at any given temperature. For this reason, the diagrams which follow show the variations of the *true* specific heat with the temperature.

[There were here thrown upon the screen a number of diagrams, with running comments by the lecturer. It has been thought advisable in printing the lecture to incorporate these diagrams into an Appendix, in which is discussed the specific heat of each of the metals separately at a length which would have been undesirable, and indeed impossible, during the delivery of the lecture.]

[To be continued.]

CAUSES OF FIRES.

BY C. JOHN HEXAMER.

[Concluded from vol. LXXXV, p. 299.]

CAUSES OF FIRES IN DWELLINGS.

Statistics on the causality of fires are very meagre. The best general tables we have in this country, are those of the *Chronicle*. Mr. F. A. Montgomery has made a number of interesting calculations from the *Chronicle* tables, published in 1892, his purpose being "to ascertain the relative importance of the *principal* causes of fires, peculiar to certain classes of risks, incendiarism omitted." Exposure fires also were not taken into account. The results reached in regard to *dwellings and tenements* showed the following table of causes of fires:

<i>Chief Causes.</i>	<i>Relative Percentage of Inherent Physical Hazard.</i>
Defective flues,	21
Matches,	9
Explosions, lamps,	9
Forest fires,	9
Sparks,	7
Stoves,	6
Gas jets,	3
Lamp accidents,	3

Chief Cause.	Relative Percentage of Injuries Physical Hazard.
Explosions, oil stoves,	3
Lightning,	1
Carelessness,	1
Open fireplace,	1
Fireworks,	1
Candle,	1
Accident,	1
Cigar stub,	1
Fire crackers,	1
Stove-pipe,	1
Ashes,	1
Furnaces,	1
Oil stove accident,	1

BOARDING HOUSES.

Defective stoves,	18
Explosions, lamps,	16
Gas jets,	9
Matches,	8
Stoves,	7
Cigar stubs,	6
Sparks,	5
Open fireplaces,	3
Lamp accidents,	3
Ashes,	2
Explosions, oil stoves,	2
Carelessness,	1
Stove-pipe,	1
Candle,	1
Fireworks,	1
Furnace,	1
Spontaneous combustion,	1

A table, published in the *American Exchange and Review* (June number, 1892), shows that the number of fires in fifteen years (1876, 1878-1891) in dwelling houses in Massachusetts were 12,814, property loss \$8,082,322, and the causes of the 1,213 fires in the year 1891 were reported as follows:

Ashes in wooden vessels,	12
Ashes from pipe and pipe in clothes,	27
Burning off paint,	1
Careless use of matches,	50
Children playing with matches,	101

Cigar stub in wooden spoons,	5
Clothes near stove,	17
Curtains near gas or candle,	38
Defective chimney,	172
Exposure,	111
Electric wires,	3
Fireworks and fire crackers,	11
Fat boiling over,	2
Fumigating with sulphur,	4
Gas leaking,	4
Explosion of gas,	4
Hot iron on wood,	7
Incendiary,	54
Breaking lamp,	77
Breaking lantern,	3
Explosion of lamp,	50
Explosion of lantern,	1
Explosion of oil stove,	30
Lightning,	6
Mice and matches,	36
Overheated stoves,	50
Overheated steam-pipe,	1
Open funnel hole,	1
Plumbers' fire-pot,	7
Rags in funnel hole,	1
Sparks from chimney,	35
Sparks from locomotive,	12
Sparks from stove and fireplace,	14
Spontaneous ignition of rags,	10
Spontaneous ignition (cause unknown),	9
Soot igniting,	23
Starting fire with oil,	1
Thawing water pipe,	3
Tar boiling over,	1
Timber built into chimney,	1
Wood-work near stove,	6
Wood-work exposed to gas or candle,	14
Volatile oil (naphtha),	5
Smoking in bed,	9
Slaking lime,	1
Powder explosion,	1
Unknown,	157

In Massachusetts boarding and lodging houses, in the above-mentioned fifteen years, 150 fires occurred with a property loss \$155,808.

