No. ... 50 cts.

GAS-LIGHTING

AND

GAS-FITTING.

THIRD EDITION.

BY

WM. PAUL GERHARD, C.E.,

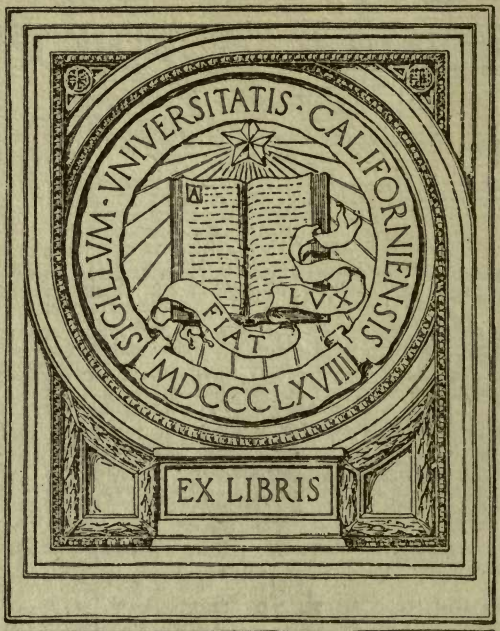
Consulting Engineer for Hydraulic and Sanitary Works, New York City.

NEW YORK:

D. VAN NOSTRAND COMPANY,

PUBLISHERS.

1904.



No. 13. **GASES MET WITH IN COAL MINES.** By J. J. Atkinson. Third edition, revised and enlarged, to which is added The Action of Coal Dusts by Edward H. Williams, Jr.

No. 14. **FRICTION OF AIR IN MINES. By J. J.** Atkinson. Second American edition.

No. 15. **SKEW ARCHES. By Prof. E. W. Hyde,** C.E. Illustrated. Second edition.

No. 16. **GRAPHIC METHOD FOR SOLVING** Certain Questions in Arithmetic or Algebra. By Prof. G. L. Vose. Second edition.

No. 17. **WATER AND WATER-SUPPLY. By** Prof. W. H. Corfield, of the University College, London. Second American edition.

No. 18. **SEWERAGE AND SEWAGE PURIFI**cation. By M. N. Baker, Associate Editor "Engineering News." Second edition, revised and enlarged.

No. 19. **STRENGTH OF BEAMS UNDER** Transverse Loads. By Prof. W. Allan, author of "Theory of Arches." Second edition, revised.

No. 20. **BRIDGE AND TUNNEL CENTRES. By** John B. McMaster, C.E. Second edition.

No. 21. **SAFETY VALVES. By Richard H. Buel,** C.E. Third edition.

No. 22. **HIGH MASONRY DAMS. By E. Sherman** Gould, M. Am. Soc. C. E. Second Edition.

No. 23. **THE FATIGUE OF METALS UNDER** Repeated Strains. With various Tables of Results and Experiments. From the German of Prof. Ludwig Spangenburg, with a Preface by S. H. Shreve, A.M.

No. 24. **A PRACTICAL TREATISE ON THE** Teeth of Wheels. By Prof. S. W. Robinson. 3d edition, revised, with additions.

No. 25. **THEORY AND CALCULATION OF** Cantilever Bridges. By R. M. Wilcox.

No. 26. **PRACTICAL TREATISE ON THE PROP**erties of Continuous Bridges. By Charles Bender, C.E.

No. 27. **BOILER INCRUSTATION AND CORRO**sion. By F. J. Rowan. Now edition. Revised and partly rewritten by F. E. Idell.

No. 28. **TRANSMISSION OF POWER BY WIRE** Ropes. By Albert W. Stahl, U.S.N. Fourth edition, revised.

No. 29. STEAM INJECTORS, THEIR THEORY and Use. Translated from the French by M. Leon Pochet.

No. 30. MAGNETISM OF IRON VESSELS AND Terrestrial Magnetism. By Prof. Fairman Rogers.

No. 31. THE SANITARY CONDITION OF CITY and Country Dwelling-houses. By George E. Waring, Jr. Second edition, revised.

No. 32. CABLE-MAKING FOR SUSPENSION Bridges. B. W. Hildenbrand, C.E.

No. 33. MECHANICS OF VENTILATION. By George W. Rafter, C.E.. Second edition, revised.

No. 34. FOUNDATIONS. By Prof. Jules Gaudard, C.E. Translated from the French. Second edition.

No. 35. THE ANEROID BAROMETER: ITS Construction and Use. Compiled by George W. Plympton. Tenth edition, revised and enlarged.

No. 36. MATTER AND MOTION. By J. Clerk Maxwell, M.A. Second American edition.

No. 37. GEOGRAPHICAL SURVEYING: ITS Uses, Methods, and Results. By Frank De Yeaux Carpenter, C.E.

No. 38. MAXIMUM STRESSES IN FRAMED Bridges. By Prof. William Cain, A.M., C.E. New and revised edition.

No. 39. A HANDBOOK OF THE ELECTRO-Magnetic Telegraph. By A. E. Loring. Fourth edition, revised.

No. 40. TRANSMISSION OF POWER BY COM-pressed Air. By Robert Zahner, M.E. New edition, in press.

No. 41. STRENGTH OF MATERIALS. By Wil-liam Kent, C.E., Assoc. Editor "Engineering News." Second edition.

No. 42. THEORY OF STEEL-CONCRETE Arches, and of Vaulted Structures. By Prof. Wm. Cain. Fourth edition, thoroughly revised.

No. 43. WAVE AND VORTEX MOTION. By Dr. Thomas Craig, of Johns Hopkins University.

No. 44. TURBINE WHEELS. By Prof. W. P. Trowbridge, Columbia College. Second edition. Revised.

BY THE SAME AUTHOR:

HOUSE DRAINAGE AND SANITARY PLUMBING.

(Science Series No. 63.)

Tenth Edition, revised and enlarged.

With Illustrations. 1903.

RECENT PRACTICE IN THE SANITARY DRAINAGE OF BUILDINGS.

(Science Series No. 93.)

Second Edition, revised and enlarged.

THE DISPOSAL OF HOUSEHOLD WASTES.

(Science Series No. 97.)

Second Edition. 1904.

Price, post-paid, 50 cents each.

GAS-LIGHTING AND GAS-FITTING,

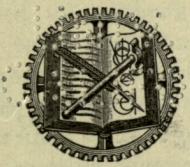
A POCKET BOOK FOR GAS COMPANIES, GAS ENGINEERS AND GAS FITTERS, FOR MANUFACTURERS OF GAS FIXTURES AND DEALERS IN GAS APPLIANCES, FOR GAS CONSUMERS, ARCHITECTS AND BUILDERS, HEALTH OFFICERS AND SANITARY INSPECTORS.

THIRD EDITION.

BY

WM. PAUL GERHARD, C.E.,

Consulting Engineer for Hydraulic and Sanitary Works, New York City.



NEW YORK:

D. VAN NOSTRAND COMPANY,

23 MURRAY AND 27 WARREN STREETS.

1904.

PREFACE.

The following "*Notes on Gas Lighting and Gas Fitting*" were first published by the author in 1887. In 1892 he prepared a special pamphlet containing "*Hints to Gas Consumers*," of which over 5,000 copies were bought and distributed by gas companies.

It has been the author's intention to re-write the entire matter and to publish a larger manual on the subject of the domestic uses of coal gas, but the pressing demands upon his time of a large and constantly increasing practice in the field of domestic engineering and of house sanitation in particular, have prevented the author so far from carrying out his plan.

The larger book is, however, in actual preparation, and pending the publication of the same, it was deemed desirable to supply the demand for a small guide on the subject, written from an American standpoint, by issuing this little volume, which in addition to the two articles mentioned above, contains an introductory article on "*Artificial Illumination, Historical Notes on Gas Lighting, and on the Advantages of Gas,*" first published in the *American Architect*, an article on "*Gas for Cooking and Heating Purposes,*" published first in *Domestic Engineering*, and the admirable "*Rules and Regulations on Gas,*" issued by the Municipal Department of the City of Munich, translated by the writer.

WM. PAUL GERHARD.

NEW YORK, December, 1893,
36 Union Square.

GAS-LIGHTING AND GAS-FITTING.

Artificial Illumination.

Numerous and varied are the methods employed at the present day for obtaining artificial illumination. Leaving out of consideration the electric light which occupies a position by itself, we may, broadly speaking, distinguish between solid, liquid and gaseous illuminants, of which the candle, the oil-lamp and the gas-flame are representative forms.

It would be interesting and instructive to trace the history of the different kinds of artificial light employed both in domestic and in street lighting at various periods of history, and to follow the successive improvements in lighting introduced by men of talent and inventive genius. It seems indeed a gigantic step forward from the crude methods of lighting employed by

the ancients to the gas-light and the electric-light of the nineteenth century. But the glow of the camp-fire, the light from blazing logs, or from torches made of splinters of resinous wood, as exclusively employed by our forefathers, may even nowadays be found in use by the Indians and other uncivilized tribes. It may, therefore, be said that the means for artificial illumination employed at the present time are an indication of the more or less advanced state of civilization of a nation.

The burning log and the blazing resinous pine torch are the oldest and crudest methods of lighting.

Oil was burnt by the Phœnicians, the Greeks and the Romans in primitive forms of open-vase lamps, into which a cotton or flax wick dipped.

The Romans used the first candles in the form of rushes covered with wax or tallow, or of rope saturated with pitch or resin. These candles were gradually improved and formed, during the Middle Ages, the principal means of church illumination, and were likewise used in castles at court festi-

vals. Later on, the smoky and ill-smelling tallow candle was replaced by the better forms of drawn or cast candles, made from sperm, paraffine, wax and stearine. The modern improved candle differs from the candles employed in the last century principally in the method of manufacturing the wick, which as the candle grows shorter in burning, is consumed and reduced to ashes, thus rendering the use of the "snuffers" of our grandfathers, which many of us still may remember, unnecessary.

The rude forms of lamps employed by the Romans and Etruscans have been gradually displaced by lamps of improved construction, with closed oil-reservoirs, improved wicks and variously shaped burners. Argand invented and developed the round form of burner and wick, the oil ascending from the reservoir into the wick and to the tip of the burner by capillary attraction. Carcel made further improvements by placing the oil-reservoir at the bottom of the lamp, where it would not throw a disagreeable shadow. In this

form of lamp the oil has to be forced up to the wick by means of a pump, or in the later "moderator" lamp, by a spring acting upon a leather plunger. The liquid illuminant employed in these lamps was either colza oil, olive oil or some other vegetable oil.

Still later, and belonging to the present century, came the use of kerosene or mineral oil in lamps, this illuminant being a liquid improved by distillation and refining, which operations remove the more volatile, highly inflammable and, therefore, dangerous ingredients of the oil.

Equally as varied as the means employed for domestic illumination have been those in use at different periods of history for the lighting of streets, highways and public squares. In the larger cities the darkness of the evening hours was at first dispelled in a measure by the use of flaming torch-lights, of fire-baskets and of candles burnt in glass-lanterns, which were either carried by hand or hung out from windows. Later on, the candle-lanterns were replaced by oil-lamps, with wick and reflector, and

these in turn were superseded by the introduction, at the beginning of this century, of coal-gas burnt in street-lanterns, while to the gas-light now so universally employed, both for domestic and street lighting, a formidable rival has during the past ten years arisen in the electric arc-light and the incandescent electric glow-lamp.

Historical Notes on Gas Lighting.

Wonderful as have been the many and rapid improvements made in this last form of illumination, viz., the electric-light, it must be admitted that the progress of gas-lighting has been no less astounding.

The present generation who have witnessed the advent of the electric-light have become so accustomed to the use of the ever-ready gas-flame, that few are probably aware of the difficulties which beset the path of the talented men of science who created and introduced lighting by gas.

It is a matter of historical record that when Murdock, one of the pioneers of gas-lighting, appeared in 1809 before the

House of Commons Committee, he was asked by one of the members of the Committee, "Do you mean to tell us that it will be possible to have a light *without a wick?*" and upon his replying, "Yes, I do indeed," the same person replied, "Ah, my friend, you are trying to prove too much."

We are also informed that Samuel Clegg, an engineer to whom the world is indebted for many important improvements in gas-manufacture and gas-distribution, was sarcastically asked by Sir Humphrey Davy, who considered the idea of public gas-lighting ridiculous, if Mr. Clegg intended to take the Dome of St. Paul's for a gasometer.

The great Napoleon laughingly remarked of gas-lighting, "*C'est une grande folie,*" and Sir Walter Scott considered it a visionary scheme and expressed fears that "London would be on fire by it from Hackney Gate to Tyburn" [east and west extremities, then, of London].

Indeed, when the House of Commons was first lighted by gas, the astonished

citizens of London were in such fear of burning their fingers when touching the gas-pipes for the conveyance of gas that they first carefully put on their gloves.

When Westminister Bridge was first fitted up for illumination by gas-lamps, the lamplighters refused to light the lamps. In 1815, the London Fire Insurance Companies refused to insure buildings lighted with gas. To overcome their prejudices, Samuel Clegg invited the Underwriters to inspect the gas-works, and after explaining to them the process of gas-manufacture, and the method of storing the gas at the gasometer, he quickly took a pick and cutting a hole in the dome of the gas-holder, lighted the escaping gas without danger or explosion, and thus demonstrated to their satisfaction the comparative safety of the new light.

Advantages of Gas.

Many are the advantages of gas for household purposes, and its disadvantages are comparatively few, and for this reason

it is probably more used in houses at the present day than any other form of artificial illumination.

Gas-light is relatively cheap, although kerosene oil *per se*, is probably cheaper. But, in comparing gas and oil, one should not forget the additional cost caused by wear and tear and breakage of oil-cans, glass-chimneys and shades of oil-lamps.

Gas-light is convenient, and saves domestic labor by being always ready for instant lighting, whereas lamps require preparation in filling and in trimming the wicks, while time and labor are consumed in procuring candles or oil.

Gas-light is superior in point of cleanliness to oil-lamps and candles, because there is no spilling of oil, no dropping of candle-grease, no greasy or oily hands from the cleaning of lamps; there is no smoking of candles and no offensive odor such as attaches to oils and fats.

Gas-light is brilliant, yet easily controlled, readily increased or diminished, and not difficult to manage by persons of ordinary intelligence.

Gas-light is comparatively much safer than candles or lamps in which colza oil or kerosene is burned. The carrying about of candles or lamps, with the unavoidable danger from fire or from lamp explosions, is rendered unnecessary, as only a match is required to light the gas at the burner.

Gas-light, finally, creates in proportion to the light developed less disagreeable heat and is less unhealthful than candles or oil-lamps, where proper ventilation of rooms is provided. The increased illumination by gas-light in our streets, squares and parks, as compared with the former semi-darkness, has been a great protection to property and life, and the parks and alleys of our cities are not so much as formerly the haunts of the vicious and the criminals, for efficient pnblic lighting is the best safeguard against the commitment of crimes.

With the advent of gas-light an entire revolution in social life has taken place, and civilization owes not a little of its progress to the increased illumination of

the streets as well as of buildings for amusement, worship and education.

Incidentally I would call attention to the many other uses to which coal or illuminating gas has in recent years been put. Gas is used for heating rooms, heating sadirons, heating water; gas is employed for cooking, roasting, baking, steaming, frying, boiling and broiling; gas is adopted as fuel to drive small domestic motors, gas-engines of various kinds, gas and caloric pumping-engines, also for heating soldering-irons, and for various other industrial purposes, and, finally, it is extensively employed for artificial ventilation by means of gas-jets burning in exhaust-flues, or by the use of sun-burners.

More recently, with the arrival of the incandescent electric glow-lamp, much has been said about the injurious influence of gas-lights upon health, of the vitiation of the atmosphere of rooms, and of the destructive effects of gas, when imperfectly consumed, upon the furniture and decorations of a room, to say nothing of the smoking-up of ceilings and walls.

But notwithstanding the rapid development of domestic electric-lighting, and notwithstanding also the recent return in dwellings to the use of oil-lamps, which on account of their softer and steadier light, are by many preferred for reading and sewing, and to the use of extensive and costly paraffine and wax candles in luxurious gilt or silver candelabras and sconces, a use dictated by the ruling fashion on account of the beautiful soft and mellow illumination obtained, the use of gas in dwelling-houses, offices and stores is undoubtedly so convenient and comparatively safe, that for many years to come it will constitute the chief means of artificial illumination.

To quote from R. H. Patterson's article on "Gas-burners and the Principles of Gas Illumination" in King's "*Treatise on Gas*": "Any one who learns from the experience of human customs and affairs, will feel assured that gas-light, although perhaps with shorn honors, has still a long career of usefulness before it, and that the admirable improvements in its ap-

pliances made within the last twelve or fourteen years, will not be robbed of their usefulness by a shunting aside of the illuminant to which they have given a new economy and additional brilliance, and which still, as of yore, is of such vast and ever-ready service to mankind.

"Gas-lighting has undoubtedly been the most beautiful, and well-nigh the most useful triumph which human invention has yet achieved in the present century. For marvellousness it cannot vie with the electric telegraph; for utilitarian value it cannot rank with the steam locomotive and railways. Nevertheless, but for its commonness, even poetic genius would find a congenial theme in the process which evokes the 'spirit of coal,' and, converting it into a spirit of light, conveys it as an invisible fluid under our streets—rising from below, wherever required, in pillared jets, to displace the darkness of the night hours, and flood our roads and streets with a warm and comely radiance. No spirit of the mine, even in fairy tale, has so blessed mankind. Passing from our

streets it enters our dwellings, both rich and poor, as an ever welcome and valued visitor, giving to the word 'home' a new attraction, brightening the dwelling, and enabling us to pursue our work, and to taste the enjoyments of common life, as if we could command the sweet daylight to attend us at our pleasure. Thanks to gas-light, there is no night in our dwellings save such as we choose for our own comfort. It has illumined the former darkness of our halls and crooked staircases. From the gaselier in the dining-room it has made sparkling the glass and silver on the festive board, and lit up the kind and jovial faces of the company, making banquet or homely board lightsome and merry ; while in drawing-room or 'assembly' it has flooded the room or hall with a radiance but for which the dance would lose much of its gaiety, and beauty with its bright costumes would be shorn of its brilliance. In the bed-room, too, still more where there is helpless infancy or sickness—where child has to be watched, or some sore-pained and weary-hearted invalid has

to be tended, longing at times for light to break the dull, drear monotony of night's darkness—there, too, has the 'spirit of coal' been a priceless boon; existing when not wanted, as a mere speck of light within the mellowed globe through which it shows softly as a spot of luminous haze; yet ever ready, on the mere turning of a tap, to spring instantaneously into full illumination"

I do not propose to treat in these pages of the various processes used in the manufacture of coal or illuminating gas, nor of the proper distribution of gas through the streets of a city, nor shall I discuss the public lighting of streets, alleys, squares and parks.

I shall take up the subject of gas from the point when it is brought to the consumers' premises, and shall endeavor to explain how gas may advantageously be employed in the illumination of our dwellings, incidentally mentioning other domestic uses of coal gas.

My book will not give detailed technical or workshop instruction regarding the

practical work of the gas fitter in piping a house for gas, from the gas-fitter's point of view only.

The following pages are intended chiefly for the instruction of the gas consumer, the householder, but incidentally they will contain much information useful to those contemplating the building of a house, and to architects, builders, gas engineers and gas-fitters as well as sanitary inspectors, enabling them to acquire a better knowledge as to how best to introduce, distribute and utilize gas and gas-lights in buildings.

Usual Defects of Gas-Lighting and Gas Piping.

It is, unfortunately, true that, as a rule, not much attention is paid by architects and builders in the erection of new buildings to the means required for artificial lighting by gas. In the case of ordinary dwelling houses and stores the whole matter of gas distribution is left to the gas-fitters, many of whom employ either incompetent,

inexperienced or careless mechanics, the architect concerning himself chiefly with the selection of ornamental gas fixtures which form a part of the interior house decoration. The details of gas-piping and gas-fitting are seldom looked into, except in the case of large and important structures, such as churches, halls of audience and theatres.

Wherever gas-light illumination is deficient, laymen are generally inclined to grumble about the gas-works, attributing the cause to the poor quality of the gas furnished by gas companies or to lack of pressure in the pipe system. There is, of course, occasionally good reason for the complaint that the gas supplied to consumers falls far below the standard, but in the majority of cases the chief causes of bad illumination may be looked for in the gas apparatus of dwellings, in other words, in defective gas-fixtures, gas-burners, gas-globes and gas-piping.

The general public is usually ignorant and indifferent about the subject. The gas companies, with few exceptions, do not

keep the householder or gas consumer informed about the "mysteries" of the subject, although it would be to their interest, without doubt, to enlighten the public, and to help them in every way possible to get the maximum amount of light and illumination from the consumption of a given quantity of gas.

Next to plumbing, heating and ventilation, there is no part of interior house construction requiring as much attention as the gas piping and gas fitting.

Gas piping in buildings should be done according to carefully drawn specifications, experienced gas fitters should be employed in the work, no part of the work should be "skimped," and the distribution system with its numerous connections should receive a proper amount of attention on the part of the superintendent of the building in order to insure that the gas fitting is done right and that there are no defects. The gas fitter should work from a carefully drawn sketch plan, showing the run and distribution of all gas service pipes in the building, showing location of the gas meter, or

the several gas meters (where the building is subdivided into suites of rooms, each suite having its separate meter,) also the location of the main gas cock, or of the several shut offs, in the case of large buildings. The plan should also indicate the precise location of the gas risers, and the size of the same, and in each room and in the halls the side or bracket lights and the drop or centre lights should be clearly marked. The number of outlets on each floor, the number of burners at each outlet and the sizes of pipes should also be indicated, and the superintendent should allow no deviation from the sizes specified.

But, let us inquire what the usual practice in this respect is? A brief specification calls for "the house to be piped for gas in the best manner, and according to the rules and regulations of the gas company which is to furnish the gas to the house." The work is, as a rule, given out by contract to the lowest bidder. In the majority of cases the gas fitting of a building is included in the plumber's work, and in estimating for both plumbing and gas

fitting a small amount is usually allowed for the gas fitting work. If the contractor has put in a low bid for the whole work to cut out more honest competitors, the gas fitting work is usually the feature most readily neglected. Gas companies do not, nowadays, exercise a general supervision over the piping, and rarely send a gas inspector when the pressure test is being applied. The gas fitting is not looked after by the architect, and in order not to lose money on his contract, the contractor buys an inferior quality of gas pipes and fittings, reduces the sizes of all service pipes and puts in a much larger amount of the smaller sizes of pipes than is allowed. The jointing is done in a slovenly manner, and the whole work is usually put up in a great hurry, the gas fitter being notified at the last moment that the lather and plasterer are waiting. The pipes are covered up, permanently hidden from sight, and buried in plastering as soon as put in place. The testing of the pipes cannot be done in a thorough manner, because the gas fitter is hurried, and the result is necessarily that

instead of obtaining a system of gas pipes of proper size, properly run, properly graded, and perfectly tightened, the work is more or less defective, containing pipes of too small calibre, which soon choke up with rust and obstruct the flow of gas, split pipes, fittings full of sand holes, loose and leaky pipe joints, drops taken out from the bottom of running lines, bracket lights run from overhead instead of from below, condensation running into fixtures instead of into risers, nipples not at right angles to the wall or ceiling from which they project, distributing pipes trapped by sagging, etc. All such errors in the gas piping often lead to an inadequate supply of gas and subsequent trouble with bad light.

Of course, it is supposed to be the architect's or superintendent's duty to see that all this does not happen, but there are in house-building so many other important matters of detail to be looked after, that the gas fitter is allowed to do as he pleases, except as to the exact location of side lights and chandeliers, which are laid out by the architect. Even where a careful

gas-fitting specification has been drawn, irresponsible gas fitters will pay little attention to its requirements, unless carefully and continually watched.

Since there is no official inspection of gas piping in most cities, smaller towns, villages and particularly in the case of isolated country residences, the house owner has to rely almost entirely upon the honesty of the gas fitter, hence there is wisdom in employing only first-class firms in this work.

Aside from the obvious necessity of doing gas piping in the best manner in order to obtain good illumination, defects in gas piping should be avoided to guard against unhealthful influences, such as gas leaks, to which we shall refer hereafter. A strict inspection and supervision is, therefore, much to be desired from a health point of view, and the whole subject is properly deserving the attention of those who make a specialty of sanitary house construction.

Gas Service Pipes and Gas Meters.

The gas service pipe by which gas is "laid on to a house" is always put in by the gas company. The size of the service pipe is governed by the number of burners to be supplied, but the rule should be laid down that no service, even for the smallest house should be less than one inch inside diameter. While this size is slightly larger than called for by the requirements of small dwellings, it will prove more satisfactory in the end, as such pipe is not so liable to stoppages, and the cost of using the larger pipe is but a trifle more. Besides, it often happens that additions are subsequently built to the house, and the pipes of such houses often become insufficient and inadequate for the service which they have to perform unless allowance is made in the beginning for a possible increase in the number of lights. In determining the sizes of service pipes—and this refers to the distributing pipes in the house as well—it should be borne in mind that where water gas or naphtha gas is used, the sizes should be increased 15 to

20 per cent. over those required for coal gas.

The material for the main service pipes from the street into the house is either lead or wrought iron. Cast iron pipes with lead caulked joints are used only for very large buildings, *i. e.*, those requiring gas pipes, four inches in diameter and upward. As a rule, wrought iron screw-jointed service pipe is preferred to lead, at least in America, probably because lead pipe is liable to sag in the trench and thus create dips in the pipe, which would accumulate water of condensation and thereby become the cause of the flickering of lights, or may even cause the gas to cease flowing. Certain precautions must, however, be observed, in the use of wrought iron service pipes, such as laying the pipes in trenches with a firm bottom and protecting the outside of the pipes with asphalt or coal tar, where they are laid in soils containing acid or alkaline residues, or mixed with ashes, cinders, furnace slag or chemical refuse, which cause a quick corrosion and destruction of the pipe.

The service pipe should preferably rise from the street gas main toward the house, in order to allow all condensation to run back into the mains. This, however, cannot always be accomplished, owing to the relative levels of the street main and the gas meter in the house. The latter should be placed in a cool, easily accessible and well-lighted place at the lowest point at which gas is to be burned, usually the cellar, which in city houses is below the level of the street gas main. It, therefore, becomes necessary to carry the service pipe in a descending line towards the house, and a drip pipe, usually called a "siphon" by gas-fitters, is put in the cellar, and left capped. When water accumulates at this point, the cap is removed and the pipe drained. Under no circumstances should there be a trapped gas service pipe between the house and the street main. The gas company supplies and sets the gas meter, usually a "dry" meter, which is preferred in America, because it registers more accurately, requires less attention and is not as liable to be injured or deranged in

frosty weather than a wet meter. The dry meter is apt to give trouble only where the gas is very impure and contains large amounts of naphthaline, causing the diaphragm in the dry meter to stick. The size of the meter must, of course, be in proportion to the total number of lights supplied, and it is well to obtain a gas meter of ample capacity. Occasionally the cause of bad illumination may be found in a gas meter of insufficient capacity.

The gas company usually places a stop cock or valve turned by a long key on the service pipe near the curb, in order to be able to control and shut off the gas from each building separately. This is always done on service pipes 1½ inches and larger, and it is insisted on by building laws in the case of theatres, but it is well not to omit the shut off, even in the use of smaller services.

The meter is connected with both the service pipe and the main house pipe by means of short connections of extra heavy lead pipe. A gas cock is placed near the meter, and in large buildings this is

arranged so that a lock may be attached to it, when the gas is shut off, the company retaining the key to the lock. Globe valves as well as stop cocks do not open to the full capacity of the service pipe, hence straight-way or gate valves on gas service pipes which give an unrestricted flow of gas are much to be preferred.

Gas Distributing Pipes.

