heart of Big Smoky and Blue Ridge Mountains, on the banks of the beautiful French Broad River. The location is 1,700 or 1,800 feet above the sea level. The atmosphere is dry and invigorating and the climate mild and equable, there being a very large proportion of clear days. The springs have long been popular in the South, but in recent years they have come into high favor with Northern visitors also. They are about twenty in number, and the temperature of the waters ranges from 96° to 104° F. They form one of the only two groups of hot springs east of the Mississippi from Canada to the Gulf of Mexico. The following analysis was recently made by Professors Chandler and Pellew, of New York:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	1.08
Potassium chloride	.62
Potassium sulphate	1.62
Calcium sulphate	20.04
Magnesium sulphate	7.20
Ammonium bicarbonate	Traces.
Calcium bicarbonate	9.02
Iron bicarbonate	.10
Sodium phosphate	Traces.
Alumina	.04
Silica	3.14
Organic and volatile matter	Traces.
Total	42.86

The waters are quite similar to those of the Arkansas Hot Springs. Several of the springs have been encompassed in the limits of a fine, large bath-house, which is divided into sixteen separate pools, nine feet long by six feet wide and four to five feet in depth. The water pours into these pools directly from the springs. The visitor will find here all of the modern appliances and improvements which go to make up a first-class bathing establishment of the day. Guests are received at all times of the year. With its lovely mountain scenery, its exhilarating climate, its thermal waters, and many other natural attractions, combined with a hospitable and scientific management, this resort is well deserving of the wide reputation which it has obtained. *James K. Crook.*

HOT SULPHUR SPRINGS.—Middle Park, Grand County, Colorado.

POST-OFFICE.—Hot Sulphur Springs. Hotels.

ACCESS.—Viâ Union Pacific Railroad, 50 miles west from Denver to Georgetown; thence by daily stage 50 miles to springs, passing over the Snowy, or main range, of the Rocky Mountains, at 11,250 feet altitude.

These springs are located in the Middle Park on the banks of the Grand River, 7,625 feet above the sea level. This river forms the only drainage outlet to the Middle Park, a mountain basin 90 by 50 miles in extent. The enclosing peaks vary in height from 9,000 to 14,000 feet.

The prevailing weather in this section is clear, with westerly winds. There is considerable snow in winter, with a steady range of temperature of about 32° to 50° F., but occasionally dropping to 20° or 25° below zero. As many as twenty-two of the springs are well situated for improvement, but, according to the latest reports we have had, the baths now in use take water from only three or four. The exact flow of water cannot be stated, but it is believed to be greater than that of the Arkansas Hot Springs. A strong smell of sulphureted hydrogen pervades the neighborhood of the springs, and with a favoring wind may be noticed for a considerable distance up the valley. The channels through which the waters flow are lined with a soft yellowish-white, velvety substance having the odor of sulphur (probably a confervoid growth known as sulfuraria). This substance is evidently not a sediment, as it stands up like the pile of velvet or plush, and is not deposited in layers, while the water itself is as clear and bright as that of any mountain spring. It is said to be very palatable and to rest well on delicate stomachs. The following analyses were made some years ago by Professor Mallett, Jr.:

ONE UNITED STATES GALLON CONTAINS:

Solids.	No. 1—Red sulphur, temp. 109.5° F. Grains.	No. 2—Saline, temp. 91° F. Grains.	No. 3—Alum, temp. 97.5° F. Grains.	No. 4—Little sulphur, temp. 111° F. Grains.	No. 5—Big sulphur, temp. 80.56° F. Grains.	No. 6—Bath spring, temp. 117° F. Grains.
Calcium carbonate	10.08	......	......	8.46	3.68	6.43
Sodium carbonate	58.57	50.45	20.37	29.42	39.37	22.42
Magnesium sulphate	......	......	5.26			
Magnesium carbonate	6.57	4.14	......	2.66	1.93	
Sodium chloride	14.61	......	13.29	12.18	13.97	13.11
Sodium sulphate	8.48	8.97	17.53	14.25	9.85	25.11
Sodium silicate	......	1.46				
Potassium sulphate	.50	.07	1.03	7.03	.96	1.69
Free carbonic acid	2.94	......	8.42	.42	9.49	4.69
Silicic acid	......	......	.61	.54	1.31	1.36
Lithia	Trace	Trace	Trace			
Iron	Trace	Trace	Trace	Trace	Trace	Trace
Ammonia	......	Trace	Trace	Trace	Trace	Trace
Total	101.75	65.09	66.51	74.96	80.56	74.81

The supply of water furnished for this analysis was insufficient to detect solids present in minute quantities. The lithia was discovered by means of a spectroscope in the residue left after evaporating 300 c.c. of the water. No gaseous constituents are shown, as the analyses were made from bottled water, which had been standing for some time after removal from the springs, and it is believed that the sulphureted hydrogen (or other gas) which may have been present had either escaped or been oxidized to sulphuric acid.