CAUSES OF TWENTY-THREE FIRES IN 1891.

Defective chimney,	4
Curtain near gas,	2
Careless use of matches,	4
Smoking in bed,	2
Unknown,	1
Exposure,	2
Spontaneous ignition,	2
Overheated stove,	1
Mice and matches,	1

Perhaps it will be of local interest to compare the origins of Philadelphia's ash pile, costing \$19,319,202.53 in a decade. The statistics contained in the annual report of the Insurance Patrol are worthy of investigation. In the April number of the *American Exchange and Review*, 1893, the results of the decade 1883-1892 have been compared. In order to reduce statistical quotations to a minimum, we quote now all the parts in this comparison we shall hereafter need.

As an approximation, the value of combustible property in the city of Philadelphia may be placed at \$1,200,000,000; amount insured, \$800,000,000—more than one-half of the insurance on dwellings and contents.

Fire loss in its aggregation is according to value of property per square foot of ground area under equal conditions, otherwise, of ignition, combustibility and fire extinguishment. In other words, loss is according to concentration of value. Philadelphia, like other modern cities, tends to concentrate values. Measured by decades, the fire history of the city shows from about \$500 loss per fire to about \$3,000 loss per fire. The data of three decades are as follows :

Decades.	Total Fires	Loss per Fire
1856-65,	3,679	\$1,772
1866-75,	6,154	3,041
1883-92,	10,801	1,788

(In the decade 1866-75, a period of great manufacturing development, the conflagrative force of the city was at the highest point it has ever attained.)

From 1856 to 1892 the population doubled and combustible value trebled, but the city was burning at about the

same rate of combustion at the end as at the beginning of this period—notwithstanding growth of concentration with augmenting aggregation; an evidence of effective fire extinguishment and fire salvage.

The Patrol report enumerates the 1,410 fires in 1892 as burning \$1,684 per fire. Increase in rate of ignition is notable. There were 114 more fires in 1892 than in 1891, with eighty-four more fires in dwelling-houses and fifty-one more fires in stores. The 1,278 fires of 1891 assailed \$1,555,664 more insurance than the 1,410 fires of 1892, and the loss of 1892 was \$298,901 less than that of 1891. The saving in fire cost in 1892 was due to stores and warehouses, which burned \$540,979 less in 1892 than in 1891; woollen goods in 1891 burned more than double all the store and warehouse fires in 1892.

If we take the increase of Philadelphia combustible value from 1883 to 1892 as forty per cent., the \$1,172,732 of fire loss in 1883 would have as its equivalent in 1892, \$1,641,824, but

	<i>Fires.</i>	<i>Loss per Fire.</i>
1883,	853	\$1,374
1892,	1,410	1,684

With 853 fires in 1883, the equivalent ignition in 1892 would have been 1,194 fires, and the excess of \$735,639 in proportionate loss in 1892 was largely due to excess of ignitions. But in 1883, the combustible force was about one-half of that of 1884.

We cite the following annual comparisons of the decade, given in the Patrol report:

<i>Years.</i>	<i>Fires and Alarms.</i>	<i>Insurance.</i>	<i>Losses.</i>	<i>Per Cent.</i>
1883,	853	\$8,054,985 00	\$1,172,731 75	14'87
1884,	897	8,193,526 36	1,254,412 66	15'31
1885,	1,078	10,115,704 66	1,755,575 46	17'33
1886,	1,153	13,209,584 00	2,717,444 74	20'57
1887,	1,041	8,727,679 00	1,253,492 94	14'34
1888,	761	9,519,334 39	1,128,136 58	11'85
1889,	954	13,855,616 31	1,570,528 61	11'34
1890,	1,341	16,222,981 77	1,442,945 09	8'89
1891,	1,296	20,689,271 65	1,676,363 87	8'09
1892,	1,415	19,133,628 32	2,377,462 83	12'36
		\$127,652,301 48	\$19,319,202 53	15'11

The annual reports for the last three years of President Wagner, of the Philadelphia Patrol, present the following recapitulations:

BUILDINGS AND CONTENTS.

