WATER GAS, CARBURETTED WATER GAS, AND CARBON MONOXIDE POISONING.

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INTRODUCTION.

THE adoption in recent years by municipal and private gas companies of carburetted water gas as a substitute for, or as an admixture of, illuminating gas has given rise to some important questions from the public health and forensic points of view. These points, be it said at once, have reference mainly to increased risks of danger to health and life. The reasons which have prompted these companies to its use have doubtless much attraction from the standpoint of the gas-producer, not less probably from the economic side as from the comparative simplicity of production. These reasons may be briefly summed up as follows, viz.: (1) the plant required being more compact demands smaller ground space for its installation; (2) the product can be more quickly produced and therefore can be supplied more rapidly on occasions when a large supply of gas has suddenly to be provided in populous centres—as, for example, on sudden onset of fogs; (3) it requires fewer hands in its manufacture; and (4) it is cheaper, therefore, on the whole to produce. Whatever be the reasons, however, which have incited its adoption, the fact is established that in America, Great Britain, and other countries numerous cities have employed, and are now employing, it either as a substitute for ordinary coal gas or as a percentage admixture of coal gas.

It will be well at the outset to recall what is exactly meant by the gaseous compounds known as *water gas*, *producer gas*, and *carburetted gas*, and to contrast the composition of these with that of ordinary coal gas, as it is important, when the term "carburetted gas" is used, that its exact composition should be remembered. It should be understood that the two former are used for the motive power of gas engines and for heating purposes, whereas for public or domestic lighting purposes it is carburetted gas alone or carburetted water gas mixed with coal gas that is used. What are producer gas and water gas and how are they made? The former is made by passing air, or a mixture of air and steam, through incandescent coke or anthracite coal in a furnace generator or retort. The carbon ought to be about the temperature of 2000° F. in order to attain the point of maximum production of the gas. This is the mode by which it is made in the Dowson producer. The product consists of a mixture of hydrogen, nitrogen, marsh gas, and carbon monoxide, with carbon dioxide as its principal impurity. The latter, water gas, is manufactured essentially in the same way, except that steam only is passed through the incandescent coke, the product being chiefly carbon monoxide and hydrogen, in terms of the following equation: $C + H_2 = CO + H_2$. If, however, the temperature of the carbon be much lower than 2000° F. there is a relative increase of the CO_2 , thus: $C + 2H_2O = CO_2 + 2H_2$. Temperature of production, therefore, has an important influence on the percentage amounts of CO and CO_2 in the compound produced, and as the former gas is the desideratum, regulation of temperature of the carbon is of importance. According to Sachs¹ wood charcoal at 350° C. (662° F.) gives off 78·6 per cent. of CO_2 and 21·4 per cent. of CO, whereas at 1100° C. (2012° F.) it yields 1·3 per cent. of CO_2 only, and 98·7 per cent. of CO. Carburetted gas, or carburetted water gas as it is sometimes called, is a different product from both of the foregoing. It is manufactured by passing water gas, made as above, over a large superficies of heated refractory material charged with oils rich in hydrocarbons. The effect of this procedure is that the more volatile hydrocarbons are vapourised or rendered gaseous, and are thereby mixed with the water gas, the resultant product being what is called carburetted gas. The volatilised hydrocarbons thus incorporated are mainly benzene and benzene congeners, and they impart to the carburetted gas an odour similar in kind at least to the characteristic odour of illuminating gas made solely from coal.

The difference in composition between carburetted gas and olefiant or coal gas depends entirely on the mode of manufacture. Coal gas is a compound mixture of gases produced by the destructive distillation of bituminous or cannel coal in air-tight retorts by the agency of high temperature, which mixture, after having been purified by washing or scrubbing and by lime to rid it of objectionable ingredients, chiefly the sulphur compounds, is employed for municipal and domestic lighting and for power purposes. It is not necessary now to enter into details concerning the relative utility of these products further than to say that, in relation to coal gas, producer gas and water gas have low illuminating qualities and high heat-producing properties. From the public health point of view, however, it is important to note that the chief difference in the composition of producer gas, water gas, and carburetted gas, when contrasted with coal gas, is the relatively much higher proportional amounts of carbon monoxide which they contain. Coal gas, for example, may be said to contain on the average from 6 to 9 per cent. of carbon monoxide, whereas producer gas or water gas contains as much as from 25 to 50 per cent., and carburetted gas about 30 per cent. By reason, therefore, of the large increases of carbon monoxide in these last-named products, it will readily be perceived how, in certain circumstances of exposure to leakage, risks to health and danger to life will be substantially increased by the use of the former compared with the use of coal gas.