The gas pipes inside of a house are, as a rule, wrought iron pipes, except where carried exposed in offices, or on walls lined with enameled brick or tiles, when copper or polished brass pipes are sometimes used. In England and on the Continent lead and composition pipes are much used, occasionally even block tin pipes, but in America, all soft metal pipes are considered objectionable for the same reasons which in plumbing work govern the preference of heavy iron to lead soil and waste pipes. All soft metal pipes, if used for gas, are liable to sag and have depressions, accumulating water of condensation. When carried under floors or buried in

walls or in partitions, they are very liable to have picture or other nails driven into them by careless workmen. In places acessible to, or frequented by rats, exposed lead pipes are liable to be gnawed, and finally they melt quickly during a fire, thus adding fuel to the flames.

The chief requirements of plain wrought iron pipes for distributing gas are that they are carefully welded and that they are perfectly round and regular in section. The fact that gas pipes often split in cutting or threading them on the pipe bench, and that in testing gas piping, lengths are occasionally found with flaws at the weld, will be better understood when it is considered how such wrought iron pipes are manufactured at the mills.

Long strips of wrought iron varying slightly in thickness and of different widths corresponding to the diameter of the pipes, are bent into a circle. When the two ends or butts of the iron meet, the same are, while still hot, welded together under pressure. It is, therefore, apparent that the weld is the weakest part of the

pipe and that it must be done with particular care and skill. Where pipes are required to stand a great internal pressure, as when used to convey water or steam under pressure, the welding is rendered stronger by overlapping one butt over the other, and the pipe is accordingly called "lapwelded" pipe. Gas pipes are not required to withstand any strong internal pressure; nevertheless the welding should be perfect, and hence it is better to use, at least for sizes above 1¼ inch, lapwelded gas pipe. The smaller sizes, from ⅜ inch up to 1¼ inch are buttwelded. Pipes should be examined for such defects by hammer test and sounding.

The other requirement, namely that the pipe should be perfectly circular in section, is equally important. All gas pipes are put together with screw joints, a thread being cut upon the outside of the pipe. Where the pipe contour is irregular the threading will be more or less imperfect, and as a result there will be defective joints. A good gas-fitter must, therefore, examine all gas pipes as delivered at the

building, and observe either by the eye or by means of calipers the regularity of the section. In some cases it is advisable to cut test threads. All defective pipe, whether imperfect in welding or in contour, should be rejected and at once removed from the building. In this as in so many other matters, the contractor can protect himself, at least to a certain extent, by buying his pipe from reputable firms only, who are known to be reliable, and by insisting that all pipes be tested under hydrostatic pressure at the pipe mills before being delivered at the building.

Plain wrought iron pipe is liable to corrode and to rust on the inside, especially where the gas supplied is imperfectly purified, and the smaller sizes are particularly liable to become obstructed. At the foot of vertical risers and branches the iron scale is very apt to lodge, and hence it may be advisable to use, under certain conditions, pipes made rustless, either by the Bower-Barff process or by galvanizing in the best possible manner. In practice it is found that the danger of rust is confined

to the smaller sizes, hence it is not necessary to use pipes protected against rust, for the main riser and the larger distribution pipes. Still, where economy is no object, it seems to me to be preferable to use rustless gas pipes throughout, and I have had many first-class residences piped in this manner with the best results.

Pipe Fittings and Pipe Joints.

In joining together lengths of wrought iron gas pipes, certain fittings are used, for instance sockets or couplings for straight runs, and elbows, tees and crosses for changes of direction and for taking out branch pipes. Other fittings not so extensively used, are the union, the flange union, the running socket and the right and left couplings, the latter used where pipes can be sprung. These fittings are either of cast iron, or of malleable iron, the latter preferred for the smaller sizes. Fittings may be galvanized or made rustless by the Bower-Barff process, and it is particularly necessary that sandholes be avoided in all cast fittings.

In making pipe joints the gas fitter should make use of red lead or red and white lead mixed on all joints to make up for any possible imperfections in the threads; but I may here remark that I consider the dipping into, or filling of fittings with, red lead objectionable as having a tendency to reduce the full bore of the pipe. The use of gas fitters' cement on pipe joints should be absolutely prohibited. It is also important that each length should be screwed entirely home before the next length is put on. It is always a wise precaution, in putting the gas-piping together, to examine every length of pipe carefully to make sure against any obstructions on the inside of the pipe.

How to Run Gas Pipes in Buildings.

The proper manner of running the gas distributing pipes in a building is sufficiently explained in a subjoined "Specification for Gas Piping," and a few hints given here may suffice.

It should be the rule to keep all large gas risers exposed, instead of burying them in the walls or plaster, and to arrange the piping as much as possible so as to be readily got at. All horizontal distributing pipes must run with an even, though slight pitch toward the riser, and all depressions in such pipes must be avoided as tending to collect water and forming traps, hence pipes should be firmly supported at frequent intervals, particularly the smaller sizes which are not as stiff and easily sag or bend in the middle. Floor boards over all horizontal gas pipes should preferably be fastened down with brass screws to admit of easy removal for alterations, inspections or repairs. When it becomes unavoidable to trap a pipe, a drip with drain cock must be put in, but this should be avoided under floors, and always put in an accessible position, for occasional removal of the condensed water or deposit of pitch which collect in the drip. The gas fitter must use his best judgment in substituting at suitable points cross pieces instead of Tee branches, and closing the

opening of the cross opposite the branch by means of a plug forming a cleaning cap. All these precautions are particularly necessary where the gas is apt to leave deposits of tarry matter or naphthaline in the pipes which cause obstructions and require in their removal the use of a force pump.

The proper size for all distribution pipes should be regulated by a table of sizes, one of which is given in the appended specification, while another may be found in the Munich gas rules at the end of the book. Both tables, which the writer has applied in many cases in his own practice, give sizes slightly larger than required for coal gas, but it is always poor economy to use pipes of too small calibre, which soon become insufficient to furnish the quantity of gas required at burners, particularly at chandeliers and Argand burners. It should be a rule that no pipe for a drop light should be less than ½ inch in diameter, and no pipe for side lights less than ⅜ inch.

Testing Gas Pipes.

As soon as the gas piping is completed it should be tested by means of a gas fitter's pump and manometer or mercury gauge. Before proceeding with the pipe testing all deviations from the true position of nipples for brackets or centre lights must be rectified. In the case of large buildings, the gas fitter should preferably test the pipe system in sections, one floor at the time, and afterwards, when all floors are connected with the main riser or risers, the whole system should be subjected to a final strong test in the presence of the architect, engineer or a gas company's inspector, who furnishes a certificate to the owner. All leakage revealed by the test should be at once repaired, avoiding entirely the use of gas fitter's cement, which cracks and breaks off very easily, or melts from heat where gas-pipes are located in close proximity to steam-pipes. The test must then be repeated until the whole system is perfectly air tight under an air pressure of from 15 to 20 inches of mercury.

This testing of gas-pipes is of the utmost importance to prevent subsequent annoyance, trouble and danger from gas leaks, resulting from pin holes in pipes, sand holes in fittings, split pipe, loose joints, imperfect threads, or outlets carelessly left without capping.

Regarding the careful proving of gas-piping in buildings in course of erection, as well as in buildings already completed and occupied, I cannot do better than quote the following clear description, given in the *Sanitary Engineer and Building Record*, Vol. XI., May 14, 1885:

"If the house is in progress of construction, see that all the outlets are carefully closed with caps, and that the foot of the rising line is stopped. Then at any convenient side-light attach the ordinary gas-fitters' pump, which is simply an air-pump. To the same side-light, or an adjacent one, attach the mercury-column gauge used by gas-fitters with a column from fifteen to twenty inches in length.

"Great care must be now taken to prove that there are no leaks in the gauge or its

connections or cock, and in the pump and hose connection, and a good cock should be used between the permanent gas-pipe and any temporary connections to pump, so that it may be closed immediately after the pumping stops, to prevent back-leakage of air through the pump-valves or hose-joints.

"When all is complete, pump the pipe system in the house full of air until the mercury rises at least twelve inches. Then close the intermediate cock before mentioned, and should the mercury column be found to "stand" for five minutes, it is reasonable to assume that the pipes are sufficiently air and gas tight for any pressure they can afterwards be subjected to. But it is the rule in the most carefully done gas-pipe work to find the mercury will not "stand," as there will be leaks that would escape the most careful workman, it is necessary then to locate them.

"Should there prove to be a very large leak, it will be apparent at once, as it will be impossible to get a pressure worth con-

sidering, the mercury simply bobbing up and down in the tube.

"It may be an outlet that has been neglected to be closed, or it may be a long split in the pipe. If the former, and very close to the pump, the mercury will not respond; but should it be far away, with considerable length of pipe to cause resistance, the mercury will jump and return as suddenly. But should there be a split pipe or an aggregation of small leaks, the mercury will run back steadily, though slower than it rises, between the strokes of the pump. Should it rise well in the glass and sink at the rate of about one inch in five seconds, small leaks only in fittings or joints may then be anticipated. Of course, there are exceptions to these rules, which are only for general guidance.

"To locate a leak, then, that cannot be heard blowing, strong soap water applied with a brush or sponge may be used. The liquid is rubbed over suspected joints or fittings and air-bubbles are blown by the escaping air.

"Sometimes it becomes necessary to use ether in the pipes in locating leaks, if the pipes are under floors or in partitions. The ether is put into a bend of the hose or into a cup attached to the pipe and blown into the pipes with the air. By following the lines of the pipes the approximate position of a leak may then be determined by the odor of escaping ether.

"In very large work it is well to prove a floor at a time, and when all are done, connect them with the riser and prove as a whole.

"The best thing for making pipes tight for coal-gas is gas-fitters' cement, which is a common grade of sealing-wax. The threads of the pipes should be immersed in it when warm and let drain, and the fittings also are sometimes so treated. To put the pipes and fittings together both are warmed and screwed tightly and allowed to cool. Porous places incidental to malleable iron or shrinkage-cracks in malleable iron fittings are generally stopped with this cement, but a split or

crack should never be so mended, as it will be an element of danger.*

"For naphtha-gases some of the heavy body asphaltum varnishes are considered best, such as black air-drying japan, or black baking japan, but paraffine varnish should not be used. To use the japans both threads of pipes and fittings should be dipped in them and drained, and the japan should be applied with a brush when putting them together, the same as using lead. Red and white lead are also good, but are with more difficulty made air-tight.

"If the house is an old one, or has been finished, and you have to test for leaks, take off the meter and cap the bottom of the riser; also unhang the gas-fixtures and remove the brackets, and cap all outlets carefully. Then use ether and locate leaks before tearing up floors or breaking plaster.

---

* The author cannot endorse this recommendation of the use of gas-fitters' cement. He, on the contrary, considers it a dangerous practice, which should be prohibited strictly, for such cement is liable to crack and break when cold, and when exposed to the heat of steam-pipes it is apt to melt at any time, and hence joints made tight with gas-fitters' cement cannot be relied upon to remain so.

"The mercury should be made to stand —remain stationary in the glass—if possible, before the work is passed, but a fall of one inch of mercury in an hour would indicate a comparatively tight job.

"Occasionally, when a gas-fitter cannot get a job tight, there is a possibility he may cut off the part or floor of the building he cannot get sufficiently tight to suit the inspector's idea of perfection. The inspector can only prove such practice by removing or slacking off a cap here or there about the house if he suspects such an attempt. If no air escapes, then he has the dead end."

Mr. William Eassie, the well known English sanitary expert, writes on this subject in his "Sanitary Arrangements of Dwellings" as follows:

"In England as a rule, we are culpably careless about our gas supply. A gas company, for instance, receives notice that the service of such and such a house is ready to be connected with their main, and when they have obtained a signed agreement setting forth who is responsible for pay-

ment, the meter is connected forthwith, and there is an end of it. The gasfitter may have done many things badly, and not done some things at all, but the gas company seldom, very rarely ever, exercises any jurisdiction. The gasfitter next sends in his account, which is paid, and when the smell of escaped gas from some faulty portion of the pipes has become unbearable, he is sent for to remedy it, and charges for the rectification. The workman may be thoroughly incompetent, as gasfitting is not, as it should be, a separate trade. Indeed, the artisan who performed the work may be a blacksmith, whitesmith, glazier, brazier, plumber, bellhanger, and gasfitter all rolled into one.

"A gas-fitter *who is a gas-fitter*, and who understands his business, will never take leave of a house until he has tested the pipes for leakage. Where this trouble is taken, the ordinary practice among us is as follows:—When the pipes have been laid throughout the house, and the company's main connected to the meter, a temporary burner is fixed to each floor of the house,

and the gas is turned on. The gas is now ignited at these trial jets and allowed to burn for some little time. The main is then turned off, and at the same time the exact reading of the index is taken. When the gas left in the pipes has burnt out, the taps of the experimental lights are turned off, and if, after the lapse of an hour or so, the dial of the meter continues to indicate a consumption of gas, it is plain that it somewhere escapes, and the leak is searched for by the sense of smell, &c., and remedied."

The same writer describes his own practice of testing gaspipes as follows:—

"Before the gas-fitter asks the gas company to make the connection with their main, he sets about proving the pipes. He stops up, with one exception, all the outlets which have been left for brackets and pendants with plugs or with screwed caps. On the one not so stopped he attaches a force-pump, into the interior of which has been put a few drops of sulphuric ether. This pump is now connected with a gauge, and it is then set to work, generally until

a high pressure is registered. A high pressure in a gas-pipe at first appears unnecessary, but gasfitters know very well that iron pipes have many latent weaknesses, so to speak—seams just ready to open, pinholes filled with grease, &c., which might not drop out for years, and a good pressure exerted would rip up the one and cause the others to fall out. When the gauge indicates a certain figure, therefore, the pumping ceases, and if the mercury falls, it is evident that there is one or more palpable leaks, which are at once sought for. The escaped ether will guide the fitter to these, and the defaulting pipes are replaced by others. The pumping is now continued, and the same routine recommences. If the mercury still descends and it cannot be detected, even by the sense of smell, the joints are separately lathered over with soap, whereupon the weak places will be indicated by bubbles. These parts are then marked, heated by means of a portable spirit lamp, made for the purpose, and covered over with an approved and durable cement. When the

inspector arrives, the pump is once more set in action, and as the pipes are now tight, he has simply to cast an eye upon the gauge, the column of which no longer shows signs of sinking; examine, as before mentioned, how the pipes have been laid, and sign the requisite order."

Gas Leaks.

We must now consider more in detail the injurious effects of gas leaks in dwellings. Leakage of gas may be caused either by defective gaspiping or by worn out burners, or by badly jointed fixture connections, or finally by imperfect, loose or worn stops or keys of gas fixtures. The first cause has been discussed in detail heretofore, and of the latter causes and the best way to avoid them we shall speak more fully hereafter.

Escape of coal gas into houses also takes place from broken or defective gas mains in the streets, particularly in winter time when the road surface is frozen hard, and when owing to the heating of the houses these act like chimneys, as it were, draw-

ing gases from the soil upwards into the living rooms. Many cases of poisoning by coal gas and not a few cases of gas explosions due to this cause are on record, but we must dismiss the subject with these few words as we have reference here only to gas leaks existing inside of a building owing to one or the other of the above mentioned defects.

All gas leakages must be looked upon as harmful from three different points of view. First, as regards the pocketbook of the consumer, for all gas escaping unburnt through leakages is registered at the gas-meter. Hence arise frequent complaints of exorbitant gas bills and the general and often unjustified distrust of householders against the meter.

Fortunately, larger leaks, especially at the gas fixtures are soon announced and easily detected owing to the well-known pungent odor of the escaping gas. Not so, however, with small hidden leaks which may go on unperceived, often for years, being comparatively odorless and causing not only a useless increase of gas

bills, but what is much more important, a steady and injurious contamination of the air of rooms. We must, therefore, regard gas leaks, second, in their injurious effects on the health of human beings.

It should be remembered that carbonic oxide forms one of the components of illuminating gas. This gas is well-known to be a deadly poison, causing asphyxia and death if enhaled in large quantities, while if present in the air we breathe in smaller volume, it is the cause of headache, nausea and giddiness, and will in course of time show its steady and injurious influence upon those members of the household who live the greater part of their lives indoors. In coal gas the percentage of carbonic oxide averages 7 to 8 per cent. while in water gas the proportion is much higher, being in the average about 25 per cent. This explains the greater danger incident to the more recently introduced water gas. *

* For a very interesting account of the relative poisonous effects of coal and water gas, the reader is referred to the investigation of Profs. W. T. Sedgwick and W. Ripley Nichols, published in the Sixth Annual Report of the Massachusetts State Board of Heal h (1885).

Long ago, Mr. Wm. Eassie, the well-known English sanitary engineer, stated that if it were a rule in all towns to have the gasfitters carry a certificate of competency much sickness, according to many eminent physicians, would be prevented. Dr. B. W. Richardson, a well-known English sanitarian and authority, called attention to this matter by stating that wherever carbonic oxide becomes diffused in small quantities either through leaky pipes or defective burners and gas fixtures into the air of badly ventilated rooms or workshops, it becomes a common cause of nervous derangement and dyspepsia.

More recently, Prof. W. H. Corfield, at a meeting of the London Society of Medical Officers of Health read a very interesting paper entitled "Outbreaks of sore throats caused by slight escapes of coal gas," an abstract of which is given in the May 16, 1887, issue of the London *Sanitary Record.*

He pointed out first that in considering the deleterious effects of escapes of coal gas into dwelling rooms, attention has

hitherto been almost entirely directed to cases of poisoning by asphyxia, due to the carbonic oxide contained in the coal gas. Prof. Corfield next stated that during the past few years his attention had been gradually arrested by cases of illness and more especially of relaxed and even of ulcerated sore throats, occurring in persons sleeping in rooms in which there were defective gas burners or pipes, but living in houses of which the sanitary condition was otherwise as perfect as the application of modern sanitary knowledge could make them. That the slight escapes of coal gas were the cause of the sore throats was proven by the fact that the persons attacked became quite well on the defects in the gas burners or pipes being remedied. He, therefore, had no doubts that the cause of the sore throats was the breathing for weeks or months, especially at night, of air contaminated with a small proportion of coal gas, and believed that the effective agents in producing the irritation in the throat were the bisulphide of carbon and other sulphur compounds contained in the gas.

He was convinced that in numerous instances these ulcerated throats were thought to be due to foul air from drains when they were really due to escapes from gas pipes or gas fixtures.

In the discussion which followed the reading of this paper, Mr. Rogers Field, M. Inst. C. E., referred to numerous cases in his practice as sanitary engineer, where offensive smells attributed to defective drainage, were found to be due to escapes of gas. He, therefore, made it a practice always to have the gas pipes tested and made thoroughly sound after the drainage of a house had been reconstructed. He found the only effectual method of testing the gas pipes and fittings to be to attach a pressure gauge and then pump air into the pipes. If the gauge stood the pipes were sound; if it fell, there was a leakage which had to be found out and remedied, and the work was not left as completed until the pressure gauge would stand.

The writer could quote several instances from his own practice where plumbing work thought to be defective was found

after careful inspection to be tight and in good condition, whereas the bad odors complained of were traced to leakage from furnace smoke flues, or to leakage of illuminating gas. It is somewhat unfortunate that of late years it has become customary to raise the cry of "sewer gas" whenever any contamination of the house air is noticed. While it is true that defective plumbing work is, in many instances, without doubt, the cause of bad odors in houses, the contamination of the air and noxious smells are also not infrequently traceable directly to other sources, such as leaks in the joints of furnaces, or leaks in brick smoke flues, or finally leaks in the gas piping, or at the gas burners and fixtures.

Thirdly, gas leaks become objectionable owing to the accompanying danger of an explosion. When illuminating gas escapes unburnt from a gas burner, or from a leaky pipe-joint or defective fitting, it mixes with the air in the room and when this mixture reaches a certain proportion it becomes explodible. Hence the rule should

always be observed *when an escape of gas is noticed, never to search for the leak with a light.* A gas meter has often slight leaks at the couplings, and, therefore, a meter should never be examined except in day light. It is astounding how often in every day life these plain rules are violated even by intelligent mechanics. Gas explosions often occur with very fatal results to life and property. Many fires owe their origin to such accidents, and the greatest care should therefore, be observed to prevent them by avoiding all leakages.

Precautions Against Danger from Fire.

Much ignorance prevails among the public as well as among builders as to certain precautions which must be observed to render gas lighting safe from the point of view of fire. A few hints regarding prevention of fires from this cause may not seem out of place here.

First, the house owner or householder should ascertain that the system of gas piping is perfectly sound and tight, and

kept as much as possible accessible for occasional inspections, also that the burners and fixtures do not leak.

Next, great care should be exercised in every household in the use of matches for lighting the gas. Matches should always be kept in closed earthen or metallic vessels or boxes, and it is a wise precaution to provide a second receptacle to receive burnt matches. Matches must be kept out of reach of children, as well as rats and mice, which latter seem to have a special preference for phosphorus and often carry matches into hiding places under floors or behind baseboards or wainscoting and cause the matches to ignite by gnawing at them. So-called parlor matches of wood or wax are particularly dangerous, as they easily ignite by friction. Safety matches, such as the Swedish, which can only be ignited on specially prepared surfaces are much better. For lighting chandeliers wax tapers are preferable to matches. A still better, more convenient and safer arrangement for lighting up gas consists in the use of portable safety-lighters, either

mechanical or electric torches. The best method is, undoubtedly, a well arranged system of electric gas lighting with automatic or pull-burners, and it is to be recommended, in building new houses, to wire all gas outlets for it.

Other precautions against fire relate to the construction and location of gas fixtures. All side or bracket lights should be kept at a safe distance from windows, doors or other inflammable woodwork, and from curtains, portieres, lace work or other hangings. Lights in exposed positions should always be enclosed in glass globes because strong draughts of air will sometimes blow unprotected flames sideways very far endangering combustible objects near by. Swinging or folding bracket-lights are particularly dangerous and should be avoided wherever possible, particularly on stud partitions or cabinet woodwork, and rigid brackets should be used instead. If swinging gasbrackets must be used they should be fitted with guardrings of large diameter. Even fixed bracket-lights should never be so placed that an

opening door would come into contact with the gasjet.

Portable gas fixtures, connected with rubber tubing to a wall gas outlet or to a chandelier are also, to some extent, dangerous and must be handled with care.

There should always be a distance of three feet between all burners and the ceiling or woodwork, and in places having low ceilings metal, glass or porcelain bells or shields should be hung over the flame to protect inflammable ceilings, and incidentally to prevent the ceiling from becoming smoky owing to accumulations of small particles of unconsumed carbon. If shields are used the minimum distance between burner and ceiling should be 18 inches.

In basements, and in the servants' department of a house generally, such as the kitchen, laundry, ironing room, linen closet, wardrobes, and all other places where inflammable articles of wearing apparel may come into contact with gas jets, or where in stores or warehouses much material of a combustible nature is handled,

strong and large round metal wire cages, guards or screens, at least 10 inches in diameter, and with close meshes, and so shaped and constructed that any combustible material coming in contact therewith shall be out of reach of the flames, should be fitted and attached to the gas brackets in a firm manner, preferably soldered.

In case many lights are suddenly turned out it often happens, especially on the higher floors of buildings of many stories, that a single flame left burning jumps up or flares, generally with a whizzing or singing noise, due to the temporary excess of pressure, to such a height that it may set woodwork on fire. The same sudden flaring up of a gas jet may occur when a lava tip cracks or breaks off. As we will see later on pressure regulators, or better still, governor burners will prevent this occurrence.

After this slight digression relating to fires directly or indirectly caused by gas lighting apparatus in houses, we will continue our consideration of the proper means

for obtaining a satisfactory gaslight illumination.

Gas Burners.

We have given, heretofore, as concisely as possible, the requirements of a good gas piping system. The next point requiring attention is the burner at which the gas distributed by the pipe system, is ignited and consumed, giving off light. In order to have a better understanding of the requirements of a good burner, it is necessary to say a few words relating to the composition of illuminating gas and the mode in which by combustion it is turned into a light giving flame.

Lighting gas is a very complex mixture of gases, of which various chemical compounds of carbon and hydrogen—the hydrocarbons—form the chief light-giving constituents. Gas always contains more or less impurities, the principal ones being carbonic oxide, carbonic acid, ammonia, sulphuretted hydrogen and bisulphides of carbon. These are partly removed by

purifying processes before the gas leaves the works.

When the gas jet is ignited the inflammable hydrogen is consumed in the lower part of the flame, producing sufficient heat to render the infinitesimal particles of carbon incandescent. The hydrogen in the process of combustion combines with oxygen from the air forming an invisible vapor of water, while the carbon unites with oxygen forming carbonic acid. Hence we see that water and carbonic acid are the products of combustion of perfectly purified gas when perfectly consumed, but in reality it is seldom that gas is so perfectly purified and that combustion is perfect. The carbonic acid of unpurified gas reduces its illuminating power, and the other gaseous admixtures (chiefly compounds of sulphur) are converted by combustion into harmful vapors injurious alike to the human system when inhaled, to house plants, and finally to the interior decoration of houses.

Various reasons tend to render combustion incomplete. There may be excessive

pressure of gas, and there may also be lack of air to the flame, and finally the burners may be defective. The pressure in the street mains must necessarily be somewhat higher than required in the house services on account of the differences in the street levels of a district. An excess of pressure at the burners causes a reduction of the amount of illumination, and it becomes desirable to reduce the pressure which can be accomplished by several means, to which we shall refer below. On the other hand it may happen that the pressure is insufficient, and in that case the heat of the flame will not reach a degree sufficient to raise the carbon to white heat, and as a result the flame will smoke. It follows that for every burner there is a certain amount of pressure and corresponding flow of gas which will cause the brightest attainable illumination. It is found by experience that gas should be burnt at the lowest practical pressure consistent with adequate supply, and where the size of the meter and the diameter of the house distributing pipes and of the tub-

ing of gas fixtures is ample, the intensity of illumination will depend chiefly upon the conditions under which gas is burnt.

As a rule the gas pressure at the burners is excessive, particularly in the upper stories of houses, located on high ground. Too much pressure is readily detected by the hissing or roaring sound of the gas flame. The result of incomplete combustion is a waste of gas, it being stated by good authorities that as usually burnt from 20 to 50 per cent. of the gas registered at the house meter, is actually wasted. This waste is very objectionable, first because it causes high bills to the consumer, second —and this is of vastly more importance— because it contaminates the atmosphere of the house, and thus injures the health of the inhabitants, thirdly, because the injurious compounds of sulphur due to incomplete combustion of gas are destructive to furniture, bookbindings, wall papers, picture frames, decorations and gilt work, while the smoke incident to imperfect combustion blackens ceilings and walls.

It seems deplorable, that the gas com-

panies, with perhaps a few exceptions, do not show any interest in making efforts to stop the waste of gas in houses. What they are chiefly concerned in are the gas leaks at the works, in the street mains and at the connections of the house services with the main, and the fact that all such leaks constitute a direct loss to the company and not to the consumer, may perhaps be taken as a sufficient explanation.

The waste of gas due to incomplete combustion is still further increased by the use of defective burners, the best of them after some years' use becoming worn out and imperfect. It is, therefore, desirable to use the greatest care in the selection of proper burners, by paying due regard to their construction, material, shape and size. It has been ascertained by carefully conducted experiments that poor burners give only from 20 to 50 per cent. of the light which can be obtained by the consumption of a given quantity of gas under proper conditions.

It would require more space than is at my disposal to describe and explain in de-

tail the construction and working principles of the many kinds of burners invented and put on the market since the introduction of lighting gas into dwellings. Broadly speaking, we may distinguish six principal types of burners, viz.:

1. The Single Jet Burner.
2. The Fishtail Burner.
3. The Batswing Burner.
4. The Argand Burner.
5. The Regenerative Burner, and
6. The Incandescent Burner.

The single jet burner is the simplest kind of burner, having only one small hole from which the gas issues. It is only suitable where a very small flame is required.