<i>Stores and Warehouses :</i>			
Number of fires,	1890. 336	1891. 239	1892. 290
Insurance loss,	\$218,186	\$655,790	\$114,801
<i>Textile Works :</i>			
Number of fires,	64	69	78
Insurance loss,	\$404,322	\$1,238,009	\$1,191,432
<i>Metal Works :</i>			
Number of fires,	16	40	37
Insurance loss,	\$1,429	\$68,851	\$63,904
<i>Wood Works :</i>			
Number of fires,	44	48	49
Insurance loss,	\$385,075	\$45,477	\$168,456
<i>Printers and Bookbinders :</i>			
Number of fires,	1	13	9
Insurance loss,	\$15,040	\$209,856	\$101,744
<i>Dwellings :</i>			
Number of fires,	543	445	569
Insurance loss,	\$34,947	\$29,313	\$56,005
<i>Stables and Barns :</i>			
Number of fires,	60	59	60
Insurance loss,	\$39,064	\$52,000	\$15,663
<i>Churches :</i>			
Number of fires,	9	3	6
Insurance loss,	\$3,694	\$12,169	\$14,861
<i>Miscellaneous :</i>			
Number of fires,	222	331	312
Insurance loss,	\$321,210	\$344,898	\$630,596

CAUSES OF FIRE IN PHILADELPHIA IN 1892.

Statement showing the causes of fires, number of fires from each, and the losses resulting therefrom :

Cause.	No. of Fires.	Insurance.	Insurance Loss.
Boilers,	13	\$391,756 00	\$6,271 76
Boiling over of fat, oils, etc.,	25	125,700 00	4,772 81
Bonfires,	11	9,900 00	2,433 00
Candles,	41	\$21,800 00	118,194 30
Defective flues,	128	668,700 00	12,103 35
Dry rooms,	5	139,200 00	55,967 64

<i>Causes.</i>	<i>No. of Fires.</i>	<i>Insurance.</i>	<i>Insurance Loss.</i>
Electric light wires,	17	\$238,400 00	\$16,597 44
Fire-pots (tinnerns'),	5	408,400 00	17,790 51
Fireworks,	36	241,700 00	2,736 68
Friction,	13	710,100 00	100,872 90
Gas jets,	71	2,705,799 00	300,330 14
Heaters,	23	244,080 00	5,756 65
Hot ashes,	19	93,800 00	3,601 76
Kilns,	3	583,500 00	131,224 53
Lightning,	5	443,000 00	10,043 41
Low-down grates,	5	24,000 00	689 00
Matches,	93	545,100 00	9,120 02
Oily rags,	5	138,500 00	6,152 35
Ovens,	8	51,300 00	566 00
Pickers,	24	623,700 00	5,289 74
Ranges,	19	55,500 00	1,262 45
Roasters,	3	79,700 00	2,161 88
Roofers' wagon,	1	25,250 00	5,464 99
Rubbish,	46	871,200 00	10,188 12
Smoking,	16	64,406 66	10,617 64
Sparks from emery wheel,	1	61,500 00	7,907 64
grinder,	1	9,500 00	2,995 80
locomotive,	23	132,100 00	20,156 42
Spontaneous combustion,	26	588,700 00	227,802 38
Stoves, cook and parlor,	93	310,175 00	22,818 96
Stove-pipes,	12	28,200 00	1,589 02
Supposed incendiary	12	18,000 00	2,064 28
Suspicious,	10	217,900 00	43,116 27
Unknown,	230	4,339,556 66	1,148,634 21
Sundry causes, losses of which do not reach \$500,	126	2,425,820 00	2,337 05
Total,	7,169	\$18,033,143 32	\$2,319,770 00