There can be no doubt whatever of the toxic effects of carbon monoxide gas when inhaled, and since this may be taken for granted no further elaboration of statement is at this stage needed. It has been argued by some, however, that the toxic influence following the inhalation of coal gas, or of carburetted gas, is not solely or entirely due to the carbon monoxide which each contains, but to the benzene and benzene congeners which each contains. Let us for a moment inquire if there be substantial ground for this belief, and if so, how far benzene present in the inhaled gas is a determining influence in the causation of death.

In a paper read before the Royal Society by Staehelin, in which were presented the results of a research into the action of coal gas on frogs, it was shown that on exposure of these animals to coal gas motor phenomena were produced which were not found if the coal gas had been previously purified by passing the gas through oil, and also that these motor phenomena could be reproduced if the purified gas were made to take up benzene vapour. Staehelin indicates that this research was initiated by reason of a statement by Vahlen that a difference does exist between the toxic action of common coal gas and that of carbon monoxide. It would appear from Staehelin's experiments that these differences depend on the presence of benzene in coal gas. Vahlen asserted that warm-blooded animals and frogs died more rapidly after exposure to coal gas than ought *a priori* to be expected from the amount of carbon monoxide which the gas contained. But Staehelin's experiments on warm-blooded animals with air containing a small percentage of benzene showed that no evil effects were observable. This, it was believed, is due to oxidation of the benzene within the body to an aromatic sulphate, in which form it is excreted from the body. The net result of these experiments by Staehelin seems to be that inhalation of benzene in coal gas does not produce definite appreciable toxic effects on man, and that the toxic effects produced must be held attributable to the contained carbon monoxide.² Moreover, the experiments made on behalf of the Departmental Committee on Water Gas, 1899, by Professor J. Lorrain Smith, showed that the evil effects of both coal gas and carburetted water gas are due to carbon monoxide alone and not to any other constituents, which are relatively harmless.³ From experimental evidence, therefore, as well as from experience, we are bound to consider the toxic influence of inhalation of these gases, apart from their general asphyxiating action, to be entirely due to carbon monoxide.

When pure, carbon monoxide is a colourless gas, with a very faint odour, and has a specific gravity of 0·9678. It is sparingly soluble in water, does not support combustion, burns with a pale blue light, and in burning unites with an additional molecule of oxygen from the air to form carbon dioxide. Producer and water gas have some, though slight, odour due to volatile products from the coke, while

¹ Die Kohlenoxyd-vergiftung in ihrer Klinischen, Hygienischen, und Gerichts-Aertzlichen Bedeutung, 1900.

² Transactions of the Royal Society, 1904; THE LANCET, Feb. 20th, 1904, p. 526.

³ Report of the Departmental Committee on Water Gas, 1899, Appendix vii., p. 127.

carburetted gas and coal gas possess a much more marked odour, the latter more than the former, due to the benzene which they contain. It has not uncommonly been supposed that one of the chief dangers of use of carburetted gas is the relative absence of tell-tale odour; this, however, is erroneous, since that gas on being passed as water gas over the oil-carrying material becomes charged to some extent with benzene and other odorous substances, which are readily detectable by anyone possessing the ordinary sense of smell, and who is physically fit to detect odours. Experiments have abundantly proved this. One only need be cited. In a report to the Edinburgh and Leith Gas Commissioners as to the advisability of that corporation laying down plant for the manufacture of carburetted gas, Professor A. Crum Brown narrates the results of some experiments he had instituted on this point. "An experiment," says he, "was made in a room into which carburetted water gas was allowed to pass from a bracket at the side at the rate of five cubic feet per hour. In less than two and a half minutes there was a quite distinct smell of gas in the centre of the room; in five minutes it was so strong as to be decidedly unpleasant. At that time, the proportion of carburetted water gas in the room would be one part in about 800 parts of air." So far as odour is concerned, as a sensible means of detection, it may be taken for granted that that is sufficiently marked in carburetted water gas.

USE OF CARBURETTED WATER GAS BY GAS CORPORATIONS.

Within the last 20 years there has been a movement on the part of gas companies to adopt carburetted water gas either in lieu of coal gas entirely, or to mix some proportionate amount of the former with the latter. This movement had its inception in America. The propriety of this policy has given rise to much controversy, the issue being the increased danger to the users from the larger amounts of carbon monoxide which carburetted gas admittedly contains. Opinion may be said to be divided on this point into two factions—viz.: (a) those who maintain that the policy is economically sound, and that the admixture of the gas with coal gas may be as safely used as ordinary unmixed coal gas; and (b) those who do not question the economic wisdom of the policy, but who assert that under present conditions the practice is likely to be attended by increased risks to the public health from small leakages in dwellings and from improper modes of consumption, and by increased fatal results in cases of large accidental leakages or misuse of gas arrangements.