The batswing or slit burner has a hemispherical tip with a narrow vertical slit from which the gas spreads out in a thin flat sheet, giving a wide and not very high flame, resembling in shape the wing of a bat (hence the name). The common kind of slit burners are not suitable for use with globes as the flame is liable to crack the glass.

The union-jet or fishtail burner consists of a flat tip slightly depressed or concave in the centre, with two small holes drilled under a certain angle to each other. Two jets of equal size issue from these holes, and by impinging upon each other produce a flat flame, longer and narrower in shape than the batswing, and not unlike the tail of a fish, wherefrom the burner derives its name.

The gas consumption of the fishtail burners in cubic feet per hour is stamped on them, while on all slit burners the number of cubic feet of gas consumed per hour are indicated by the number of rings on the outside of the tip, each narrow ring indicating one cubic foot, while a broad ring stands for four cubic feet. But, inasmuch as the volume of gas consumed depends on the pressure of gas at the burners not less than upon the size of the opening or slit, this method of designating the burners is obviously unreliable. Both kinds of burners require no chimney, but the flames are usually encased with glass globes.

The argand burner consists essentially of a hollow ring of metal, connected with the gas tube and perforated on its upper surface with a series of fine holes from which the gas issues, forming a round flame. This burner requires the use of a glass chimney, properly proportioned in diameter and height, to induce perfect combustion by increasing the air supply to the flame.

The above are the principal burners more commonly used in domestic gas-lighting. The argand as well as the bat-swing and fishtail burners have recently been much improved by Messrs. Sugg, Broenner, Bray and Silber, prominent European manufacturers of gas-lighting apparatus. Further vast improvements in the shape of gas-burners have been effected since the introduction of the incandescent electric light threatened to revolutionize domestic lighting. Not only have fishtail and batswing burners been much improved, but more recently burners constructed upon entirely new principles have

been introduced, namely the regenerative and the incandescent gas burners.

In all regenerative burners, such as those of Siemens, Grimston, Bower, Wenham, Lungren, Sugg and Bray, the high temperature due to the combustion in a gas flame is directly utilized to raise the temperature both of the gas before ignition and of the air before combustion, the result being an intensified combustion and a vastly increased illuminating power. These powerful burners are in successful use for lighting up streets and squares, stores and halls of audience.

In the incandescent burners, finally, the heat of the flame is applied to raising to incandescence some foreign material, either a basket of magnesia (Lewis burner), or wires of platinum (Clammond lamp), or a funnel shaped asbestos wick or mantle, treated chemically with sulphate of zirconium and other rare chemical elements (Welsbach incandescent light). The latter burner gives a particularly brilliant and white light when used in connection with water gas unmixed with naphtha gases, but

the mantle is very fragile, and soon loses its incandescence, particularly when exposed to an atmosphere containing much dust.

Attempts have also been made in the so-called Albo-Carbon light to obtain a greater brilliancy and increasing illuminating power by enriching ordinary coal gas with the vapors of naphthaline contained in a metal reservoir connected with the gas-burner.

The brilliancy of all kinds of gas flames is reduced, as we have explained heretofore, when gas issues under too great a pressure, and also when the passages for gas, the pipes, the gaskeys and the holes or slits in the burners become obstructed. An intense heat of combustion being favorable to increased luminosity of the flame, it is desirable that the latter should not be unduly cooled. The incandescence of the carbon is the more perfect the higher the temperature of the flame. Hence it follows that the burners or burner tips should not consist of a material which cools the flame. Metal tips for gas-burners, and iron or brass

burners are, on this account, inferior to burners or tips made of some non-conducting material, be this soapstone, steatite, lava, adamant or enamel. Metal tips are, furthermore, objectionable, because they rapidly corrode and thus obstruct the free flow of gas at the burner, and this is a second reason why burners made of non-corrosive material should be preferred. Nickeled tips are said to be somewhat better than iron or brass tips, especially for water-gas, but soapstone or steatite tips are undoubtedly superior. But even non-corrosive tips clog up in the course of time with incrustations of carbon, causing badly proportioned flames of irregular shape and leading to a waste of gas. Burner tips may and should be cleaned from time to time, but this should be done with care so as not to enlarge unduly the slits of the batswing or the holes of the fishtail burners. Occasional renewal of burners will often help to improve gas-light illumination.

Gas Pressure Regulators.

A good remedy for places where exces-

sive gas pressure prevails consists in the use of pressure governors or regulators, placed on the main house gas pipe near the meter.

Oftentimes governors are combined with the gas-burners in the shape of so-called governor burners, which will prevent the jumping or flaring up of flames on upper floors of high buildings (the gas pressure increasing with the numbers of stories) more effectually than any pressure governor at the meter. Both kinds of regulators prevent the waste of gas, give a more uniform and steady gas-light and secure economy by reducing the gas bills, but they should not be used together, and at least in the case of high buildings the governor burners are preferable to pressure regulators.

Ventilating Gas Burners.

The excessive heat caused by the combustion of gas, and the resulting impurities contaminating the air, are often causes of annoyance, discomfort and occasional suffering. To remedy this several forms

of ventilating gas-lights have been proposed from time to time and introduced to a limited extent, such as the sun-burner, the globe light and others. They are designed and constructed in such a manner as to remove at the ceiling the surplus heat and the incidental impurities of air due to gas illumination, by having outlets in the ceiling or over the gas flame connected with properly constructed vent flues in the walls.

Some of the above mentioned regenerative gas-burners are at the same time ventilating burners. All the various types of ventilating gas-fixtures, whether chandeliers or sidelights, are desirable from a sanitary point of view. In using them attention should be paid to the proper protection of woodwork in ceilings coming in contact with the tin branch vent flues, as the temperature of the escaping air may be quite high. It is desirable that the products of combustion be removed from near the level of the burners which may be accomplished by arranging metal bells over the flame, and connecting them with

the vent flues. It is also necessary in order to accomplish good results, as regards ventilation, that the tin vent flues in the ceilings be made as large as possible.

Gas Globes and Globe Holders.

Next to the burners the shape of the glass globes or shades surrounding the flame has much to do with proper illumination. The unsuitable arrangement of glass globes constitutes another factor contributing a share to the gas wasted by imperfect combustion. In order to obtain the maximum degree of light and also to avoid an unsteady and flickering light, the flow to the flame of the air necessary for combustion should be slow and regular, steady and uniform. Where the air supply is insufficient the flame is apt to smoke, blackening ceilings and contaminating the air. Where, on the other hand, a violent current of air rushes to, and impinges upon the flame, the light flickers in an annoying manner and the flame looses some of its heat and brilliancy by cooling.

The old-fashioned styles of glass globes were made with very narrow openings at the bottom (often but 2 or 2½ in. diameter) and complaints of unsteady lights were common. Such globes with narrow bottom openings are objectionable and should be entirely discarded, and globes with bottom orifices four inches or more in diameter should always be used.

All glass globes absorb more or less light and hence cause a loss of illuminating power and a waste of gas. Experiments show that, according to the thickness and opacity of shades the light is obstructed as follows:—

By clear glass globes, from 10—15 per cent.

By slightly ground globes, about 24 per cent.

By globes ground all over, from 25—40 per cent.

By opal glass globes, from 35—60 per per cent.

By colored or painted globes, about 64 per cent.

It follows that clear glass globes are

much to be preferred and more economical, although where softness of light is particularly desired the use of opal globes is rendered necessary. The globe holders, too, should be as little light-obstructing as possible. An incidental advantage of glass globes of large bottom diameter is that a portion of the light falls directly into the room without being obstructed.

Gas Fixtures.

I must, in conclusion, offer a few remarks as regards the selection and construction of proper gas fixtures. Many times poor illumination is caused by ill-contrived, poorly constructed or defective chandeliers and bracket fixtures. Gas fixtures are, almost without exception, designed solely from an artistic point of view and without any regard to the proper conditions which alone enable us to obtain a maximum degree of light. Fixtures having an over-abundance of meaningless scrolls or spirals may, in the case of imperfectly purified gas or improperly run gas-pipes, accumulate a large amount of tarry deposit which

in time hardens and obstructs the passages for gas.

Another fault is the use of too small tubing for the gas fixtures. Having taken pains to pipe a house with adequate sized pipes, it is equally necessary to have the passages for gas in the fixtures of ample bore, in other words, the main tube of the chandelier should be proportioned to the total number of lights which the chandelier carries, and the side tube for each light as well as the orifice of its gas key should be made ample in size to supply each burner with the requisite volume of gas.

A still more serious defect consists in the many leaky stop-cocks of gas fixtures caused either by defective workmanship or by keys becoming worn or loose. It is very rare indeed, to find a house piped with gas where the pressure test could be successfully applied without first removing the fixtures. It is an almost universal experience that the joints of folding brackets, of extension or telescopic pendants, and the gas keys leak much more than the system of piping, hence all chandeliers and bracket

fixtures should always be proved and tested before being hung and their keys made tight-fitting.

It is equally important that the mechanic who hangs fixtures (usually not the gas-fitter) should use particular care in making the joint where the fixture is attached, perfectly tight.

Another point of importance, to which the writer has frequently drawn attention in his practice as well as in his writings, is the use of old-fashioned gas fixtures with so-called "all-round" cocks, *i. e.* cocks not provided with stop pins. Such worthless fixtures are oftentimes the cause of gas leaks and become dangerous, particularly in hotels, apartment and lodging houses, when the gas key is incompletely closed, or by the accidental turning on of the gas after the key has been turned off and the light extinguished, causing frequent cases of death by inhalation during sleep of escaping coal gas or of the much more fatal water gas.

The use of cocks without check pins or stops should, in my judgment, be pro-

hibited by act of legislature. In fixtures of modern manufacture pin stops are always provided, but here we often find another defect, the metal of which they consist, being much too light and cracking or bending out of shape with repeated use. It cannot be too strongly insisted upon that all check pins attached to gas keys should be of good size and made extra strong.

Waterside chandeliers or waterjoint pendants, which are extensively used in England and on the Continent, are another fruitful source of gas leaks, owing to the evaporation of the water in the joint. This can be avoided by frequent additions of water, or better still by using a tablespoonful of sweet oil or glycerine which retards the evaporation of the water. Fortunately, such waterjoint pendants are not much used in the United States, being replaced by the much to be preferred extension joint chandelier with packed stuffing-box joints.

When we consider the many deaths

caused by inhalation of illuminating gas, and the injurious influence upon health, of slight gas leaks and of noxious compounds due to imperfect combustion of gas, it seems highly desirable that some kind of official and periodical supervision, similar to the one now exercised over the general construction of buildings, and over the plumbing and drainage in particular, should be carried out concerning the arrangement and quality of gas-piping and gas-fixtures in buildings occupied as residences or as offices.

Until such official inspection will be secured it becomes the householder's duty to ascertain the tightness of gas-pipes and pipe joints and soundness of fixtures and fixture keys.

With advancing interest in this important and hitherto somewhat neglected subject, we shall hear in the future less complaints about vitiated air, destructive gas-light fumes, immoderate heat, unsteady, flickering or poor light, blackening of ceilings and destruction of decoraations, picture frames and bookbindings.

HINTS TO GAS CONSUMERS ON THE PROPER USE AND MANAGEMENT OF GAS.

The following hints to householders and to gas consumers generally on the management, the proper application and the economical use of gas for lighting and other purposes, will prove to many interesting and useful.

They are derived partly from personal, practical experience and observation, and partly gleaned and compiled from various sources.

Advice to Persons Building a House as to Size of Service Pipe and House Piping, Gas Meter, Gas Burners, Gas Fixtures, Gas Globes and Pressure Regulators, Supply to Gas Logs and Gas Stoves.

As soon as your house plans are ready, determine and locate on the floor plans the exact location of all outlets for both side

and drop lights. Next ascertain the number of lights or burners in the house, and secure from the gas company a correspondingly ample size service pipe, never less than 1 inch in diameter. See that the gas service pipe is laid at a depth of 4 feet below the surface, and that it is not exposed by crossing open areas. Where it must unavoidably pass through these, the gas pipe should be well protected by some non-conducting covering to prevent the watery vapor in the pipes from congealing and freezing in winter.

The service pipe should be laid with a pitch towards the street main, or where this is impracticable, the service pipe should be graded towards the cellar, where a proper emptying pipe and cleanout plug should be provided. It is also desirable to have an outside gas shut-off cock or valve, located near the curb in the sidewalk.

The shut-off cock in the cellar near the gas meter should be a roundway cock, to insure a full supply of gas. Obtain from the gas company a gas meter of ample size, never less than of 5-light capacity for the

smallest house. For medium sized houses take a 10-light meter, and for larger houses at least a 20-light meter. Place the gas meter in a cool, well lighted, easily accessible place.

Make sure that the distribution pipes are properly and amply proportioned to the number of lights which they have to supply, and that the pipes are well run, well supported, free from traps or low places, and have a continuous pitch to the gas riser or the gas meter. *Do not allow the gas fitter under any circumstances to use gasfitter's cement to tighten joints or to close up sand-holes.*

Be sure to have the whole gas piping rigidly inspected and tested with force-pump and mercury gauge under a heavy air pressure, before the gas-fixtures are hung or screwed on.

Purchase only properly constructed, tested gas-fixtures, of first-class quality, with large supply tubes, and with proper heavy, tight-closing gas keys with strongly made pin stops. Make sure that when the fixture man hangs the fixtures, all fixture joints

—that is, the places where the fixtures are secured to the gas outlets—are made absolutely tight.

Provide the very best quality burners, of large size, with lava or enamel tips. Buy only the best kind of shadowless wire prong holders, and enclose the flames with glass globes with wide bottom openings of 4 or 5 inches in diameter, and of thin and clear glass.

On the main supply pipe near the gas meter fit up a proper gas pressure regulator, or else in large houses and in buildings of many stories, use on the side brackets and chandeliers volumetric governor burners.

Keep a plan showing the location of the meter, of the gas riser and of the distributing gas-pipes. Such a record will be useful for reference in case of future alterations, or in case of hidden leakages, especially in large buildings, and by its aid much unnecessary cutting up of walls and floors in the search for pipes may be avoided.

For all outside lights on porches, verandas, and for places not readily heated in winter time, provide a separate supply with

shut-off located inside of the house, so as to enable you to shut these lights off in severe cold weather.

Keep bell wires away from gas pipes, particularly from lead or composition pipes. Cases are on record where such wires, in constant contact with a gas-pipe during years of use, have acted like a saw in gradually cutting the pipe, finally causing a hidden leakage of gas, which to find and locate is often an extremely difficult matter. As a measure of precaution it is advisable to keep gas pipes away from steam, hot water or hot air pipes, also from electric light wires.

Should you build additions to your house, or should you add to the number of lights in your office building, or manufacturing establishment, make sure that your gas service pipe and riser, as originally put in, are ample in size to supply the additional lights. It is far better, however, in order not to impair the illumination of the original lights, to run a separate service pipe to supply the extension or addition. Where

this is done, have the gas meter replaced by one of larger capacity.

If you introduce gas logs in fire-places, or contemplate the use of gas heating stoves, or of gas cooking ranges, always supply these from a separate service pipe starting at the house side of the meter between the same and the gas pressure regulator, and make the pipes of ample size to supply the requisite volume of gas.

Be sure to provide an outlet flue for the gases of combustion where gas-stoves are used for cooking or heating, or for warming the bath water.

Maintenance of Gas Fittings.

Be sure to have the gas keys at your gas fixtures tightened by screwing them up when they become loose in time.

Under no circumstances tolerate gas keys without proper and secure pin stops.

If gas keys turn too hard have them properly greased from time to time so as to work easily and smoothly. A good key grease is made by melting together one part of beeswax and two or three parts of

tallow, the mixture to be well strained after melting.

When a pin becomes defective or breaks have it replaced at once.

All types of gas burners should be examined from time to time, and kept clean and unobstructed. When a once well shaped gas flame becomes ragged and uneven, the burner needs cleaning.

In cleaning the slits of batwing and the holes of Argand and fishtail burners by means of the tools sold for this purpose, be careful not to injure the burners. For slit burners the cleaning is readily accomplished with a thin strip of brass with handle attached. For union jet burners a small awl is made for the purpose.

Worn out burners should be removed from time to time, and it is well to make it a rule to replace all burners in constant use in a dwelling house with new ones about once a year, as gas burners, no matter how well made, will not last forever.

Cracked or split lava burner tips should at once be replaced to avoid any danger from fire.

Glass chimneys of Argand burners, the globes or shades of all gas fixtures, and mica protectors and metal reflectors must be kept scrupulously clean and bright to avoid loss of light.

All low places or drips in a gas-piping system should be cleaned and the accumulated water and naphthaline removed from time to time.

Chandeliers must be inspected, and, if necessary, taken down and to pieces, and all stoppages in the tubing removed.

Management of Gas.

Householders are sometimes advised, as a matter of precaution, to keep the gas turned off during the night at the meter. It is much safer, in my judgment, to keep the gas permanently turned on at the main, during the day and night, while a dwelling house is occupied. In the first place, a gas light is frequently wanted during the night time, and it is an incidental advantage of buildings to which gas has been laid on, that a light may always be had whenever wanted, by simply turning a fixture tap and

applying a match, without the necessity and the inconvenience of having to go down to the cellar to open the main stop-cock. Second, and this is more important, escapes of gas and subsequent explosions may occur in dwelling houses where the practice prevails of turning off the gas at night at the main stop-cock, before all burners are turned off. On turning open the stop-cock at the meter the next morning, gas may escape at some burner left open the previous night, in considerable quantities, before the fact is discovered.

On the other hand, in unoccupied buildings, and in all buildings closed from Saturday until Monday, or on holidays—such as factories, workshops, stores, office buildings, theatres and other large establishments—the gas should always be turned off at the main after first shutting off all the burners.

In all large buildings the janitor, or the engineer or a foreman should have a proper supervision of the gas arrangements.

Never examine a gas meter with a candle-light, owing to the danger of a gas explo-

sion, unless you have ascertained beforehand that the meter itself and all its piping and connections are absolutely tight.

For the same reason it is well to be careful not to use near a gas meter tools or instruments causing flying sparks.

Never use the heat of a flame to thaw out a frozen wet gas meter. Use warm bags of sand or cloths dipped in hot water. Draw off some of the water and substitute alcohol or glycerine.

See that your gas service main from the street to the meter is protected against freezing wherever exposed, by felting or other non-conducting material. Otherwise it may happen in very cold weather that your gas flames will burn very badly, or may suddenly go out altogether, owing to the freezing of the watery vapor in the pipe. If a service pipe in the street freezes, an excavation must be made and heat applied to the earth.

In lighting gas-burners, gas-lamps, gas-stoves and gas-logs, always apply the match or the taper simultaneously with the turning of the gas key or gas valve. If the

cocks are turned on first, and the light applied after the lapse of more or less time, a puff of unburnt gas escapes, causing waste of gas and a bad smell, or in the case of gas-logs and cooking-stoves a small explosion, and sometimes more or less injury.

Never use candles to light gas, as the melting wax or tallow easily chokes up the holes or slits of the burners. Wax matches should always be avoided, and if wax tapers are used great care should be exercised. Better means of lighting gas flames are the electric and dynamic portable gas torches, or the electric gas-burners.

In using portable or desk gas-lights, connected with a fixed light or gas outlet by means of rubber tubing, always close the fixture key when turning out the light, before closing the key at the portable lamp, for otherwise the rubber tubing remaining full of gas after some use becomes saturated with gas and ill-smelling.

Never keep a gas flame turned down low in bedrooms. Many people are so sensitive to light that they cannot obtain

perfect rest where even a dim light burns in a sleeping apartment. Again, it should be borne in mind that, owing to the resulting imperfect gas combustion, the air of the bedroom must necessarily become contaminated. Moreover, there is a possibility of the pressure in the street mains becoming reduced temporarily to such an extent as to extinguish the flame. When the pressure is afterwards increased, illuminating gas would escape unburnt at the burner, exposing sleeping persons to the danger of being asphyxiated by gas. Finally, a flame turned down low is liable to be put out with a sudden puff or draught of air, the result being an escape of unburnt gas, causing possibly asphyxia or the death of persons occupying the room. Precautions in this respect are particularly necessary where water gas or a mixture of water gas and naphtha is supplied to consumers.

Ignorant people and persons unaccustomed to the use of gas often, on retiring, blow out the gas. In hotels and lodging houses this is a frequent cause of death

from the inhalation of water or coal gas. A measure of safety consists in putting up appropriate signs over all gas flames of bedrooms, warning people of the danger. Hotel proprietors should exert constant watchfulness on all bedroom floors during the night. Some recently introduced safety devices or so-called "automatic" gas burners, which shut off the gas supply automatically as soon as the gas is blown out, offer a valuable remedy.

In the older hotels, and in many lodging houses, old-fashioned fixtures are often found which have no stops on the gas-keys, and with these it frequently happens that the stop-cock is turned too far in putting out the gas-light. It also sometimes happens that the stop pin, not being durable, breaks. In both cases a dangerous escape of gas may follow. The remedy is to provide all gas keys with strong metal stop pins.

Suggestions for the Treatment of Persons Overcome by the Inhalation of Gas.

In regard to the treatment of persons

overcome with gas—either coal gas or water gas (the latter being far more dangerous)—either in the trenches when laying gas mains, or by escape of gas into bedrooms through leaky fixtures, or when the gas is "blown out," or from escape of gas into houses from breaks in street mains, the following are a few suggestions offered by prominent physicians.

Take the person at once into a place where the air is pure and cool. Don't crowd around him. Keep him on his back. Don't raise his head or turn him on his side. Loosen his clothing around the neck and remove all tight clothing. Give a little brandy and water (not more than four tablespoonfuls of brandy). Give the ammonia mixture—1 part of aromatic ammonia to 16 parts of water—in small quantities at short intervals (a teaspoonful every two or three minutes). Slap face and chest with the wet end of a towel. Apply warmth and friction if the body or limbs are cold. If the breathing is feeble or irregular, artificial respiration should be used, and kept up until there is

no doubt that it can no longer be of use. Administer oxygen.

Another physician advises giving a tablespoonful of olive oil, or of common sweet oil, where a man is able to swallow. Then give him a little milk, or some brandy, whisky, or other stimulant on hand. Loosen his garments, place him in a half reclining position so he may breathe easily, create a circulation of air by fanning, or placing him in a draught. Place a sponge with strong vinegar under his nose, wash the forehead with it, and the temples. Rub the body. Apply means for restoring respiration. When consciousness returns, wrap the person in blankets and allow free perspiration, sleep and rest.

Gas Leaks.

Gas leaks and escapes of illuminating gas may be the cause of accidents such as gas explosions or fire, besides the above-mentioned poisoning or asphyxia from gas inhalation.

Gas leaks arise either from defects in the street mains, the gas penetrating in many

cases through the soil and foundation walls, particularly in winter time; or they may be caused by imperfections in the gas meter and its connections, or in the gas pressure regulator, or in the house pipe system or, finally, they are due to bad fixtures, bad burners, or defective gas heating and cooking stoves.

In case a gas leak is discovered in a room, open at once the windows and the doors, in order to let the gas escape into the open air. Coal gas being lighter than air, the escaping gas will accumulate at the ceiling, and hence the upper sash should be let down. *Under no circumstances use any light nor search for the leak with matches.* The utmost care is to be observed in this respect, as the mixture of atmospheric air with illuminating gas in certain proportions, forms a very explosive compound, which, if brought in contact with a flame, will cause much injury and damage by gas explosion. If a burner is found to be accidently left open, or only partly turned off, the key should be at once closed. If the escape of gas is due

to a hidden leak, close the main gas cock, then locate the leak, and having found it, take at once and without delay the necessary steps to have it stopped and repaired.

Make it a rule never to allow any body to sleep in a room in which the faintest odor of illuminating gas is perceptible.

Avoid lead or composition gas-pipes which, in hidden places, are easily gnawed by rats, causing gas leaks, explosions or fire.

Precautions Against Fire.

In order to guard against all danger from fire, see that all gas-flames are at a safe distance from woodwork or inflammable material.

Where ceilings are low, and where the distance from the gas-light to the ceiling is less than three feet, provide metal or glass shields or bells as a protection, and have them hung so that they swing freely.

Enclose lights in positions exposed to drafts of air with glass globes. A draft of air may blow a gas jet as much as twelve inches sideways, and thus cause the scorch-

ing of woodwork or the blazing up of curtains, etc.

Avoid swinging gas brackets in dangerous positions, such as near doors, windows, blinds, curtains, portieres, or shelves. Rigid gas brackets are much safer and better.

Swinging bracket lights should be fitted with metal guard rings of large diameter to act as stop in preventing a gas jet from coming in contact with inflammable material.

In basements, cellars, in the servants' department of a house, particularly in the laundry, ironing room and in linen closets and in wardrobes, protect the naked gas-flames with securely fastened large, round metal wire cages, guards or screens.

Paper or cardboard reflectors on gas-lamps should be avoided. It is better and safer to use only metallic reflectors.

Where ventilating or regenerative gas-burners or "sunlights" are used, care should be taken to have the ventilating flues well constructed of metal and free from contact with woodwork.

Set the gas meter in a well ventilated

place, having, if possible, communication with the outside air.

Gas jets often blaze up from a temporary excess of pressure or from a lava tip cracking or jarring off, where a heavy weight is dropped on the floor overhead.

In lighting the gas-fixtures care should be observed in the use of matches. Parlor and wax matches are dangerous, and the use of "safety" matches, lighting by friction on specially prepared surfaces only, is recommended.

Provide metal or earthen boxes for the common kind of matches, and have also a second receptacle to receive the burnt matches. Matches, tapers or fuses should not be thrown on the floor unextinguished. The common phosphorous matches are hard to extinguish, and the practice of smokers of carelessly throwing them on the floor unextinguished is exceedingly reprehensible.

Keep matches out of reach of mice and rats, and do not leave them where they are exposed to the rays of the sun. Full boxes of matches are sometimes ignited by fric-

tion by the sliding motion of the boxes, in opening or shutting.

In large establishments the general lighting up should be made the duty of a special employee. He should either use a wax taper, or better, portable electric torches. Alcohol torches are dangerous.

The "matchless" burners may be used in halls, toilet rooms, etc., and at these places one may thus dispense with the use of matches.

Irregularities in the Gas Supply.

When householders experience trouble with the burning of gas lights, the irregularities may, in general, be looked for as being due to one or several of the following causes, viz.:

(1.) To defects in the gas fixtures and gas burners.

(2.) To defects in the house pipes between the gas meter and the gas burners.

(3). To defects in the gas meter, particularly where wet gas meters are used.

(4.) To defects in the service pipe, between the street gas main and the meter.

(5.) To defects in the system of street mains.

(6.) To defects or troubles at the gas works.

When the gas lights of neighboring houses, or of houses in the same street, show more or less the same troubles as those you experience in your house, the cause may with certainty be attributed to either (5) or (6), or to both.

If the trouble does not exist in adjoining houses, but is confined to your own house, you may be sure that it can only be due to one or more of the causes (1), (2), (3) or (4). In that case inquire and examine into the four points named to find out if one or more of these are the cause. In doing this remember that if all gas flames in your house are equally affected, the trouble must be due to causes (2), (3) or (4), and it will, in most cases, be found to be due to defect (2), usually in the house pipes between the gas meter and the first branch or to irregularities in the meter (3).

The following detailed explanations will be helpful in remedying the defects.

(*a.*) If a once satisfactory gas flame is found to be burning with inferior light, the cause is either an obstruction in the burner, or else accumulation of rust at the foot of vertical gas pipes, or the service pipes are partially choked with tar or naphthaline, or condensed watery vapor. When the gas flame is "ragged" the burner tip is partially stopped up, and the burner should be cleaned, or a new burner should be substituted. If this does not remedy the trouble, rust accumulations may be the cause. Remove these by blowing out the service pipe by means of a service force pump. If condensed gas vapor or naphthaline obstructs the pipes, remove same at the drips or siphons. The meter, if a wet one, may have too little or too much water, or in winter time, the water collected in siphons or in the meter, may be frozen, and the pipes or the meter need thawing out.