Flammable Fires:

Explosions of benzine,	9	\$46,800 00	\$5,193 15
coal oil,	5	12,250 00	355 75
gasoline,	6	17,450 00	523 25
naphtha,	1	51,400 00	200 00
Lamps, coal oil,	146	746,360 00	44,690 12
gasoline,	12	34,000 00	401 60
Overheated oil tank,	1	76,900 00	2,002 66
Stoves, coal oil,	21	40,325 00	1,901 85
gasoline,	40	74,800 00	1,333 45
	241	\$1,100,485 00	\$57,692 83
Total,	1410	\$19,133,628 32	\$2,377,462 83

We will now turn from bare figures to a more general description of the origins of fires in dwellings. One of the most prolific causes of fires is incendiarism. This is of two sorts, (1) by dishonest policy holders, and (2) by acts of revenge and pyromania, which I believe to be a variety of mental disease as prevalent as kleptomania. There has been much debate on the amount of the former. To what extent the insurance companies are annually the losers through this crime it is impossible to say. A good system of fire coroners in our country would do much to lessen the number of such losses, as well as to give us more reliable statistics. Australia, which has led the English-speaking world in many useful reforms, has tried this system. The following editorial notice in the *Chronicle* (April 13, 1893) gives us an idea of the results to be expected and the importance of the work.

"The *Australasian Insurance and Banking Record* publishes a record of inquests on fires in New South Wales in 1892, which should interest the fire inquest people in the United States. The total number of inquests was 139, but in ninety-one cases the evidence was so incomplete that the fire coroners could not decide whether the fire originated accidentally or was caused by an incendiary act. Out of forty-eight cases in which the coroner reached conclusions, nineteen fires were decided to have had accidental origins, while twenty-nine fires were attributed to arson. In other words, sixty per cent. of the fires whose causes were ascertained were incendiary and the remaining forty per cent. accidental. This abnormally large percentage of incendiarism will create surprise, even among those American fire underwriters who are most suspicious of the honesty of policy-holders. The Australasian coroners' decisions would appear more trustworthy if the proportion of their indecision was not so large. No information is given by the *Record* as to the number of alleged incendiary fires in which insurance policies were involved."

Man's domestic customs and habits undergo fewer mutations than do the operations of his business life.

In the latter he is quick to appreciate and to follow im-

proved methods, but in the construction of his dwellings and in his manner of life within their walls he clings tenaciously to practices which have long outlived their usefulness.

It is our purpose to confine ourselves at present to a consideration of the *causes* of fires, interesting as might be a study of the historical evolution of our dwelling-houses, a comparison of our homes with the *oikoi* of the Greeks, or with the houses and *insulae* of the Romans, with whom the tenement house, generally supposed to be a modern institution, was not wanting, or a contrast between the English homes of the time of Shakespeare (so charmingly described by William Harrison, in *Hallimshed's Chronicles*, 1577, Book II, Chapter 10; 1587, Book II, Chapter 12.) and those of the present day. But why, it is pertinent to inquire, do we not introduce in our dwelling constructions the slow-burning principles now universally employed in properly built manufactories, many of which could advantageously be utilized without deteriorating the æsthetic effect?

The majority of fires in dwellings are caused by heating and lighting apparatus.

The heating apparatus of a house should be centralized as much as possible. One fire is by far less hazardous than a number of them, for every one is an additional source of danger. Whatever system may be used, whether hot air, steam, or hot water, great care must always be exercised that inflammable substances are not placed in the immediate neighborhood of the heating apparatus.