The question as to the propriety and safety of using illuminating gas mixed with carburetted gas came before the English Local Government Board in August, 1897, in consequence of a communication to that Board from the borough of Stockport. A communication in the following terms was sent in reply to the borough by the Board: "The Board are satisfied from the information which they have received that the supply of 'water gas' might be attended with serious results, and they have in contemplation the appointment of a departmental committee to consider the whole question." Such a committee was appointed, with which I shall deal later; in the meantime we may consider certain statistical facts which were put before that committee, bearing on the question of increased fatality following the use of carburetted gas.

From Table I. the following facts emerge—viz., that in England and Wales, for a population equal in number to the population of London in 1896, the number of accidental cases of gas poisoning in places where coal gas alone was used, was *three* only; that in places outside London, where the same condition obtained, the total deaths numbered 4·2; and that in places outside London, where coal gas partly mixed with water gas was employed, the total deaths were 10·4. In 88 American cities supplied with coal gas only the number of deaths was three only. Following out some of these American statistics, we get closer detail in figures. In the twelfth annual report of the Gas and Electric Lighting Commissioners of the Commonwealth of Massachusetts, 1896, the Commissioners, in accordance with the requirements of Chapter 350, Section 2, of the Acts of 1888, publish information respecting the cases reported of death and bodily injuries from gas poisoning during that year. Therein it is stated that the attention of the board had been called to 76 different cases of escaping gas, from which the deaths of 51 persons and bodily injury of 118 persons resulted. In the preceding years, 1893, 1894, and 1895, in the same State, the deaths from this cause numbered 23, 23, and 22 respectively. In the thirteenth report for 1897 it is

TABLE I.—Taken from a Memorandum prepared for the Water-Gas Committee by Dr. J. S. Haldane (Appendix I., p. 71).

Place.	Kind of gas distributed.	Annual deaths by gas poisoning for a gas distribution equal to that of London in 1896.		Annual deaths by gas poisoning for a population equal to that of London (6,000,000).		Years.
		Total.	Accidental.	Total.	Accidental.	
England and Wales.	Coal gas.	3	3	3	3	1886-91
England and Wales (outside London).	Coal gas only.	4·2	3·4	—	—	1896-97-98
England and Wales (outside London.)	Coal gas partly mixed with water gas.	10·4	9·5	—	—	1896-97-98
88 American towns.	Coal gas.	—	—	3	—	1875-85
Boston.	90 per cent. water gas.	620	460	520	390	1896-97
New York.	80 per cent. (?) water gas.	275	130	263	124	1896-97
Brooklyn.	97 per cent. water gas.	400	215	235	120	1896-97
Chicago.	100 per cent. water gas.	—	305	—	155	1890-91-92
San Francisco.	70 per cent. (?) water gas.	—	—	940	270	1895-97
Philadelphia.	38 per cent. water gas (not mixed ?)	240	122	172	87	1896-97
Baltimore.	100 per cent. (?) water gas.	—	—	120	—	1895-96
Washington.	100 per cent. (?) water gas.	—	—	295	175	1896-97
Toronto.	50 per cent. water gas (mixed).	45	—	32	—	? 1897

Note.—It must be understood of this table (1) that several of the results have been calculated by Dr. Haldane from data supplied; (2) that many of them are comparative figures (*not actual results*) in order that comparisons may be instituted, founded on (a) proportion of gas distribution equal to that of London in 1896, and (b) on a population basis equal to that of London. The reason for the basis (a) is that the gas supply per annum per head in most American cities is so much less than that of London.

reported that 60 persons died and 74 others were injured by gas poisoning. In Boston alone 75 per cent. of these fatal cases occurred. It is noteworthy to observe that, in some of the instances in which a fatal issue ensued, conditions of comparatively free ventilation prevailed in the apartments in which the deaths took place. In other cities of the United States using admixtures of carburetted gas similar increases in the death-toll have been recorded. According to the reports of the Sanitary State Board of Health of Massachusetts and to the reports above named it is stated that in the combined populations of New York, Brooklyn, and Baltimore, amounting to 2,000,000, for the 13 years prior to the introduction of water gas (which was introduced in 1880) there had only been registered 16 cases of gas poisoning, whereas during the seven and a half years after its introduction the number of deaths from that cause had risen to 120, of which, in some of the later years of that period, New York had contributed in an individual year as many as 30 deaths. According to a statement made by Dr. James O. Bayley in a paper published in the *Medical News* of New York of August 23rd, 1902, the gas supplied by companies for illuminating purposes to all the cities of New York State consisted of carburetted water gas containing from 30 to 45 per cent. of carbon monoxide.⁴

Of Philadelphia in 1896 Dr. Cattell⁵ writes: "There seems to have been recently an epidemic of accidental and suicidal deaths from illuminating gas. During 1896 the coroner held inquests on 33 cases in which death was

⁴ *Medical News* of New York, August 23rd, 1902; THE LANCET, Oct. 11th, 1902, p. 1007.