(*b.*) If a gas flame goes out suddenly, this will be found to be due either to air in the pipes, or it may be due to accumulations of condensed vapor in the house pipes. Remove the same by opening the main

drip or plug of the service main, near the gas meter, and when doing so be sure not to have any light anywhere near you.

Where a wet meter is used, and the gas goes out suddenly at all the fixtures lighted, it may be caused by a deficiency of water in the meter, or else by an excess of water. In winter time it may be due to the freezing of the gas meter, or of the service pipe from the street to the house.

Where the lights in several houses go out suddenly, the trouble is either in the street mains or at the gas works.

(*c.*) If a certain number of gas lights are burning, and upon lighting several more either on the same or on other floors, the former flames are unfavorably affected, that is, if they show a reduction in size or in brilliancy, it may be taken as an indication that the house pipe system has pipes of insufficient calibre to supply all the lights. This trouble can only be remedied by repiping the house with larger gas pipes.

(*d.*) If gas, upon being ignited at a burner, burns with a bluish flame, this is a sure indication that there is air in the house

pipes. This is liable to happen where it is made a rule—although it is a bad practice—to shut off the main gas cock over night. Air then fills the pipes through leaky joints in the pipe system, and upon again turning on the gas, air is driven out at the burners. The remedy is to search for the leaks and to make the piping and the gas-fixtures absolutely tight.

(*e.*) If one or more gas lights bob up and down or flicker, it is an indication that water has accumulated in the branch pipes supplying these lights. If all lights flicker the trouble may be looked for in the main house service pipe. The water should be removed, either at the fixture keys, or else at low places where "siphons" are provided in the distribution system.

Where a wet meter is used, this bobbing up or down is sometimes caused by there being either too much or too little water in the gas meter.

Where the gas lights, as sometimes happen, flicker in several adjoining houses, the cause is, obviously, not to be looked for in the house service, but in the street mains,

and in such a case the gas company should be notified.

(*f.*) It sometimes happens that the gas consumer cannot get sufficient pressure to supply his burners, and an insufficient illumination is the result. The trouble is usually, by laymen, attributed to the poor quality of the gas, whereas the real source of the difficulty will, in most cases, be found in

(1.) Insufficient pressure at the gas works, or

(2.) Too small or obstructed gas mains in the street, or in siphons in street mains which have become filled with water; but, if confined to a single house, the trouble is due to

(3.) Insufficient or obstructed house service pipes.

(4.) To gas meters of insufficient size or capacity, or to an obstruction in the meter.

(5.) To insufficient capacity or obstruction of the house pipes.

(6.) To obstructions in the tubing or keys of gas-fixtures.

(7.) To defective, obstructed or insufficiently large burners.

Sometimes the trouble is due to the use of bad pressure regulators, or to the use of pressure regulators in districts where the gas pressure at best is poor.

(*g.*) The roaring or hissing sound of a gas jet indicates that the trouble lies in the opposite direction, viz.: That there is too much pressure in the house pipes or at the burners, and that the consumer is paying for gas wasted.

The best results in gas illumination are always obtained when gas issues at the orifices of the burners with a slow velocity, through large burner slits or holes. This pressure of illuminating gas is measured in tenths of inches of a column of water, and the rule is that the pressure at the gas meter should not exceed six-tenths or seven-tenths of an inch; the loss in passing through the meter amounts to one-tenth to two-tenth inches, the loss through friction in the pipes, if these are properly adjusted in calibre, one-tenth of an inch, leaving a pressure of gas at the burners of four-tenths to five-tenths of an inch.

The consumer should regulate and re-

duce any excessive pressure. This may, to some extent, be accomplished either by partly closing the main stop cock at the gas meter, or by partially turning off and adjusting carefully the taps at each burner. Both methods are imperfect as far as the regulation of the pressure is concerned, because the pressure continually varies. The better remedy consists in the use of either pressure regulators, attached to the main service pipe at the house side of the meter which regulate the pressure in the pipes automatically, or, in the use of check burners, or better, volumetric governor burners.

(*h.*) If a dwelling adjoins a theatre, hall of amusement, or a large store or manufacturing establishment, where a great number of lights are kept burning, the gas jets will often jump up suddenly owing to an increase in the gas pressure caused by the sudden turning off of a large number of lights when the above establishments are closed.

For all dwellings so located, a gas governor attached to the house pipe near

the gas meter, or on every floor, will be of much usefulness.

(*i.*) The smoking of walls and ceilings can be avoided by the use of improved burners. It can also be remedied by the use of mica smoke catchers, attached to the top of globes, or of chimneys of Argand burners, or by smoke bells or shields of glass or metal, hung twelve to eighteen inches above the gas jets.

Consumption of Gas and Control and Reduction of Gas Bills.

Assuming the average burner consumption to be 5 cubic feet per hour, the cost of a single gas-light per hour, taking gas at its present price in N. Y, City and in Brooklyn, viz., $1.25 per 1,000 cubic feet, would be

$$\frac{5 \times 125}{1{,}000} = 0.625 \text{ cents.}$$

Assuming the average number of hours per year for each gas flame to be 1,500, which corresponds to the time from sunset until ten o'clock each night during the entire year, we have

$$1{,}500 \times .625 = \$9.37\frac{1}{2} \text{ cents}$$

as the average yearly cost of each gas flame.

When the gas flames are kept burning on the average from sunset until midnight, the average annual number of hours is 2,250, and therefore we have

$$2{,}250 \times .625 = \$14.06\frac{1}{4} \text{ cents}$$

as the yearly cost of each burner.

For gas jets burning constantly, day and night, such as are used in connection with ventilating gas jet burners in vent flues of water closets or toilet rooms, the annual cost of a gas flame would be approximately

$$\frac{24 \times 5 \times 1.25}{1{,}000} \times 365 = \$54.75.$$

If the burner consumes 3 and 4 instead of 5 cubic feet per hour, the cost would be reduced to $32.85 and $43.80 respectively.

The following useful Table I., compiled by a German gas engineer, gives the hours of burning gas at different seasons of the year, for the latitude of Dresden:

Table I.—Showing Number of Hours during which Gas is Burnt.

Months.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Per Year.
From sunset till 10 P. M.	186	140	139½	105	77½	60	62	93	120	155	180	201½	1,520
" " 11 P. M.....	217	168	170½	135	108½	90	93	124	150	186	210	232½	1,885
" " 12 P. M.....	218	196	201½	165	139½	120	124	155	180	217	240	263½	2,250
12 P.M. to sunrise.....	248	210	201½	165	139½	120	124	155	165	201½	225	248	2,200

Table II.

Total Consump'n in Cub. Ft. per Year.	Jan.	Feb.	Mar.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec,
1,000.....	111	92	88	71	61	52	56	68	80	95	106	117
8,827.....	**1,000**	814	773	630	541	460	491	600	700	836	936	1,033
10,833.....	1,227	**1,000**	950	772	664	566	606	737	860	1,030	1,150	1,268
11,410.....	1,292	1,053	**1,000**	814	700	595	638	776	904	1,082	1,210	1,335
14,020.....	1,588	1,294	1,228	**1,000**	860	735	784	954	1,111	1,330	1,487	1,640
16,315.....	1,848	1,506	1,430	1,164	**1,000**	851	912	1,140	1,292	1,547	1,729	1,909
19,152.....	2,170	1,770	1,678	1,367	1,174	**1,000**	1,061	1,303	1,518	1,812	2,030	2,241
17,875.....	2,025	1,650	1,566	1,275	1,096	933	**1,000**	1,217	1,425	1,700	1,900	2,090
14,692.....	1,664	1,356	1,287	1,048	909	767	822	**1,000**	1,164	1,400	1,558	1,719
12,618.....	1,430	1,164	1,106	900	774	660	760	860	**1,000**	1,200	1,338	1,477
10,540.....	1,195	973	924	751	644	550	592	717	835	**1,000**	1,118	1,233
9,429	1,068	870	826	672	578	492	527	642	747	895	**1,000**	1,103
8,546	968	789	749	609	524	446	478	581	677	810	963	**1,000**

The daily, weekly, monthly and yearly gas consumption may also be approximately calculated by recording the number of gas lights in the occupied rooms of a house and the respective hours during which they are kept burning each evening. Of course, it is necessary to know the consumption of gas at the various gas burners, and where volumetric gas burners are in use, this is an easy matter. With these data on hand, the monthly gas bill can be checked very nicely within certain limits. See the following example:

Month of Year.	Name of Room.	Number of BurnersLighted	Consumption of each Burner.	Number of hours for each Burner.	Gas consumed per day.
Ju	Kitchen,	1	3½	2	7 cub. ft.
	Dining room,	2	5	1½	15 "
	Library,	3	4	3	36 "
	Hall,	1	3	2	6 "
	Bedroom No. 1	1	4	1	4 "
	" No. 2	1	4	1	4 "
	" No. 3	1	4	1	4 "
	Bath room,	1	4	½	2 "
				Per night,	78 cub. ft.

Or $30 \times 78 = 2{,}340$ cubic feet, at \$1.25 = \$2.93, as the monthly gas bill.

It is recommended to gas consumers to keep a small book in which the gas consumption and the gas bills are regularly entered from month to month. A simple schedule for such a book is the following:

Date.	Reading of Meter.	Gas Consumption in cubic feet.	Price per 1,000 cub. ft.	Amount of gas bill.
January 1st,	8760	.....	.....	.....
January 31st,	12540	3780	\$1.25	\$4.73
February 28th,	14970	2430	1.25	3.04
March 31st,	16990	2020	1.25	2.53

Again, the consumption of the corresponding months of successive years may be compared in a summary like the following:

Month of Year.	1889.	1890.	1891.	1892.	Etc.
	Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic Feet.
January	.....	.....	.....	.....	.....
February.....	.....	... .	.....	.....	.. ..
March	.....	.....	.....	.....	.....
April, etc.....	.....	.....	.....	.....	.....

Table II. (see page 111,) is also useful in comparing the proportionate consumption of gas during the different months of one year. In this table it is assumed that the same number of gas-lights is kept burning regularly in a house during successive months, the number of hours per month varying as per Table I.

The use of Table II. will be readily understood from the following example: During the month of June the consumption of gas in a dwelling amounted to 2,700 cubic feet of gas; what will the consumption in the same house be in December, if the same number of burners are in use? Answer: The consumption in December would be—

$$2{,}700 \times \frac{2{,}241}{1{,}000} = 6{,}050 \text{ cubic feet.}$$

Or, if the consumption of gas for the month of September is equal to 3,000 cubic feet, what would be the annual consumption? Answer:

$$3{,}000 \times \frac{12{,}618}{1{,}000} = 37{,}854 \text{ cubic feet.}$$

In large establishments it is suggested to keep a *daily* record of the gas meter readings. This will not only enable one to detect wasteful use of gas and leakages, but it will also show whether the meter continues to work properly.

A foreman should be entrusted with this matter and with the keeping of a monthly gas consumption account book. This man should also have charge of the gas meter or meters, of the gas pressure regulator, and of the burners. It should also be his duty to attend to the periodical cleaning of the burners, shades, chimneys and globes, and he should renew defective and worn out burners, or broken, cracked or split lava tips.

How to Reduce High Gas Bills.

In order to reduce high gas bills the householder should endeavor to follow the hints given above.

He should above all make sure that his gas-pipes and gas-fixtures are absolutely tight and that there is no leakage and waste of gas anywhere on his premises.

He should endeavor to obtain a maximum amount of illumination with a minimum gas consumption by using only the best kind of gas-burners and the most improved forms of glass globes, with shadowless holders.

He should, moreover, use either pressure regulators or governor burners, in case of excessive gas pressure.

Finally, he should read the index of his gas meter frequently to make sure that there is no wasteful use of gas by children or servants, and also to control approximately the gas consumption.

How to Read the Index of the Gas Meter.

Every gas consumer ought to be able to read the index of his own gas meter, in order to be able to tell how much gas he consumes per month, or to veryify the monthly account rendered by the gas company, and to check at once any wasteful consumption in his household.

Different gas meters vary slightly in the arrangement of the dials. In larger meters there are four or even five dials, but those in general use for dwelling houses and stores have only three dials. Fig. 1 is an

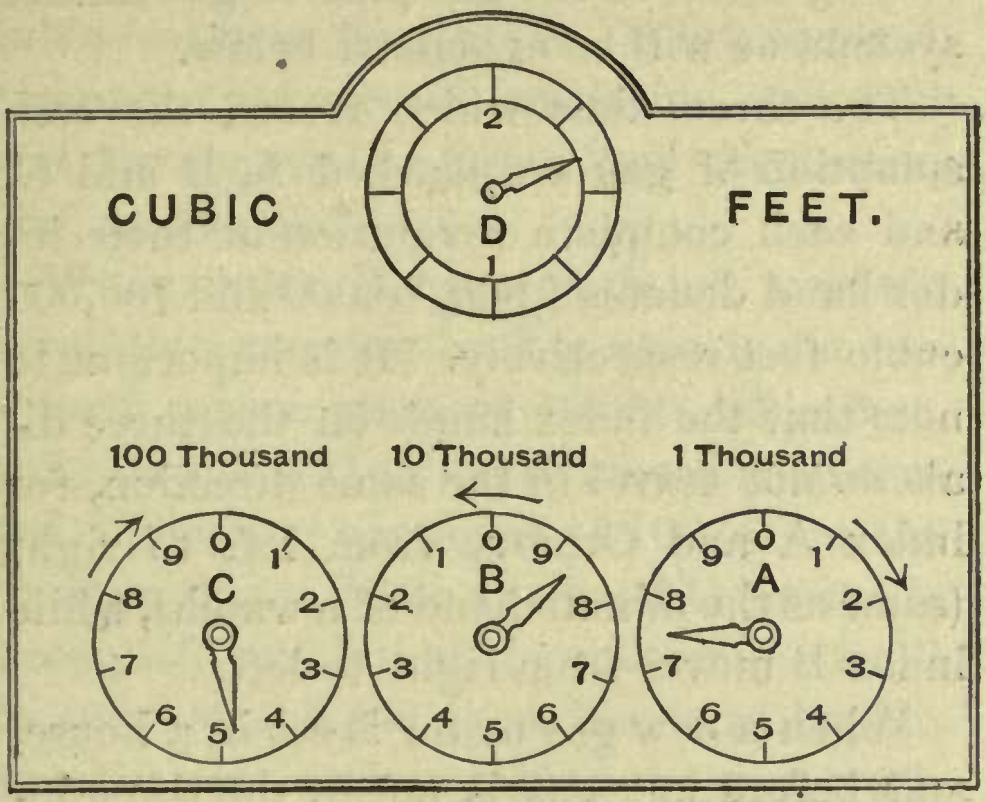


Fig. 1 Read 48,700 Cubic Feet.

illustration of the index of a dry meter as commonly used. The small index hand D at the upper dial is not taken into consideration by the meter inspector when taking his monthly record of the state of the meter. Each complete revolution of this in-

dex hand (usually a smaller one) is equivalent to a consumption of two cubic feet. This index is intended merely for testing purposes, and it is useful for ascertaining the rate of consumption of gas, or for detecting leaks in the gas pipe or gas-fixture system, as will be explained below.

The three dials which record the consumption of gas are marked A, B and C, and each complete revolution of their index hand denotes 1,000, 10,000 and 100,000 cubic feet respectively. It is important to note that the index hands on the three dials do not travel in the same direction, for index A and C move from left to right (same as the minute hand of a watch), while index B moves from right to left.

When a new gas meter is set in a house, and before any gas is burnt, the three index hands point to zero. When gas begins to pass through the meter, index A moves first toward the right. When it reaches the figure 1 it signifies that one hundred cubic feet have passed through the meter (whether consumed, wasted, or lost by leakage). As the consumption increases index

A passes successively the figures 2, 3, 4, etc., up to 9, and when it again reaches the zero point 1,000 cubic feet have passed through the meter, and index B, on the middle dial, will now stand at figure 1, denoting that one-tenth of 10,000, or 1,000 cubic feet have been used. When index A completes its second revolution, index B will have moved to figure 2 on the central dial, and so on.

When index B has completed a whole revolution, arriving back at zero, it denotes a total consumption of 10,000 cubic feet, and now index C will have moved from zero to 1, indicating one-tenth of 100,000 as the consumption. When the hand C has made a complete revolution, the consumption will be 100,000, and the three hands will again stand at zero, and in taking the next reading it is necessary to add 100,000 to the new reading of the meter.

Take, for instance, the position of the three hands as shown in Fig. 1. The reading would be 40,000+8,000+700=48,700. Suppose that after the lapse of three months the meter should indicate as in Fig. 2.

The reading, in this case, would be 60,000 + 4,000 + 900 = 64,900. Therefore, if we

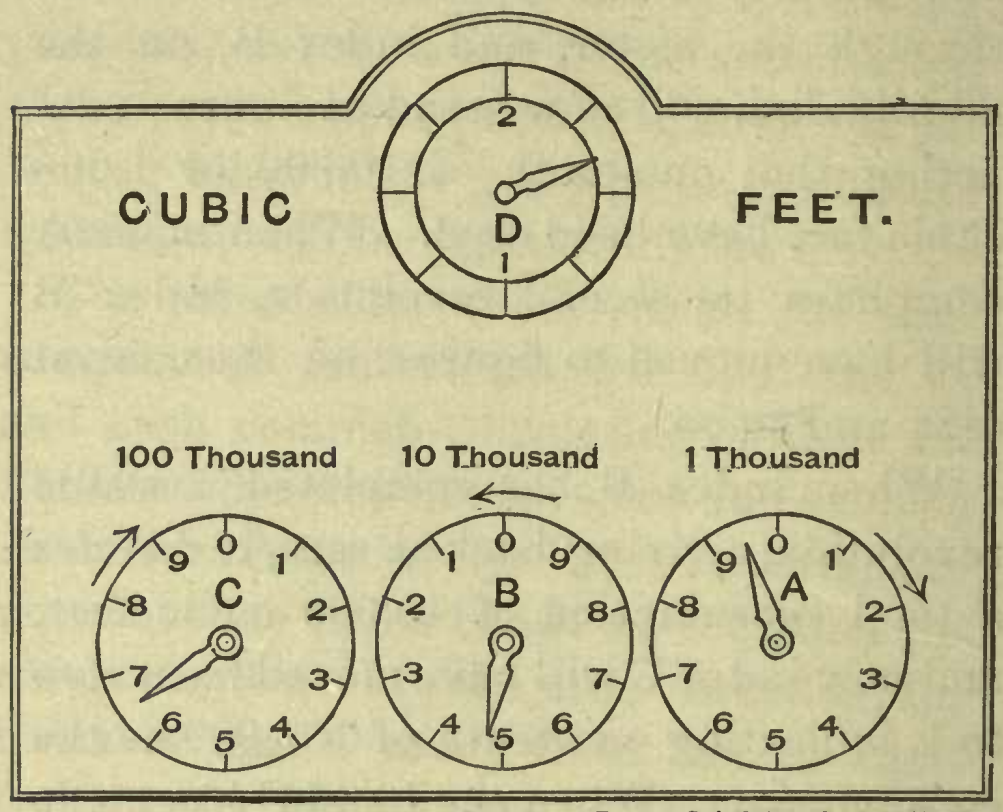


Fig. 2 Read 64,900 Cubic Feet.

subtract the second from the first reading, we have

64,900
less 48,700

= 16,200 cubic feet

as the gas consumption during the period of three months.

It will be seen from the preceding, that

ordinarily the reading of the index of a gas meter presents no difficulty. There occur, however, certain positions of the hands on the dials which to the inexperienced may be puzzling, such, for instance, as shown in Fig. 3. A person would be very apt to

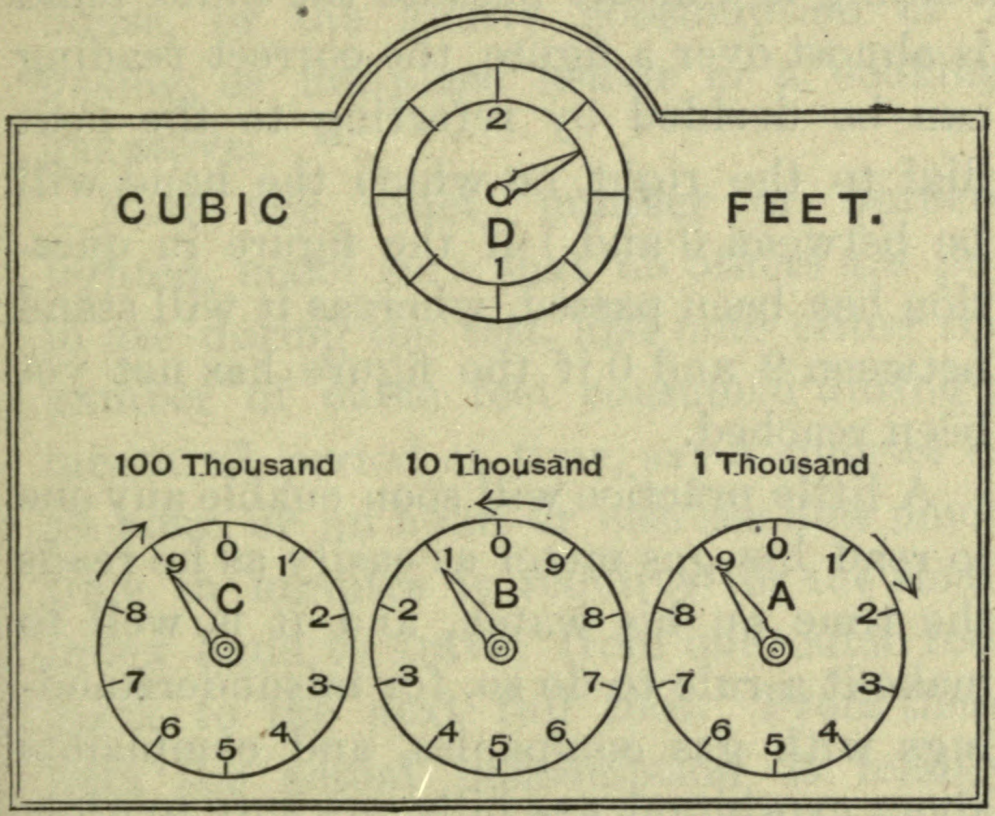


Fig. 3 Read 90,900 Cubic Feet.

make a mistake here in taking the reading down as 91,900. If this were correct, index B should stand very near to figure 2 instead of at figure 1. By referring to dial A it is evident that index B has not yet

reached figure 1, as index A stands at 9, and the correct reading is therefore 90,900.

It is easy to avoid such errors by remembering the rule to take the figure on the index which the hand has passed, and not the figure which it is approaching. If the reading is difficult because the index hand is almost over a figure, the correct reading can be decided by referring to the next dial to the right, on which the hand will be between 0 and 1 if the figure in question has been passed, whereas it will stand between 9 and 0 if the figure has not yet been reached.

A little practice will soon enable any one to read his gas meter as easily as he reads the time on his watch, and it is well to make it a rule to do so, for misunderstandings with gas companies, and complaints about exorbitant gas bills, are sure to grow less wherever the consumption of gas is ascertained and checked by the consumer at frequent intervals.

How to Ascertain the Quantity of Gas Consumed.

The small dial of the gas meter is useful for ascertaining, with a reasonable degree of accuracy, the consumption of gas from one or more burners in various parts of a house, or the hourly consumption of a gaslog, or fire-place heater or a cooking gas stove.

Note the exact number of burners lighted, make sure that no others are put in use during the test, and note either the number of cubic feet consumed during a measured period of time, say a quarter of an hour, or an hour, or else see how much time in minutes it requires for the small index hand to travel from one cubic foot mark to the next full foot. From these data the actual consumption is readily ascertained by a simple calculation.

How to Detect Gas Leaks or Escapes of Gas.

There is a very simple and effective method by which every consumer may

readily and with very little trouble ascertain whether there is any escape of gas on his premises. Make sure that none of the burner keys are open, and with the main stop cock at the meter open, notice carefully for some length of time the position of the index hand on the small upper dial of the meter index. If it moves, it is a sure indication that there is either a gas escape or a leak somewhere. By noting the time required for the index hand to travel once around the small dial, the actual quantity of gas escaping, in other words, the extent of the leak, may be ascertained with accuracy.

It is equally feasible to detect an escape of gas by the sense of hearing. Place your ear on the meter casing, and if you notice a rumbling sound, it is a sign that gas is passing through the meter and that there is a leak somewhere.

The Use of Gas for Cooking and Heating.

For many years after the invention of gas-lighting, coal gas was regarded only

as a useful medium for obtaining artificial light. But, besides serving the purpose of lighting our streets, parks and squares, and our dwellings, stores, offices, workshops and places of amusement, there are many other uses to which coal gas can be put, in dwellings as well as in workshops.

Coal gas is, beyond doubt, eminently adapted as a fuel for cooking and for heating, and gaseous fuel has more recently begun to be recognized as playing an important role in promoting domestic comfort and rendering household duties pleasant.

Cooking as well as heating by gas is rapidly extending and becoming more popular as its many advantages are becoming recognized. Moreover, each year witnesses new and successful applications of gas, such as heating laundry irons, heating water for bath purposes, not to mention an almost endless list of industrial and commercial purposes in which gaseous fuel is employed as a source of heat.

"It is only a question of time," says C. W. Siemens, the famous inventor, "when

the solid fuel will be replaced by gaseous fuel, particularly by the coal gas whereby the present enormous waste of fuel will be effectually prevented."

Indeed, it does not require a prophet to foresee that in the same manner as gas-light, although more costly, replaced the illumination by candles or by oil lamps, so will gaseous fuel in time replace the solid fuels, such as wood and coal.

It is but natural that at first many deeply rooted prejudices had to be overcome, which greatly retarded the extended application of gas as a source of heat. One serious objection to the use of gaseous fuel was the high price of the gas, but with the general and considerable reduction made recently in the price charged by gas companies, cooking and heating by gas have become more economical, and now it may be truthfully asserted at least of cooking by gas that it is cheaper than cooking with coal.

As the many merits and advantages of the new method became more widely recognized and the value of gaseous fuel more ap-

preciated, the popular prejudice that cooking and heating by gas are only adapted for the rich, was gradually overcome, until now it is sufficiently demonstrated that gas as a fuel is, on the contrary, especially adapted to the needs of small households.

For cooking with gas, small, simply constructed appliances for conveniently and quickly heating water or warming food by attaching same directly to illuminating fixtures were first brought out. Then came the cheaper forms of portable gas cooking stoves, which are plain in arrangement and may be set on the kitchen range and connected by a flexible gas tube to the nearest gas pipe. More recently elaborate, compact, convenient and more or less costly appliances have been perfected for the complete preparation of all food, and these are usually connected with the gas supply pipes in a permanent manner.

For heating by gas various appliances have likewise been devised, giving quickly an intense and direct radiant heat, suitable for warming rooms, in the shape of

gas stoves, gas radiators, gas logs and gas grate fires.

Enterprising manufacturers are now doing excellent work in getting up an endless variety of pleasing as well as useful designs of well constructed, efficient cooking and heating stoves and ranges, in which gaseous fuel, the "fuel of the future," as it is so aptly termed, is employed, in preference to the solid and liquid fuels employed in the past, such as coal, wood, peat, coke, oil, gasoline, alcohol, etc.

There have been so many improvements in these apparatus that cooking by gas will soon become common in all kitchens, while the use of gas heating stoves, or of gas grate fires and gas logs will likewise increase.