Two things in every household, which frequently fail to receive the proper amount of attention, and which, in view of their importance, should be erected only by the best workmen, are the systems of drainage and heating. A defect in the first menaces health, and in the second involves danger from fire. We frequently find that in erecting heating apparatus, no thought has been given to the fact that heat will expand substances, and especially metals, to a considerable degree. This negligence in construction causes the formation of cracks and breaks which allow sparks to penetrate into the surrounding air. Where hot-air registers are used in floors (if possibly avoidable do not have them) cover the openings

with wire netting: especially in places where dirt and other refuse are apt to drop in, or where children could throw inflammable substances into them. At least one register in every house should be so arranged that it cannot be closed, for many fires are caused by hot-air flues becoming overheated when all registers are closed and the hot air cannot escape. Strict cleanliness in every detail of heating arrangements, is of prime importance, and before "firing up" in autumn the entire apparatus should be thoroughly examined. New heating apparatus is especially dangerous, as it has not stood a trial. Be specially on the alert in very cold weather, as artificial heating must then be increased to a dangerous degree.

Separate stoves should not be put up in out-of-the-way rooms. See that your central heating apparatus gives satisfaction, as frequently these stoves are neglected and cause fires. Stoves should be free from cracks and the floor protected by pieces of metal under them. These metal protectors should be amply large, so that hot coals which may fall from the stoves may be received on them, and not fall on the wooden floor or carpet. Brick platforms are not as safe as tin, as stoves are not apt to remain as stable on brick as on metal. Stoves should never be placed on ash receptacles, as they afford little stability and tend to cause stoves to lean and upset. The plastering of walls around stoves should be unbroken, and particular care should be taken that laths are not exposed to the escaping sparks. Wood-work near stoves should be protected with bright tin, which acts as a reflector to the heat rays, while a black or rough surface absorbs them. The storing or piling of wood near stoves is a frequent cause of fires. Particular care must be paid to stove-pipes to keep them at all times sound and in good order. They should never enter chimneys at points which cannot at all times be inspected, such as unused rooms, closets, and the like; nor should a stove-pipe extend through any place where it is not at all times visible, as fires may be caused by the accumulation of dust and fine organic matter upon it. The tops of

stove-pipes should be frequently looked after and cleaned. The joints or elbows of pipes should be well riveted, so that sparks may not be ejected through the breaks, and the entire pipe should be well supported by wire hangers or braces. Where pipes pass into chimneys they should be well fastened by a metal or terra-cotta collar, which, as well as the pipe, should be tightly wedged into the opening so that the pipe cannot disengage and thereby emit sparks into the room. Care must be taken never to allow stove-pipes to enter a flue vertically, as soot which may accumulate in the pipe is readily ignited and may cause larger fires. Stove-pipes should never pass out of the sides of a building or through windows.

Ashes should be kept in metal receptacles, never in wooden, or as is sometimes the case, in pasteboard boxes. Ashes have the remarkable property of holding heat for a long time, and for this reason ashes which are seemingly cooled should never be placed in wooden barrels and stood alongside of frame buildings or fences, as several cases are known in which spent ashes on being piled in quantity again became heated and ignited adjacent wood-work. All chimney flues should be properly "pargeted" on the inside, the brick-work should be of sufficient thickness between the floors or studding, and all wood-work should be well trimmed away from flues with safe air spaces between. Before plastering the inside, however, the architect, or better still, the proprietor, should see that the bricks of the chimney are solidly laid in mortar and well pointed. Many chimneys are laid almost dry, and when the plastering drops off such chimneys become exceedingly dangerous.

Instead of laying brick or stone on planks and flooring to form hearths, the latter should be protected by brick arches. This is the safest method. If brick arches cannot be so placed, then a layer of thick asbestos paper or concrete should first be laid on the wood-work, upon this a layer of sand and concrete, and then bricks laid in good cement; upon this another layer of bricks should be laid, but in such a manner as to leave an air space between it and the preceding course.

The safest system of heating is by hot water. In this case, the room is heated by radiation from pipes filled with water which has been heated in a boiler, preferably outside of the building to be heated.