The waters are recommended in cutaneous, hepatic, uterine, neuralgic, gouty, and rheumatic disorders, and for the manifestations of tertiary syphilis. As with thermal waters generally, they are contraindicated in most acute diseases, in tuberculosis and cancer, in fatty degeneration of any important structure, in aneurism or organic heart disease, and in predispositions to cerebral, gastric, pulmonary, or intestinal hemorrhage. There are two hotels at the Hot Sulphur Springs and several private houses where guests may obtain accommodations.

James K. Crook.

HOUSE SANITATION.—The primary objects of habitations is to secure protection from the influence of heat and cold, rain, sunshine, and storms, and thus promote the health and happiness, and indirectly also, the morals and culture of the human race. The influence of sanitary houses cannot be overestimated. Dr. Villermé, in an investigation in France from 1821 to 1827, found that of the inhabitants of arrondissements containing 7 per cent. of badly constructed dwellings, 1 person out of every 72 died; of inhabitants of arrondissements containing 22 per cent. of badly constructed dwellings 1 out of 65 died; while of the inhabitants of arrondissements containing 38 per cent. of badly constructed dwellings 1 out of every 45 died. The history of improved dwellings for wage-earners shows everywhere a lessened death rate.

1. *Site.*—One of the first requirements of a sanitary home is a salubrious building site with a thorough exposure to air and sunlight; the top of a small elevation is always to be preferred, because of better natural drainage, purer air, freedom from dampness, and greater safety from inundations. Hippocrates and Vitruvius have referred in their writings to elevation as a desirable factor. The tops of the highest hills are usually too much exposed to the wind, and when chosen in certain climates the house should be protected by trees on the windward side; next to the top of a hill, the slopes should be preferred with a southern, southeastern, or southwestern exposure, on account of the advantages of sunlight and greater cheerfulness. Sites located in depressions which receive the natural drainage from surrounding slopes should be avoided, as they are not only damp, but likely to be surrounded with cold air and chilling mists. It is scarcely necessary to insist that so-called "made soil" and close proximity to marshes and injurious industrial establishments should be avoided.

Next to the topography of the site the character of the soil is important in its influence upon the healthfulness of the home. In a general way a gravelly, sandy, or chalky soil of good depth on a slope makes the best building site, provided soil pollution has not taken place and the deposit is not upheld by some impermeable stratum of clay or rock near the surface. Clay, marl, peat, and made soils should be avoided, because they are damp and the presence of organic matter, apart from favoring the proliferation of disease germs, also tends to pollute the ground air which is in constant communication and interchangeable with the atmosphere. (See Dr. Charles Smart's article on *Air*, p. 159, Vol. I.)

While rock affords easy facility for surface drainage, Mr. T. M. Clark (REFERENCE HANDBOOK OF THE MEDICAL SCIENCES, first edition, Vol. III., p. 423) regards it as very objectionable, as the ledges are full of seams through which water usually flows, and the trenching necessary for the interception of the springs formed in this way is so costly that it is usually neglected, and cellars built on rock are in consequence generally damp.

The temperature of the upper layers of soil, and hence also its dryness, depend largely upon its exposure to the sun; but it is well known that heat is variably absorbed and retained in different soils equally shielded or unshielded by vegetation. The following table by Schubler shows the capacity of different soils of absorbing and retaining heat—100 being assumed as the standard:

Land with some lime	100.0	Clayey earth	68.4
Pure sand	95.6	Pure clay	66.7
Light clay	76.9	Fine chalk	61.8
Gypsum	72.2	Humus	49.0
Heavy clay	71.1		

It will be seen, therefore, that sandy soils are warmer and clayey soils are not only damp but also very much colder.

Unfortunately, "ideal building sites" are within the reach only of comparatively few, and steps must therefore be taken to render objectionable sites as sanitary as possible; for the purpose of securing dryness, attention must be paid to the prompt removal of surface water and of subsoil water, the site should be drained by means of suitable drains four to six feet below the floor of the cellar or basement; indeed this precaution should not be neglected even in comparatively dry soils in order to limit the fluctuations of the ground water. In the preparation of the building site it is always desirable to excavate sufficiently deep to get rid of surface pollution, and it is perhaps needless to insist that in grading no soil containing the rubbish and wastes of human life and occupation should be used. In isolated buildings the surface drainage should be directed away from the house and the environments improved, with due regard to light and air, by either favoring the growth of vegetation or by removal and pruning of excess and overproduction.