While much progress has been attained in the past, much more may be accomplished in the future, if gas companies would offer to their consumers all possible encouragement and all reasonable facilities for using gas as a fuel. Inasmuch as the use of coal gas as a source of light is at present somewhat in danger of suffering seriously by competition with

the electric light, gas companies should welcome and promote all efforts tending to increase the day use of gas. They should try to popularize the use of gas-not only by exhibitions of proper light, ing appliances, improved gas burners and gas lamps, but also by exhibiting to the public at their offices a suitable collection of gas cooking and gas heating apparatus, and enlightening the public as to the use of the same by lectures and practical demonstrations on cooking, and by distributing practical and popular pamphlets on the subject.

It is, furthermore, desirable that gas companies should encourage the use of gaseous fuel by establishing a lower price for gas consumed in cooking and heating stoves, as is already done in many cities of Europe and in a few places in the United States.

Furthermore, gas companies may increase their revenues by the renting out of gas cooking and gas heating appliances to people of small means.

With the increased use of coal gas in the household gas works would become central

stations, as it were, for the production and distribution of heat as well as light.

Owing to the cheaper price at which the non-luminous water gas can be manufactured, some have proposed to utilize it for cooking and heating purposes, but this would require a double system of gas mains in our streets, and as this obviously would add complication without opening up new uses for the coal gas employed in lighting, the proposition has been rejected as impracticable.

Of course, it is necessary, in arranging for a supply of coal gas in dwellings for cooking or warming purposes, that independent and separate lines of gas distributing pipes from those for the lighting of the premises be put in, and these lines from the house side of the gas meter to the gas heating and gas cooking appliances should be proportioned ample in size for the service which they have to perform.

The branch supply pipe to small gas ranges, gas stoves and gaslogs should not be less than one-half inch bore. A gas riser from which two gaslogs are supplied, should

be ¾ inch in diameter, and where three or more gaslogs are supplied it should be increased to 1 inch. Larger gas cooking ranges require supply pipes from ¾ to 1½ inch in size, according to the number of burners and the estimated consumption of each of these.

The same gas service pipe from the street main to the house will usually answer the purpose, but a gas meter of larger capacity generally becomes necessary. It is even better to have a separate gas meter, or at least an intermediate meter on the fuel supply line, to keep a proper control and to prevent wasteful use of gas cooking appliances, and also to ascertain by comparison with coal the cost of cooking and heating by gas.

Another caution of equal importance which should be observed is that wherever gaseous fuel is used for cooking, heating or warming bath water there should be an outlet flue provided for the complete removal of the products of combustion, and no gas stove should be considered safe without such a flue.

Finally, although gas cooking and heating appliances require a stronger pressure of gas than is best adapted for gas burners for lighting, this gas pressure should be uniform and not excessive; and in order to control same it is advisable to place on the fuel gas service pipe a good pressure regulator to maintain a constant and equable pressure in the gas supply.

Cooking by Gas.

In the majority of dwelling-houses we find gas cooking stoves used as an auxiliary means for preparing the food during hot weather, or else they are brought into use when extra meals are required.

It is a common experience that wherever servants once get used to gas cooking stoves in this way, they will thereafter prefer this method to the coal range or the oil stove.

The modern improved gas cooking ranges are so perfect in construction and equipment as to form complete substitutes for the cumbersome coal ranges. They enable the cook to perform all the numerous cooking processes, such as boiling and roast-

ing, stewing and frying, broiling, toasting and baking, and they also heat the water in the house boiler. Their efficiency is largely the result of the adaptation of, and improvements in, the atmospheric or non-luminous burner which gives little light but an intense, even and readily controlled heat. While it is true that some excellent cooking ranges are made in which the luminous flame is retained, the majority of gas cooking appliances have atmospheric or Bunsen burners adapted for cooking, and it must be conceded that the latter class of burners have the practical advantage that cooking utensils are kept more free from soot.

It would be impossible, in a general article on this interesting subject, to give a detailed description of the construction of modern gas cooking apparatus, and I must refer the reader in search of such information to the many well illustrated catalogues of the manufacturers.

Not only in private houses are gas cooking ranges found useful and convenient, they have been fitted up in large establish-

ments, such as restaurants, oyster and chop houses, club houses and hotels, in hospitals and public institutions, in prisons and military barracks, in seminaries, cooking schools, and in manufacturing establishments, and the general experience has been that they work very successfully and that the cooking is done economically.

I will briefly state a few of the principal advantages of cooking by gas.

Cooking by gas is less expensive and less troublesome than by coal or wood, oil or gasoline, and it is more healthful on account of the absence of waste heat, of smoke, dust and smell.

A gas cooking range is always ready for use, even at unusual hours. There is no loss of time in starting the kitchen fire. No carrying of coal and kindling wood is necessary, because gaseous fuel is readily conveyed in small, tight pipes to any place in the house where wanted, and is at once ready for use.

The gas range is instantly lighted by applying a match to the burner; there is no waiting for the fire to burn up briskly

or the oven to get hot; no delay of any kind; the fire when lighted is at once capable of doing its full work, any degree of heat can be almost instantly had and the flame is just as quickly extinguished when the work of the cook is done and fire is not wanted, and from this moment all consumption of fuel ceases.

Any food wanted in case of emergency, or for a large party can be gotten ready in a short time at all hours of the day or night, and no extra fire need be maintained for such exceptional cases.

A gas range is more easily kept clean than a coal range. No poking of the fire, no cleaning and shaking of the grate, no knocking off of clinkers is required. There is no dirt, no smoke, no soot, and no carrying away of ashes.

Gas ranges are, for all these reasons, a source of great comfort and convenience to the housewife, and a saving of labor to the domestic or the cook. In the absence of servants the cooking can be performed by the housewife without much trouble or discomfort.

A gas cooking range is better and more easily controlled and regulated than a coal range, and the cooking is performed quicker. The combustion in the gas range is perfect, the heat of the fire is even and uniform, and can be adjusted perfectly and at will. The fire needs no constant watching or frequent looking after and replenishing, and it is, of course, perfectly safe as regards danger from fire.

Above all, there is no discomfort in summer time from the overheating of the kitchen due to a coal range. When a fire is not wanted, it is at once put out by the simple turning of the gas key or valve. The exact consumption of fuel is recorded by the gas meter, and any useless waste can be readily checked. Hence, if properly managed, there is in a gas range absolutely no waste of fuel as in the case of coal or wood kitchen ranges, while the room remains cool and comfortable, because as soon as the gas is shut off there is no further radiation of heat.

Moreover, food cooked on gas ranges becomes more palatable and nutritious. there

is less loss of weight, and the meats and roasts remain more juicy, while all cooking operations are performed more quickly.

Cooking by gas also requires no storage or handling of solid or liquid fuel.

Again, gas cooking ranges are simple in construction and very durable and require few if any repairs, and the expensive and annoying frequent relining of the fire pot with fire bricks, as in coal ranges, is done away with.

Compared with oil cooking ranges, gas ranges are far superior in management. There is no handling of the oil fuel, no filling of oil reservoirs, with its incidental bad smell, soiling of hands and danger from fire. There is, furthermore, no adjustment or trimming of wicks, no oil smoke and no disagreeable odor.

It is, moreover, true that in a given space one can do more work on a gas range than on a coal range of corresponding size, and finally it may be worth while to mention that where the larger sizes of gas ranges are installed, these are always so arranged that each burner can be lighted separately, thus

enabling the cook to prepare food on one and the same apparatus economically, for a few as well as for a great many persons.

It follows from the above that the use of gas in the preparation of the dishes is valuable to rich and poor alike, and if gas is only carefully used, cooking by gas will be found quite as economical in the case of small households as it has proven to be in large institutions.

It remains to discuss a few objections often heard against the new method of cooking by gaseous fuel.

One objection to gas cooking appliances often made by householders is that, in winter time the kitchen is not heated, because in the construction of the better class of gas ranges every precaution is taken to prevent undue loss of heat by radiation. This objection is readily met in steam heated dwellings and apartment houses by providing a steam radiator in the kitchen, and where steam is not available for heating, a small gas stove may be put up alongside of the gas range, or sometimes a gas grate is

combined for this purpose with the gas range.

To meet a second objection sometimes raised, viz., that in using gas ranges we must do away with the convenient hot water boiler, a water heating attachment with separate gas burners has been devised which may be connected with the gas cooking range, or else fitted up separately. A somewhat different apparatus, the instantaneous water heater, with gas fire, may be used instead in the kitchen, bathroom or the housemaid's closet, and offers the advantage that hot water may be had almost instantly without lighting up the kitchen fire. To provide for hot dinner plates, simple gas plate warmers, or hot ovens, with gas burners are obtainable, which may be fitted up either in the kitchen or in the pantry.

A third objection, often heard and made by persons inexperienced and not accustomed to cooking by gas, is that viands so cooked acquire a certain objectionable taste of gas. This statement, is not, however, founded on facts. On the contrary, scientific cooking experiments have demonstrat-

ed that the quality of cooking is rather improved, and that there is less loss in weight of the prepared food.

Enough has, I believe, been said to show that the advantages and conveniences of a gas cooking range are so many as to render it obviously desirable that every household should be provided with this modern appliance, and no kitchen can be considered fully equipped without at least one of the smaller portable gas cooking stoves. Those who have had experience in this extremely useful application of gas will be able to confirm these statements, and the comforts and convenience of cooking by gas will be thoroughly appreciated by them.

Heating by Gas.

The method of warming apartments by the combustion of coal gas as fuel is of comparatively recent origin. Gas as fuel has not been utilized to any large extent, its application having been generally confined to the heating of single rooms. Very few attempts have been made to heat entire

buildings with gas. One reason for this is that, unlike cooking by gas, a gas fire is not as cheap as a coal fire when kept constantly going. In other respects, heating with gaseous fuel is just as effective and quick as cooking with gas, and for heating smaller apartments, or rooms where heat is only occasionally wanted, and then only for brief periods of time, it is well adapted and offers many advantages. For instance, to heat bed-rooms, bath-rooms or dressing-rooms and nurseries, a gas fire is preferable to other modes of warming and fully as economical in use.

Heating with coal gas is effected by means of fire place gaslogs made of metal or terracotta and asbestos; by asbestos incandescent grate fires; by gas-stoves with brightly polished corrugated copper reflectors and by gas radiators. Quite recently a warm-air furnace has been devised with coal gas or natural gas as a source of heat instead of the usual coal fire pot.

Heating by gas is, without doubt, destined to come into more general use as

the advantages of the method are becoming recognized.

It may be used, on very cold winter days, as a supplementary source of heat in houses heated by stoves or by furnaces. Again the gas fire may be utilized as a substitute for the regular heating apparatus in a house in the spring or in the autumn, when the fire in the furnace or steam boiler has not yet been started.

A gas fire is frequently of use as an auxiliary heater to counteract the chilling effects of very large window surfaces. It is largely employed as the only means of heating smaller bedrooms, guest rooms, bathrooms, rooms in hotels, or other rooms not constantly occupied. Gas fires and gas stoves are now much used, particularly in Germany, for the heating of church buildings, and of guests rooms in hotels which do not require a continuous heat.

Very often portable gas stoves are put up to heat rooms in which a stove cannot be set because no chimney flue is available. But this practice cannot be recommended on sanitary grounds, because under all cir-

cumstances the removal of the unhealthful products of combustion must be attended to. It is equally obvious that where there is a smoky chimney flue, or a flue with constant down draught, or a flue in any way defective, gas stoves or gas fires cannot be successfully used.

In briefly enumerating the advantages of heating by gas, a repetition of much that has been said in reference to cooking by gas cannot well be avoided.

First, all types of gas heaters have the advantage of not requiring a large annual outlay in advance for the purchase of coal and wood, and of not requiring the space for the storage of such fuel in the cellar. The user of gas for warming purposes finds the fuel conveyed or "laid on" to his house, ready for immediate use by the lighting of a match or torch or wax taper, and the gaseous fuel is sold to him on a thirty days' credit, the gas bills being usually rendered at the end of each month.

All gas stoves or heaters save much work to the servants of the household, and thereby simplify to some extent the servant girl

question. Here, as with the gas cooking range, there is no filling of coal scuttles, no carrying of coal or wood up stairs, and no carrying away of coal or wood ashes. Gas fires require no servants or attendants, no troublesome lighting of the fire, no delay or waste of time until the fire burns briskly, no watching of the fire, no poking or shaking of the grate, no putting on of new fuel. There is no smoke, no soot and no dust, no fenders or pokers to be polished, no chimney flues to be swept.

The lighting of the fire is conveniently and quickly done, a glowing fire is obtained almost instantly, the heat is easily controlled, and can be increased or diminished to suit the conditions of the weather by the mere turning of a gas shut off valve. The consumption of fuel is under full control, and useless waste may be checked by frequently reading the gas meter.

The fire can be instantly put out when not wanted, and all waste of fuel, as in the case of coal fires, is thus avoided.

All gas fires are clean and smokeless. If provided with outlet flue and connection to

a chimney they are without odor, and there is considerably less danger from fire than with other heating apparatus.

If gaseous fuel would be universally adopted for heating instead of the solid fuel, the smoke nuisance in large cities could be almost abolished.

It is, therefore, obvious that gas as a source of heat is destined to come into much more general use, and it is safe to assert that, if gas stoves or gas grate fires are applied with discrimination and used with a reasonable degree of intelligence and care, they will in practice be found to be economical, and the many other advantages enumerated may often be taken as counterbalancing the slight increase in the cost of the gaseous fuel over the price of coal or wood.

In a recent publication on "Gas as Fuel in the Household" an experienced gas engineer has given the following comparisons between the new method of cooking and heating by gaseous fuel (coal gas or natural gas) and the old method in which other

fuel materials (such as coal, wood, oil, gasolene are employed).

Although some of his remarks and criticisms do not apply to American conditions of household management, his summary as a whole is interesting and instructive.

Procuring the Fuel.—The inspection, selection and purchase of the fuel for the household at places of sale, which are often located at an inconvenient distance, and can only be visited during business hours, is done away with entirely, because the gaseous fuel is ever ready in the gas service pipes for immediate use at all hours of the day as well as during the night.

The troublesome and annoying negotiations regarding the price of coal or wood, which fluctuates according to market rates, according to season, and according to quantity and quality of the material to be bought, drops out, because price and quality of gas is regulated and fixed generally for a number of years in advance, sometimes by contract agreement and oftener by act of legislature.

All contract agreements as to the man-

ner of delivering and breaking up the fuel material, taking same into the cellar bins, etc., are rendered unnecessary because gas, as delivered by gas companies, is always ready for immediate use in the gas cooking and heating appliances.

The control and inspection of the coal or wood fuel, while it is being broken up or cut to the size required, or while it is weighed, delivered and carried into the cellar and stored in the various bins is done away, because the consumers of gaseous fuel are simply charged the quantity of gas actually consumed as recorded by the monthly readings of the index of the gas meter.

All insurance against fire, by spontaneous combustion or otherwise, of the fuel stored in the cellar, is done away with because gaseous fuel cannot become ignited in the pipes.

Securing the fuel from being stolen (as in cellars of apartment houses) is rendered unnecessary because gas cannot be readily carried away.

The daily trips to the cellar to take up-

stairs the quantity of fuel needed, and carrying same in coal scuttles to the kitchen range, the laundry range, the stoves and fireplaces, are rendered entirely unnecessary, because the gaseous fuel is carried in tight service pipes of ample size to all the places where it is burnt, and because gas is ready and forever available in any desired volume, as soon as the gas service pipe is connected with the street main.

All risks to workmen while loading the coal or wood trucks, all interruption of public traffic in carting the materials through streets with steep grades, or at street intersections, all perils to pedestrians from open coal shutes in the sidewalk, all danger from open cellar gratings, and all danger of fire in dwelling houses from the storage of coal, oil or gasoline is done away with, because the gasworks where an inexhaustible supply of gaseous fuel is produced are brought into direct communication with the houses of the consumers through the network of underground tight gas mains, and because the only operation necessary to make gaseous fuel available,

consists in merely turning a small tap provided at the gas-cooking range, at the gas logs and fireplace heaters and at gas stoves of all descriptions.

The unavoidable loss of coal or wood during loading, carting, unloading and storing, and the waste of fuel as occuring in coal ranges, with clinkers and ashes, is avoided where gaseous fuel is used, because even the smallest quantity of gas can be immediately lighted and is always entirely consumed.

The loss of one or several months' interest on the sum invested in the purchase of the supply of fuel is avoided, because gas bills are rendered monthly and the gas consumed is not to be paid for in advance.

The extra fees for laborers hired for breaking up the fuel to the size required, or for cutting and sawing wood, or for putting the fuel into the cellar bins is done away with where gaseous fuel is used, because the price to be paid for gas consumed refers to the finished product of the gas works as delivered through the gas service pipes into the dwellings of the consumers.

All incidental expenses, such as rent of cellar for storage of fuel, and premium for insurance against fire, fall out because for gaseous fuel no cellar or storage place and no insurance are needed.

Application of the Fuel.—The loss in the kitchen of valuable space required for the cooking ranges, which are often large and cumbersome, is avoided where gas cooking ranges are used, because even the most complete gas ranges are somewhat smaller, and because the smaller sizes suitable for the cooking of a small household can be placed almost anywhere on any kind of support.

With coal or wood ranges, the lighting and getting ready of the fire is troublesome and consumes much time; the filling and lighting of oil or gasoline ranges may become dangerous owing to the easily explosive character of the liquid fuel, whereas the gas in gas ranges can be readily and safely lighted by the application of a match to one or more of the burners, and the lighting is rendered equally easy by the

pilot lights for the gas ovens and gas broilers.

While the management and control of a coal fire in the ordinary kitchen range is troublesome, on account of the necessity of frequent lifting of covers to put fresh fuel into the fire pot, on account of escape of unhealthy gases, and the incidental unavoidable loss of heat, the gas burners of a gas cooking range give their full heat effect almost from the instant when the gas is lighted, and the control of the heat is easy because the size of the gas flame can be regulated to a nicety simply by the turning of the gas cock or gas valve.

In the coal range we have a continual setting away and moving of the cooking vessels to prevent the overflowing of boiling liquids and the burning of thick dishes, whereas in the gas cooking range the intensity of the heat of each separate burner flame can be instantly adjusted and regulated according to the amount of heat which the dishes may require.

On a coal range the preparation of a larger meal occasionally required for visit-

ors or for dinner parties, demands difficult and troublesome preliminaries, whereas in a gas range a larger number of gas burners can be lighted as occasion may require, each burner being separate and controlled by its own independent gas shut off.

As regards the finishing up of the family washing, the maintenance of a large fire in the kitchen range or in a separate laundry range for ironing purposes only, is expensive and wasteful of fuel, and where ironing is done in a room separate from the kitchen, and where there is no separate laundry stove, the exchange of sadirons is troublesome and involves loss of time, whereas where gaseous fuel is used to heat sadirons, these are directly heated by the steady gas flame conveniently placed in the laundry where required, and can be exchanged without loss of time.

Dishes often acquire a disagreeable taste from the smoke of a coal or wood range. Heating rooms where no chimney flue is available to take away the smoke from the burning coal or wood is difficult to accomplish. Curtains are rendered dirty by the

smoke from a grate fire; furniture, draperies, pictures and gilt picture frames are quickly destroyed. The breathing organs become affected by the continuous cloud of smoke from stoves, fireplaces, ranges and furnaces of your own and neighboring houses, but all this is obviated where gaseous fuel is used, because this does not produce smoke or soot during its combustion, particularly where non-luminous atmospheric burners are used.

The quantity of solid fuel, coal and wood needed for heating and cooking, cannot often be accurately determined beforehand, because unforeseen circumstances, such as unusually mild or very severe winter weather may arise, but where gaseous fuel is used the required volume of gas can be readily computed, and it is always controlled by the simple reading of the gas meter.

In houses or apartments fitted up with coal ranges and with coal grate fires or stoves, the services of a servant girl are indispensable for cooking, ironing and attending to the fires, and all this work is

performed slowly and requires much time, and on account of the trouble involved the housewife cannot devote herself so well to her other duties, especially to the care and education of the children, which should be the highest aim of every family, whereas in using gas as a fuel every one of the operations named requires only about one half of the time, which is usually necessary. All annoyances are done away with, owing to the cleanly, sure and effective method of regulating the fires. The preparation of savory and nutritious meals become a pleasure, and not as heretofore a burden, interest in cooking is awakened or promoted, while at the same time the housewife is enabled to devote her time not only to the household but to the family and children as well.

SPECIFICATION FOR GAS PIPING.

General Conditions.—The gas fitting work must conform to the general rules

and regulations of the gas company supplying the district in which the building is located, with gas.

The plumber is to notify the gas company and is to obtain a proper and large gas service pipe, of ample capacity to supply all present and future gas outlets, run by the company into the cellar of the building.

The supply pipe leading from the street main shall be provided with a stop valve placed in the sidewalk near the curb, so arranged that the gas may be turned off at this point from the building.

The gas company will furnish and set the gas meter, which is to be located in cellar where directed. The meter to be placed where it will be convenient for the consumer to turn off the gas, and for the meter inspector to read the index, or the employees of the gas company to put meter in order when repairs are required.

In no case shall the gas meter be set where it will be exposed to damp or frost, or liable to injury from any cause.

The gas company shall make the connec-

tions of the meter with the street service and with the house pipe.

The plumbing contractor shall pipe the whole building for gas in the most approved manner, and all his work must be in strict accordance with the following detailed specifications. The whole piping is to be completed before plastering is commenced.

The contractor shall be responsible for all his work and material, and shall replace without extra charge any thereof which may have become stolen, damaged, broken or otherwise found deficient.

He is to clean out all pipes which may be found stopped up, and he shall deliver the entire gas piping work throughout in good order, whole, clean and perfect, and guarantee the entire work and all its parts, and keep same in repair for the period of one year from the date of the final certificate.

Pipes.—Best quality wrought iron welded gas pipe of sizes to conform to the scale given below shall be used. All pipe up to 1 inch diameter to be butt welded, larger

pipes to be lap welded. All pipe to be free from splits, flaws or other defects, and to be of a true and uniform section. All pipe must be tested at the mills by hydrostatic pressure.

[State if pipe is to be of plain wrought iron, or galvanized, or made rustless by the Bower-Barff process.]

Fittings.—All fittings, such as sockets, elbows, bends, tees, crosses, reducers, etc., under two inches diameter shall be extra heavy malleable iron fittings; fittings of larger diameter to be cast iron fittings.

[State if fittings are to be plain, or galvanized or Bower-Barffed.]

The use of galvanized malleable iron fittings is recommended, the coating of zinc if properly applied effectually covering up all blowholes, and thereby avoiding the temptation of using the perishable gas-fitter's cement.

Joints.—All piping and fittings are to be put together with screw joints and red lead, or red and white lead mixed. All joints are to be made perfectly gastight. The use of gas-fitters' cement in the making of

pipe joints will not, under any circumstances, be permitted. Care to be taken not to put too much white or red lead in the fitting or on the pipe which, when pipes are screwed together, might obstruct the clear bore of same.

Valves and Stopcocks.—In smaller buildings use brass lever handle stopcocks to shut off gas at meter. In larger buildings use full way brass finished stop valves on all rising lines and on each floor to control and shut off separately the flow of gas to the various floors and to the separate wings of the building.

Sizes of Pipes.—All rising and distributing pipes and all branches to bracket and centre-lights, shall be of ample and sufficient size to supply the total number of burners indicated on plans.

In determining the sizes of pipes do not confound outlets and number of lights. The pipe should correspond to the greatest number of lights or burners it supplies irrespective of the number of outlets.

No pipe shall be less than ⅜ inches in diameter, and this size shall be used only

for not more than one or two bracket-lights. No pipe for chandeliers shall be less than ½ inch inside diameter up to four burners, and it shall be at least ¾ inch in diameter for all chandeliers with more than four burners.

The gas-fitter shall proportion the sizes of risers, distributing lines and service branches by the following scale for gas piping, which scale calls for piping slightly larger than that ordinarily put in.

TABLE.

Size of Pipe.	Greatest Length Allowed.	Greatest Number of Burners to be Supplied.
⅜ inch	20 feet	2
½ "	30 "	4
¾ "	50 "	15
1 "	70 "	25
1¼ "	100 "	40
1½ "	150 "	70
2 "	200 "	140
2½ "	300 "	225
3 "	400 "	300
4 "	500 "	500

Main Pipe and Risers.—Run main iron service pipe exposed at cellar ceiling wherever best or where directed, and put up as many gas risers as may be necessary for the proper distribution of gas piping in the building. Risers shall not be run along outside or exposed walls. If this cannot be avoided the pipes shall be protected with some approved non-conducting covering.

Outlets.—Provide all outlets for gas where shown on gas-fitter's plans. The foreman gas-fitter must verify the exact position of all outlets for brackets, mirror and center lights.

Note.—Here insert a detailed list of outlets to be provided in each room, also a list of burners at each outlet, and give key explaining the different marks used on plans showing location of outlets.

Location and Manner of Running Distribution Pipes.—All main risers are to be carried exposed, wherever practicable, and where concealed in wall recesses or in stud partitions they should preferably be rendered accessible. All other service and

distribution pipes are to be carried in walls and partitions and between floor beams.

No gas pipes are on any account to be placed at the bottom of floor beams which are to be lathed and plastered, where they would be inaccessible in case of leaks or alterations. All piping is, as far as practicable, to be laid so as to be got at in case of repairs.

Where gas pipes under floors run across wooden beams, the latter are to be cut, notched or bored, at no greater distance than two feet from their bearings, and on no account shall pipes be let into the beams more than two inches in depth. All the cutting which the gas-fitter needs shall be done for him by the carpenter.

Running lines shall not be placed under tiled or parquet floors, under marble platforms or under hearth stones, where this can be avoided. Wherever practicable the running lines shall be kept accessible by screwing down the floor boards over the gas pipe with brass screws.

Drop-lights must in all cases be supplied

from special branches taken from the running lines.

All pipes shall be run as direct as possible, and with a true grade and fall toward the rising lines and the gas meter (or the gas generator where the house is supplied with an air gas machine), so as to prevent the accumulation of condensed vapor or water and consequent trapping.

The inclination of the pipe to be determined by the use of a spirit level, and all sags in the pipe to be done away with.

Where needed special drip-pipes, closed tightly with screw plugs, must be provided. Long runs of horizontal distribution pipes are to be firmly and strongly supported, at short intervals so as to prevent the pipe sagging in the centre and becoming trapped by water from condensation.

Outlets, Bracket Pipes and Drops.—All branch outlet pipes shall be taken from the sides or tops of running lines, never directly from below. Bracket lines shall always run up from below, and must not

be dropped from overhead except in the cellar or lowest floor of a building. Drop-lights shall have branches taken from the side or top of the pipe, never from the bottom of a running line.

The foreman gas-fitter must pay particular attention to these requirements, and must constantly bear in mind that the whole pipe system shall be free from any low places or traps, and that every pipe in the building shall be so inclined that all condensation will flow back to the rising pipe or pipes and thence to the gas meter or the gas generator.

Before any pipe is put into position, it should be blown and looked into as a precaution against obstructions.

Method of Fastening Outlet Pipes.—All outlet pipes shall be securely and rigidly fastened in position with gas-fitter's hooks, galvanized iron straps or holdfasts secured with screws, so that there will be no possibility of any portion of the pipe settling and forming traps, or of the pipes moving when the gas fixtures are attached.

Centre pipes shall rest on solid supports

or cleats fastened to the floor beams near their top. The pipes shall be securely fastened to the support in such a manner as to prevent any lateral movement.

All drop-pipes shall be perfectly plumb and shall pass through a guide fastened near the bottom of the floor-beams, in order to be well stayed at both top and bottom of floor joists.

Height of Bracket or Side lights.—Outlets for bracket lights shall be placed 5′ 6″ high from finished floor in rooms, 6′ 6″ high in halls, and 6′ 0″ in bathrooms, unless otherwise directed. Mirror light outlets shall be 8′ 0″ above finished floor, except where such lights are to be droplights.

Length of Nipples and of Drops.—All upright branches shall be plumb and the nipples projecting from walls or partitions shall be perfectly level or perpendicular to the wall from which they project. All nipples shall be of the exact length for putting on fixtures, and shall project not more than ¾-inch from the face of the plastering.