⁵ *International Medical Magazine*, 1897.

determined to have been directly due to this cause. . . . Water gas is largely used in Philadelphia, and death in these cases is due to poisoning by carbon monoxide, as it forms one-third of the illuminating gas." In 1897 the deaths in that city numbered 34 from this cause, of which 14 were accidental, 18 were suicidal, and two were homicidal. In 22 cities and towns of the United States in 1889 the deaths from gas inhalation numbered 107, in 1890 they rose to 174 of which 139 were accidental, and in the first half of 1891 they numbered 100. Regarding the danger to life from the use of carburetted gas it should be noted that in the Massachusetts Commissioners' report for 1896 a minority of the Commissioners express themselves as follows: "That the increase [of deaths] is due to the substitution of 'water gas' for coal gas; that it was a mistake to allow the manufacture of water gas in 1890, which mistake it was easier then to make than it is now to remedy. The minority of the committee believing that prohibition of water gas is now a practical impossibility, suggests that an Act be passed to compel the operation of the existing coal-gas plants in Boston and the mixture of coal gas with the present gas so as to reduce the proportion of carbon monoxide in the mixture."

USE IN GREAT BRITAIN.

Here, as in America, many gas-producing companies have adopted carburetted gas plant as part of their manufacturing equipment. By the year 1898 the cities of Birmingham, Liverpool, Preston, Belfast, Dublin, and Edinburgh, with many others had adopted the use of this gas as an admixture of coal gas. Glasgow does not now supply, and has not for many years supplied, carburetted gas as a constituent part of its illuminating gas. According to a paragraph in the *British Medical Journal* of Feb. 12th, 1898, "Glasgow tried water gas for three years and renounced it, simply because it could not be produced for anything like the same price as coal gas"; and in a letter to Dr. Cayzer⁶ the late Mr. Foulis, then gas engineer to that corporation, wrote as follows: "We do not now make carburetted water gas as we find it more economical for enriching purposes to make undiluted oil gas, and so, of course, we have no trouble with carbon monoxide." Edinburgh, however, adopted its use, chiefly on the strength of a report by Professor Crum Brown, already referred to. In that report Professor Crum Brown pointed out that the chief safeguard in the use of coal gas was its distinctive penetrating odour, and that the odour was mainly due to the small amount of benzene vapour existing in the gas. But he further pointed out, also, that carburetted water gas likewise contained benzene vapour and to as great an extent as in coal gas. It followed that even pure carburetted gas in the air of a room became very offensive from its smell long before it was dangerous as a poison, and the risk from its ordinary use might be neglected practically as in the case of coal gas. In the case of leakage into rooms where people were already asleep or where people were unaccustomed to the use of gas, the danger was certainly greater with carburetted water gas than with common coal gas, as the proportion of carbonic oxide was about three times as great. In the case of an admixture containing carburetted water gas and coal gas in the proportion of one volume of the former to two of the latter, the percentage of carbonic oxide would be about 17 or 18, as compared with 10 or 11 in pure coal gas. Such cases of leakage were quite exceptional and when they did occur the amount of carbonic oxide might become excessive and the danger great in a very short time, even in the case of common coal gas, so that the difference as between carburetted water gas and coal gas was small compared with the total risk. The increased amount of carbonic oxide was, therefore, no real objection to the introduction of carburetted water gas for illuminating purposes in place of coal gas. It was apparent that the drawbacks generally urged against the use of carburetted water gas were more imaginary than real. On the other hand, there were distinct advantages. From a chemical point of view the process of making illuminating gas from water gas and oil was greatly superior to that of making it from coal. In the former case great uniformity was possible, owing to the facility with which the operations could be controlled and adjusted; the process was also a very clean one and free from many of the objectionable features of coal gas making. It was claimed for carburetted water gas that it was remarkably free from sulphur compounds; that was to be expected, as practically all the sulphur compounds in the

coke and oil must be converted into sulphuretted hydrogen, which is easily removable. Such was the burden of the report. Edinburgh has thus been supplying more or less carburetted gas in its illuminating gas-supply for the past nine years, but, as may be seen in Table VIII., only in relatively small proportions.

