be filled; at the same time, vessel No. 1 is emptied; then, No. 2 being filled, descends, bringing vessel No. 3 in position to be filled; and so on continuously, causing the vessels to revolve with the axle in the direction of the arrows, so long as there is a supply of liquid. We will suppose each of these vessels to contain one quart, so that each time they revolve, four quarts, or one gallon of liquid, must be received and delivered by them; and in order to avoid the necessity of continuously counting each revolution of the measures, or in other words, the quantity received and delivered, we make it a self-recording instrument.

This would be done by fixing on the axle a suitable screw or worm, working into a toothed wheel in communication with a dial; thus if the wheel had twenty teeth, the measures, in revolving twenty times, would cause its axle to revolve once, and indicate 20 gallons; and the motion being further communicated to an index by suitable wheelwork, the quantity passing would be recorded with much greater accuracy than any human supervision could attain.

This supposed instrument is based on precisely the same principle as the gas-meter; for in the latter, there are four measuring vessels attached to, and revolving with a shaft, which are filled with gas, and emptied in succession, and the number of times they revolve, or the quantity of gas received from the company and delivered to the consumer, is indicated on the dial of index, a similar apparatus to those mentioned, but differing in shape—for instead of the vessels being cylindrical, as shown in *figs.* 8 and 9, or like quart measures, as in *fig.* 10, they are now each of the form of the fourth part of a cylinder or drum, which works on a hinge or axle, so that in filling, it makes the fourth part of a revolution. When expelling the gas, it of course moves in the opposite direction. There are two corresponding pipes for the admission and emission of the gas, similar to those mentioned in the former illustration. (See *fig.* 9.)

It is almost unnecessary to observe that the alteration of shape or mode of action does not make any change in the principle; a self-acting apparatus for the supply, and recording mechanism for the index, would convert this, like the last, into a means of measuring gas.

Let us now imagine such apparatus in combination, the chambers for the gas being attached together, and working on the same axle A in a suitable tank filled with water (as shown in *fig.* 11), with corresponding pipes

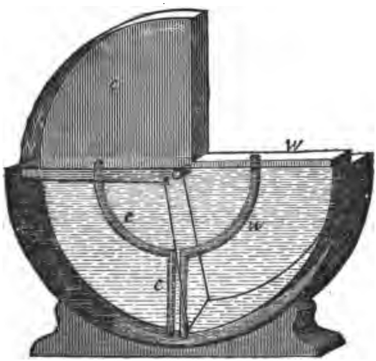


Fig. 11.

for the ingress and egress of the gas. Here it will be observed that the chamber *c* is filled with gas, and that marked *w* nearly filled with water; if now the gas from the company be allowed to enter chamber *w* by its corresponding pipe, which protrudes just above the water level, the force of the gas entering *w* would cause it to rise and fill, expelling at the same time the gas from *c*, both chambers making the fourth part of a revolution in the direction of the arrows, when *w* would be full of gas, and the other, *c*, immersed in the water. This demonstrates very clearly how gas, by the force with which it issues from the works, is capable, when entering one chamber, of expelling that which exists in another in combination with it.

If now we make the action just explained continuous by having four chambers attached to the same axle, and causing the gas to enter them successively, always at the side *w*, and to expel that from the chambers at the side *c*, then a rotary and continuous motion and supply would be the result — and this is precisely what occurs with the wet gas-meter.

The annexed figure (12) is a section of the instrument when in operation; *a a a a* is the outer case, filled with water a short distance above the centre, as shown by the dotted lines; in this is a cylindrical vessel, *b b b b*, called the "drum," which revolves freely on its axle *a*. This vessel is divided by the partitions *p p p p* into four distinct measuring chambers, 1, 2, 3, and 4, and by a very ingenious contrivance the pipes alluded to in former illustrations are dispensed with — the passages for the ingress and egress of the gas being attached to each respective chamber, which passages are opened and closed in succession as desired, through the intervention of the water and the revolving motion of the drum.

The gas, in the act of being measured, enters the chambers alternately; that marked 1, as seen, has just received its supply, and is full, when both its inlet and outlet are closed by the water; but as the gas enters chamber 2, it expels that from chamber 4, and the drum moving round in the direction of the arrows, opens the outlet of chamber 1, from which, in its turn, the gas is likewise

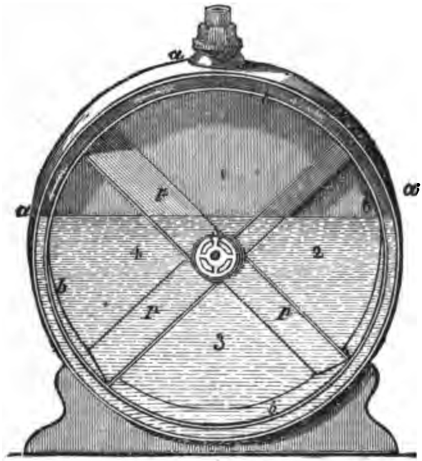


Fig. 12.

expelled; afterwards chamber 2 attains the central position, when, having its supply of gas, the passages thereto are closed; and so on continuously, the drum revolving, receiving gas from the company, and delivering it to the consumer as required, the water entering freely into the various chambers, and so expelling the gas.

It is evident that if each of these chambers be of the capacity of one-fourth of a cubic foot, that every time the drum revolves, one cubic foot of gas must be delivered by the company and received by the consumer; and if the number of these revolutions be recorded on the index by a simple train of wheelwork, then it can be easily understood how the quantity of gas which has passed can be faithfully measured.

The measuring drums of these instruments are made in accordance with the quantity of gas to be consumed from them. That for a meter for five lights contains one-fourth of a foot, for ten lights one-half a foot, and so on in proportion.

But it will be observed, on referring to last figure, that each of the compartments, when filled with gas, is defined at the side nearest the axle, by the water, and if no provision were made to regulate the height of this, their capacity would be increased or decreased, according to the level of that, when the instrument would be useless. This, however, as will be seen, is arranged in a very simple manner.

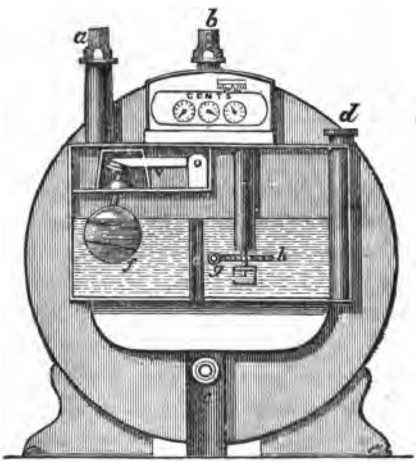


Fig. 13.

Fig. 13 represents the front part of a meter, with the plate removed for the purpose of showing the interior: *a* is the inlet, *b* the outlet; *f* is a float attached to the cover of a valve, which is enclosed in the box *v*; when there is a sufficiency of water, this float lifts the cover, opens the valve, and permits of the free passage of the gas; but in the event of the water being below its proper level, the float falls, closes the valve, and stops the supply of gas. In order to provide against the other contingency—an excess of water—there is a pipe *e*, through which the gas must pass to be consumed; the top of this pipe is exactly at the desired height for the proper level of the water, therefore any surplus will pass down this to the box beneath; and should there be a considerable excess, the passage of the gas will be stopped thereby; *g* is the axle, having at its extremity a worm or screw, which works into the toothed wheel *h*, and so conveys to the index the number of times the wheel revolves, or the quantity of gas consumed.

With this meter, it sometimes happens that sudden extinction takes place, putting the premises in total darkness, and serious delay ensues before the gas-fitter can be found; it is therefore essential the consumer should be enabled in such extreme cases to correct the evil himself.

To remedy this, shut the main tap, turn on one of the taps of the burners, take out the plugs, *c* and *d* (see *fig.* 13), and at the orifice *d* pour in gently a small quantity of water until it issues from the orifice *c*; and on this ceasing to flow the plugs must be carefully replaced, when the meter will be in working order. But the opposite of this—an excess of water—may occur, when by simply taking out the plug *c*, and allowing it to flow out, on replacing the plug, the supply will be resumed. In such cases, it is imperative that no light be approached near the meter; the strictest care should be taken to replace the plugs, and the main tap should be shut during the operation.

A difficulty in severe frosty weather, when this meter is exposed to its influence, is that the liquid therein freezes, and prevents the gas passing. In this case a small quantity of boiling water should be poured into the orifice *d*, and after a lapse of a few minutes the surplus allowed to flow from the plug *c*. When a wet meter is placed in an exposed position, it should be embedded in some non-conducting material, such as straw, sawdust, etc., which will prevent the water therein from freezing.

DESCRIPTION OF THE DRY METER.

If a small balloon be attached to the company's pipe and filled with gas, which is afterwards detached and pressed between two flat surfaces or plates, so as to expel the whole of its contents into any receptacle, it is certain that, if the capacity of the balloon be known, by this means gas could be measured with the same facility as liquids; for if it hold exactly a cubic foot each time on being filled, that quantity of gas would be delivered by the company, and on being emptied, would be received by the consumer. Although this is not practically useful, it will illustrate in a simple manner the operation of the dry meter.

The dry meter, now most extensively manufactured and used, consists of a quadrangular case, divided into two chambers; the lower and larger containing two flexible measuring vessels, these, with their corresponding valves, being necessary to give uniformity of action. The upper chamber contains two slide valves, for the ingress and egress of the gas; with means of communicating motion thereto, also means of indicating on the dial the number of times the measuring vessels are filled and emptied, or in other words, the quantity of gas passed.