Outlets which come in connection with

any cabinet work are to be made temporary, and must be brought to their exact position at such time as the cabinet work is put up.

Drop centre pipes shall project 1½ inches below the furrings where no stucco or centre pieces are used. Where the latter are used the drop shall be left about one foot below the furring. All drops must be exactly perpendicular.

Pressure Test and Inspection.—When piping is completed, and before plastering is commenced, all gas outlets shall be tightly capped and the whole system of gas piping shall be tested by a low pressure spring gauge or better, a mercury gauge and forcepump, and proved to be air and gas tight under a pressure of air that will raise the column of mercury eighteen inches in the glass tube, equal to about 9 lbs. pressure per square inch. The system of piping shall remain under test at least one hour, and any leaks indicated by the falling of the mercury in the glass gauge must be at once repaired and made good, and the test repeated until all leaks have

been repaired and the whole made absolutely and perfectly gas tight.

No split pipe or broken or defective fitting repaired with gas-fitter's cement or with solder will be permitted.

In the stopping of leaks at joints, or of sand holes in fittings, the use of gas-fitter's cement will not be permitted, for when cold it is liable to crack off, and when near hot air flues or steam pipes it is liable to melt.

When the pressure test has proved the system to be tight, the caps should be removed from the gas outlets in different parts of the building, to observe if the whole of the system has been under pressure. This test will at the same time reveal if all pipes and branches are clean and free from obstruction.

After the test, all outlets are to be left capped and tight at the completion of the work.

When running extra outlets or making changes in new buildings after the original work is completed and tested, the gas-fitter shall again put on the gauge and

test the altered work in the same manner as above described.

Gas Fixtures.—It is understood that the gas fixtures are not to be furnished by the party contracting for the gas piping.

Test of Piping to be Repeated before the Fixtures are hung.—Before the gas fixtures are hung or put up, the gas-fitter shall repeat the air pressure test in the presence of the owner or the contractor for the gas fixtures, and shall demonstrate to their satisfaction that the whole gas piping is absolutely tight.

The gas-fitter shall do this for his own protection so that when the gas is turned on at the fixtures and any escape of gas is subsequently noticed, it is obvious that the leak is at the fixture joint for which the gas fixture man and not the gas-fitter shall be solely held responsible.

Gaslogs and Gas Fire Place Heaters.—Where fire places are to be fitted with gaslogs or gas grates separate rising lines not less than three-quarter inches in size are to be run for same from the cellar upward.

For each gaslog provide a half-inch

branch gas supply with plated wheel-handle valve placed in floor where directed.

Gas Cooking Range.—Where gas cooking ranges are to be fitted up provide a a separate service pipe of sufficient size (at least three-quarters of an inch for small gas cooking stoves and from one to one and one-half inches in diameter for the large gas cooking ranges). Provide in kitchen a gas outlet for gas range, about two feet from floor, properly capped.

Gas Heating Stoves, Gas Plate Warmers, Instantaneous Water Heaters, etc.—Where rooms are to be heated by gas stoves, or where gas plate warmers or gas water heaters are to be set up, provide separate service pipes of ample size, and provide outlets where wanted, and leave same properly capped.

Gas Main for Cooking or Heating.—The rising lines for gaslogs, gas stoves, gas ranges or gas plate warmers may be connected together in the cellar into a large main, of sufficient size, determined by the hourly consumption of the gas appliances

to be fitted up. This main must begin at the gas meter and shall be arranged with separate shut off or gate valve.

MUNICIPAL RULES AND REGULATIONS REGARDING GAS PIPING AND GAS FITTING IN THE CITY OF MUNICH, GERMANY.

Obligations of Gas-fitters.—All persons carrying on the trade of gasfitting must be licensed, and must give a bond to the city for the faithful performance of all their work, in accordance with the rules and regulations given below. No person will be permitted to do gas piping or fitting without having obtained such a license.

Rights of Gas-fitters.—Gas-fitters may undertake the furnishing and constructing of all new gas piping, including gas-fixtures, and also the alteration or extension of existing gas pipe and gas-fixture systems, whether for lighting, cooking, heating or other purposes.

The furnishing and laying of the gas service pipes from the street mains to the gas meters, the furnishing and putting in of main shut off cocks or valves on the services, the fitting up of main as well as intermediate gas meters, and the connection between the gas meters and the service and house pipes by licensed gas-fitters will not be permitted. This work shall be done by the gas company. Gas-fitters and house owners are also prohibited from disconnecting gas meters and service pipes, which work shall only be performed by the gas company.

Rights of the Gas Company.—The laying of gas services, by which term are designated those pipes which convey the unmeasured gas from the street mains to the main gas meter, and the putting in of all main shutoffs on the services can only be done by the gas company, who also furnishes the necessary materials and fittings for this work.

The owner of a building must notify the gas company in writing whenever he wishes such work done.

The owner may obtain the main gas meter and all needed intermediate meters, either from the gas company or from gas-fitters, but in the latter instance the gas company shall have a right to have such gas meters as are furnished by gas fitters, tested by the official meter inspector and examined as to their construction and durability. The gas company shall have the right to condemn all gas meters which the written report of the inspector declares to be for any reason unfit or unsatisfactory.

Owners must pay the gas company for all work performed and material furnished in the laying of service pipes and fitting up of gas meters.

Gas Meters.—Only such gas meters, which have been examined and tested by the official meter inspector and provided with his official seal, are permitted to be used.

The size or capacity of the gas meters depends upon the number of lights which they are to supply, or upon the consumption of gas, corresponding to the number of

lights, including all outlets for gas cooking and heating appliances.

The largest number of lights which can be supplied from a gas meter of a certain capacity is given in the following table:

TABLE I.

Size of Meter.	Number of Lights Supplied	With a Total Consumption per hour of.
3 lights.	4 lights.	21,2 cubic feet.
5 "	6 "	31,8 " "
10 "	12 "	63,6 " "
20 "	24 "	127,2 " "
30 "	36 "	190,8 " "
40 "	48 "	254,4 " "
60 "	72 "	381,6 " "
80 "	96 "	508,8 " "
100 "	120 "	636,0 " "
150 "	180 "	954,0 " "
200 "	240 "	1272,0 " "

Where still larger sizes of gas meters are required, the municipal department determines the size of the gas meter, basing the calculation upon a minimum consumption of five cubic feet per hour for each light.

Wherever new buildings are piped for gas, and it is contemplated to use temporarily only a part of the lights or of the pipe system, the owner may apply for a temporary gas meter of smaller capacity sufficient to supply the number of temporary lights, but in all such cases the gas piping or gas service shall conform in size to the requirements of the whole building.

All gas meters must be protected by the owner from damage of any kind and must be kept in a good condition.

All main gas meters and shutoffs shall be placed and fitted up in an easily accessible, well lighted position near the front wall of the house and at the point of entrance of the main gas service.

All intermediate gas meters shall be so placed as to be easily accessible, and where they cannot be set directly upon the floor, the bottom of the meter shall not be elevated more than eight feet from the floor.

Wherever this appears impracticable, or where the gas company and the gas-fitter or the owner cannot agree as to the best

position for the meter, the same shall be decided by the municipal department.

Gas meters shall not be placed in rooms which cannot be entered with an open light, or where explosive substances are stored or manufactured.

Gas Piping in Buildings.—All gas pipes inside of buildings shall be wrought iron pipes and must be put together in an absolutely tight manner.

Lead pipes can only be used when approved in writing by the municipality. Rubber tubing will only be permitted for single portable lights or for connections with portable gas cooking or heating appliances. The metal pipes to which the rubber flexible tubing is connected must be provided with a tight shutoff cock.

The inside diameters of the gas service pipe, of the inlet and outlet supply pipes at gas meters, of the inlet and outlet couplings of gas meters, and of the gas distributing pipes in all buildings shall be determined according to the number of lights to be supplied, by the following table of pipe sizes:

Table II.

Length of Gas-pipe in Meters (approx. yards).	⅜ inch =9,5mm.	½ inch =12,5mm.	⅝ inch =16mm.	¾ inch =19mm.	1 inch =25,5mm.	1¼ inch =32mm.	1½ inch =38mm.	2 inch =51mm.
2	3	10	18	30	60	120	180	400
4	3	8	16	25	50	100	150	320
6	2	6	13	20	40	80	120	260
8	2	5	10	15	32	64	100	220
10	1	4	8	13	25	50	80	180
15	1	3	5	9	20	40	60	155
20	....	2	5	8	17	35	55	132
25	....	1	4	7	15	30	50	120
30	....	1	4	6	12	25	45	112
35	....	....	3	5	11	22	40	103
40	....	....	2	4	10	20	35	96
45	....	....	2	4	9	19	30	88
50	....	....	1	3	8	17	28	80
60	....	....	1	3	7	16	26	70
70	....	....	.....	2	6	15	24	65
80	....	....	.....	2	5	14	22	60
90	....	....	.....	1	4	13	20	55
100	....	....	.....	1	3	12	18	50
150	....	....	.....	.....	2	9	15	43
200	....	....	.....	.....	1	8	13	36
250	....	....	.....	.....	.....	7	12	30
300	....	....	.....	.....	.....	6	11	25

In still larger buildings the dimensions of gas pipes will be determined by the municipal department.

No pipe shall under any circumstances be smaller than $\frac{3}{8}$ inch $= 9.5^{mm.}$ inside diameter.

In the case of larger buildings containing rooms devoted to different purposes, such as school-rooms, work-rooms, halls for amusement and living rooms, there shall be several sub-divisions with separate gas meters and separate shut offs.

Before commencing the gas piping in such buildings the gas-fitter or architect shall notify the municipal department, and if required must file detailed plans of the proposed gas piping for approval.

Pipe Joints.—All pipes and fittings shall be connected by screw joints. In special cases, other joints will be permitted only upon the approval of the municipal department.

All pipe threads shall be covered with thin layers of hemp dipped in or saturated with white lead or red lead, or a mixture of both.

All joints which are not tight, shall be at once repaired, or removed and replaced by tight joints.

The covering of leaky joints with putty, gas-fitter's cement or similar material is unreliable and will not be permitted.

Covering joints with paint before the gas piping has been tested, is forbidden.

All fittings must be either of wrought iron or of malleable iron.

Grade and Position of Pipes.—All gas distributing pipes must be laid with a uniform fall towards the gas meter, must be kept easily accessible, and where carried exposed must be protected against accidental injury.

At all places, where the continuous grading of the pipes must be interrupted, or where pipes pass from a warm room into a cold place, siphons must be provided in order to remove all water from condensation accumulating at these points.

Gas pipes must never be carried under fire places or under kitchen ranges, nor through chimney flues or other inaccessible places.

Where pipes have been covered over, they can only be tested and put to use if the inspector has previously inspected the same and has approved of their being covered up.

Wherever gas pipes are carried through exposed or open ground they should have at least three feet of covering.

Fastening and Support of Pipes and Gas Fixtures.—Dropells fastened to the ceiling beams and Tees or ells with lugs screwed to the wall furring or studding shall in all cases be used for attaching the ceiling and wall fixtures.

It is not permitted to hang chandeliers to curved pipes. The fastening of chandeliers must be sufficiently strong to carry four times the weight of the fixture without loosening any joint. All chandeliers weighing more than 22 lbs. shall be hung with ball and socket joints.

Only such gas keys shall be used at fixtures which shut off the gas by a quarter turn, which are provided with strong stop pins and cannot be pulled out.

All gas keys and movable or swing

joints must be ground so as to be perfectly gas tight. All fixtures shall be connected with the gas pipes by perfectly tight joints. All joints of extension pendant fixtures must be absolutely gas tight.

So-called Cork Joint Pendants are prohibited ?

The hydraulic seal of sliding chandeliers must be filled instead of with water with glycerine or with some oil which does not evaporate, does not thicken and set hard, and does not freeze.

Protection of Gas Flames.—In all rooms, where the use of an open light is prohibited, open or unprotected gas flames shall not be used, and in all places where explosives are either manufactured or stored, gas-lights shall not be used at all.

Wherever a gas flame is nearer than 60 cm. = 24 inches to the ceiling or to any inflammable material, the gas flame shall be protected by a suspended metal shield placed at least 2½ inches from the material to be protected.

Wherever swinging gas brackets would come in contact with inflammable material

the gas flames must be surrounded with wire globes or cages, or else the bracket lights must be made rigid.

All gas-fixtures must be so fastened or hung as not to be liable to injury by ordinary use, or so as to come into contact with inflammable objects.

The fitting up of sunburners requires the special approval of the municipal department.

Notices to the Department.—Every gas-fitter shall report in writing at the municipal department, when a gas piping job which he is doing in new buildings as well as in extensions, additions or alterations of existing buildings, is completed. He will then be informed as to the method and time for the test of the completed work. The necessary blanks for such notices may be obtained at the municipal department.

In the case of older buildings the gas piping must be gotten ready for the test before such notice is sent. Covering up any gas pipes, or connecting up the gas meter before sending such notice is pro-

hibited. All gas outlets and the end of the main distributing line or riser are to be capped perfectly air tight, and the gas-fitter must provide the gas testing apparatus, force pump, rubber tubing, connecting nipples and the pressure gauge.

The same requirements as to testing shall be observed in the case of additions or alterations of existing buildings, provided more than 30 feet of gas piping and more than two gas outlets are put in.

Small jobs of gas piping, requiring not more than 30 feet of pipe, or not more than two gas outlets, or both, may be connected to the existing gas piping without official testing, but a notice of such work must be sent in every case to the municipal department. This notice shall contain:

1. The full name and business of the owner.

2. The name and number of the street in which the building is located.

3. The number of gas lights or the expected consumption of gas for which the piping to be tested is to serve.

Such notice blanks must be filled in and

signed by the gas-fitter who has the order or the contract for the work.

The municipal department fixes the date of the test which must take place within 24 hours after receipt of the notice.

At the date set for testing the gas-fitter must personally be present at the building the gas piping of which is to be tested, and he must give to the inspector such information about the work as the latter may require. He shall give all necessary assistance in the test, and must remain present during the whole test.

Test of the Gas Piping.—Before applying the pressure test, the whole gas piping job shall be thoroughly inspected as regards the position and run of the gas pipes, as regards pipe sizes and pipe joints, as regards quality of the pipe and fittings, and as regards the proposed location of the gas meter.

If no defects are found the inspector shall proceed to test the gas pipes. The test is usually carried out with a water pressure gauge or manometer.

For the purpose of testing the pipes and

the pipe joints the whole gas piping system shall be put under air pressure corresponding to a column of water 10 inches high equivalent to about ¾ inches of mercury).*

Should the column of water in the gauge keep its level or drop not more than three-sixteenths inches per minute, the piping will be considered tight. Should it fall more than this amount, the test will be interrupted, and will only be resumed after the gas-fitter has sent a second notice stating that the existing defects have been removed.

In the case of extensive gas pipe systems the test shall be made in sections.

Filling gas pipes with water, in order to detect defective joints or other leaks, is strictly prohibited. Any gas piping so treated shall remain excluded from the test until all the pipes which have been

---

* This test is less severe than the test usually applied in the American practice of gas piping. The usual height of the column of mercury is five to six inches, but the better class of work is tested under a pressure of a column of mercury from 10 to 15 inches in height. The writer has found it expedient to call in his specifications for a column of 18 inches of mercury.—W. P. G.

filled with water, are taken apart, cleaned and dried.

In case of temporary gas piping for a circus or other show, or for halls arranged for festivals, if the conditions relating to dangers from fire will permit, the inspector, with the approval of the owner, may give a written permit to connect the gas pipes with the gas service for the purpose of testing the pipes with the gas turned on (either by watching the small index of the gas meter or by looking for leaks by the sense of smell).

If no defects of importance are discovered, the inspector may permit the gas to be left turned on.

Gas Inspector's Certificate.—If the test of a system of gas piping in a new building turns out satisfactorily, the gas-fitter receives from the inspector a certificate in duplicate, in which the number of lights, or else (where gas is to be used otherwise than for lighting) the consumption of gas is stated. In this certificate the inspector is also to state whether or not there are any objections on technical grounds to the

putting of the gas service or main supply with its shut-off, and to the setting up of the gas meter.

If the certificate relates to additions or enlargements of the gas piping in an old building, the same must also state the number of additional lights put in or the capacity to which the system has been increased. The certificate must further state whether the main gas meter is of sufficient capacity for the total number of lights or for the increased consumption, or whether a new larger meter must be substituted.

One copy of the certificate, which also contains the application for a gas service and a gas meter, shall be filled out and signed by the owner, and then handed to the gas company, and thus serves as a written order for the work which the gas company is to perform for the owner.

The gas company shall fill the order within the following three days (except where the ground is frozen in winter) or in case of alterations or additions, the gas

company must exchange and set the necessary main or intermediate meters.

Without such official certificate the gas company will not be permitted, either in new buildings or in alterations, to set up or exchange gas meters and to turn on the gas.

Maintenance of the Gas Lighting System.—The owner shall in all cases be responsible for the maintenance of the gas piping system.

In cases where the municipal department discovers that a gas piping system, either in a new or in an old altered building, has been put in use without first obtaining the certificate prescribed by law and without the piping having been tested, or in cases where there are serious defects in the gas-piping of old buildings, the department has the right to order the owner to have a proper test applied by a licensed gas-fitter. Should the owner refuse to do so, the further use of the gas piping system may be prohibited and the gas may be turned off from the building.

Should the gas meter be suspected of registering incorrectly, the gas company shall, upon an order from the municipal department, exchange the gas meter and test the suspected meter in the presence of an inspector.

Should the test prove the meter to be correct, the expense of the test must be be borne by the complainant who requested the making of the test. If the meter is found to register incorrectly, the same shall be repaired, re-tested or replaced by a new one at the expense of the owner, who shall also pay for the testing of the defective meter.

Penalties.—Any person violating this ordinance shall pay a fine up to fifteen dollars, or shall be sentenced to imprisonment up to two weeks.

Fees.—For each official inspection and test the owner of the building shall pay to the municipal department a fee, the amount of which is calculated according to the number of gas outlets in the building, viz.:

For	4	outlets	.....	$0.50
From	5 to 10	"	.....	.75
"	11 " 20	"	.....	1.00
"	21 " 30	"	.....	1.25
"	31 " 50	"	.....	1.50
"	51 " 100	"	.....	2.00
More than	100	"	.....	2.50

For the inspection of gas piping put in without the outlets being used, or for the examination of plans for additions or alterations, or for tests of gas piping suspected to be defective, a fee is charged in proportion to the time spent, each hour of the official inspector being charged at fifty cents, and each hour of his assistant at twenty-five cents.

In case the first test proves the gas pipe system to be leaky and defective or not in accordance with the above regulations, the defects are to be repaired, and for each additional test one-half of the above fees is charged.

INDEX.

INDEX—*continued.*

CATALOGUE

OF THE

SCIENTIFIC PUBLICATIONS

OF

D. VAN NOSTRAND COMPANY,

23 MURRAY STREET AND 27 WARREN STREET, N. Y.

A. B. C. CODE. (See Clausen-Thue.)

ABBOTT (A. V.). The Electrical Transmission of Energy. A Manual for the Design of Electrical Circuits. Fourth edition, revised. Fully illustrated. 8vo, cloth..... $4 50

ABBOT (Gen'l HENRY L.). The Defence of the Seacoast of the United States. Lectures delivered before the U. S. Naval War College. 8vo, red cloth. 2 00

ADAMS (J. W.). Sewers and Drains for Populous Districts. Embracing Rules and Formulas for the dimensions and construction of works of Sanitary Engineers. Fifth edition. 8vo, cloth. 2 50

A1. CODE. (See Clausen-Thue.)

AIKMAN (C. M., Prof.). Manures and the Principles of Manuring. 8vo, cloth..... .... 2 50

ALEXANDER (J. H.). Universal Dictionary of Weights and Measures, Ancient and Modern, reduced to the Standards of the United States of America. New edition, enlarged. 8vo, cloth..... ... 3 50

ALEXANDER (S. A.). Broke Down: What Should I Do? A Ready Reference and Key to Locomotive Engineers and Firemen, Round House Machinists, Conductors, Train Hands and Inspectors. With 5 folding plates. 12mo, cloth..... ..... 1 50

ALLEN (C. F.). Tables for Earthwork Computation. 8vo, cloth..... ..... 1 50

ANDERSON (J. W.). The Prospector's Hand-book; A Guide for the Prospector and Traveller in search of Metal-bearing or other Valuable Minerals. Seventh edition, thoroughly revised and much enlarged. 8vo, cloth..... 1 50

ANDERSON (WILLIAM). On the Conversion of Heat into Work. A Practical Hand-book on Heat-Engines. Third edition. Illustrated. 12mo, cloth. 2 25

ANDES (LOUIS). Vegetable Fats and Oils; their Practical Preparation, Purification and Employment for various purposes. Their Properties. Adulteration and Examination. A Hand-book for Oil Manufacturers and Refiners, Candle, Soap and Lubricating Oil Manufacturers and the Oil and Fat Industry in general. Translated from the German. With 94 illustrations. 8vo, cloth..... 4 00

——— Animal Fats and Oils. Their Practical Production, Purification and Uses for a great variety of purposes, their Properties, Falsification and Examination. A Hand-book for Manufacturers of Oil and Fat Products, Soap and Candle Makers, Agriculturists, Tanners, etc. Translated by Charles Salter. With 62 illustrations. 8vo, cloth.....net 4 00

ARNOLD (Dr. R.). Ammonia and Ammonium Compounds. A Practical Manual for Manufacturers, Chemists, Gas Engineers and Drysalters. Second edition. 12mo, cloth..... 2 00

ARNOLD (E.). Armature Windings of Direct Current Dynamos. Extension and Application of a General Winding Rule. Translated from the original German by Francis B. DeGress, M. E. With numerous illustrations. 8vo, cloth..... 2 00

ATKINSON (PHILIP). The Elements of Electric Lighting, including Electric Generation. Measurement, Storage, and Distribution. Ninth edition. Fully revised and new matter added. Illustrated. 12mo, cloth..... 1 50

——— The Elements of Dynamic Electricity and Magnetism. Third edition. 120 illustrations. 12mo, cloth..... 2 00

ATKINSON (PHILIP). Power Transmitted by Electricity and its Application by the Electric Motor, including Electric Railway Construction. New edition, thoroughly revised, and much new matter added. Illustrated. 12mo, cloth.... ..... 2 00

ATKINSON (Prof. A. A., *Ohio Univ.*). Electrical and Magnetic Calculations, for the use of Electrical Engineers and Artisans, Teachers, Students, and all others interested in the Theory and Application of Electricity and Magnetism. 8vo, cloth, illustr....net 1 50

AUCHINCLOSS (W. S.). Link and Valve Motions Simplified. Illustrated with 29 woodcuts and 20 lithographic plates, together with a Travel Scale, and numerous useful tables, Thirteenth edition, revised. 8vo, cloth..... 2 00

AXON (W. E. A.). The Mechanic's Friend. A Collection of Receipts and Practical Suggestions. 12mo, cloth 1 50

BACON (F. W.). A Treatise on the Richards, Steam-Engine Indicator, with directions for its use. By Charles T. Porter. Revised, with notes and large additions as developed by American practice; with an appendix containing useful formulæ and rules for engineers. Illustrated. Fourth edition. 12mo, cloth 1 00

BADT (F. B.). New Dynamo Tender's Hand book. With 140 illustrations. 18mo, cloth..... 1 00

—— Bell Hangers' Hand-book. With 97 illustrations. Second edition. 18mo, cloth..... .... 1 00

—— Incandescent Wiring Hand-book. With 35 illustrations and five tables. Fifth edition. 18mo, cloth. 1 00

—— Electric Transmission Hand-book. With 22 illustrations and 27 tables. 18mo, cloth..... . 1 00

BALE (M. P.). Pumps and Pumping. A Hand-book for Pump Users. 12mo, cloth..... ..... 1 50

BARBA (J.). The Use of Steel for Constructive Purposes. Method of Working, Applying, and Testing Plates and Bars With a Preface by A. L Holley, C. E. 12mo, cloth..... ..... 1 50

BARKER (ARTHUR H.). Graphic Methods of Engine Design. Including a Graphical Treatment of the Balancing of Engines. 12mo, cloth.... ..... 1 50

BARNARD (F. A. P.). Report on Machinery and Processes of the Industrial Arts and Apparatus of the Exact Sciences at the Paris Universal Exposition, 1867. 152 illustrations and 8 folding plates. 8vo, cloth..... 5 00

BARNARD (JOHN H.). The Naval Militiaman's Guide. Full leather, pocket form..... 1 25

BARWISE (SIDNEY, M. D., London). The Purification of Sewage. Being a brief account of the Scientific Principles of Sewage Purification and their Practical Application. 12mo, cloth. Illustrated. 2 00

BAUMEISTER (R.). The Cleaning and Sewage of Cities. Adapted from the German with permission of the author. By J. M. Goodell, C. E. Second edition, revised and corrected, together with an additional appendix. 8vo, cloth. Illustrated..... 2 00

BEAUMONT (ROBERT). Color in Woven Design. With 32 Colored Plates and numerous original illustrations. Large 12mo..... 7 50

BEAUMONT, W. and DUGALD CLERK. Autocars and Horseless Carriages..... .....(In Press.)