Steam is now frequently employed for heating dwellings. Special care must be taken to hang pipes free from wood-work and away from all places where dust, dirt, sweepings and so on may accumulate. Where it is possible, as in tenement houses, servants' apartments, store-rooms, etc., steam pipes should be hung along the ceiling, about twenty-four inches below it (as is the usual method in the best modern factory buildings), instead of along the sides of the room as in the old fashion. The theory, often advanced, that with pipes hung below the ceiling, the same amount of heat cannot be obtained as when placed along the sides of the room, is erroneous. The following table, which shows the results of a series of experiments made by Mr. C. J. Woodbury, demonstrates this.

Hourly thermometrical observations were taken in a room 75 x 400 feet, supplied with five rows of steam pipes. In the first instance, the pipes were placed against the walls near the floor, and in the second there were four rows of pipe around the room, two feet from the walls and hung the same distance below the ceiling, requiring only three-quarters as much pipe as in the first instance.

MEAN TEMPERATURE OF HOURLY READINGS.

THERMOMETER PLACED IN CENTER OF ROOM.	DAILY AVERAGE.	
	Pipes at Side. Dec. 29th to Jan. 5th	Pipes Elevated. Jan. 5th to Feb. 5th
Nineteen inches from ceiling,	80° 24	80° 54
Midway,	70° 34	70° 30
Seventeen inches from floor,	72° 08	69° 00
Average,	77° 24	73° 23

The reasons why steam pipes ignite wood are twofold:

(1) By allowing the water to run low, the steam becomes superheated, causing a true combustion, and (2) pipes

containing steam at the usual temperature may cause the secondary phenomenon of spontaneous combustion. In the latter case, the steam pipes slowly dry the wood, the contained moisture being vaporized, and at last the wood assumes a state resembling charcoal; whereupon the glowing or combustion, well known in the case of charcoal, takes place spontaneously.

At a discussion of the French Academy, in 1879, this was brought out clearly. M. Cosson described an accident which had occurred in his laboratory a few days before. While the narrator was working in the laboratory, a portion of the boarding of the floor spontaneously took fire. The boards were in the vicinity of an air hole, fed with warm air from a stove four metres away on the floor below. A similar accident had taken place a few years before, and in consequence M. Cosson had replaced the boards adjoining the air hole by a slab of marble. The boards which now ignited adjoined the marble. The heat to which the boards were subjected was, however, very moderate, being only that of warm air at 25° C. Nevertheless, M. Cosson said the wood had undoubtedly been slowly carbonized. Being thus rendered extremely porous, a rapid absorption of the oxygen of the atmosphere had resulted and sufficient caloric was thereupon produced to originate combustion. The danger thus disclosed, said M. Cosson, is one to which the attention of builders ought to be directed. In the instance in question, M. Cosson was able to extinguish the fire with a little water, as he was present and witnessed its beginning; but had it occurred at night, during his absence, it would undoubtedly have completed its work of destruction. M. Faye stated that at Passy, a few days before, a similar case of spontaneous fire, due to the action of the warmth from the air hole of a stove upon the woodwork, had occurred at the house of one of his friends.

Mr. C. C. Hine, the veteran editor of the *Monitor*, expatiates on this topic as follows: "The Institute of Technology, of Boston, long ago decided upon the danger of steam pipes passing through and in contact with wood. It was shown that the wood, by being constantly heated, assumes the

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condition, to a greater or less degree, of fine charcoal, a condition the most favorable to spontaneous combustion. This is so important and interesting a point that we may be pardoned for enlarging upon it somewhat in contrast to the brevity of the foregoing paragraphs.

"Steam was generated in an ordinary boiler and was conveyed therefrom in pipes which passed through a furnace and thence into retorts for the purpose of distilling petroleum. Here the pipes formed extensive coils and then passed out, terminating at a valve outside the building. To prevent the steam, when blown off, from disintegrating the mortar in an opposite wall, some boards were set up to receive the force of the discharge, and as often as the superheated steam was blown against them, the boards were set on fire! This occurred in an oil refinery in Pittsburg, Pa.