In several towns and cities using carburetted gas fatal gas poisonings have occurred. In Liverpool, for example, the following cases have been recorded. Four men were occupying a room of 963 cubic feet capacity which had no fireplace but which was provided with two ventilators. In the morning the gas-light was found to be extinguished, although the gas was still turned on, and the window and the larger ventilator were found to be closed. One of the men was found to be dead and his three companions to be unconscious. It was supposed that one of the men had extinguished the light by blowing it out. The body of the deceased man bore externally the distinguishing characteristics of carbon monoxide poisoning. In a report to the corporation the medical officer of health stated that water gas had been supplied to parts of the city in varying proportions, and owing to the much larger amount of carbon monoxide contained in the water gas over ordinary coal gas that the danger to the inhabitants in the districts so supplied was correspondingly increased. Again, on Oct. 5th of this year, a family composed of a man and three children were found unconscious in the rooms occupied by them which were found to be filled with the fumes of gas. The man died soon after, notwithstanding the use of restorative measures. It was reported later that a second victim had succumbed. In the newspaper recording the incident it is noted that some time ago the attention of the city council had been called to the dangers of water gas in Liverpool and the question was being asked whether this gas had anything to do with this mishap. Fatal cases have likewise been reported from Belfast, Dublin, and other places, some of which will be referred to later.

In accordance with the declared intention of the English Local Government Board a departmental committee was appointed in 1898 to consider the question of water gas. Its members were Lord Belper, who was chairman, Sir William Ramsay, Dr. Haldane and Dr. H. F. Parsons, and Mr. Cunyngame of the Home Office. The report of the committee, after hearing evidence, was published in 1899 and the substance of its recommendations was as follows: 1. That it should be illegal for any person to make and distribute for heating and lighting purposes any poisonous gas which does not possess a distinct and pungent smell. 2. That all persons applying for statutory powers to make and distribute gas should be required to state in their application the kind of gas which they propose to sell—viz., whether ordinary coal gas, carburetted water gas, plain water gas, or other variety of gas—separately or mixed. 3. That before any kind of water gas is distributed in any place due public notice of the proposal should be required to be given and that so long as there is any water gas in a gas supply that fact should be stated on every demand note. 4. That where water gas is distributed records should be kept by the producer showing the respective amounts of the gases issued day by day, distinguishing the gas supplied to each area (if more than one and separately served) and the day and night supply; that these records should at all times be open to inspection by any gas consumer or ratepayer of the district and should be published quarterly in a local newspaper; and that a new column should be added to the annual returns made by the Board of Trade giving the total amount of water gas issued as compared with coal gas. 5. That power be conferred on a central department to make regulations enforceable by adequate penalties, limiting the proportion of carbonic oxide in the public gas supply at 12 per cent., or such greater amount as the department may consider desirable. These regulations might be applicable either generally over the United Kingdom or to any particular locality, and might contain such conditions, if any, as appeared necessary. 6. That powers should also be given for the regulation of the distribution and use of gas by means of by-laws, made subject to the approval of a central department and administered under local control. The matters to be so dealt with might include the following: the hours during which, or the arrangements by which, the limit imposed on carbonic oxide should be enforced; the use in emergencies of more than the authorised proportion of carbonic oxide; the character of the gas-burners, fittings, and apparatus to be used having regard to the circumstances of their employment; the testing of the gas; and other

⁶ On Carburetted Water Gas and Carbon Monoxide Poisoning, fourth edition, 1898.

similar questions. 7. That the provisions of Sections 28 to 34 of the Gasworks Clauses Act, 1871, should be made applicable to the testing of gas for carbonic oxide, and that in all cases where a limit has been placed on the carbonic oxide in the gas supply of a locality there should be some person empowered and required to test for carbonic oxide and to publish the results periodically. Lastly, that some steps should be taken to secure that the verdicts (of coroners' juries) should lend themselves more readily to clear classification by the Registrar-General, and, in particular, that in every case where the coroner is in possession of a medical certificate of death or where medical evidence has been taken at the inquest, a copy of that certificate, or an abstract of that evidence, should be appended to the coroner's certificate when sent to the Registrar-General. The only outcome of the work of that Commission, so far as we can gather, has been the incorporation in the Board of Trade returns of information concerning the amounts of carburetted water gas made and used by gas undertakers.

The following tables which have been compiled from the Board of Trade returns for 1904 and 1905 serve to illustrate, among others, the following points, viz. : (a) the increase in manufacture and supply of water gas in the United Kingdom ; and (b) the percentage admixtures of water gas with coal gas in different cities and towns in the kingdom.

TABLE II.—Comparative Table for the United Kingdom for the Year 1904 (Gas Undertakings other than Local Authorities).

Year.	Number of gas undertakings other than those of local authorities.	Number of cubic feet of gas made.	
		Coal gas.	Water gas.
1898	439	(a) 86,705,723	(b) 5,125,804
1903	459	(a) 101,490,084	(b) 13,056,741
1904	469	(c) 91,£93,123	(b) 13,718,857

(a), Including water gas ; (b), amount of water gas supplied ; (c), coal gas only.

TABLE III.—Showing Percentage Amounts of Water Gas admixed with Coal Gas in Supplies of Illuminating Gas by Gas Companies other than Local Authorities.