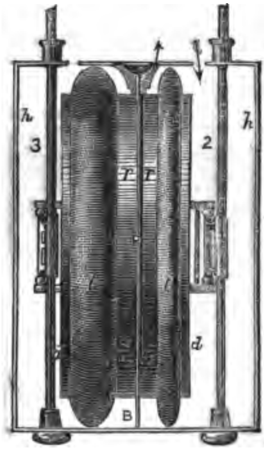


Fig. 14.

Fig. 14 represents a side view of the lower part of the meter, where the measuring is effected, the outer case being divided by a partition (P) into two distinct compartments, and in each of these is a flexible gas-tight chamber, formed by the rings, *r r* (which are soldered to the partition P), the disks, *d d*, and the leather bands, *l l*; each band is firmly attached to its ring *r*, and disk *d*, resembling in form and action a flattened balloon attached to two plates. Thus there are four distinct measuring chambers, numbered 1, 2, 3, and 4, into which the gas passes in and out alternately by their corresponding orifices, in communication with their respective slide valves

—the disks being supported by the vertical rods, *h h*, and moving to and fro according as the flexible chambers of which they form part are filled and emptied.

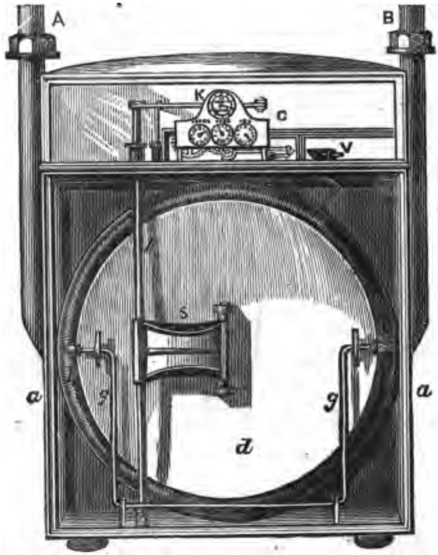


Fig. 15.

Fig. 15 is a front view of the meter. A is the inlet, B the outlet, *d* one of the disks attached to the leather band *l*, constituting one of the flexible chambers. The disks work freely on the supports *s*, which are attached to the vertical rods *h h*, and these pass through stuffing-boxes to the chamber *c* above, where are situated the slide valves *v*, which are caused to open and shut as required by the levers R R. The guides *g g* keep the disks always in the same plane, and the leather bands have their peculiar form for the purpose of obtaining the greatest freedom of action and durability.

The operation of the meter is this. The gas to be measured passes by the pipe A, and from thence into the box containing the valves *v*, and as seen in *fig.* 15, gas is entering chamber 2, and expelling that from chamber 1. The gas will afterwards pass into chamber 3, and expel that from 4, so being received and delivered by the various chambers continuously—the disks moving to and fro, receiving gas on one side, and expelling it from the other as described; and the distance through which these move, considered with their respective areas, will necessarily be equal to the volume of gas received and expelled. For example, if the area of each disk be exactly one superficial foot, and if each of these move through a distance of three inches, either when the chambers are being filled or emptied, then the quantity of gas received and delivered by the four measuring chambers would be equal to one cubic foot. The action being continuous, the quantity of gas passing is indicated on the dial of index by a suitable wheel with the strictest accuracy.

The other dry meter in general usage is that known as Defries's. This consists of an upright cylindrical vessel, divided horizontally into two distinct parts, the lower being considerably larger than the upper. The lower part is divided from its axis to the periphery into three separate vertical compartments, and these again are subdivided vertically by square flexible partitions, composed of leather and metallic shields, so forming six different measuring chambers. Each of these partitions is set in motion alternately by the force of the gas, and when distended to the utmost, assumes a form similar to a pyramid, first on the one side, then on the other, and the volume of gas received and expelled is equal to the space through which the partitions travel to and fro.

The centre of these partitions are in communication with vertical rods which pass to the upper division of the meter, and by means of levers attached to them, give motion to a rotary valve, which admits and emits the gas alternately to the respective chambers, similar in operation to those already described. The quantity of gas displaced by each vibration of the series of flexible partitions being known, it is easy to understand how, by a suitable train of wheelwork, the gas, in its passage, may be indicated with the utmost precision on the dial of the index.

Having thus described both wet and dry meters, I must observe there are few subjects upon which greater opposition of opinion exists than on the relative merits of these two classes of machines; for while some companies use exclusively the one, others employ only the other, they being principally guided in their selection by their respective engineers. However, much of the opposition to the use of the dry meter may, undoubtedly, be due to old prejudice. Twenty-five years ago, the wet meter only existed; since then the other has been created, and has proved a most formidable rival to its more ancient opponent.

Meters are made of certain sizes, according to the number of lights to be supplied. They are usually constructed respectively for 3, 5, 10, 20, 30, 50, and 60 lights, etc.; between these there are no intermediate sizes. In the choice of the size of a meter for premises, it is not only necessary to consider the number of lights, but the quantity of gas to be consumed. The lights for which they are made are calculated to consume about 6 feet per hour each; therefore a 5-light meter will supply

30 feet per hour, and this may be distributed in any number of lights, so long as the quantity is not much exceeded. When the pressure in the company's main is abundant, the quantity can be increased; but a difficulty which then arises is, that the float referred to in the wet meter is liable to close the valve, and suddenly extinguish the gas.

By the foregoing it will be remarked that the meter indicates the quantity or volume of gas passing, but has no reference to the *quality* of that employed; the latter is of important consideration, as with an inferior description of gas a greater quantity will be required to produce a given light; it is, moreover, the direct interest of companies to furnish good gas, in order to insure an increased number of consumers; besides, the difference between the cost of production of good and bad gas, when derived from the best coal, is next to nominal.

The question is often asked, Which is the best meter, the wet or dry? — which burns the least gas? In reply to this, they each possess certain advantages. The wet meter is considered the most durable, particularly when the outer case is of cast-iron, and, on account of simplicity of construction, is not so liable as the other to injury in transport. Against this, dry meters have the advantage of requiring no attention for the supply or abstraction of water; they are not liable to obstruction by frost; they do not, like the other, occasion deposits of water in fittings; nor are they susceptible of sudden extinction. Respecting the question of measurement, whether this be effected by the wet or dry meter, it is alike, there being no more difference between them in this respect than in the measurement of liquids by a copper or tin vessel; but, as explained, much remains with the consumer to apply gas thus measured to the best advantage. There is no operation where a stricter surveillance is kept than by the gas-meter. A light, if only burned for a few minutes, is faithfully noted; if there should exist an escape of the most minute description on the premises, it is recorded by that instrument; and any waste, any carelessness or extravagance, will be most assuredly confirmed by it; therefore consumers who desire economy should attach all importance to its functions.

The method of furnishing meters is variable. Some companies supply them on hire, making a small quarterly charge for them. Some furnish them without any charge or rental, and in making this concession they are generally rewarded by a considerable increase of business. Other companies require the consumer to purchase his own meter; this is a privilege which every one can exercise should he prefer it; but in this case, in the event of it requiring reparation at any time, the expense and inconvenience must be borne by the consumer; whereas if he employs that of the company, all charges are included in the rental.

Whilst on this subject, we will refer to some popular errors entertained by a certain class of people who believe and assert that companies force the gas with undue pressure, in order to cause the meters to "spin round faster," and so tell unfairly against the buyer. This, although often asserted, is completely ridiculous, inasmuch as any increased pressure could not cause the meter to go quicker, unless the consumer permitted the gas to be wasted. The meter is a measurer of volume, and unless a certain volume passes, it cannot be registered; and if the consumer exercises ordinary care it cannot pass. On the contrary, the interest of companies is to deliver their gas with as weak a pressure as possible, so as to diminish the loss by leakage from the mains in the streets, which always unavoidably occurs.

Another popular error is that companies pump air into their gas-holders to intermix with the gas, in order to increase the volume, and influence the indication of the meters. The gross absurdity of this will be apparent, when it is stated that if one per cent. of air be mixed with gas, the illuminating power of the latter is diminished about six per cent.; and if one-fifth of air be mixed with four-fifths of gas, no useful light can be derived from the compound.

CHAPTER VIII.

INDEX OF THE GAS-METER.

THE recording part of the gas-meter, or, as termed, the index, is often a stumbling-block with consumers, and it is a matter of astonishment that people do not take a little pains to understand this simple instrument, instead of complaining of its mystery, and remaining dissatisfied; for with a few minutes' attention, a knowledge of it may be acquired.

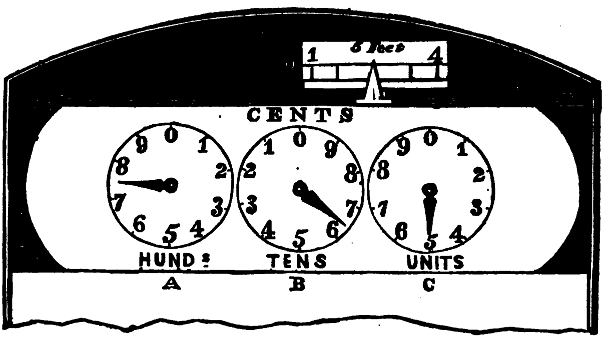


Fig. 16.

The above is a drawing of the ordinary wet meter index; the cylinder *o* at the top revolves, and by means of the fixed pointer indicates the units of feet passing. This is intended for testing the accuracy of the instrument by short experiments; it likewise serves for the consumer to make any brief periodical observations of his consumption; and lastly, to ascertain if there be any loss or leakage on the premises.

On the upper part of the dial is the word *cents*, signifying that cents, or *hundreds of cubic feet*, are recorded thereon. There are three circles, marked in sketch A, B, C. Under the circle C, is "Units," denoting that its pointer indicates units of *hundreds of feet.* As seen, the quantity of 500 feet of gas has passed. But in due time, when 1,000 feet will have been consumed, the pointer will then arrive at 0, when, if no provision were made to avoid it, the account would be lost.