"Some years since, while on a visit at the Institution for the Deaf and Dumb, in Illinois, of which an esteemed friend is principal, we called attention to the manner in which some steam coils were secured to wooden supports, and pronounced them unsafe. They were shown to be a thousand feet or so—as the pipes ran—from the boiler, and our caution only provoked a smile. The next year we visited, as usual, and, upon taking the principal's hand, he said—before exchanging salutations or inquiries: 'Come with me; I wish to show you something,' and led the way to the room where, a year ago, his attention had been called to the steam pipe. 'There,' said he, 'examine that; I have been saving it for you since last winter; the coil fell down, and investigation showed that the screws had let go because the wood had been turned to charcoal and had no more strength to hold them.' The experience was new to him; it may be old to some of our readers, but its introduction here will illustrate a fact which is now becoming an admitted one among those who have given this matter attention.

"An experiment illustrating the effects of superheated steam was tried as follows: Steam was taken from an ordinary boiler through a pipe forty feet long. Ten feet from the farther end a collar of wood was fitted closely to the pipe: ten feet nearer the boiler a lighted kerosene lamp

was placed under the pipe. In ten minutes the wooden collar was on fire."

To resume our text, then, carelessness causes the greatest number of fires: carelessness in regard to heating, and lighting and in storing inflammable and self-inflammable substances. We pass now to the next series of hazards, those of lighting.

The usual method of lighting in the larger cities of America is by gas. The greatest care must be taken to arrange fixtures so that they cannot swing against combustible substances, such as curtains and woodwork. Swinging brackets are largely responsible for fires in dwellings, and should, as much as possible, be done away with. A gas flame is the producer of intense heat, tending to thoroughly dry all substances around it and transform them into a state ready for ignition. A systematic arrangement and solid construction of the entire system of gas supply throughout a house is of prime importance. Frequently, the installation of gas fittings is left to "cheap" employes or apprentices, and this, of course, carries serious results with it. Not only do fires originate through leaking gas pipes, but many lives also have been lost by gas poisoning and suffocation. A valve which cuts off the main supply, to which any member of *every* household can readily have access, and which *can be turned without trouble*, is of great importance, as sometimes it is impossible to stop leaks without the aid of a mechanic, and fires have been caused by persons going into rooms with lights "searching for the leak." They usually find it by this method; not, however, in a manner agreeable to themselves.

In installing a system of gas lighting, particular attention must be paid that every gas flame, which, through the heat which radiates from it, forms a certain globe or radius of danger around it, is at a safe distance from inflammable substances. A gas flame should be at least thirty-six inches from the ceiling, and when nearer to an inflammable substance than this, the latter should be covered with metal, care being taken to allow an air space between the metal and the wood or other inflammable substance, so that it

cannot be ignited or charred by conduction, which might otherwise be the case. Where swinging brackets are used (avoid them wherever you can), these should be provided with stops to prevent them from swinging against woodwork. A very good method of arranging gas lights, which has not been carried out in dwellings, but which is required in theatres, is to place wire baskets or cages around them. These cages are made of wire, and attached to the bracket. The gas can be readily lit by protruding a lighted taper or match between the wires (electric lighters now generally introduced make the ignition of gas still easier) while the globe of wire prevents combustible substances from coming in contact with the flame or inside of the sphere of danger. Such cages should by all means be fastened to those long swinging brackets in chambers, which are usually found near windows on both sides of looking glasses. It will be objected that the wire guards in theatres are unsightly, but these devices could be made of brass in beautiful designs so as to be an ornament. If a window be opened a draught blows the lace curtain into the flame, and a fire results. This winter, a number of fires were caused in Philadelphia by persons who in attempting to light the gas from such brackets near window curtains, succeeded in igniting the latter.