Place.	Percentage.	Place.	Percentage.
Maidenhead	40	Folkestone	40
Falmouth	33	Gravesend	33
Durham	20	Rochester	27
Barking	17	Tonbridge	25
Hartlepool	20	Tunbridge Wells... ..	25 to 30
Colchester	26	Liverpool	50
Ilford	21	Preston	36
Lea Bridge	40	Ramsbottom... ..	25
Romford	29	Stretford	33
Southend	50	Cleethorpes	15
Waltham Abbey	3	London :—*	
West Ham	29	Commercial	38
Merthyr Tydvil... ..	31	(average 28)	
Swansea	25	South Suburban	36
Bournemouth	30	Wandsworth	41
Gosport... ..	30	Brentford	40
Portsea... ..	24	Hampton Court	30
Southampton	35	Harrow	48
Winchester... ..	8	Hornsey... ..	46
Watford	32	North Middlesex	54
Dartford	27	Southgate	61
Faversham	15	Staines	25
Tottenham	54	Kingston-upon-Thames	24
Newport (Mon.)... ..	27	Wimbledon	36
Norwich	£2	Redhill	35
Rushden	25	Bexhill	41
Newcastle	7	Brighton	38
Bath	50	Eastbourne	20 to 30
Taunton	35	Hastings	45
Bilston	10	(average 28)	
Caterham	20	Horsham	40
Croydon	41	Bridlington	33
(average 32)		Hull... ..	32
Dorking	50	Malton	22
Epsom	34	Scarborough... ..	23
Guildford	25 to 33	York	21

* Of the total quantity of gas sent out 11 per cent. was unmixed with water gas. Of the remainder 62 per cent. contained a maximum

proportion of 29 per cent. of water gas ; 9 per cent. a maximum proportion of 33 per cent. ; 8 per cent. a maximum proportion of 37 per cent. ; 12 per cent. a maximum proportion of 37 per cent. ; and 9 per cent. a maximum proportion of 41 per cent.

TABLE IV.—In Scotland.

No private gas undertaking supplied carburetted water gas.

TABLE V.—In Ireland.

Place.	Percentage.
Dublin	47
Londonderry	20
Wexford	20

The next series of tables shows the same facts with respect to gas undertakings by local authorities as the former do with respect to gas undertakings other than those by local authorities.

TABLE VI.—Comparative Table of Gas Undertakings by Local Authorities.

Year.	Number of gas undertakings.	Number of cubic feet of gas made.	
		Coal gas.	Water gas.
1898-99	222	(a) 51,441,272	2,278,390
1903-04	260	(a) 62,717,759	4,850,007
1904-05	265	(b) 58,302,053	5,033,643

(a), Total amount of gas, including water gas ; (b), coal gas only.

TABLE VII.—Showing Percentage Amounts of Water Gas admixed with Coal Gas in Supplies of Illuminating Gas by Local Authorities who are Gas Undertakers.

In England and Wales (1905).

Place	Percentage.	Place.	Percentage.
Stockport	25	Lincoln (day)	33
Carlisle	28	„ (night)	None.
Stockton-on-Tees	21	Nottingham	Inappreciable.
Accrington	20	Longton	33
Barrow	14	Smethwick	12 5
Blackburn... ..	25	Stafford	20 3
Burnley	34	Tipton... ..	Not stated.
Chorley	20	West Bromwich	18 5
Manchester (Bradford-road Works)	37	Birmingham	25
Manchester, in total	22	Coventry	35 66
Oldham	41*	Oldbury	20
Southport... ..	56	Halifax	20
Todmorden	20	Hebden Bridge	20 to 25
Loughborough... ..	2	Leeds	25
Leicester	12	Middlesbrough	No limit.

* At one station only on one day only.

TABLE VIII.—In Scotland (1905).

Place.	Percentage.	Place.	Percentage.
Dundee... ..	25	Paisley	4 (oil gas).
Edinburgh and Leith	4-23	„	1-77 (water gas).

TABLE IX.—In Ireland (1905).

Place.	Percentage.
Belfast	52-2

From a statistical consideration of the foregoing Parliamentary returns for 1904 it will be found that of 454 gas undertakers other than local authorities in England and Wales, 68 supply some measure of admixed carburetted water gas in their illuminating gas supply, or, approximately, 15 per cent. of the total number of producers in this class ; that in Ireland, of ten undertakings three supply some admixture, or nearly one-third of the whole ; and that in Scotland, of five producers none supply any proportion of carburetted gas.

From the returns for 1905 of local authorities who are gas undertakers, it will be found that of 208 local authorities in England and Wales 28, or approximately 13·5 per cent., provide admixtures ; in Scotland, of 46 corporations, three only, or 6 5 per cent., supply admixtures ; and in Ireland, of 11 municipal producers, only one, or 9 per cent., provides admixture of carburetted gas with coal gas.