This, however, is prevented by circle B, having underneath it "Tens," denoting tens of hundreds, or *thousands of feet.* Thus while the pointer of circle C makes an entire revolution, that of B moves from one figure to the next. As shown, it is beyond the 6, indicating 6,000 and a fraction of 1,000, that fraction being the 500 recorded on the circle C, making together 6,500 feet.

Here, again, for ordinary purposes, a higher denomination is required, which is furnished by the circle A, having beneath it "Hundreds"—that is, hundreds of cents, or *tens of thousands;* so that the pointer of this circle indicates the tens of thousands of feet passed, and is a distance beyond the 7, indicating that 70,000, and a fraction of 10,000 (the 6,500 recorded by the others), altogether 76,500, feet of gas passed to the consumer.

This detail is for the purpose of explaining the operation of the index, but in practice a much simpler method is adopted to ascertain the consumption. This is done by merely noting on paper the numbers each respective pointer *has passed*, and marking them in the position as seen; thus 765, afterwards adding two cyphers (00) for the cents, we have 76,500 feet indicated by the meter.

It is imperative to take the numbers the pointers have passed, inasmuch as that of A could not be at 8 until that of B arrived at zero, and this could not occur until the pointer of C had made the necessary revolutions.

Although the index of the dry meter varies slightly in its superscription, in reality it is identical with that described, the difference consisting in this recording "cubic feet," instead of "cents," and each of the circles having above, or underneath it, the total quantity indicated by a complete revolution of its respective pointer.

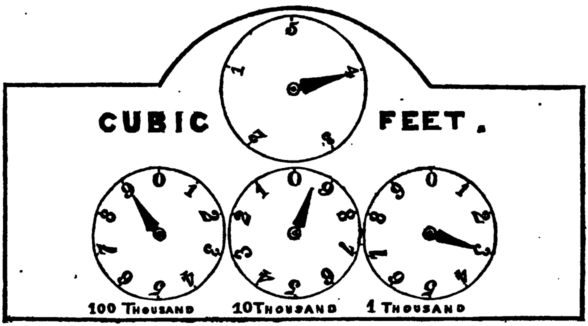


Fig. 17.

Fig. 17 is a representation of a dry meter index, the circle at top in centre indicating the units of feet, and the others show 89,300. Here will be observed the importance of taking only those figures which the pointers have passed, and not those they arrive at; for if this were not strictly attended to, the indication might easily be mistaken for 99,300, so committing a very egregious error.

Supposing the consumer to understand the index of his meter, it then becomes his duty to keep check against the officers of the gas company, in the same manner that he verifies goods and invoices delivered by others; and although if an error were to be committed by taking the wrong account one quarter, it would be rectified the next, still it is far better to avoid the possibility of misunderstanding.

It is important in large establishments to keep periodical statements of the consumption, and to make the necessary comparisons, in order to ascertain if there exists any waste or loss.

The manner of keeping the statements of the meter is exceedingly simple. For the purpose of explanation, we will imagine the indication at the end of a quarter to be 96,700, and that of the previous quarter, 89,300; the latter quantity subtracted from the former gives a consumption of 7,400 feet during the intervening period. To illustrate a difficulty which sometimes occurs, let us conceive the consumption during the following quarter to be 5,600, when, on referring to the index, we find it only shows 2,300. This is often a cause of surprise; but, as the meter can indicate only up to 100,000, it follows that in reality this must be 102,300, from which the former consumption is subtracted. In all subsequent notations the higher denomination is omitted.

The inspectors of most gas companies leave a statement of the meter index, with the quantity consumed at the time of their making the observation, which the consumer should take the trouble to verify.

It is often argued by dissatisfied consumers, as there is wheel or clockwork in a gas-meter, that, like the clock, it must be subject to variation. Than this nothing can be more erroneous. The wheelwork of a clock is the perfection of mechanism, for it records faithfully and continuously the vibrations of the pendulum; these vibrations are made to correspond with certain periods of time, and so long as the pendulum moves at the precise speed calculated, the clock will be correct; but any deviation from this causes it to vary. Therefore the defect is not occasioned by the wheelwork, but by the pendulum.

With the gas-meter, the wheelwork records on the dial the number of times the measuring chambers have been filled and emptied. These, as we have shown, are not susceptible of variation, so that there is no comparison between the action of the clock and gas-meter, except as regards the unfailing accuracy of the wheelwork.

The gas-meter, when once properly made, cannot indicate against the consumer, as each of the measuring vessels must be filled and emptied in succession the necessary number of times before the dial can record the corresponding quantity; but by wear and tear, and accidental damage, it may indicate to the prejudice of the company, and only register a portion, or perhaps none of the gas passing, when it is pronounced to be "out of action."

This defect arises from a small hole occurring by rust or decay in part of the case, or measuring-wheel, of the wet meter, or in the case or leather of the dry meter, by wear and tear, or other contingencies, which permit the gas to pass without being measured.

In these cases the defective meter is replaced by a perfect one. The result of such exchange is often unsatisfactory to the consumer, who perhaps for years has only been paying for a portion of the gas consumed, and it is sometimes difficult to impress him with the equity of the case. When the meter has not registered, it is customary for companies to charge an average estimate account from previous corresponding quarters, which is the only equitable manner that can be adopted when such contingencies occur.

CHAPTER IX.

THE GAS REGULATOR.

Various circumstances connected with the distribution of gas cause the pressure or force with which it is expelled from the company's pipes to vary in such a manner as to occasion great irregularity in the supply to the consumer's premises—sometimes at one period during the evening there being just a sufficiency, and at another time a superabundance of gas. Under such conditions, continued attention is required on the part of the consumer to adjust the taps, in order to obtain the proper degree of light, or to prevent waste of gas, with production of smoke, and breakage of glasses. In other localities there is always a continuous excess of pressure, when, if improper burners be used, a considerable loss of the available light from gas is the serious consequence, as shown in the chapter on burners. These inconveniences are avoided by the use of the Gas Regulator.

This is a small self-acting instrument, generally attached to the outlet of the gas-meter at the entrance to the premises, and contains a suspended plug or cone, which opens or closes the orifice through which the gas passes, in direct accordance with the decrease or increase of the pressure in the company's pipes. By this means the pressure in the consumer's premises may always be maintained at one uniformity, so long as there is a sufficiency of supply.

Regulators are of various constructions, but all embrace the principle just mentioned. Some are made so as to require oil or water for their action. The first possesses an inconvenience that after a length of time the oil congeals. The second is very effective, but requires to be placed in a situation of moderate temperature, to prevent the water freezing or evaporating. Others, called "dry" regulators, are made with a flexible partition of very thin pliable leather, which carries the suspended cone and adjusts the supply. This class of instrument is most extensively used in England for regulating the flames of the street lamps, and is becoming very much employed for consumers' premises. Another instrument of the kind is called the "Mercurial" regulator; wherein mercury is applied as the flexible medium. Many of this description have been in operation for twelve or fourteen years without requiring the least attention or repair.

The regulator, when properly constructed, fulfils the important office of continuously adjusting the supply; and whether one burner or all on the premises be lighted, it is equally effective, so that by the employment of proper burners, already alluded to, and by so adjusting the pressure that it shall not exceed four-tenths on the premises, the maximum of light is then obtained from a given quantity of gas, there is no irregularity in the height of the flames, there is no waste, and but little smoke. The economy derived by the use of the regulator must depend on circumstances, such as the pressure of the gas in the locality, the care previously employed in adjusting the lights, the kind of burners employed before and after using the instrument; but it is by no means uncommon for a saving of from 25 to 40 per cent. being effected by its use, and still retaining the same amount of light. Professor Silliman gained even better results than these by using a regulator, thereby, as he stated, effecting a saving of nearly 50 per cent. Others, however, may not be so fortunate.

To obtain the full benefits of the regulator, care should be taken that the pressure yielded thereby does not exceed that indicated; the most appropriate burners should be adopted to consume the gas, and the pipes on the premises should be sufficiently large, so as to enable all the lights to be amply supplied with the diminished pressure. There are some localities, although exceedingly rare, where the pressure is so weak and uniform as to render the instrument in question quite useless; but wherever the reverse happens, wherever there is an excess or irregularity in the pressure, then, for the objects of economy and comfort, the regulator is indispensable.

In all large establishments of several stories high, a distinct regulator is essential for each floor, inasmuch as gas, by its lightness, has a tendency to ascend; so that in the absence of this instrument there is often an excess of gas in the upper portion of a building, whilst the lower premises are in comparative obscurity.

Nevertheless, with all the various advantages enumerated to be attained by the use of these instruments, it very often happens that they are most unjustly condemned; for whenever a defect exists, such as a partial stoppage in some part of the consumer's fittings, or perhaps from these being too small, or more frequently through defective burners, the gas-fitter, instead of taking the trouble to ascertain the defect and correct it, on finding a regulator on the premises, he at once attributes the fault to this, which is removed, and much to the prejudice of the consumer's interest. This should never be permitted; for although the instrument prevents an excess of gas to pass, on the other hand, the pipes should be of sufficient capacity to permit it to be employed; and if any alteration be required to effect this, the increased expense would be trifling when compared with the economy to be derived. In the event of a proposition being made to remove a regulator, the party supplying it should be applied to, who for his credit's sake would see justice done to it. Hundreds of these instruments have been displaced from circumstances like these, bringing an amount of discredit upon them which they never merited, and causing consumers a vast unnecessary expenditure for gas.