Where Siemens regenerative burners are used, ventilating flues should carry off the heat generated and the products of combustion. These flues should be well constructed of metal, free from woodwork, as large burners of this kind give off a great amount of heat.

Petroleum is much used for lighting in smaller dwellings, and in reading lamps, thanks to Philadelphia gas, even in finer residences. In order to be fit for use it should have a flash test of at least 130° . This can readily be tested by pouring some of the oil into a dish placed on a layer of sand contained in another receptacle, so that the heat may be distributed evenly throughout the oil, applying heat to the outer receptacle containing the sand, and placing a thermometer in the oil. An ignited taper (the flame as small as possible, so as not to heat the oil on the surface) is then held above

the oil, but not allowed to touch it. The temperature of the oil is then accurately observed, and if the vapor from the oil flashes before it has a temperature of 130° , it is unfit for use in households.

It is exceedingly difficult to extinguish petroleum fires, and the explosiveness of this substance is well known, as there is scarcely a week, or even a day, in which we do not hear of some sad accident caused by this substance. *Do not, therefore, attempt to light fires with petroleum.*

Dr. Schlumberger, who has given his special attention to this subject, some years ago stated that, according to the statistics which he had collected, out of ten persons who attempt to extinguish burning petroleum, six are killed.

Frequently dealers adulterate oils by mixing heavy oils with lighter and more explosive products. Petroleum is composed of the elements of carbon and hydrogen, and its products range, by almost imperceptible degrees, from oils which are very light and inflammable, to those of a consistency of molasses, which can only be ignited at very high temperatures.

The following are the principal products obtained by the distillation of crude petroleum, but chemists have obtained by fractional distillation many other substances holding intermediate positions in the list and to these they have given as many different names.

	Specific Gravity Water, 1.	Specific Gravity, Baumé	Boiling Point Fahr.
Eligolene,	463	=	65°
Gasoline,	663	85	170°
C Naphtha,	706	70	180°
B Naphtha,	724	67	200°
A Naphtha,	747	63	210°
Kerosene oil,	801	53	260°
Mineral sperm oil,	847	46	325°
General lubricating oil,	903	39	375°
Paraffine,	941 & 2.		

The explosiveness and inflammability of an oil, however, do not depend upon its specific gravity, for the oil may not

be a stable one but a mixture of a lighter and a heavier oil, so that while the hydrometer may show its specific gravity to be comparatively high, it may be an extremely dangerous oil, as, on a slight elevation of temperature, the lighter constituent will be given off in the form of vapor.

[*To be continued.*]

THE COMMITTEE ON SCIENCE AND THE ARTS
OF THE FRANKLIN INSTITUTE.

REPORT No. 1706.

Subject—MARKS' IMPROVEMENTS ON ARTIFICIAL LIMBS.

At the stated meeting of the Committee on Science and the Arts of the Franklin Institute, held February 1, 1893, the following report was adopted and ordered to be issued over the signature of the Chairman and the certification of the Secretary, viz :

This invention consists of an improved method of making artificial limbs, adapted to amputations in the ankle, or below, in the tarsus or metatarsus in which the former modes of construction, with articulated ankle joints of wood as the material, were impracticable and unsatisfactory in result; although sometimes made when wood was employed as a material, these were always clumsy, and when the articulated ankle was attempted, it proved inoperative. The new method of construction involves the use of aluminum as the material to form the shell socket or sustaining frame, as it might be called, the aluminum shell supporting the body, and forming the attachment for the elastic rubber foot, which acts as a rolling elastic segment simulating the functions of the natural foot in walking, and acting as an elastic cushion in relieving the wearer from the jar or shock of resting the weight upon the limb. At the same time they resemble the form of the natural foot more closely than was possible with previous constructions.

The invention is described and set forth in United States Letters Patent, No. 470,431, to George E. Marks, of New York City, N. Y., dated March 8, 1892.