The percentage amounts of carburetted gas in the admixtures actually purveyed by gas undertakers other than local authorities in England and Wales vary considerably. These range from 3 per cent. in Waltham up to 60·7 per cent. in

Southgate. Southend, Liverpool, North Middlesex, Tottenham, Norwich, Bath, and Dorking supply admixtures containing carburetted gas to the extent of between 50 and 60 per cent.; Maidenhead, Lea Bridge, Folkestone, Wandsworth, Brentford, Harrow, Hornsey, Croydon, Bexhill, Hastings, and Horsham, between 40 and 50 per cent.; Falmouth, Bournemouth, Gosport, Watford, Gravesend, Preston, Stretford, London (Commercial and South Suburban), Hampton Court, Taunton, Epsom, Wimbledon, Redhill, Brighton, Bridlington, and Hull Station, between 30 and 40 per cent.; while Durham, Hartlepool, Colchester, Ilford, Romford, West Ham, Swansea, Dartford, Chatham, Tonbridge, Ramsbottom, Staines, Newport (Mon.), Rushden, Newcastle, Caterham, Guildford, Kingston-upon-Thames, Eastbourne, Malton, Scarborough, and York add only between 20 and 30 per cent. The remainder supply less than 20 per cent. In Scotland, as has been noted, no company in this class purveys carburetted water gas. In Ireland, the percentages run from 47 per cent. in Dublin to 20 per cent. in Londonderry and Wexford.

The percentage admixtures actually supplied by local authorities who are gas undertakers in England and Wales vary from 12 per cent. in Leicester to 55·86 in Southport. Oldham supplies between 40 and 50 per cent.; Burnley, Manchester, Lincoln, Longton, and Coventry between 30 and 40 per cent.; Stockport, Carlisle, Stockton-on-Tees, Accrington, Blackburn, Chorley, Todmorden, Loughborough, Stafford, Birmingham, Oldbury, Halifax, Hebden Bridge, and Leeds between 20 and 30 per cent.; and the remainder less than 20 per cent. Of the three municipal undertakers in Scotland, Dundee adds 25 per cent., Edinburgh 4·23 per cent., and Paisley less than 2 per cent. of carburetted water gas.

From the comparative tables (II. and VI.) it will be seen that the total annual output of this gas, by both private and municipal undertakers is on the increase. In 1898 the number of private undertakers being 439, the total output of carburetted water gas was a little over 5,000,000 of cubic feet, whereas in 1904 the number of undertakings having only increased by 30, the output had risen to 13·5 millions of cubic feet. Respecting the corporation gas undertakings it will be perceived that in 1898-99 the number of undertakers was 222 and the total output of water gas was 2·25 millions of cubic feet, whereas in 1904-05 the number of undertakings having risen to 265, the output has increased to over 5,000,000 of cubic feet.

FITNESS OF CARBURETTED WATER GAS FOR DOMESTIC LIGHTING PURPOSES.

It is not my intention under this heading to discuss the question of fitness from the economic point of view, but solely from the public health standpoint, because it appears to me that the latter is much the more important. But in passing it may be observed, judging from the opinion of the Glasgow gas authority, that difference of view may even be entertained regarding the relative cost of production of water gas and coal gas. But, however that may be, there would seem to be some difference of opinion among experts even regarding the risks of admixture of water gas with coal gas to the users. Professor Crum Brown, in his advice to the Edinburgh gas authority, is said to have reported that the increased amount of carbonic oxide in a mixture containing carburetted water gas and coal gas in the proportion of one volume of the former to two of the latter, and in which the carbonic oxide would be about 17 or 18 per cent. as compared with 10 or 11 per cent. in pure coal gas (which last figures are above the average), "was no real objection to the introduction of carburetted water gas for illuminating purposes in place of coal gas," and that "the drawbacks generally urged against the use of carburetted water gas were more imaginary than real."

This opinion seems at first sight incompatible with another statement in the same report—viz.: "In the case of leakage into rooms where people are already asleep, or where people were unaccustomed to the use of gas, the danger was certainly greater with carburetted water gas than with common coal gas, as the proportion of carbonic oxide was about three times as great." It is obvious that the writer had in his mind the use of carburetted water gas conveyed in gas-tight pipes and fittings and an intelligent use of the commodity by the users. If we could assume, or even if experience showed, that all pipes and fittings were sound and would continue in that condition, and that all users of gas were intelligent and careful in its use, then, so far as safety to

health and life were concerned, all would be agreed as to the absence of increased danger, no matter the composition of the illuminant used. But this is precisely what does not exist and cannot be secured. Pipes will grow old; fractures and corrosions of fittings will occur; accidents, trivial in themselves, will take place; there will always be careless users; and therefore in average circumstances we are compelled to assume increased risks to health and life whenever additions of carbonic oxide are made to illuminating gas. In Great Britain, moreover, another condition relative to ownership of fittings and pipes probably tends to neglect of pipes, and that is that the control of the gas authority stops at the door of the house, if we except the gas-registering apparatus; in other words, the gas authority may lay main pipes and may make branch-pipe connexions to dwellings, but they have no control over the fittings within the dwellings, their safeguard being that all gas registered in the gas-meter must be paid for by the occupant. This, however, is not always the same thing as saying that all gas registered in the meter has been consumed.