The term regulator is, however, very often misapplied to arrangements which do not fulfil the object desired. Some of these are small vessels filled with tow, cotton, shot, etc., attached to the burners, which obstruct the passage of the gas when the pressure is great, but they likewise prevent a proper and sufficient supply under opposite conditions. Indeed, instead of economy resulting from their use, sometimes the contrary takes place, this arising from the consumer relying on the efficiency of the instrument, and neglecting to pay that attention to the adjustment of the taps which he observed previous to their use. The term is also applied to a mode of adjusting the main tap by means of wires in communication with a dial. Although useful, this demands repeated attention, and never insures the economy and advantages to be derived from the regulators described.

When a reliable regulator cannot be obtained, *check* taps will be found of great value, provided any kind of regulation is needful. When one or two lights are fixed, proceed to turn the burner taps on, then adjust the main tap so as to pass a full flame, without roaring; you may then depend upon having no more gas in the house or premises, than is actually wanted for consumption.

In large buildings a *check* tap for each floor or story will be found useful. These check taps do not diminish the pressure, but lessen the quantity passing to the burners.

CHAPTER X.

VENTILATION.

All systems of artificial illumination have a deteriorating effect upon the air of an apartment, and, if possible, more so than the respiration of an equivalent number of human beings.

It has been repeatedly proved that gas (for a given quantity of light produced) is more salubrious than any other material employed for artificial illumination; but on its introduction anywhere, a considerable increase of light is invariably required, when a proportionate increase of heat and noxious products are the natural result, and, in consequence, additional care must be adopted, so that the ventilation should be in accordance therewith. For the purpose of making the subject of ventilation intelligible, we will submit to the reader a few observations on the chemical nature and properties of the atmosphere, together with the compounds formed during combustion and human respiration.

As already stated, the air we breathe is composed of two gases, oxygen and nitrogen, in the proportions of about one-fifth part of the former and four-fifths of the latter. Oxygen may be termed the "aerial food" for fire and animal life, as both are entirely dependent upon it for existence. The nitrogen may be considered the diluent of this, and possesses no life-sustaining properties.

To illustrate the action of oxygen: if a glass tumbler or similar vessel be inverted, on placing a lighted taper therein, gradually the flame diminishes, and is speedily extinguished—this being due to the oxygen of the enclosed air combining during combustion with a portion of the material forming the taper, which assumes the gaseous state, so producing a poisonous compound gas (called carbonic acid), which suffocates the flame. But if, previous to extinction, a stream of oxygen gas were to be injected into the inverted vessel, the flame would revive, and burn with an intensity proportionate to the quantity of that gas supplied.

Or if a number of persons be assembled together in a confined place where the supply of fresh air is limited, they, by the process of respiration, in a manner analogous to the action of the fire, vitiate the air and produce the same poisonous compound as that, and when air is contaminated with this, it is productive of lassitude, headache, and sickness to the persons breathing it. Should the atmosphere inhaled by the lungs contain only one per cent. of carbonic acid, it is exceedingly unhealthy; and when it contains from three to four per cent. of that, persons breathing it would speedily die; but by the timely administration of oxygen gas, or fresh air, of which it is a constituent, the calamity would be averted.

Again, if a person were to descend by means of an ordinary diving-bell into water, without any communication with the atmosphere, in a short time the small quantity of air contained in the bell would become empoisoned by the emanations from his lungs, and death would ensue; but by resorting to the science of chemistry, and providing himself with a store of oxygen gas sufficient for the time he wishes to remain beneath the water, and being further provided with the means of absorbing the carbonic acid produced, with impunity he may then continue submerged for a considerable time without fear or danger.

Thus we learn that oxygen, or fresh air which contains it, is most essential to fire and animal life; that when it contributes to the one or the other, a poisonous compound is evolved, which, when breathed even in a limited quantity, is injurious to the human frame. This poisonous compound may be evolved so as to be pernicious by one person or many, dependent on the locality and means of ventilation. Or it may be produced by lights, as candles, lamps, or gas, burning in an enclosed place. Lastly, by resorting to proper means, the evils arising from this pernicious compound may be averted, which is the object of proper ventilation.

The enormous quantity of carbonic acid continually being produced from animal life and fire, is absorbed by trees and plants, which in their turn give out the oxygen thereof in a pure state, retaining the carbon for their growth. Like all other gases, carbonic acid is readily diffused, and, aided by the winds, is carried in all directions from cities and towns, where it is largely generated, to supply the vegetable kingdom. Following this law, every facility should be given in all buildings to permit the vitiated air to escape, and for the free admission of fresh and pure air.

There is another effect produced from flame of all kinds; that is the production of vapor or water, caused by the oxygen of the atmosphere combining with the hydrogen, constituting a portion of the material consumed; and, in the act of combustion, water is produced, which exists as vapor in the air wherever there is a flame; therefore, in proportion to the gaslight so will be the amount of vapor formed. A similar process takes place with animal life; for at each expiration, vapor intermixed with the breath is expelled, which may be made evident by condensing it on a cold looking-glass or other similar object. In cold weather this is very perceptible, when issuing from the mouth. There is also a considerable quantity of vapor given off by the pores of the body.

The presence of these vapors is made palpable in several ways: firstly, if a pitcher of iced or very cold water be taken into a room which is apparently quite dry and warm, speedily the surface of the pitcher is covered with a thick dew, caused by the vapor floating in the air, being condensed thereon by the action of the cold water within. Or in frosty weather, where a gaslight is burning in an apartment, the vapor arising therefrom will be condensed upon the glass of the windows, and become frozen.

The same effect is witnessed in bed-rooms when a portion of the vapor given off by the occupants is frozen on the glass; and on a frosty morning, in passing through the streets, by observing the frost upon the windows, one may indicate with tolerable accuracy the various rooms which have been inhabited during the night.

We have therefore in ventilation two considerations — the one to have the full quantity of fresh air necessary to our health and comfort, and in certain places to avoid the accumulation of vapor, which may be highly destructive to many classes of merchandise; and although the means employed for the effectual fulfilment of the first requirement would accomplish the second, still we have thought it better to embrace the two subjects, as the latter will explain many causes of complaints of gas consumers.

The effect of the heat and vapor from combustion is frequently very objectionable; for instance, a wareroom or shop, the lower part of which may be only at a temperature of from 60° to 70°, in consequence of the hot air ascending, and there being no means of its escaping, the temperature near the ceiling in the same apartment will probably be 130° or 140°. Therefore when goods or books exist in such localities, and are subjected to this high temperature and corresponding vapor, it cannot be a matter of surprise if they become injured or destroyed. Yet the preventive is exceedingly simple; but instead of being applied, the defect is at once attributed to the bad quality of the gas. For the proper protection of goods when placed in such localities, a thorough system of ventilation is necessary, so as to permit the hot air and vapor to pass off freely from the upper part of the premises.

When gaslights are in enclosed places, as shop windows, good ventilation is indispensable, or the vapor will be condensed upon the glass, entirely obscuring it. Sometimes in winter this is found to be frozen on shop windows in the morning, on opening them, and appears a mystery. However, this can only arise from a person or persons having slept in the locality, or from a gas or other light having been burned there.

Although apparently so simple, the general question of ventilation is very difficult to treat with, for sometimes the means adopted to insure a good supply of fresh air may answer admirably for a period; but unexpectedly, perhaps, from a change in the direction of the wind, suddenly it is found to be defective, and, to the great disappointment of the proprietor of the premises, the system has to be abandoned. Arrangements which may be perfection in calm or warm weather, are often highly objectionable in cold or boisterous weather, when, instead of the noxious products of combustion passing off, the reverse takes place, and the flame is caused to become smoky and agitated, necessitating a discontinuance of the mode of lighting.

For public buildings of every denomination, the Sun Light may be considered the most effective means of lighting and ventilation, so far as regards the supply of air to aliment the flames; but with respect to the general ventilation of such places, much remains for the architect to accomplish.

In warehouses, shops, apartments, etc., where gas is much used, and defective ventilation exists, one or more openings should be made in the highest part of the locality, which openings may be regulated by a valve or valves, and these should be under control as desired according to circumstances. The number and size of such openings will depend on the dimensions of the building, the number of persons generally assembled there, and the lights employed. They may be led into a staircase, passage, or other similar place where the noxious products of combustion and respiration will become cooled, and, being heavier than the atmospheric air, will descend and be diffused. When ventilating openings communicate direct with the open air, the serious inconveniences of sudden draughts are to be contended against, for in all places there is a particular point from whence the wind blows, which at certain periods causes considerable annoyance. This, however, may be remedied to a great extent by closing the orifice with a sheet of pierced zinc or wire cloth, which has the effect of checking the evil.

In order to permit the vitiated air to issue with every facility, openings should exist in the lowest part of the apartment for the admission of fresh air; and if carefully distributed in a series of small orifices, at the back of, or in, the skirting boards, then no draught will be perceptible. If the supply of fresh air be regulated by a valve similar to that mentioned for the egress of the vitiated air, this system of ventilation will then be found admirably adapted for either winter or summer. The error is often committed to leave a large opening in the roof or ceiling for the emission of the impure air, without making any provision in the lower part for the supply of fresh air. Under such circumstances, proper ventilation is impossible.

In many modern-built first and second-rate houses, the architect makes provision for ventilation by constructing main air flues, which pass from the bottom to the roof, but terminate inside, so as not to receive the direct action of the various winds. Into this are conducted the branch air flues, which receive the vitiated and heated air from the various apartments, and so carry it away. This system is highly recommended, and it is desirable that it should become more general.

There are several systems of ventilating gasaliers, more or less effective; in these, the air for supplying the flames is conducted by a tube from the exterior, another tube conveying away the noxious products, so that the air in the apartment is not influenced by the burning gas. When this class of gasalier is employed, both tubes should communicate with some enclosed place, otherwise efficiency cannot be expected, for at one period or another, the inconveniences of down draught, smoky flames, and broken glasses will be experienced, and causing the very opposite effect to that desired.