BECKWITH (ARTHUR). Pottery. Observations on the Materials and Manufacture of Terra-Cotta, Stoneware, Fire-Brick, Porcelain, Earthenware, Brick, Majolica, and Encaustic Tiles. 8vo, paper. Second edition..... 60

BERNTHSEN (A.). A Text-Book of Organic Chemistry. Translated by George M'Gowan, Ph.D. Fourth English edition. Revised and extended by author and translator. Illustrated. 12mo, cloth..... 2 50

BERTIN (L. E.). Marine Boilers: Their Construction and Working, dealing more especially with Tubulous Boilers. Translated by Leslie S. Robertson, Upward of 250 illustrations. Preface by Sir William White. 8vo, cloth. Illustrated..... 7 50

BIGGS (C. H. W.). First Principles of Electricity and Magnetism. Being an attempt to provide an Elementary Book for those intending to enter the profession of Electrical Engineering. Second edition. 12mo, cloth. Illustrated..... 2 00

BINNS (CHAS. F.). Manual of Practical Potting. Compiled by Experts. Third edition, revised and enlarged. 8vo, cloth.....net 7 50

——— Ceramic Technology; being some aspects of Technical Science as applied to Pottery Manufacture. 8vo, cloth.....net 5 00

BLAKE (W. P.). Report upon the Precious Metals. Being Statistical Notices of the Principal Gold and Silver producing regions of the world, represented at the Paris Universal Exposition. 8vo, cloth 2 00

BLAKESLEY (T. H.). Alternating Currents of Electricity. For the use of Students and Engineers. Third edition, enlarged. 12mo, cloth..... 1 50

BLYTH (A. WYNTER, M. R. C. S., F. C. S.). Foods: their Composition and Analysis. A Manual for the use of Analytical Chemists, with an Introductory Essay on the History of Adulterations, with numerous tables and illustrations. New edition.. ...(In Press)

——— Poisons: their Effects and Detection. A Manual for the use of Analytical Chemists and Experts, with an Introductory Essay on the growth of Modern Toxicology. Third edition, revised and enlarged. 8vo, cloth..... 7 50

BODMER (G. R.). Hydraulic Motors; Turbines and Pressure Engines, for the use of Engineers, Manufacturers and Students. Second edition, revised and enlarged. With 204 illustrations. 12mo, cloth..... 5 00

BOILEAU (J. T.). A New and Complete Set of Traverse Tables. Showing the Difference of Latitude and Departure of every minute of the Quadrant and to five places of decimals. 8vo, cloth..... 5 00

BOTTONE (S. R.). Electrical Instrument Making for Amateurs. A Practical Hand-book. With 48 illustrations. Fifth edition, revised. 12mo, cloth..... 50

——— Electric Bells, and all about them. A Practical Book for Practical Men. With more than 100 illustrations. 12mo, cloth. Fourth edition, revised and enlarged..... 50

———The Dynamo: How Made and How Used. A Book for Amateurs. Eighth edition. 12mo, cloth... 1 00

BOTTONE (S. R.). Electro Motors: How Made and How Used. A Hand-book for Amateurs and Practical Men. Second edition. 12mo, cloth..... 75

BONNEY (G. E.). The Electro-Platers' Hand-book. A Manual for Amateurs and Young Students on Electro-Metallurgy. 60 illustrations, 12mo, cloth.. 1 20

BOW (R. H.). A Treatise on Bracing. With its application to Bridges and other Structures of Wood or Iron. 156 illustrations. 8vo, cloth..... 1 50

BOWSER (Prof. E. A.). An Elementary Treatise on Analytic Geometry. Embracing Plane Geometry, and an Introduction to Geometry of three Dimensions. 12mo, cloth. Twenty-first edition..... 1 75

——— An Elementary Treatise on the Differential and Integral Calculus. With numerous examples. 12mo, cloth. Seventeenth edition..... 2 25

——— An Elementary Treatise on Analytic Mechanics. With numerous examples. 12mo, cloth. Fourteenth edition..... 3 00

——— An Elementary Treatise on Hydro-Mechanics. With numerous examples. 12mo, cloth Fifth edition..... 2 50

——— A Treatise on Roofs and Bridges. With Numerous Ex-rcises. Especially adapted for school use. 12mo, cloth. Illustrated.....net 2 25

BOWIE (AUG. J., Jun., M. E.). A Practical Treatise on Hydraulic Mining in California. With Description of the Use and Construction of Ditches, Flumes, Wrought-iron Pipes and Dams; Flow of Water on Heavy Grades, and its Applicability. under High Pressure, to Mining. Fifth edition. Small quarto, cloth. Illustrated..... 5 00

BURGH (N. P.). Modern Marine Engineering, applied to Paddle and Screw Propulsion. Consisting of 36 colored plates, 259 practical woodcut illustrations, and 403 pages of descriptive matter. The whole being an exposition of the present practice of James Watt & Co., J. & G. Rennie, R. Napier & Sons, and other celebrated firms. Thick quarto, half morocco. 10 00

BURT (W. A.). Key to the Solar Compass, and Surveyor's Companion. Comprising all the rules necessary for use in the field; also description of the Linear Surveys and Public Land System of the United States. Notes on the Barometer, Suggestions for an Outfit for a Survey of Four Months, etc. Seventh edition. Pocket-book form, tuck..... 2 50

CALDWELL, (G. C.), and A. A. BRENEMAN. Manual of Introductory Chemical Practice. For the use of Students in Colleges and Normal and High Schools. Fourth edition, revised and corrected. 8vo, cloth Illustrated..... 1 50

CAMPIN (FRANCIS). On the Construction of Iron Roofs. A Theoretical and Practical Treatise, with wood cuts and Plates of Roofs recently executed. 8vo, cloth..... 2 00

CARTER (E. T.). Motive Power and Gearing for Electrical Machinery. A Treatise on the Theory and Practice of the Mechanical Equipment of Power Stations for Electric supply and for Electic Traction. 8vo, cloth. Illustrated..... 5 00

CATHCART (Prof. WM. L.). Machine Elements: Shrinkage and Pressure Joints. With tables and diagrams. 8vo, cloth. Illustrated.....net 2 50

—— Marine Engine Design.....(In Press.)

CHAMBER'S MATHEMATICAL TABLES, consisting of logarithms of Numbers 1 to 108,000, Trigonometrical, Nautical, and other tables. New edition. 8vo, cloth..... 1 75

CHAUVENET (Prof. W.). New Method of Correcting Lunar Distances, and Improved Method of Finding the Error and Rate of a Chronometer, by Equal Altitudes. 8vo, cloth..... 2 00

CHRISTIE (W. WALLACE). Chimney Design and Theory. A Book for Engineers and Architects, with numerous half-tone illustrations and plates of famous chimneys. 12mo, cloth..... 3 00

CHURCH (JOHN A.). Notes of a Metallurgical Journey in Europe. 8vo, cloth..... 2 00

CLARK D. (KINNEAR, C. E.). A Manual of Rules, Tables and Data for Mechanical Engineers. Based

on the most recent investigations. Illustrated with numerous diagrams. 1,012 pages. 8vo, cloth. Sixth edition 5 00
Half morocco 7 50

CLARK D. (KINNEAR, C. E.). Fuel; its Combustion and Economy, consisting of abridgements of Treatise on the Combustion of Coal. By C. W. Williams; and the Economy of Fuel, by T. S. Prideaux. With extensive additions in recent practice in the Combustion and Economy of Fuel, Coal, Coke, Wood, Peat, Petroleum, etc. Fourth edition. 12mo, cloth.... 1 50

——— The Mechanical Engineer's Pocket-book of Tables, Formulæ, Rules and Data. A Handy Book of Reference for Daily Use in Engineering Practice. 16mo, morocco. Second edition..... 3 00

———Tramways, their Construction and Working, embracing a comprehensive history of the system, with accounts of the various modes of traction, a description of the varieties of rolling stock, and ample details of Cost and Working Expenses. Second edition. Re-written and greatly enlarged, with upwards of 400 illustrations. Thick 8vo. cloth. 9 00

——— The Steam Engine. A Treatise on Steam Engines and Boilers; comprising the Principles and Practice of the Combustion of Fuel, the Economical Generation of Steam, the Construction of Steam Boilers, and the Principles, Construction and Performance of Steam Engines, Stationary, Portable, Locomotive and Marine, exemplified in Engines and Boilers of recent date. 1,300 figures in the text, and a series of folding plates drawn to scale. 2 vols. 8vo, cloth. 15 00

CLARK (JACOB M.). A new System of Laying Out Railway Turn-outs instantly, by inspection from Tables. 12mo, leatherette.... 1 00

CLAUSEN-THUE (W.). The A. B. C. Universal Commercial Electric Telegraphic Code; especially adapted for the use of Financiers, Merchants, Shipowners, Brokers, Agent, etc. Fourth edition. 8vo, cloth. 5 00
Fifth edition of same 7 00

——— The A1 Universal Commercial Electric Telegraphic Code. Over 1,240 pp., and nearly 90,000 variations. 8vo, cloth..... 7 50

CLEEMANN (THOS. M.). The Railroad Engineer's Practice. Being a Short but Complete Description of the Duties of the Young Engineer in the Preliminary and Location Surveys and in Construction. Fourth edition. Revised and enlarged. Illustrated. 12mo, cloth..... 1 50

CLEVENGER (S. R.). A Treatise on the Method of Government Surveying as prescribed by the U. S. Congress and Commissioner of the General Land Office, with complete Mathematical, Astronomical and Practical Instructions for the use of the United States Surveyors in the field. 16mo, morocco... ... 2 50

COFFIN (Prof. J. H. C.). Navigation and Nautical Astronomy. Prepared for the use of the U. S. Naval Academy. New Edition. Revised by Commander Charles Belknap. 52 woodcut illustrations. 12mo, cloth ....net. 3 50

COLE (R. S., M. A.). A Treatise on Photographic Optics. Being an account of the Principles of Optics, so far as they apply to Photography. 12mo, cloth, 103 illustrations and folding plates..... 2 50

COLLINS (JAS. E.). The private Book of Useful Alloys, and Memoranda for Goldsmiths, Jewelers, etc. 18mo, cloth.... 50

CORNWALL (Prof. H. B.). Manual of Blow-pipe Analysis, Qualitative and Quantitative. With a Complete System of Determinative Mineralogy. 8vo, cloth. With many illustrations..... 2 50

CRAIG (B. F.). Weights and Measures. An Account of the Decimal System, with Tables of Conversion for Commercial and Scientific Uses. Square 32mo, limp cloth..... 50

CROCKER (F. B.). Electric Lighting. A Practical Exposition of the Art, for use of Engineers, Students, and others interested in the Installation or Operation of Electrical Plants. Second edition. Revised. 8vo, cloth. Vol. I. The Generating Plant..... 3 00
Vol. II. Distributing Systems and Lamps. Third edition. 8vo, cloth. Illustrated..... 3 00

CROCKER, (F. B.), and S. S. WHEELER. The Practical Management of Dynamos and Motors. Fourth edition (twelfth thousand). Revised and enlarged. With a special chapter by H. A. Foster. 12mo, cloth. Illustrated..... 1 00

CUMMING (LINNÆUS, M. A.). Electricity treated Experimentally. For the use of Schools and Students New edition. 12mo, cloth..... 1 50

DAVIES (E. H.). Machinery for Metalliferous Mines. A Practical Treatise for Mining Engineers, Metallurgists and Managers of Mines. With upwards of 400 illustrations. Second edition, rewritten and enlarged. 8vo, cloth.....net 8 00

DAY (CHARLES). The Indicator and its Diagrams. With Chapters on Engine and Boiler Testing; Including a Table of Piston Constants compiled by W. H. Fowler. 12mo, cloth. 125 illustrations..... 2 00

DERR (W. L.). Block Signal Operation. A Practical Manual. Oblong, cloth..... 1 50

DIXON (D. B.). The Machinist's and Steam Engineer's Practical Calculator. A Compilation of Useful Rules and Problems arithmetically solved, together with General Information applicable to Shop-Tools, Mill-Gearing, Pulleys and Shafts, Steam-Boilers and Engines. Embracing valuable Tables and Instruction in Screw-cutting, Valve and Link Motion, etc. 16mo, full morocco, pocket form..... 1 25

DODD (GEO.). Dictionary of Manufactures, Mining, Machinery, and the Industrial Arts. 12mo, cloth ... 1 50

DORR (B. F.). The Surveyor's Guide and Pocket Table Book. 18mo, morocco flaps. Fifth edition, revised, with a second appendix..... 2 00

DRAPER (C. H.). An Elementary Text Book of Light, Heat and Sound, with Numerous Examples. Fourth edition. 12mo, cloth. Illustrated.. ..... 1 00

——— Heat and the Principles of Thermo-Dynamics. With many illustrations and numerical examples. 12mo, cloth..... 1 50

DUBOIS (A. J.). The New Method of Graphic Statics. With 60 illustrations. 8vo, cloth..... 1 50

EDDY (Prof. H. T.). Researches in Graphical Statics. Embracing New Constructions in Graphical Statics, a New General Method in Graphical Statics, and the Theory of Internal Stress in Graphical Statics. 8vo, cloth..... 1 50

——— Maximum Stresses under Concentrated Loads. Treated graphically. Illustrated. 8vo, cloth..... 1 50

EISSLER (M.). The Metallurgy of Gold; a Practical Treatise on the Metallurgical Treatment of Gold-Bearing Ores, including the Processes of Concentration and Chlorination, and the Assaying, Melting and Refining of Gold. Fifth Edition, revised and greatly enlarged. 187 illustrations. 12mo, cloth.... 7 50

———The Metallurgy of Silver; a Practical Treatise on the Amalgamation, Roasting and Lixivation of Silver Ores, including the Assaying, Melting and Refining of Silver Bullion. 124 illustrations. Second edition, enlarged, 12mo, cloth..... 4 00

———The Metallurgy of Argentiferous Lead; a Practical Treatise on the Smelting of Silver Lead Ores and the Refining of Lead Bullion. Including Reports on Various Smelting Establishments and Descriptions of Modern Smelting Furnaces and Plants in Europe and America. With 183 illustrations. 8vo, cloth 5 00

——— Cyanide Process for the Extraction of Gold and its Practical Application on the Witwatersrand Gold Fields in South Africa. Third edition, revised and enlarged. 8vo, cloth. Illustrations and folding plates 3 00

——— A Hand-book on Modern Explosives, being a Practical Treatise on the Manufacture and use of Dynamite, Gun Cotton, Nitro-Glycerine and other Explosive Compounds, including the manufacture of Collodion-Cotton. with chapters on explosives in practical application. Second edition, enlarged with 150 illustrations. 12mo, cloth..... 5 00

ELIOT (C. W.), and STORER (F. H.). A compendious Manual of Qualitative Chemical Analysis. Revised with the co-operation of the authors, by Prof. William R. Nichols. Illustrated. Twentieth edition, newly revised by Prof. W. B. Lindsay. 12mo, cloth.....net 1 25

ELLIOT (Maj. GEO. H.). European Light-House Systems. Being a Report of a Tour of Inspection made in 1873. 51 engravings and 21 woodcuts. 8vo, cloth 5 00

ELLISON, (LEWIS M.). Practical Application of the Indicator. With reference to the adjustment of Valve Gear on all styles of Engines. Second edition, revised. 8vo. cloth, 100 illustrations..... 2 00

EVERETT (J. D.). Elementary Text-book of Physics. Illustrated. Seventh edition. 12mo, cloth 1 50

EWING (Prof. A. J.). The Magnetic Induction in Iron and other metals. 159 illustrations. 8vo, cloth 4 00

FANNING (J. T.). A Practical Treatise on Hydraulic and Water-Supply Engineering. Relating to the Hydrology, Hydro-dynamics, and Practical Construction of Water-Works in North America. 180 illustrations. 8vo, cloth. Fifteenth edition, revised, enlarged, and new tables and illustrations added. 650 pages..... 5 00

FISH (J. C. L.). Lettering of Working Drawings. Thirteen plates, with descriptive text. Oblong, 9x12½, boards..... 1 00

FISKE (Lieut. BRADLEY A., U. S. N.). Electricity in Theory and Practices or, The Elements of Electrical Engineering. Eighth edition. 8vo, cloth 2 50

FISHER (H. K. C. and DARBY, W. C.). Students' Guide to Submarine Cable Testing. 8vo, cloth..... 2 50

FISHER (W. C.). The Potentiometer and its Adjuncts. 8vo, cloth..... 2 25

FLEISCHMANN (W.). The Book of the Dairy. A Manual of the Science and Practice of Dairy Work. Translated from the German, by C. M. Aikman and R. Patrick Wright. 8vo, cloth..... 4 00

FLEMING (Prof. J. A.). The Alternate Current Transformer in Theory and Practice. Vol. 1—The Induction of Electric Currents; 611 pages. New edition. Illustrated. 8vo, cloth..... 5 00
Vol. 2. The Utilization of Induced Currents. Illustrated. 8vo, cloth 5 00

——— Electric Lamps and Electric Lighting. Being a course of four lectures delivered at the Royal Institution, April-May, 1894. 8vo, cloth, fully illustrated 3 00

FLEMING (Prof. J. A.). Electrical Laboratory Notes and Forms, Elementary and advanced. 4to, cloth, illustrated..... ..... 5 00

FOLEY (NELSON), and THOS. PRAY, Jr. The Mechanical Engineers' Reference Book for Machine and Boiler Construction, in 2 parts. Part 1—General Engineering Data. Part 2—Boiler Construction. With fifty-one plates and numerous illustrations, specially drawn for this work. Folio, half mor. ...25 00

FORNEY (MATTHIAS N.). Catechism of the Locomotive. Second edition, revised and enlarged. Forty-sixth thousand. 8vo, cloth..... 3 50

FOSTER (Gen. J. G., U. S. A.). Submarine Blasting in Boston Harbor, Massachusetts. Removal of Tower and Corwin Rocks. Illustrated with 7 plates 4to, cloth..... .... 3 50

FOSTER (H. A.). Electrical Engineers' Pocket Book. 1000 pages with the collaboration of Eminent Specialists. With innumerable tables, diagrams and figures. Third edition, revised. Pocket size, flexible leather..... .... 5 00

FOSTER (JAMES). Treatise on the Evaporation on Saccharine, Chemical and other Liquids by the Multiple System in Vacuum and Open Air. Second edition. Diagrams and large plates. 8vo, cloth.... 7 50

FOWLER. Mechanical Engineers' Pocket Book for 1900..... .... 1 00

FOX (WM.), and C. W. THOMAS, M. E. A Practical Course in Mechanical Drawing, second edition, revised. 12mo, cloth, with plates..... 1 25

FRANCIS (JAS. B., C. E.). Lowell Hydraulic Experiments. Being a selection from experiments on Hydraulic Motors, on the Flow of Water over Weirs, in open Canals of uniform rectangular section, and through submerged Orifices and diverging Tubes. Made at Lowell, Mass. Fourth edition, revised and enlarged, with many new experiments, and illustrated with 23 copper-plate engravings. 4to, cloth.....15 00

FROST (GEO. H.). Engineer's Field Book. By C. S. Cross. To which are added seven chapters on Railroad Location and Construction. Fourth edition. 12mo, cloth..... 1 00

FULLER (GEORGE W.). Report on the Investigations into the Purification of the Ohio River Water at Louisville, Kentucky, made to the President and Directors of the Louisville Water Company. Published under agreement with the Directors. 4to, cloth. 3 full page plates.....net 10 00

GEIPEL (WM.), and KILGOUR, (M. H.) A Pocketbook of Electrical Engineering Formula. Illustrated. 18mo, morocco..... ..... 3 00

GERBER (NICHOLAS). Chemical and Physical Analysis of Milk, Condensed Milk and Infant's Milk-Food. 8vo, cloth. 1 25

GESCHWIND (LUCIEN). Manufacture of Alum and Sulphates, and other Salts of Alumina and Iron; their uses and applications as mordants in dyeing and calico printing, and their other applications in the Arts, Manufactures, Sanitary Engineering, Agriculture, and Horticulture. Translated from the French by Charles Salter. With tables, figures and diagrams. 8vo, cloth, illus.. ....net 5 00

GIBBS (WILLIAM E.). Lighting by Acetylene, Generators, Burners and Electric Furnaces. With 66 illustrations. Second edition revised. 12mo, cloth.. 1 50

GILLMORE (GEN. Q. A.). Treatise on Limes, Hydraulic Cements, and Mortars. Papers on Practical Engineering, United States Engineer Department, No 9, containing Reports of numerous Experiments conducted in New York Cityduring the years of 1858 to 1861, inclusive. With numerous illustrations. 8vo cloth.... .... 4 00

——— Practical Treatise on the Construction of Roads. Streets, and Pavements, with 70 illustrations. 12mo, cloth. 2 00

——— Report on Strength of Building Stones in the United States, etc. 8vo, illustrated cloth..... 1 00

GOLDING (HENRY A.). The Theta-Phi Diagram. Practically applied to Steam, Gas, Oil and Air Engines. 12mo, cloth. Illustrated.....net 1 25

GOODEVE (T. M.). A Text-Book on the Steam Engine. With a Supplement on Gas-Engines. Twelfth Edition, enlarged. 143 illustrations. 12mo, cloth... 2 00

GORE (G., F. R. S.). The Art of Electrolytic Separation of Metals, etc. (Theoretical and Practical.) Illustrated. 8vo, cloth.... .... 3 50

GOULD (E. SHERMAN). The Arithmetic of the Steam Engine. 8vo, cloth..... 1 00

GRIFFITHS (A. D., Ph. D.). A Treatise on Manures, or the Philosophy of Manuring. A Practical Hand-Book for the Agriculturist, Manufacturer and Student. 12mo, cloth..... 3 00

GROVER (FREDERICK). Practical Treatise on Modern Gas and Oil Engines. 8vo, cloth. Illustrated 2 00

GURDEN (RICHARD LLOYD). Traverse Tables: computed to 4 places Decimals for every ° of angle up to 100 of Distance. For the use of Surveyors and Engineers. New Edition. Folio, half morocco. .. 7 50

GUY ARTHUR (F.). Electric Light and Power, giving the Result of Practical Experience in Central Station Work. 8vo, cloth. Illustrated.. ..... 2 50

HAEDER (HERMAN C. E.). A Hand book on the Steam Engine. With especial reference to small and medium sized engines. Englisb editicn re-edited by the author from the second German edition. and translated with considerable additions and alterations by H. H. P. Powels. 12mo, cloth. Nearly 1100 illustrations..... 3 00

HALL (WM. S. Prof.). Elements of the Differential and Integral Calculus. Second edition. 8vo, cloth. Illustrated.....net 2 25

HALSEY (F. A.). Slide Valve Gears; an Explanation of the action and Construction of Plain and Cut-off Slide Valves. Illustrated. 12mo, cloth. Sixth edition..... 1 50

—— The Use of the Slide Rule. Illustrated with diagrams and folding plates. 16mo, boards..... 50

HAMILTON (W. G.). Useful Information for Railway Men. Tenth Edition, revised and enlarged. 562 pages, pocket form. Morocco, gilt..... 2 00

HANCOCK (HERBERT). Text Book of Mechanics and Hydrostatics, with over 500 diagrams. 8vo, cloth..... 1 75

HARRISON (W. B.). The Mechanics' Tool Book. With Practical Rules and Suggestions for use of Machinists, Iron-Workers, and others. Illustrated with 44 engravings. 12mo, cloth..... 1 50

HASKINS (C. H.). The Galvanometer and its Uses. A Manual for Electricians and Students. Fourth edition. 12mo, cloth 1 50

HAWKE (WILLIAM H.). The Premier Cipher Telegraphic Code Containing 100,000 Words and Phrases. The most complete and most useful general code yet published. 4to, cloth 5 00

—— 100,000 Words; Supplement to the Premier Code. All the words are selected from the official vocabulary. Oblong quarto, cloth 4 20

HAWKINS (C. C.) and WALLIS (F.). The Dynamo; its Theory, Design and Manufacture. 190 illustrations, 12mo, cloth 3 00

HAY (ALFRED). Principles of Alternate-Current Working. 12mo, cloth, illustrated 2 00

HEAP (Major D. P., U. S. A.). Electrical Appliances of the Present Day. Report of the Paris Electrical Exposition of 1881. 250 illustrations. 8vo, cloth 2 00

HEAVISIDE (OLIVER). Electromagnetic Theory. 8vo, cloth, two volumes each 5 00

HENRICI (OLAUS). Skeleton Structures. Applied to the Building of Steel and Iron Bridges. Illustrated 1 50

HERRMANN (GUSTAV). The Graphical Statics of Mechanism. A Guide for the Use of Machinists, Architects, and Engineers; and also a Text-book for Technical Schools. Translated and annotated by A. P. Smith, M. E. 12mo, cloth, 7 folding plates. Third Edition 2 00

HERMANN (FELIX). Painting on Glass and Porcelain and Enamel Painting. On the Basis of Personal Practical Experience of the Condition of the Art up to date Translated by Charles Salter. Second greatly enlarged edition. 8vo, cloth, Illustrations, net 3 50

HEWSON (WM.). Principles and Practice of Embanking Lands from River Floods, as applied to the Levees of the Mississippi. 8vo, cloth 2 00

HILL (JOHN W.). The Purification of Public Water Supplies. Illustrated with valuable Tables, Diagrams and Cuts. 8vo, cloth, 304 pages 3 00

—— The Interpretation of Water Analyses. (In Press)

HOBBS (W. R. P.). The Arithmetic of Electrical Measurements with numerous examples. Fully Worked, 12mo, cloth..... .50

HOFF (WM. B., Com. U. S. Navy.). The Avoidance of Collisions at Sea. 18mo, morocco ..... .75

HOLLEY (ALEXANDER L.). Railway Practice. American and European Railway practice in the Economical Generation of Steam. 77 lithographed plates. Folio, cloth 12 00

HOLMES (A. BROMLEY). The Electric Light Popularly Explained. Fifth Edition. Illustrated. 12mo, paper 50

HOPKINS (NEVIL M.). Model Engines and small Boats. New Methods of Engine and Boiler Making with a chapter on Elementary Ship Design and Construction. 12mo, cloth..... .... 1 25

HOSPITALIER (E.). Polyphased Alternating Currents. Illustrated. 8vo, cloth. 1 40

HOWARD (C. R.). Earthwork Mensuration on the Basis of the Prismoidal Formulae. Containing Simple and Labor-saving Methods of obtaining Prismoidal Contents directly from End Areas. Illustrated by Examples and accompained by Plain Rules for Practical Uses. Illustrated. 8vo, cloth... ..... 1 50

HUMBER (WILLIAM, C. E.). A Handy Book for the Calculation of Strains in Girders and Similar Structures, and their Strength; Consisting of Formulae and Corresponding Diagrams, with numerous details for practical application, etc. Fourth Edition. 12mo, cloth..... ..... 2 50

HURST (GEORGE H.). Colour; A Hand-book of the Theory of Colour. Containing ten coloured plates and 72 diagrams. 8vo, cloth. Illustrated. Price.... 2 50

—— Lubricating Oils, Fats and Greases. Their Origin, Preparation, Properties, Uses and Analysis. 313 pages, with 65 illustrations. 8vo, cloth..... 3 00

—— Soaps; A Practical Manual of the Manufacture of Domestic, Toilet and other Soaps. Illustrated with 66 Engravings. 8vo, cloth..... 5 00

HUTCHINSON (W. B.). Patents and How to Make Mo ey out of Them. Member of New York Bar. 12mo, cloth. New York, 1899 ..... 1 25

HUTTON (W. S.). Steam Boiler Construction. A Practical Hand-book for Engineers, Boiler Makers and Steam Users. Containing a large collection of rules and data relating to recent practice in the design, construction, and working of all kinds of stationary, locomotive and marine steam boilers. With upwards of 500 illustrations. Third edition. Carefully revised and much enlarged. 8vo, cloth... 6 00

—— Practica Engineer's Hand-book, Comprising a treatise on Modern Engines and Boilers, Marine, Locomotive and Stationary. Fourth edition. Carefully revised with additions. With upwards of 570 illustrations. 8vo, cloth..... 7 00

—— The Works' Manager's Hand-book of Modern Rules, Tables, and Data for Civil and Mechanical Engineers. Millwrights and Boiler Makers, etc., etc. With upwards of 150 illustrations. Fifth edition. Carefully revised, with additions. 8vo, cloth..... 6 00

INNES (CHARLES H.). Problems in Machine Design. For the Use of Students, Draughtsmen and others. 12mo, cloth..... 1 50

—— Centrifugal Pumps, Turbines and Water Motors. Including the Theory and Practice of Hydraulics. 12mo, cloth..... net 2 00

ISHERWOOD (B. F.). Engineering Precedents for Steam Machinery. Arranged in the most practical and useful manner for Engineers. With illustrations. 2 vols. in 1. 8vo, cloth..... .... 2 50

JAMESON (CHARLES D.). Portland Cement. Its Manufacture and Use. 8vo, cloth..... 1 50

JAMIESON (ANDREW C. E.). A Text-Book on Steam and Steam Engines. Specially arranged for the use of Science and Art, City and Guilds of London Institute, and other Engineering Students. Tenth edition. Illustrated. 12mo, cloth..... 3 00

—— Elementary Manual on Steam and the Steam Engine. Specially arranged for the use of First-Year Science and Art, City and Guilds of London Institute, and other Elementary Engineering Students. Third edition. 12mo, cloth 1 50

JANNETTAZ (EDWARD). A Guide to the Determination of Rocks: being an Introduction to Lithology. Translated from the French by G. W. Plympton, Professor of Physical Science at Brooklyn Polytechnic Institute. 12mo, cloth..... 1 50

JOHNSTON, Prof. J. F. W., and CAMERON, Sir CHAS. Elements of Agricultural Chemistry and Geology. Seventeenth edition. 12mo, cloth..... 2 60

JOYNSON (F. H.). The Metals used in Construction. Iron, Steel, Bessemer Metal, etc. Illustrated. 12mo, cloth 75

——— Designing and Construction of Machine Gearing. Illustrated. 8vo, cloth.. .... 2 00

KANSAS CITY BRIDGE (THE.) With an Account of the Regimen of the Missouri River and a Description of the Methods used for Founding in that River. By O. Chanute, Chief Engineer, and George Morrison, Assistant Engineer. Illustrated with 5 lithographic views and 12 plates of plans. 4to, cloth... 6 00