2. *Building Material.*—The most common materials used in the construction of buildings are wood, brick, sandstone, limestone, granite, marble, iron, steel and other metals, glass, cement, mortar, asphaltum, and concrete. Of these materials, iron, zinc, copper, cement, slate, vitrified brick, and granite are quite impermeable, while others are not; depending upon the degree of their porosity and hygroscopic properties—according to Lang—

	Per cent. of water by volume.	Or, per cent. by weight.
Soft-burned bricks absorb	32.70	19.13
Hard-burned bricks absorb	28.20	16.50
Mortar burned bricks absorb	26.00	14.80
Portland cement absorbs	17.80	11.00
Limestone absorbs	17.70	7.26
Dolomite absorbs	14.70	6.50
Sandstone absorbs	10.80	4.34
Porphyry absorbs	2.75	1.05
Slate absorbs	.93	.35
Granite absorbs	.61	.23
Marble absorbs	.59	.32
Serpentine rock absorbs	.56	.22
Vitrified bricks absorb	.00	.00

A wall built of ordinary brick and mortar is capable of absorbing large quantities of water. Pettenkofer has calculated that 10,000 gallons are incorporated in a house built of 100,000 ordinary sized bricks. Bricks burned from clay containing much saltpetre and sulphate of sodium are especially objectionable, as a deposit is formed on the outside of the walls and moisture is attracted.

Galton, in his work on healthy dwellings, has shown that marble and limestone conduct more heat than an equal thickness of glass, bricks, plastering, and wainscoting. This appears to prove what experience has practically demonstrated, that frame and brick buildings are more readily warmed than marble and limestone structures of equal size and thickness of walls.

The hygienic importance of the properties of the building material cannot be underrated. Its porosity largely determines the interchange of air through the walls and the temperature of the rooms, thus greatly influencing ventilation and heating. The pores, as in the soil, contain either air or moisture; if air, the heat is conducted slowly, whilst water conducts heat readily. The hygroscopic properties of the material influence capillary attraction and diffusion of moisture, and consequently also the permeability and heat-conducting powers of the walls. Walls saturated with moisture absorb much heat and render transpiration of air impossible. It is for this reason that a house with damp walls appears much cooler to the inmates in summer than a dry one; but damp walls are decidedly objectionable, because they not only render the air of the room damp and impure and abstract more heat from the inmates, but also favor the growth of micro-organisms.

It will be readily understood that the application of paint, wall paper, and even calcimining will affect, if not completely check, the transpiration of air through the walls. For hot climates, frame and other forms of wooden buildings possess the advantage that they cool off very rapidly after the sun has disappeared, but because of their inflammability, short duration of life, and other sanitary disadvantages, such buildings cannot be recommended. But, as long as they are being extensively used in this country, special precaution should be taken in planning such buildings to prevent the entrance of cold winds at the junction of the wood walls and the stone underpinning. For this purpose Mr. Clark recommends a few courses of brick in mortar to be laid upon the cellar wall just behind the wooden sill; and as regards the exclusion of cold air through cracks or crevices in the cornice, he suggests the construction of a four-inch wall of brick and mortar on top of the plate which forms the top of the wall and supports the floor of the rafters, carrying it up until it meets the roof boarding. This wall, besides its use in keeping out cold winds, is also of some value in checking the spread of fire. Frame houses can be rendered cooler in summer and warmer in winter by double plastering inside and by covering the outside walls first with rough boards and a layer of Cabot's quilt and an exterior finish of clap-boards or shingles.

In spite of certain objections to brick, they are on the whole the most desirable material for ordinary dwellings; they resist fire better than any other material, and a hard-stock pressed brick of a light color is quite impermeable to moisture and makes a pleasing and hygienic outer wall. Next to brick, granite, marble, lime and sandstone are most frequently used, especially in connection with iron and steel in the construction of fireproof buildings. None of these rocks can resist the ravages of fire as well as brick; granite is better than marble, lime, or sandstone in this regard.

Micro-organisms in building material are especially numerous in the filler for ceiling spaces, which is frequently selected without regard to its source, old plaster and other rubbish being used; Emmerich has isolated the pneumococcus in such material, and Bonome found the bacillus of tetanus in mortar.