Other ventilating gasaliers are constructed in such a manner that the air to supply the flame is taken from the apartment where situated, and the products of combustion carried away as just mentioned. This has the great recommendation of effectually ventilating the locality where placed, and is to be recommended.

Dr. Frankland's hot-air burner, referred to in a former chapter, is calculated to contribute largely to a more perfect system of ventilation where gaslights are in use; for, as shown, the saving in gas thereby is equal to thirty-three per cent.; in consequence, the vitiated air would be decreased in the same proportion.

In many places, ventilation may be promoted by employing panes of perforated glass for the windows, or by some of the various kinds of ventilators now before the public, taking advantage, where practicable, of the means of obtaining a fresh supply of air from the lower and cooler part of a building.

"The following is one of the most simple and effective modes of ventilation, easily applied, and capable of being put in operation at a very few minutes' notice, in a house of almost any form of construction, from a palace to a cottage. Its cost is next to nothing, and is applicable to all kinds of weather, winter as well as summer, as all draught is avoided,—rainy weather as well as dry;—because, with this arrangement, the rain cannot penetrate.

"Provide a piece of wood about an inch thick, three to six inches wide, and just as long as the width of the window-casing of the room to be ventilated. Raise the lower sash of the window, lay the strip of wood on the bottom of the window-casing—its edge resting on this—and the ends in the grooves in which the lower sash slides; close the sash down snugly on the slip of wood, and you will find an opening is left between the bars of the upper and lower sashes of the window, where they meet in the centre, as shown in the engraving (*Fig.* 18). The air passes through this opening in an upward current towards the ceiling, or else will pass outward in a downward current from the top of the room, so that all danger of a

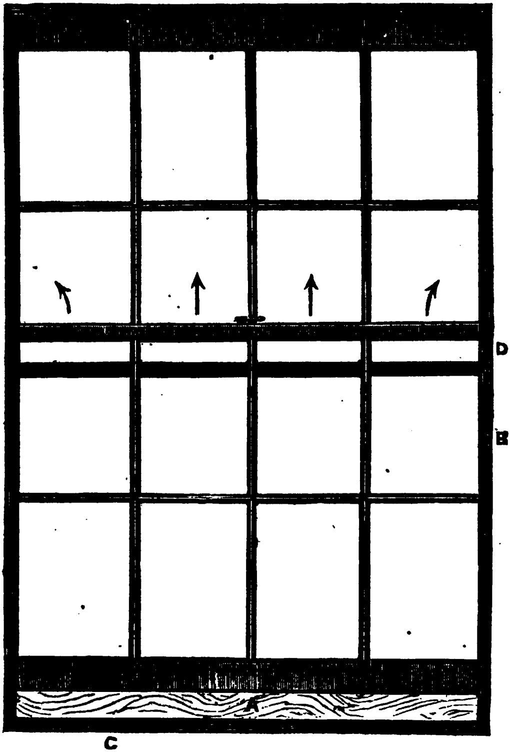


Fig. 18.

A, slip of wood, its edge resting on C, bottom of the window casing. B, lower sash raised, but closed down on A. D, opening between the sashes through which the current of air passes in direction indicated by arrows.

draught is avoided. One or more windows fitted in this manner on each side of a room (or even on the same side if windows exist on but one side), secures perfect ventilation without discomfort. On account of the difference in the temperature, and equilibrium of the air in the room and that outside, an outward and inward current will be established, a stream of fresh air passing upward in the direction of the opening between the sashes of the window toward the ceiling of the room, and another current passing downwards from the top of the room through the window on the other side, thus maintaining a nearly perfect system of ventilation, and one that can be put in operation more readily than any other plan known. The direction of the current is such, that the foul air is removed from that portion of the room where it is apt to be most abundant.

"The slips of wood can be painted of the color of the window, so that they will not be readily noticed, or they can be made of ornamental woods.

"If the slip of wood has been properly fitted to the grooves, no draught whatever will be felt at the bottom of the window."

The importance of a good system of ventilation cannot be overrated; but frequently people, by use, become habituated to breathe impure air. In some workrooms it is often insupportably injurious to those who enter casually, yet the occupants experience no inconvenience from it at the time, but slowly it does its baneful work, and many cases of consumption have their origin from this.

Badly-ventilated workrooms and workshops are detrimental in a commercial point of view, for those persons who inhabit them have considerably less energy than they would possess were proper ventilation established, and in consequence less work is done. Therefore it is directly the interest of employers to consider well this important question.

In public places of amusement, the means of ventilation are too frequently neglected; the natural consequences are, that in summer time, on this account alone, they are less patronized, for who can possibly consider it amusement to sit in a state of perspiration, and gasping for breath, as is often the case; and sacrificing the comforts of a moderate temperature, a fresh and healthy atmosphere, which can be obtained by leaving the building?

A good system of ventilation may be applied in such places by means of a fan, or vane, set in action by motive power or manual labor, with a judicious disposition of flues to conduct the supply of air to those parts of the edifice wherever requisite.

It often happens, during public or private assemblies, that the atmosphere is rendered so insupportable by the persons and the lights, that weariness and headache are the consequences — thus marring the pleasures of the evening, and carrying its injurious effects with it the following day. Fresh air costs nothing; therefore bad ventilation should be always avoided, for assuredly when this exists, its pernicious effects will be made manifest sooner or later, to a greater or less degree, in those persons who are subjected to its influence.

One mode of effecting ventilation is to place a simple catch-tube or funnel over the gas, and thus to carry away the products of combustion into a neighboring chimney, or to the outside of the house. When this plan is not available, a less perfect mode of ventilation may be adopted, by boring a number of holes through the ceiling immediately over the chandelier or burner. The holes should be about half an inch in diameter, and they should communicate with the space above the ceiling. The holes in the ceiling may be hidden from view by means of a perforated or open rosette.

CHAPTER XI.

CHEMISTRY OF GAS-LIGHTING.

A BEAUTIFUL action takes place in the combustion of an ordinary lamp or candle, in which the wick surrounded by flame represents a series of capillary tubes, to convey the melted matter in the form of gas into flame. This action will be very apparent to any one who will watch the process of combustion in an ordinary wax or tallow candle. First, he will perceive a cup of melted matter around the wick, in which a great number of small globules are seen constantly in progress toward the wick. Many of these globules are also seen standing on the wick, studding it all over like little sparkling diamonds. Let us consider what these globules contain. They are filled with the inflammable gas produced by the heat applied to the melted wax or tallow; but fortunately for the success of this method of burning, these globules do not break and set free the gas until they come into close contact with the flame, when the heat becomes so great, that the expansion of the gas causes each little globule to break, and add its contents to the already burning flame. It is obvious if the gas were to be actually formed at the surface of the small cup of melted fluid already spoken of, the surface being usually half an inch below the nearest part of the flame, that the gas would immediately diffuse itself through the air, and combustion could not proceed.

It is only through the property which the gas possesses of taking an intermediate form, and not finally assuming its gaseous condition till it reaches the flame, that the effect of continued combustion is preserved.

All organic and inorganic bodies constituting everything accessible to man, consist of, or are composed of, about sixty-four simple substances called *elements*, which are so named because they cannot by any known means be decomposed; that is, resolved into simpler kinds of matter. These elements combine with each other in certain relative proportions, and form substances called compounds.

Of the elements, those which are of immediate interest in connection with gas, there are only five: viz., oxygen, hydrogen, nitrogen, carbon, and sulphur, which are of the greatest importance on account of their vast abundance, because one or more of these exist in almost every substance or compound in nature, and they all influence the manufacture or distribution of coal-gas.

The decomposition of coal by heat, as in the manufacture of coal-gas, is entirely a chemical operation. Coal contains all the five elements named; and the result of the decomposition is, that the greatest portion of the hydrogen and the volatile carbon are expelled as gas; a portion of the oxygen and hydrogen form water; the nitrogen, with a portion of hydrogen, constitutes ammonia; a portion of the sulphur and hydrogen comprise the impurity, sulphuretted hydrogen. Another portion of sulphur unites with carbon, and produces the troublesome impurity called bisulphide of carbon. The tar is a compound of several of these elements; and the coke left in the retort is fixed carbon, intermixed with earthy substances and a minute portion of sulphur.

Gases are permanently elastic fluids — vapor or steam convey to us the idea of the bulk of gas. But this, by the diminution of temperature, condenses and becomes liquid; whereas gases, under all ordinary circumstances, are permanent in their state. Smoke issuing from a chimney or elsewhere, is a mixture of several gases combined with vapor and small solid particles of carbon, called soot.

Oxygen. — This is by far the most abundant element in nature, and in its gaseous state forms more than one-fifth part of the atmosphere by which our earth is surrounded. As a liquid, in union with hydrogen, it constitutes by weight eight-ninths of all water; as a solid, it is a portion of innumerable organic and inorganic bodies, and is estimated to form about one-third of the mineral crust of our globe.

Oxygen, when free, that is, when uncombined with any other elements, exists only as a gas (all attempts to reduce it to a fluid having failed); and this occurs either when it is emitted by the leaves of plants, etc., or when by the agency of man it is separated from other elements with which nature has caused it to combine, and form certain compounds or substances. This element is the support of all animal life and combustion, and possesses very peculiar properties; for instance, a body which burns in air when it is immersed in oxygen gas, burns with vastly increased splendor; and the wick of a recently extinguished candle, having the least part red-hot, when inserted into a jar of this gas, is immediately relighted; and a piece of charcoal with the smallest point ignited, when so treated, burns with great brilliancy.