The findings of the Departmental Committee being to the effect that the adoption of carburetted water gas by the gas companies of this country created an increased risk of danger to health and life, because of the increased content of carbon monoxide, seem to me to be most reasonable; and this is especially true of the finding which proposes that the proportion of that gas in the night-supply should be limited to 12 per cent., "or such greater amount as the department may consider desirable." And when we consider the want of average display of intelligence on the part of some users of gas, and the condition of the fittings in many places, we cannot but consider this proposal as other than most reasonable. The question arises, however, whether the proposals should end where the report of the committee left them. Should it arise that necessity prompts municipal authorities more generally to adopt the use of carburetted gas, ought not the use to be placed under State-regulated enactments such as pertain, for example, in the Public Health Acts respecting the internal drainage systems of dwellings? It would, in my opinion, be most desirable to enact by statute that before carburetted water gas was supplied to new buildings the pipes and internal fittings thereof should be inspected by a municipal officer or officer of the gas company before being allowed to be used, that in all old buildings the existing fittings should be initially inspected, and that in all buildings used as dwelling-houses in which the gas is employed as an illuminating agent, heating agent, or motive power, powers of periodic inspection by the gas authorities should be given and should be exercised. From my experience it has been forced upon me that these powers, and especially the last-named, should be made part of an Act and should become obligatory on the local authority acting as gas commissioners or upon gas companies. In all modern by-laws respecting the water-supply of houses the local authority has the power to determine what weight of pipes and what kinds of fittings shall be used. The only patent reason for this is the prevention of loss of water by insufficient fittings. There has never been, to my knowledge, any serious objection offered to such by-laws, because they commend themselves as reasonable. In the same way, by-laws may be made by the same authorities respecting the pipes and fittings of houses relative to house drainage for the purpose of preventing disease, or, to put it in other words, to protect the health of the occupants. How much more important in comparison to water fittings, from breach of which no direct injury to health is likely to follow, is appropriateness of gas fittings, especially where carburetted water gas is to be used, from breaches or defects of which impairment of health is certain to follow and loss of life itself is not improbable. It appears to me, then, that the purveying of gas rich in carburetted water gas should be accompanied by inspection of gas fittings inside dwellings, just as there is power of inspection over pipes outside dwellings, on the simple ground of increased possible risk from the substance purveyed. Logically, if the legislature believes it to be desirable to grant powers of inspection of the sanitary fittings of a dwelling where the risks from want of integrity are relatively remote and indirect, it should also give and demand powers of inspection of gas fittings for the use of carburetted water gas where the risks to health from defects or insufficiency of fittings are direct, even to the extent of loss of lives.

(To be continued.)

DOWNING PROFESSOR OF MEDICINE, UNIVERSITY OF
CAMBRIDGE, 1874-94; CONSULTING PHYSICIAN
TO ADDENBROOKE'S HOSPITAL,
CAMBRIDGE.

Clinical history.—The patient was healthy and well formed at birth. Labour was normal, no forceps being used. He was the eldest of four living children. At the age of three or four weeks "twitching of the face and nodding of the head" was noticed. Convulsions resembling those of idiopathic epilepsy commenced one year after birth. The patient's mental condition on admission to the asylum was as follows. He was a low grade idiot and was unable to do anything for himself. He would grasp and pull to pieces or twist anything that was given to him. He made inarticulate noises and was quite incapable of answering the simplest questions. In his habits he was wet and dirty. As regards his physical condition he was below the average size, the frontal region of the skull was prominent, and his head was of the usual size. The palate was of the low, broad type. The teeth were good. The lobules of the ears were deficient. He suffered from the somewhat rare skin affection known as adenoma sebaceum. Little nodules were noticed on his face, occupying chiefly the cheeks and naso-labial folds; a few were noticed on the forehead. The nodules had a symmetrical distribution on the lower part of the face: their consistence was hard, their surfaces were smooth and dome-shaped, and the skin over them showed no blocked sebaceous duct. Vascular telangiectases around and between these nodules gave the patient a pink flushed look. The heart and lungs were normal. No sensory abnormal symptoms were noticed during life. His gait was peculiar in that he had a tendency to walk on his toes and seemed incapable of walking in a straight line; he would rotate