KAPP (GISBERT C. E.). Electric Transmission of Energy and its Transformation, Subdivision, and Distribution. A Practical Hand-book. Fourth edition, revised. 12mo, cloth..... ..... 3 50

——— Dynamos, Alternators and Transformers. 138 Illustrations. 12mo, cloth..... ..... 4 00

KEMPE (H. R.). The Electrical Engineer's Pocket-Book of Modern Rules, Formulæ, Tables and Data. Illustrated. 32mo, mor. gilt..... 1 75

KENNELLY (A. E.). Theoretical Elements of Electro Dynamic Machinery. 8vo, cloth..... ..... 1 50

KILGOUR, M. H., SWAN, H., and BIGGS, C. H. W. Electrical Distribution; its Theory and Practice. 174 Illustrations. 12mo, cloth..... 4 00

KING (W. H.). Lessons and Practical Notes on Steam. The Steam Engine. Propellers, etc., for Young Marine Engineers, Students, and others. Revised by Chief Engineer J. W. King, United States Navy. Nineteenth edition, enlarged. 8vo, cloth.... 2 00

KINGDON (J. A.). Applied Magnetism. An introduction to the Design of Electromagnetic Apparatus. 8vo, cloth..... ..... 3 00

KIRKALDY (WM. G.). Illustrations of David Kirkaldy's System of Mechanical Testing, as Originated and Carried On by him during a Quarter of a Century. Comprising a Large Selection of Tabulated Results, showing the Strength and other Properties of Materials used in Construction. with explanatory Text and Historical Sketch. Numerous engravings and 25 lithographed plates. 4to, cloth.....20 00

KIRKWOOD (JAS. P.). Report on the Filtration of River Waters for the supply of Cities, as practised in Europe, made to the Board of Water Commissioners of the City of St. Louis. Illustrated by 30 double-plate engravings. 4to, cloth..... 7 50

KNIGHT (AUSTIN M., *Lieutenant-Commander, U. S. N*). Modern Seamanship. Illustrated with 136 full-page plates and diagrams. 8vo, cloth. Second edition, revised.....net 6 00
Half morocco 7 50

LARRABEE (C. S.). Cipher and Secret Letter and Telegraphic Code, with Hog's Improvements. The most perfect Secret Code ever invented or discovered. Impossible to read without the key. 18mo, cloth 60

LEASK (A. RITCHIE). Breakdowns at Sea and How to Repair Them. With eighty-nine Illustrations. 8vo, cloth. Second edition..... 2 00

——— Triple and Quadruple Expansion Engines and Boilers and their Management. With fifty-nine illustrations. Third edition, revised. 12mo, cloth.. 2 00

——— Refrigerating Machinery: Its Principles and Management. With sixty-four illustrations. 12mo, cloth 2 00

LECKY (S. T. S.). "Wrinkles" in Practical Navigation. With 130 illustrations. 8vo, cloth. Ninth edition, revised..... .... 8 40

LEVY (C. L.). Electric Light Primer. A Simple and Comprehensive Digest of all of the most important facts connected with the running of the dynamo, and electric lights, with precautions for safety. For the use of persons whose duty it is to look after the plant. 8vo, paper..... 50

LIVACHE (ACH., Ingenieur Civil Des Mines). The Manufacture of Varnishes, Oil Crushing, Refining and Boiling and Kindred Industries. Translated from the French and greatly extended, by John Geddes McIntosh. 8vo, cloth. Illustrated.....net 5 00

LOCKE (ALFRED G., and CHARLES G.) A Practical Treatise on the Manufacture of Sulphuric Acid. With 77 Constructive Plates drawn to scale Measurements, and other Illustrations. Royal 8vo, cloth. 10 00

LOCKERT (LOUIS). Petroleum Motor-Cars. 12mo, cloth 1 50

LOCKWOOD (THOS. D.). Electricity, Magnetism, and Electro-Telegraphy. A Practical Guide for Students, Operators, and Inspectors. 8vo, cloth. Third edition... ..... 2 50

——— Electrical Measurement and the Galvanometer; its Construction and Uses. Second edition. 32 illustrations. 12mo, cloth..... 1 50

LODGE (OLIVER J.). Elementary Mechanics, including Hydrostatics and Pneumatics. Revised edition. 12mo, cloth..... ..... 1 50

LORING (A. E.). A Hand book of the Electro-Magnetic Telegraph. Fourth edition, revised.....

LUCE (Com. S. B.). Text-Book of Seamanship. The Equipping and Handling of Vessels under Sail or Steam. For the use of the U. S. Naval Academy. Revised and enlarged edition, by Lt. Wm. S. Benson. 8vo, cloth..... ....10 00

LUNGE (GEO.). A Theoretical and Practical Treatise on the Manufacture of Sulphuric Acid and Alkali with the Collateral Branches. Vol. I. Sulphuric Acid, Second edition, revised and enlarged. 342 Illustrations. 8vo, cloth..... ....15 00
Vol. II. Second edition, revised and enlarged. 8vo, cloth..... .....16 80
Vol III. 8vo, cloth. New edition, 1896.....15 00

LUNGE. (GEO.), and HURTER, F. The Alkali Maker's Pocket-Book. Tables and Analytical Methods for Manufacturers of Sulphuric Acid, Nitric Acid, Soda, Potash and Ammonia. Second edition. 12mo, cloth 3 00

LUQUER (LEA McILVAINE, Ph. D.). Minerals in Rock Sections. The Practical Method of Identifying Minerals in Rock Sections with the microscope, Especially arranged for Students in Technical and Scientific Schools. 8vo. cloth. Illustrated..net 1 50

MACKROW (CLEMENT). The Naval Architect's and Ship-Builder's Pocket-Book of Formulæ, Rules and Tables; and Engineers' and Surveyors' Handy-Book of Reference. Eighth edition, revised and enlarged. 16mo, limp leather. Illustrated. 5 00

MAGUIRE (Capt. EDWARD. U. S. A.). The Attack and Defence of Coast Fortifications. With Maps and Numerous Illustrations. 8vo, cloth..... 2 50

MAGUIRE (WM. R.). Domestic Sanitary Drainage and Plumbing Lectures on Practical Sanitation. 332 illustrations. 8vo..... .... 4 00

MARKS (EDWARD C. R.). Mechanical Engineering Materials: their Properties and Treatment in Construction. 12mo, cloth. Illustrated..... 60

——— Notes on the Construction of Cranes and Lifting Machinery. 12mo, cloth..... ..... . 1 50

MARKS (G. C.). Hydraulic Power Engineering: a Practical Manual on the Concentration and Transmission of Power by Hydraulic Machinery. With over 200 diagrams, figures, and tables. 8vo, cloth. Illustrated..... ..... 3 50

MAYER (WM.). American Telegraphy: Systems, Apparatus, Operation. 450 illustrations. 8vo, cloth. 3 50

MAYER (Prof. A. M.). Lecture Notes on Physics. 8vo, cloth..... ..... 2 00

McCULLOCH (Prof. R. S.). Elementary Treatise on the Mechanical Theory of Heat, and its application to Air and Steam Engines. 8vo, cloth..... 3 50

McNEILL (BEDFORD). McNeill's Code. Arranged to meet the requirements of Mining, Metallurgical and Civil Engineers, Directors of Mining, Smelting and other Companies, Bankers, Stock and Share Brokers, Solicitors, Accountants, Financiers, and General Merchants. Safety and Secrecy. 8vo, cloth. 6 00

McPHERSON (J. A., *A. M. Inst. C. E.*). Waterworks Distribution: a practical guide to the laying out of systems of distributing mains for the supply of water to cities and towns. With tables, folding plates and numerous full-page diagrams. 8vo, cloth. Illustrated..... 2 50

METAL TURNING. By a Foreman Pattern Maker. Illustrated with 81 engravings. 12mo, cloth..... 1 50

MINIFIE (WM.). Mechanical Drawing. A Textbook of Geometrical Drawing for the use of Mechanics and Schools, in which the Definitions and Rules of Geometry are familiarly explained; the Practical Problems are arranged from the most simple to the more complex, and in their description technicalities are avoided as much as possible. With illustrations for Drawing Plans, Sections, and Elevations of Railways and Machinery; an Introduction to Isometrical Drawing, and an Essay on Linear Perspective and Shadows Illustrated with over 200 diagrams engraved on steel. Ninth thousand. With an appendix on the Theory and Application of Colors. 8vo, cloth..... 4 00

——— Geometrical Drawing. Abridged from the Octavo edition, for the use of schools. Illustrated with 48 steel plates. Ninth edition. 12mo, cloth..... 2 00

MODERN METEOROLOGY. A Series of Six Lectures, delivered under the auspices of the Meteorological Society in 1870. Illustrated. 12mo, cloth . 1 50

MOREING (C. A.), and NEAL (THOMAS). Telegraphic Mining Code Alphabetically arranged. Second edition. 8vo, cloth..... 8 40

MORRIS (E.). Easy Rules for the Measurement of Earthworks by means of the Prismoidal Formula. 8vo, cloth. Illustrated..... 1 50

MOSES (ALFRED J.), and PARSONS, C. L. Elements of Mineralogy, Crystallography and Blowpipe Analysis from a practical standpoint. Fourth thousand. 8vo, cloth. 366 illustrations..... ...net 2 00

MOSES (ALFRED J.). The Characters of Crystals. An Introduction to Physical Crystallography, containing 321 Illustrations and Diagrams. 8vo, 211 pp.....net 2 00

MOORE (E. C. S.). New Tables for the Complete Solution of Ganguillet and Kutter's Formula for the flow of liquids in open channels, pipes, sewers and conduits. In two parts. Part I, arranged for 1,080 inclinations from 1 over 1 to 1 over 21,120 for fifteen different values of (*n*). Part II, for use with all other values of (*n*). With large folding diagram. 8vo, cloth. Illustrated.....net 5 00

MULLIN (JOSEPH P., M. E.). Modern Moulding and Pattern-Making. A Practical Treatise upon Pattern Shop and Foundry Work; embracing the Moulding of Pulleys, Spur Gears, Worm Gears, Balance-Wheels, Stationary Engine and Locomotive Cylinders, Globe Valves, Tool Work, Mining Machinery, Screw Propellers, Pattern-Shop Machinery, and the latest improvements in English and American Cupolas; together with a large collection of original and carefully selected Rules and Tables for every-day use in the Drawing Office, Pattern-Shop and Foundry. 12mo, cloth. Illustrated..... 2 50

MUNRO (JOHN C. E.), and JAMIESON ANDREW C. E. A Pocket-book of Electrical Rules and Tables for the use of Electricians and Engineers. Thirteenth edition, revised and enlarged. With numerous diagrams. Pocket size. Leather.. 2 50

MURPHY (J. G., M. E.). Practical Mining. A Field Manual for Mining Engineers. With Hints for Investors in Mining Properties. 16mo, morocco tucks..... 1 00

NAQUET (A.). Legal Chemistry. A Guide to the Detection of Poisons, Falsification of Writings, Adulteration of Alimentary and Pharmaceutical Substances, Analysis of Ashes, and examination of Hair, Coins, Arms, and Stains, as applied to Chemical Jurisprudence. Translated from the French, by J. P. Battershall, Ph D., with a preface by C. F. Chandler, Ph. D., M. D., LL. D. 12mo, cloth..... 2 00

NASMITH (JOSEPH). The Student's Cotton Spinning. Third edition, revised and enlarged. 8vo, cloth. 622 pages. 250 Illustrations..... 3 00

NEWALL (JOHN W.). Plain Practical Directions for Drawing, Sizing and Cutting Bevel-Gears, showing how the Teeth may be cut in a Plain Milling Machine or Gear Cutter so as to give them a correct

shape from end to end; and showing how to get out all particulars for the Workshop without making any Drawings. Including a Full Set of Tables of Reference. Folding plates. 8vo, cloth..... ..... 1 50

NEUBURGER (HENRY) and HENRI NOALHAT. Technology of Petroleum. The Oil Fields of the World; their History, Geography and Geology. With 153 illustrations and 25 plates. Translated from the French by John Geddes McIntosh. 8vo, cloth..... net 10 00

NEWLANDS (JAMES). The Carpenters' and Joiners' Assistant: being a Comprehensive Treatise on the Selection, Preparation and Strength of Materials, and the Mechanical Principles of Framing. Illustrated. Folio, half morocco.....15 00

NIPHER (FRANCIS E., A. M.). Theory of Magnetic Measurements, with an appendix on the Method of Least Squares. 12mo, cloth 1 00

NOAD (HENRY M.). The Students' Text-Book of Electricity. A new edition, carefully revised. With an Introduction and additional chapters by W. H. Preece. With 471 illustrations. 12mo, cloth..... 4 00

NUGENT (E.). Treatise on Optics; or, Light and Sight theoretically and practically treated, with the application to Fine Art and Industrial Pursuits. With 103 illustrations. 12mo, cloth. 1 50

O'CONNOR (HENRY). The Gas Engineer's Pocket-Book. Comprising Tables, Notes and Memoranda; relating to the Manufacture, Distribution and Use of Coal Gas and the Construction of Gas Works. 12mo, full leather, gilt edges..... ..... 3 50

OUDIN (M. A.). Standard Polyphase Apparatus and Systems. With many photo-reproductions, diagrams, and tables. Third edition, revised. 8vo, cloth. Illustrated..... ..... 3 00

PAGE (DAVID). The Earth's Crust, A Handy Outline of Geology. 16mo, cloth..... 75

PALAZ (A., ScD.). A Treatise on Industrial Photometry, with special application to Electric Lighting. Authorized translation from the French, by George W. Patterson, Jr. Second edition, revised. 8vo, cloth. Illustrated..... ..... 4 00

PARSHALL (H. F.) and H. M. HOBART. Armature Windings of Electric Machines. With 140 full-page plates, 65 tables, and 165 pages of descriptive letter-press. 4to, cloth 7 50

PEIRCE (B.). System of Analytic Mechanics. 4to, cloth 10 00

PERRINE (F. A. C., A.M., D.Sc.). Conductors for Electrical Distribution; their Manufacture and Materials, the Calculation of Circuits, Pole-Line Construction, Underground Working and other Uses. 8vo, cloth. Illustrated ..... net 3 50

PERRY (JOHN). Applied Mechanics. A Treatise for the use of students who have time to work experimental, numerical and graphical exercises illustrating the subject. 8vo, cloth. 650 pages., net 2 50

PHILLIPS (JOSHUA). Engineering Chemistry. A Practical Treatise for the use of Analytical Chemists, Engineers, Iron Masters, Iron Founders, students and others. Comprising methods of Analysis and Valuation of the principal materials used in Engineering works, with numerous Analyses, Examples and Suggestions. 314 illustrations. Second edition, revised and enlarged. 8vo, cloth 4 50

PICKWORTH (CHAS. N.). The Indicator Handbook. A Practical Manual for Engineers. Part I. The Indicator: Its Construction and Application. 81 illustrations. 12mo, cloth 1 50

——— The Slide Rule. A Practical Manual of Instruction for all Users of the Modern Type of Slide Rule, exhibiting the Application of the Instrument to the Everyday Work of the Engineer,—Civil, Mechanical and Electrical. 12mo, flexible cloth. Fifth edition. 80

PLANE TABLE (THE). Its Uses in Topographical Surveying. From the Papers of the United States Coast Survey. Illustrated. 8vo, cloth 2 00

PLANTE (GASTON). The Storage of Electrical Energy, and Researches in the Effects created by Currents, combining Quantity with High Tension. Translated from the French by Paul B. Elwell. 89 illustrations. 8vo 4 00

PLATTNER. Manual of Qualitative and Quantitative Analysis with the Blow-Pipe. Eighth edition, re-

No. 45. THERMO-DYNAMICS. .New edition, in press.

No. 46. ICE-MAKING MACHINES. From the French of M. Le Doux. Revised by Prof. J. E. Denton, D. S. Jacobus, and A. Riesenberger. Sixth edition, revised.

No. 47. LINKAGES: THE DIFFERENT FORMS and Uses of Articulated Links. By J. D. C. De Roos.

No. 48. THEORY OF SOLID AND BRACED Elastic Arches. By William Cain, C.E.

No. 49. MOTION OF A SOLID IN A FLUID. By Thomas Craig, Ph.D.

No. 50. DWELLING-HOUSES: THEIR SANItary Construction and Arrangements. By Prof. W. H. Corfield.

No. 51. THE TELESCOPE: OPTICAL PRINCIples Involved in the Construction of Refracting and Reflecting Telescopes, with a new chapter on the Evolution of the Modern Telescope, and a Bibliography to date. With diagrams and folding plates. By Thomas Nolan. Second edition, revised and enlarged.

No. 52. IMAGINARY QUANTITIES: THEIR GEometrical Interpretation. Translated from the French of M. Argand by Prof. A. S. Hardy.

No. 53. INDUCTION COILS: HOW MADE AND How Used. Eleventh American edition.

No. 54. KINEMATICS OF MACHINERY. By Prof. Alex. B. W. Kennedy. With an introduction by Prof. R. H. Thurston.

No. 55. SEWER GASES: THEIR NATURE AND Origin. By A. de Varona. Second edition, revised and enlarged.

No. 56. THE ACTUAL LATERAL PRESSURE of Earthwork. By Benj. Baker, M. Inst., C.E.

No. 57. INCANDESCENT ELECTRIC LIGHTING. A Practical Description of the Edison System. By L. H. Latimer. To which is added the Design and Operation of Incandescent Stations, by C. J. Field; and the Maximum Efficiency of Incandescent Lamps, by John W. Howell.

No. 58. VENTILATION OF COAL MINES. By W. Fairley, M.E., and Geo. J. André.

No. 59. RAILROAD ECONOMICS; OR, NOTES With Comments. By S. W. Robinson, C.E.

No. 60. STRENGTH OF WROUGHT-IRON Bridge Members. By S. W. Robinson, C.E.

No. 61. POTABLE WATER, AND METHODS OF Detecting Impurities. By M. N. Baker. Second, ed., revised and enlarged.

No. 62. THEORY OF THE GAS-ENGINE. By Dougald Clerk. Third edition. With additional matter. Edited by F. E. Idell, M.E.

No. 63. HOUSE-DRAINAGE AND SANITARY Plumbing. By W. P. Gerhard. Twelfth edition.

No. 64. ELECTRO-MAGNETS. By A. N. Mansfield.

No. 65. POCKET LOGARITHMS TO FOUR Places of Decimals. Including Logarithms of Numbers, etc.

No. 66. DYNAMO-ELECTRIC MACHINERY. By S. P. Thompson. With an Introduction by F. L. Pope. Third edition, revised.

No. 67. HYDRAULIC TABLES FOR THE CALculation of the Discharge through Sewers, Pipes, and Conduits. Based on "Kutter's Formula." By P. J. Flynn.

No. 68. STEAM-HEATING. By Robert Briggs. Third edition, revised, with additions by A. R. Wolff.

No. 69. CHEMICAL PROBLEMS. By Prof. J. C. Foye. Fourth edition, revised and enlarged.

No. 70. EXPLOSIVE MATERIALS. By Lieut. John P. Wisser.

No. 71. DYNAMIC ELECTRICITY. By John Hopkinson, J. N. Shoolbred, and R. E. Day.

No. 72. TOPOGRAPHICAL SURVEYING. By George J. Specht, Prof. A. S. Hardy, John B. McMaster, and H. F. Walling. Third Edition. revised.

No. 73. SYMBOLIC ALGEBRA; OR, THE ALGEbra of Algebraic Numbers. By Prof. William Cain.

No. 74. TESTING MACHINES: THEIR HIStory, Construction and Use. By Arthur V. Abbott.

No. 75. **RECENT PROGRESS IN DYNAMO-electric Machines.** Being a Supplement to "Dynamo-electric Machinery." By Prof. Sylvanus P. Thompson.

No. 76. **MODERN REPRODUCTIVE GRAPHIC Processes.** By Lieut. James S. Pettit, U.S.A.

No. 77. **STADIA SURVEYING. The Theory of** Stadia Measurements. By Arthur Winslow. Sixth edition.

No. 78. **THE STEAM-ENGINE INDICATOR** and Its Use. By W. B. Le Van.

No. 79. **THE FIGURE OF THE EARTH.** By Frank C. Roberts, C.E.

No. 80. **HEALTHY FOUNDATIONS FOR** Houses. By Glenn Brown.

No. 81. **WATER METERS: COMPARATIVE** Tests of Accuracy, Delivery, etc. Distinctive features of the Worthington, Kennedy, Siemens, and Hesse meters. By Ross E. Browne.

No. 82. **THE PRESERVATION OF TIMBER BY** the Use of Antiseptics. By Samuel Bagster Boulton, C.E.

No. 83. **MECHANICAL INTEGRATORS.** By Prof. Henry S. H. Shaw, C.E.

No. 84. **FLOW OF WATER IN OPEN CHAN-nels,** Pipes, Conduits, Sewers, etc. With Tables. By P. J. Flynn, C.E.

No. 85. **THE LUMINIFEROUS AETHER.** By Prof. De Volson Wood.

No. 86. **HANDBOOK OF MINERALOGY: DE-termination,** Description, and Classification of Minerals Found in the United States. By Prof. J. C. Foye. Fifth edition, revised.

No. 87. **TREATISE ON THE THEORY OF THE** Construction of Helicoidal Oblique Arches. By John L. Culley, C.E.

No. 88. **BEAMS AND GIRDERS. Practical For-mulas** for their Resistance. By P. H. Philbrick.

No. 89. **MODERN GUN COTTON: ITS MANU-facture,** Properties, and Analyses. By Lieut. John P. Wisser, U.S.A.

No. 90. **ROTARY MOTION AS APPLIED TO** the Gyroscope. By Major J. G. Barnard.

No. 91. LEVELING: BAROMETRIC, TRIGONOmetric, and Spirit. By Prof. I. O. Baker. Second edition.

No. 92. PETROLEUM: ITS PRODUCTION AND Use. By Boverton Redwood, F.I.C., F.C.S.

No. 93. RECENT PRACTICE IN THE SANItary Drainage of Buildings. With Memoranda on the Cost of Plumbing Work. Second edition, revised and enlarged. By William Paul Gerhard, C.E.

No. 94. THE TREATMENT OF SEWAGE. By Dr. C. Meymott Tidy.

No. 95. PLATE-GIRDER CONSTRUCTION. By Isami Hiroi, C.E. Fourth edition, revised.

No. 96. ALTERNATE CURRENT MACHINERY. By Gisbet Kapp, Assoc. M. Inst., C.E.

No. 97. THE DISPOSAL OF HOUSEHOLD Wastes. Second edition. By W. Paul Gerhard, Sanitary Engineer.

No. 98. PRACTICAL DYNAMO-BUILDING FOR Amateurs. How to Wind for Any Output. By Frederick Walker. Fully illustrated. Third edition.

No. 99. TRIPLE-EXPANSION ENGINES AND Engine Trials. By Prof. Osborne Reynolds. Edited with notes, etc., by F. E. Idell, M.E.

No. 100. HOW TO BECOME AN ENGINEER; or, The Theoretical and Practical Training necessary in Fitting for the Duties of the Civil Engineer. By Prof. Geo. W. Plympton.

No. 101. THE SEXTANT, and Other Reflecting Mathematical Instruments. With Practical Hints for their Adjustment and Use. By F. R. Brainard, U. S. Navy.

No. 102. THE GALVANIC CIRCUIT INVESTIgated Mathematically. By Dr. G. S. Ohm, Berlin, 1827. Translated by William Francis. With Preface and Notes by the Editor, Thomas D. Lockwood, M.I.E.E. Second edition.

No. 103. THE MICROSCOPICAL EXAMINATION of Potable Water. With Diagrams. By Geo. W. Rafter. Second edition.

No. 104. VAN NOSTRAND'S TABLE-BOOK FOR Civil and Mechanical Engineers. Compiled by Prof. Geo. W. Plympton.

No. 105. DETERMINANTS. An Introduction to the Study of, with Examples and Applications. By Prof. G. A. Miller.

No. 106. COMPRESSED AIR. Experiments upon the Transmission of Power by Compressed Air in Paris. (Popp's System.) By Prof. A. B. W. Kennedy. The Transmission and Distribution of Power from Central Stations by Compressed Air. By Prof. W. C. Unwin. Edited by F. E. Idell. Third edition.

No. 107. A GRAPHICAL METHOD FOR SWING Bridges. A Rational and Easy Graphical Analysis of the Stresses in Ordinary Swing Bridges. With an Introduction on the General Theory of Graphical Statics, with Folding Plates. Second edition. By Benjamin F. La Rue.

No. 108. SLIDE-VALVE DIAGRAMS. A French Method for Constructing Slide-valve Diagrams. By Lloyd Bankson, B.S., Assistant Naval Constructor, U. S. Navy. 8 Folding Plates.

No. 109. THE MEASUREMENT OF ELECTRIC Currents. Electrical Measuring Instruments. By James Swinburne. Meters for Electrical Energy. By C. H. Wordingham. Edited, with Preface, by T. Commerford Martin. With Folding Plate and Numerous Illustrations.

No. 110. TRANSITION CURVES. A Field-book for Engineers, Containing Rules and Tables for Laying out Transition Curves. By Walter G. Fox, C.E. Second edition.

No. 111. GAS-LIGHTING AND GAS-FITTING. Specifications and Rules for Gas-piping. Notes on the Advantages of Gas for Cooking and Heating, and Useful Hints to Gas Consumers. Third edition. By Wm. Paul Gerhard, C.E.

No. 112. A PRIMER ON THE CALCULUS. By E. Sherman Gould, M. Am. Soc. C. E. Third edition, revised and enlarged.

No. 113. PHYSICAL PROBLEMS and Their Solution. By A. Bourgougnon, formerly Assistant at Bellevue Hospital. Second ed.

No. 114. USE OF THE SLIDE RULE. By F. A. Halsey, of the "American Machinist." Fourth edition, revised and enlarged.

TEXT BOOKS

FOR

Colleges and Technological Institutions.

THEORETICAL MECHANICS,

With an Introduction to the Calculus. Designed as a Text-Book for Technical Schools and Colleges, and for the use of Engineers, Architects, &c. By JULIUS WEISBACH, Ph.D. Translated from the German by ECKLEY B. COXE, A.M., Mining Engineer. One Volume, large 8vo, 1112 pages, 902 Illustrations, Cloth $6.00. Sheep $7.50.

The Graphical Statics of Mechanism.

A Guide for the use of Machinists, Architects and Engineers; and also a Text-Book for Technical Schools. By GUSTAV HERMANN, Professor in the Royal Polytechnic School at Aix-la-Chapelle. Translated and Annotated by A. P. SMITH, M.E. Fourth Ed. 12mo, cloth, illus. $2.00.

Elementary Mechanism.

Text-Book for Students of Mechanical Engineering. By ARTHUR F. WOODS, Assistant Engineer U. S. Navy, Assistant Professor of Mechanical Engineering, Illinois State University, etc., and ALBERT W. STAHL, M.E., Assistant Engineer U. S. Navy, Professor of Mechanical Engineering, Purdue University, La Fayette, Ind., etc. Fourth Edition. 12mo, cloth, illustrated . . . $2.00.

Elements of Mechanics,

Including Kinematics, Kinetics and Statics. With applications. By Professor T. W. WRIGHT, of Union College. Third Edition, revised. 8vo, cloth, illustrated . $2.50.

Bowser's Analytic Mechanics.

An Elementary Treatise on Analytic Mechanics. With numerous examples. By EDW. A. BOWSER, LL.D. 12th Edition. 12mo, cloth . . . . . $3.00.

Elementary Mechanics, including Hydrostatics and Pneumatics.

By Professor OLIVER J. LODGE. Revised Edition. 12mo, cloth, illustrated . . . . . $1.50.

Applied Mechanics.

A Treatise for the Use of Students who have time to Work Experimental, Numerical, and Graphical Exercises, Illustrating the Subject. By JOHN PERRY, M.E., D.Sc., F.R.S. 8vo, cloth . . . . . $2.50.