Oxygen gas is inodorous, colorless, and rather heavier than air, and it may be termed the aërial food of animal life; for at each respiration a portion of it intermixed with nitrogen is received into the lungs, acts on the blood, and is afterwards ejected as a poisonous compound, carbonic acid gas.

Chlorine. — This gas is of a yellowish green color, its odor very suffocating; and, if breathed, it is extremely injurious to the lungs. It destroys all vegetable colors, and is much used in bleaching.

Hydrogen. — This element is also very abundant, and does not exist free or uncombined in nature. It is a constituent of all animal and vegetable substances, forming, by weight, one-ninth part of water, and is a portion of most combustible bodies. Hydrogen gas is colorless and tasteless, and when quite pure is without odor; it is inflammable when issuing from an orifice and intermixing with the atmosphere; burning with a faint violet color, giving great heat, but very little light.

This gas is the lightest substance in nature, being a little more than one-fifteenth part of the weight of air. It is an invariable component of coal gas, both in a free state and in combination with carbon, constituting certain hydro-carbons, such as light carburetted hydrogen (or marsh gas), olefiant gas, etc.

Hydrogen, for perfect combustion, requires eight times its weight, or half its volume of oxygen, the result of the combustion being water; and in every case wherever artificial light is obtained by burning oil, tallow, gas, etc., this production of water is continually taking place, arising from the hydrogen intermixed with the material being consumed uniting with the oxygen of the atmosphere.

Nitrogen. — This element is so called from its being the basis of nitric acid, and nitre, and is sometimes named azote, from its incapability of supporting life.

Nitrogen constitutes nearly four-fifths of the air we breathe, and serves to temper the effects of the oxygen, which, if alone, or even when in moderate excess of the proportions stated, would be too energetic. It is also a component of all animal tissues, muscles, etc.

Nitrogen gas is slightly lighter than air: it has neither color, taste, nor smell; it supports neither combustion nor respiration; and is characterized by its negative properties, rather than by possessing any inherent poisonous qualities, such as are peculiar to carbonic oxide, or carbonic acid. Nitrogen is of interest to the gas manufacturer on account of its influence on the combustion of gas; also because it is one of the components of the alkali ammonia, which is always generated during the distillation of coal, in making coal gas.

Carbon.—This is likewise one of the most abundant elements, and is extensively distributed in nature as a constituent of all animal and vegetable bodies. It exists in the mineral kingdom in various forms—very largely in the state of coal. It also enters into the composition of some earthy bodies; for, united with lime, it forms marble, chalk, and limestone. The diamond, although unlike any of the substances named, is pure carbon, and is about three and a half times heavier than water. The combustion of carbon in air or oxygen, produces light more or less brilliant, according to the degree of heat to which it is raised.

Sulphur.—This exists in large quantities in nature, forming part of the ores of copper, lead, mercury, silver, and other metals. It also issues from volcanoes, in the form of gases, in great abundance, and in its solid state is well known under the name of brimstone. It exists in coal in the bright metallic laminæ which intersect it, these being chiefly a compound of sulphur and iron. Coke, even after having been submitted to a very protracted and high heat, still contains a portion of sulphur, giving rise to the noxious odor occasioned by burning it in confined places. A highly volatile compound of sulphur and carbon is produced in the distillation of coal by the combination of a certain amount of sulphur with carbon, viz.: the bisulphide of carbon.

The peculiar disagreeable odors of many of the compounds of sulphur are familiar to all, and are the most troublesome of all the impurities of coal gas, the economical removal of which has for several years defied the chemist's skill.

Composition of Coal Gas.—Coal gas, when purified, is composed chiefly of carbon and hydrogen, and consists principally of a definite compound, called light carburetted hydrogen, or marsh gas, combined with a variable mixture of vapors or gases, consisting of carbon and hydrogen, called heavy hydrocarbons, the most important of which is known as olefiant gas; carbonic oxide is also one of its constituents. The impurities are sulphuretted hydrogen, ammonia, nitrogen, carbonic acid, and bisulphide of carbon.

Light Carburetted Hydrogen, or marsh gas, is a compound of carbon and hydrogen, in the proportion of one atom of the former to four atoms of the latter. It is this compound which constitutes the inflammable fire-damp of coal mines, where it is generated spontaneously; it proceeds abundantly from the decomposition of vegetable substances, and is one of the products of the distillation of coal.

This gas is colorless, nearly inodorous, and does not affect vegetable colors, and like hydrogen, is permanently gaseous under intense cold or pressure.

Pure carburetted hydrogen gas may be respired with safety. The unpleasant smell of common coal gas is due to impurities.

Olefiant Gas, or oil-making gas, is so named from its forming an oil when combined with chlorine or bromine. It consists of two atoms of carbon united to four atoms of hydrogen. Olefiant gas containing double as much carbon as the light carburetted hydrogen, burns with much greater brilliancy, and gives out a very superior light.

There are other heavy hydrocarbons which enter into the composition of coal gas, having the same nature as olefiant gas, known as propylene, butylene, etc.

Hydrocarbons.—Coal gas, according to the description of coal from which it is produced, and the mode of distillation, contains from three to thirty per cent., by volume, of vapor or gaseous matter (carbon and hydrogen), to which the general name of hydrocarbons is applied, and the illuminating power of gas is in direct proportion to the quantity of hydrocarbon in combination therewith.

If chlorine, bromine, or dry sulphuric acid be added to a sample of coal gas, or if the gas be subjected to excessive pressure or extreme cold, the heavy hydrocarbons are deposited in the form of oil, the volume of gas being sensibly diminished in proportion to the quantity condensed.

Carbonic Oxide, or the protoxide of carbon, consists of one atom of carbon and one of oxygen. Carbonic oxide is prepared in the laboratory by passing carbonic acid over red-hot charcoal or metallic iron, by which half its oxygen is removed, and becomes converted into carbonic oxide. This change also explains the mode of its formation in the process of distilling coal for gas-making purposes. Carbonic oxide contains half its volume of oxygen, is a combustible gas, and burns with a beautiful blue flame, the product of combustion being carbonic acid. This gas is extremely poisonous — even worse than carbonic acid—is colorless, and possesses very little odor.

This compound exists more or less in coal gas, but seldom exceeding ten per cent. by volume, and generally much less. It requires one volume of oxygen for combustion, being then converted into carbonic acid. Carbonic oxide contributes to the heat of the flame, but only indirectly to the light. It is not considered an impurity in coal gas.

IMPURITIES OF GOAL CAS.

Sulphuretted Hydrogen — (hydro-sulphuric acid) is a compound which consists by weight of one part of hydrogen gas and sixteen parts of sulphur vapor. By measure it contains two volumes of hydrogen, combined with one volume of the vapor of sulphur, the two being condensed into two volumes.

This is a colorless gas, possessing acid properties, reddening litmus paper, and has a most offensive odor, similar to putrid eggs, which indeed contain it; it is very poisonous, and if breathed into the lungs is injurious to life, occasioning suffocating vapors like those arising from the burning of brimstone; it tarnishes metals, changes the color of most kinds of paint and furniture hangings; and when coal gas possessing this impurity is burned, the sulphur combines with the oxygen of the atmosphere, forming sulphurous acid. Therefore with the various evils enumerated, it is of the utmost importance that gas should be entirely free from it, and any establishment neglecting this does a serious injury to its business, as well as to the comforts and health of gas consumers.

This gas is also frequently found in low places which have been for a time the receptacles of animal and vegetable matter, and afterwards filled with earth or gravel to a higher level, for the purposes of commerce or residence. Take for example the Back Bay lands of Boston, where, although the filling has been most thorough and complete, this gas is sometimes complained of as tarnishing the silver and other metals.

Carbonic Acid is another well-known oxide of carbon. This gas is readily procured by decomposing any of the earthy carbonates, as chalk or limestone, with a stronger acid, which, forming a new combination with the earthy base, sets free the carbonic acid of the carbonate.

Carbonic acid gas is without color, and though posessing an agreeable pungent taste and odor, cannot be breathed for a moment with impunity, as it rapidly produces the effect of suffocation, insensibility, and death. This gas is familiar, as the fatal choke-damp of mines, as the fixed air in champagne, bottled beer, soda-water, etc.; and as the heavy gas which floats over the large vats in breweries while the beer is undergoing the process of fermentation. It is also produced wherever there is combustion, and should always be carried off by proper ventilation.

Not only is this gas entirely uninflammable, but it instantly extinguishes flame even diluted with three times its volume of air. The carbonic acid gas, owing to its great affinity for lime, is readily separated either by being exposed to the absorption of hydrate of lime, or that of lime diffused through water, as in wet lime purifiers. It is extremely injurious in gas intended for illuminating purposes, as it tends directly to destroy combustion.

Ammonia is produced during the distillation of coal by the union of hydrogen with the azote or nitrogen which is contained in coal, as in all other organic substances. In forming ammonia one atom of nitrogen unites with three atoms of hydrogen, the proportions by weight being 82.41 per cent of nitrogen, and 17.59 per cent of hydrogen. Ammonia is produced abundantly in nature from the decomposition of animal and vegetable substances; the gas is colorless and very pungent, acting strongly on the mucous membrane of the nose, eyes, and throat. Ammonia in small quantities is not injurious to health, but it acts on some of the metals, as brass and copper of the fittings and meters, and is so far an impurity. Against this it converts any sulphuric acid formed during combustion into sulphate of ammonia; therefore in this respect it is beneficial, and must be considered so until means are devised of freeing gas from all its sulphur compounds. A very small quantity intermixed with the gas is also considered essential, to prevent the deposition of naphthaline in the pipes.

Ammonia is a gaseous body, and that which is usually called so in the liquid state is ammoniacal gas intermixed with water, which takes up or absorbs about seven hundred times its own volume of that of gas.

Bisulphide of Carbon. — This impurity in coal gas until recently attracted very little attention, but it is now found to be most objectionable, on account of its very disagreeable odor, its injurious effects, and the difficulty of removing it.

This gas is a compound of one equivalent of carbon and two equivalents of sulphur, or by weight carbon 6, sulphur 32. It forms whenever sulphur comes into contact with red-hot charcoal or coke.

Cyanogen.—The property of nitrogen to unite with carbon and form cyanogen has been much studied. Cyanogen is an inflammable gas, burning with a beautiful purple or peach-blossom colored flame, generating carbonic acid, and setting nitrogen free. It contains one equivalent of carbon and one of nitrogen, its atomic weight being 26. This compound is not generally classed amongst the impurities of coal gas, but as some chemists of ability have decided it to be an impurity, we place it here along with the others.

CHAPTER XII.

CONCLUDING REMARKS.

Mode of burning Gas.—When coal gas is ignited as it issues from a burner, or orifice, its hydrogen is consumed at the lower part, producing the blue flame characteristic of it, and the carbon being sufficiently heated is liberated in a solid state at the upper part of the flame, if properly consumed, where it combines with the oxygen of the atmosphere, again therewith resuming the state of gas as carbonic acid; and according to the degree of heat attained by the innumerable particles of carbon, so will be the amount of light emitted by the gas.

Whenever the flame of gas is unduly cooled, or when the gas is intermixed with a portion of atmospheric air, or when it issues from the burners under great pressure, the light obtained from a given quantity is very materially reduced; and when either of these contingencies is carried to an extreme, no material light is obtained from gas.

Atmospheric Air mixed with Gas.—According to Dr. Letheby, the following are the proportions of light given by different quantities of air being intermixed with gas, supposing the light from gas unmixed with air to be 100:—

	Light.
2 per cent. of air in gas . . .	90
5 " " . . .	70
7 " " . . .	52
10 " " . . .	34
20 " " . . .	12
40 " " . . .	1
50 " " . . .	0

The pernicious effect of an admixture of air with gas is thus fully demonstrated, and requires the utmost attention to avoid it, either in the production, transmission, or consumption of gas.

The Chimneys generally produce too strong a current of air for the purpose of light; and much of the illuminating power of the gas is thereby destroyed, and a considerable amount of *heat is produced instead of light*, — the heat being produced by the combustion of an extra quantity of oxygen derived from the air. It is on this principle that the oxy-hydrogen blow-pipe is found to produce intense heat. Hence, we are led to the conclusion that *most light and least heat is produced when the gas is not exposed to too great a current of external air*, and that *most heat and least light is given by saturating the gas with external air*; sufficient air, however, must be admitted to all burners, or the combustion will be imperfect, the color of the light will be bad, and smoke will be produced. Hence, *to prevent smoke, the air admitted to the burners must be adjusted according to the nature of the burner and circumstances affecting it.*

Flickering. — This is principally caused by insufficient pressure of gas, and it is shown mostly in the horizontal burners now most improperly being much used, as they require greater pressure than other burners in the same establishment, and give much less light.

Pressure.—That the light given from gas is influenced according to the pressure with which it is emitted from the burners, may be illustrated in the following manner: Take an argand burner having fifteen holes of such dimensions as to permit five feet per hour to issue, with a pressure of about one-tenth inch, when with ordinary gas we could obtain a light equal to about twelve candles. Now, if we reserve the same form and size of burner in every respect, but diminish the size of the holes so that a pressure of five-tenths is necessary to expel the five feet of gas per hour, then the light will only be equal to five and a half candles; and if we further diminish the size of the holes so that forty-tenths pressure will be required to expel the five feet, then that quantity of gas produces a blue flame, but no material light. All descriptions of burners are subject to this variation under like conditions; and it is a most important consideration to all connected with gas lighting.

Luminosity of Gas.—The variation in the luminosity of different kinds of gas is due to the quantity of carbon they relatively contain, which carbon separates at the moment of ignition from the hydrogen, in very minute, solid particles, and by intermixing with the oxygen of the atmosphere, assumes a state of incandescence (a state of white heat); and, according to the number of these solid particles of carbon in gas, so is the amount of light to be derived from it. But it is essential for the carbon to attain the necessary degree of heat to combine with its equivalent of oxygen. For the perfect combustion of gas, the proper supply of atmospheric air requires the greatest attention. An excess of atmospheric air with the flame should be avoided on the one hand, and on the other a sufficiency should be insured to combine with the carbon of the gas.

Burners.—All burners require to be made especially for the quality of gas they are designed to consume. All the burners in a house should be of the same sort, or, if of different sorts, they should each consume the proper quantity of gas under the same degree of pressure. With regard to the size of burners, the first fact to be observed is, that *a greater amount of light is produced from a larger burner under a low pressure, than from a small one under a high pressure*, each consuming equal quantities of gas in a given time. Again, *a greater amount of light is produced from a large burner than from two small ones consuming the same quantity* as the one large one. Every size burner requires a definite amount of gas to produce the largest proportion of light: *light is as much sacrificed by using too little gas, as by using too much.* The complaints about bad gas are often without foundation; the fault being with the consumers. If they will not use the proper appliances for obtaining good light—namely, good burners and perfect regulators—to make the supply of gas uniform, they must not complain of the gas.

The effect of Gas on Health.—It is gas, and nothing but gas, that is burnt; the only difference being that coal gas is always purified before it is consumed; whereas, the extemporaneous gas of a candle or lamp is consumed without being purified at all, and hence *light for light*, it must and does vitiate the air of an apartment much more than coal gas. If, therefore, it be true that gas is insalubrious, or unhealthy, wax, oil, and tallow must be decidedly more so, from the simple fact that all the impurities they evolve pass into the atmosphere of the localities lighted; whereas, the great bulk, at least, of those from coal gas remain at the gas works. The actual question for the public to consider, is not whether the burning of gas be injurious to health, for, in one shape or other, gas must be burnt to procure light, but the point is — whether it is better to consume for this purpose gas of pure or impure quality?

Carbonization of Gas. — There is a method of enriching gas by causing it to pass, just previous to combustion, through prepared oils which are rich in carbon; by this process the gas becomes loaded with the carbon of the oil, which is thereby carried to the burners, and produces a much larger amount of light at a comparatively small cost. The apparatus is called a *Carbonizer.* This instrument is an apparatus attached to the meter, so that the gas, after leaving the meter, is made to pass through it previous to being distributed over the building or premises.

The following are the essential requisites of every apparatus for this purpose: "It should be substantial, not liable to derangement, simple in construction, having no machinery liable to get out of order, and requiring no special skill in its management; easily taken apart, readily put together again, and uniform in its action." "It should present the largest possible surface for evaporation for its bulk, or cubic contents, fire proof, and safe against any possible accident from leakage, with facilities for charging it readily, without risk of escape of fluid or vapor, and by the least possible trouble." "Its construction should be such that the pressure of the medium entering the apparatus should not be diminished at the outlet pipe, so that the size of the flame will always be the same, irrespective of the number of lights used within the capacity of the instrument." "It should be provided with a surrounding air-chamber, of a non-conducting medium, to avoid the accumulation of intense cold on the exterior of the apparatus, insuring a depressed temperature to the vaporized medium, below that to be assumed by the gas or mixture after entering the service pipes." "The fluid should leave no residue or deposit when evaporated; and its cost to consumers should be within the reach of persons of moderate means."

By the use of an apparatus of this kind, the illuminating power of gas is said to be increased two, three, and even fourfold. This greatly increased illuminating power imparted to gas affords a satisfactory means of making a saving in the consumption of gas. It renders the light of a *small flame* from carbonized gas equal to that of a much larger flame from ordinary gas. Small burners consuming but three or four feet of gas per hour, it is claimed can be substituted for larger burners, consuming from five to eight feet per hour, without any diminution of light; or, where half a dozen lights with burners of the ordinary size are needed to obtain the light desired from common gas, half that number of lights, with three-foot burners and carbonized gas, are said to serve the same purpose.

This principle of carbonizing gas is also applicable to common or atmospheric air, which as a source of illumination has, for some years past, attained a degree of popularity; and is destined in all probability to assume a prominent position, not only in places remote from gas-works, but to enter into competition with coal gas in our cities and large towns. In this process the common air is driven through gasoline, or through pumice stone and other substances saturated with this lightest product of kerosene oil. The air thus charged with volatile hydro-carbons is not only combustible, but yields a brilliant light, superior to coal gas.

Escape of Gas, etc.—Should there be an escape of gas, a deficiency of supply, or a jumping of the lights, first ascertain whether the whole of the lights, or a part only, are affected; if a *part* only, it is quite evident some portion of the fittings are wrong, but if the *whole*, the probability is the meter or service-pipe is the cause; in which case the Gas Company should be informed as early as possible, and during the hours of daylight.

Gas Regulators (sometimes called Governors) have been described in Chapter IX., and to which we add the following: These instruments are affixed to the meter, and are rendered *necessary* by the variable nature of the supply of gas. Sometimes its pressure is more than that of a column of water five inches high; at other times it will not be equal to one inch. The pressure in the street mains is continually varying, and it is to counteract the evil effects of these irregularities in the supply, that a regulator is required. This it does, maintaining an uniform degree of pressure at all times, to all the burners, preventing any *excess of pressure*, but *not checking the proper supply*. It acts only like a safety-valve when required. It is as necessary as a rudder to a ship, or reins to a horse. *No amount of personal watching can equal the unerring, immutable laws of nature by which a perfect regulator acts spontaneously when required.* Some persons unacquainted with the mechanical and pneumatic laws, imagine that they can regulate the gas by turning the main cock on or off as required. They can only admit more or less gas by that means, but it does not produce the same beneficial effects, in the slightest degree, as a perfect regulator does: the regulator *prevents* all the evils which they in vain try to cure.

Explosion of Gas.—Fitters should be careful when making a new joint, if requiring a light at the open end of a pipe, to turn the outlet tap off, or disconnect the outlet union of the meter; otherwise there is great risk in blowing up and damaging the meter.

We can look, however, with satisfaction to the advancement science has made in connection with this subject, for now we know, instead of gas being so terribly destructive, that when *unmixed* with atmospheric air or oxygen, it is as harmless as regards explosion as the water in the tank beneath it; and if it were possible to insert a lighted torch, or taper, into a holder containing gas, instead of the gas exploding, the flame would be extinguished. In other words, gas unmixed with oxygen suffocates flame, and in this state cannot ignite or explode.

A mixture of seven parts of air and one of gas is considered to be the most explosive compound, but this must depend on the quality of the gas. Mixtures of less than three of air to one of gas, or more than eleven of air and one of gas, do not explode.

Explosions from gas are exceedingly rare. The odor arising from gas is generally so repulsive as to awaken in the minds of the most callous a desire to avoid the inconvenience, and in so doing the danger is averted. However, there are circumstances where this notice by odor is not manifested, as where, from the lightness of the compound, it ascends in the atmosphere above; but when in dwellings or other buildings the slightest odor of gas is noticed, it should always be attended to.

At one period or other, gas works have been the scenes of explosions. This has sometimes arisen from a new gas-holder, when nearly terminated and ready for use, having, from a very simple oversight, been communicated with the manufacturing apparatus; and it has afterwards happened that through a leaky valve allowing the gas to pass, or perhaps by some careless person thoughtlessly opening the valve, the gas has entered, intermixed with the air in the holder, and the accidental production of a light has caused the disaster. Therefore, when new holders are constructed, they should either not be communicated with the manufacturing apparatus until quite terminated, or the pipes should be "logged" or sealed with water, so that no gas can possibly enter until quite ready for use.

Explosions of this nature have sometimes occurred when the holder was being first filled with gas. One of the most remarkable took place a few years ago, by which the engineer was killed. This arose from a defect in the construction, and want of ordinary care on the part of the unfortunate sufferer. The facts are simple, for the holder, on being charged with gas at the commencement of the operations, contained a considerable quantity of air, the two forming an explosive compound, and by a singular fatality it happened that the holder was so far bound, or set, as not to give any pressure. The engineer, desirous of judging the quality of gas, very imprudently tried it at an open orifice of about a quarter of an inch in diameter; the consequence was, the flame entering, the explosive compound in the holder ignited, and produced the disaster. Had the gas been tried by an argand or fish-tail burner, the accident could not have occurred, the holes in these being too small to permit the flame to enter.

An explosive compound of gas, when *under pressure*, *only ignites at the exterior* of the pipe; but if the *pres-*

sure be taken off, the flame enters, and it explodes. An explosive mixture always possesses a very powerful odor of gas; this is sufficient to indicate to any one, that a light should not be approached; and under these circumstances, when in dwellings, ordinary precautions only are requisite; above all, to have no lights near, and to open the doors and windows, the upper part of the latter especially, as gas, by its lightness, ascends, and will readily escape thence. The main tap should be turned off and a careful inspection made, when, perhaps, a burner will be found turned on, or an hydraulic joint without water, or some other defect which can be easily remedied. No one should ever apply a light where there is an odor of gas in the upper part of the apartment; many little mishaps have occurred through neglecting this precaution. Should there be any escape, which can only be detected by flame, the gas ought to be turned off for two or three hours, and the other precautions being adopted, the light may be applied the moment the main tap is turned on; but it is always better and safer to detect escapes in dwellings without the employment of flame, it requiring only a little more patience.

On the occasion of a fire occurring near gas-works, the public journals sometimes fall into an error by assuming the contents of the gas-holders to be explosive, and conjecture the amount of damage that would arise from this event occurring, the excitement being much increased by this misstatement. Gas-holders, when in use, that is, containing ordinary gas, cannot by any means explode, even although the plates forming them were to be made red-hot by the flames; all that could occur is that the gas, expanded by the heat, would issue in detached flames, but no explosion could take place. Another common error, when an edifice, as a theatre for example, takes fire, is to turn off the gas to prevent explosion, and this is done sometimes at the risk of putting the audience in darkness, to find their way out in the best manner they can. Nothing is more absurd; for supposing, at the worst, the fire to melt the pipes in the building, and the gas to issue, the same flame which melted the pipe would ignite the gas, so that explosion is not possible under these conditions. A good system is to have a valve or valves on the exterior of all public buildings of resort, which, in the event of a fire unfortunately occurring, can be shut off after all the people have left the building, so preventing the destructive effects of the flame should the gas ignite, and the loss of the gas.

How to stop a Leak.—When a slight leakage of a gas-tap is detected, it can, in nine cases out of ten, be remedied in the following manner: Turn off the gas back of the meter; then with a screw-driver take out the plug. Next light a wax, sperm, or paraffin candle, and drop the melted wax, sperm, or paraffin upon the surface of the plug, till it is covered with a thin layer, and screw in the tap again.

ILLUMINATING QUALITY OF GAS, ETC.

The following table shows the illuminating quality of the gas consumed in various towns in Great Britain, as determined by Prof. Frankland in accordance with the government test:

London,	12	Candles,	Birmingham,	15	Candles,
Carlisle,	16	"	Manchester,	22	"
Liverpool,	22	"	Inverness,	25	"
Edinburgh,	28	"	Glasgow,	28	"
Greenock,	28.5	"	Harwick,	30	"
Paisley,	30.3	"	Aberdeen,	35	"

In Paris, it is 12.3, Berlin, 15.5, and in Vienna only 9.

In addition to the standard, as above, for London, which is for the common gas, there is one manufactured from cannel coal, the standard of which is never below 20 candles. This gas is used in the public buildings, the dwellings of the wealthy, etc.

In this country it is very difficult to get at the quality of the gas manufactured. The companies keep it from the public; and as there is little or no law on the subject, most of the gas companies throughout the country treat the public on the principle of—"*If you don't like it, don't take it.*"

But so far as ascertained, the illuminating power of gas in this country varies from twelve to eighteen candles, taking the English standard as a measure.

In conclusion, it must be admitted that the want of knowledge on the part of the general public in matters relating to gas, has caused many persons to indulge in much ill-feeling, suspicion, and censure; which is not limited to a particular class, but shared by a large portion of the community, and undoubtedly this would be entirely avoided were they better informed on the matter. We often find persons of more than average intelligence on ordinary subjects, who regard the operations of gas companies as of a doubtful nature, who consider the measurement of gas as a mere farce, who pretend the sale of gas to be a mystery, and its profits incalculable; and, only recently, a gentleman generally remarkable for his liberality of opinion, publicly gave expression to observations calculated, if they had been true, to reflect but little honor on gas companies. To such people we would suggest that they should inquire into the subject without prejudice or bias; and when this is done, their opinions on the point will be materially changed.

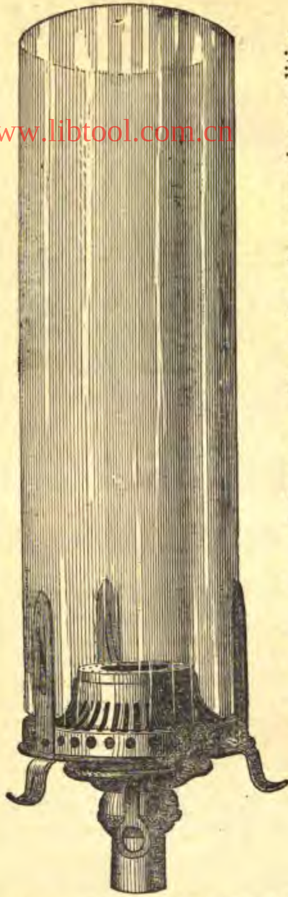
By giving contradiction to some of the many popular errors on gas, and in demonstrating and upholding the accuracy of the measurement of gas, we may be regarded by a certain class as the partizan of gas companies. On the other hand, the instructions to consumers how to economize, how to employ gas to the best advantage, how to test it for impurities — may be considered by many interested in companies as unnecessary, and detrimental to their interests; and is calculated to call forth the censure of those persons. There has been, however, but one course to pursue — to maintain the truth, and to fulfil to the best of our ability the task imposed upon us.

We are fully prepared to learn that our statements of the light derived from gas under various conditions do not always correspond with the accepted notions of gas engineers in general; but all assertions have been substantiated by repeated experiments and trials.

It may be considered that the chapter on gas-meters is too detailed, but the subject is difficult to explain otherwise; and as the information is intended for the public, and not for those engaged in gas companies, no objection can be taken to it.

The subject of ventilation is very intricate and difficult. So far as space would admit, we have given such instructions as we considered necessary relating thereto; but this is a question which continually presents difficulties, therefore our observations cannot be expected to meet all conditions and circumstances.

THE END.



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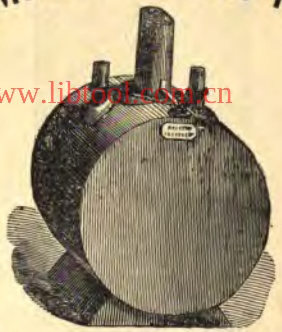

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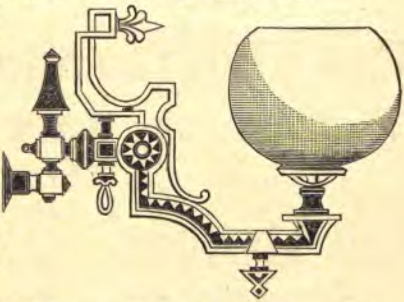

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