The latter being a mixture of sand and lime, the inference is that it was derived from sand, and that the spores were not destroyed by the action of the lime. Wall papers, unless very smooth, harbor a large number of micro-organisms; we also know the danger of house fungi, especially the "merculius lacrymans," in bringing about the "dry rot" in pine lumber, as well as the frequent occurrence of moulds in dark and damp places.

Construction of the House.—Dryness of the foundation and walls, as lready indicated, must be secured by draining the subsoil four to six feet below the cellar or base-

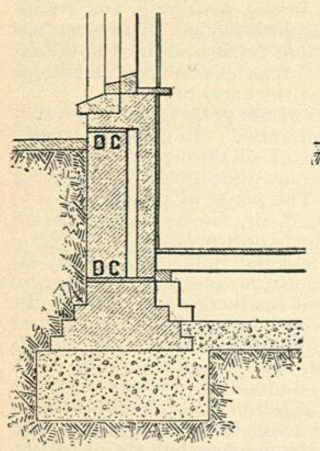

FIG.. 2711.

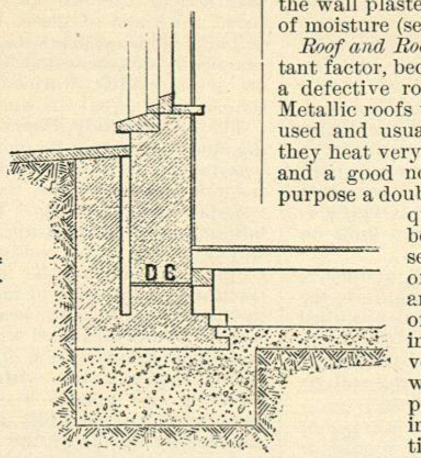

FIG. 2712.

FIGS. 2711 and 2712.—Methods of Preventing Dampness of Walls. Letters *D C* denote location of damp-proof course. (Munson.)

ment and covering the entire floor with a layer of cement concrete six inches thick, rammed solid, and this should be coated with one inch of cement. In this way not only dampness, but the equally obnoxious ground air are excluded. To prevent the dampness of the soil from rising in the walls by capillary attraction, the foundations must be laid in concrete and hydraulic cement and a horizontal course of slate bedded in cement should be interposed between the concrete footings and wall, and another course of slate just as the foundation walls reach the ground level. Since these slate courses are liable to fracture, the last damp-proof course should consist of vitrified hollow brick, which, moreover, possess the advantage of securing ventilation. Some architects recommend damp-proof courses of tarred-felt asphalt or sheet lead (Figs. 2711 and 2712).

The exterior walls of a house, whenever practicable, should be separated from the ground by an "open area," extending from the foundation upward; but where this cannot be done, a "dry area" may be formed by constructing a hollow wall to the ground level, provided with the usual damp-proof courses, and if springy, also with a subsoil drain at the bottom, at the same time protecting the wall in contact with the ground with a coat of slate embedded in cement. Mr. Clark suggests that if the ground is springy, a strip of tarred roofing felt, a little wider than the wall, should be laid upon the footings just below the cellar floor, and the stonework continued upon it. This, he says, "will prevent moisture from rising in the walls by capillary attraction from below, and with the coal-tar coat on the outside, a cellar with walls of porous material may be made dry and wholesome at small expense," but we cannot vouch for the durability of this procedure.

In localities with considerable rainfall it will be well to protect the side or rear walls of a rough brick building from driving rains with either a coat of cement, mineral paint, tar, or glazed tiles. Such a precaution is unnecessary when hard-pressed bricks are used. Reference has already been made to the fact that during the construction of a building an immense amount of water is incorporated with the bricks, mortar, and plaster. This water should be gotten rid of before the house is occupied, by thorough airing and drying; but not too rapidly, as a rapid evaporation prevents the carbonate of lime from becoming crystallized and the mortar loses its binding qualities. If the house has not been properly dried, the walls are very likely to sweat, which is in part due to their own moisture and partly to the condensation of the respiratory vapors on the damp cold walls. Laveran states, that a building is not fit for occupancy as long as the wall plaster contains more than twenty-two per cent. of moisture (see Examination, p. 768).

Roof and Roofing.—A good dry roof is another important factor, because water often gets to the walls through a defective roof and the whole house becomes damp. Metallic roofs with a sufficient pitch are most commonly used and usually secure this needed protection; but as they heat very rapidly a tin roof should be painted white and a good non-conductor should intervene. For this purpose a double course of boards with a layer of Cabot's quilt, corked or Florian building-paper may be used. The tin, of course, is properly secured to the upper sheating with a layer of felt paper directly beneath the tin. In any event there should also be an air space of two to three feet between the upper ceiling and the roof, and this space should be ventilated with perforated bricks in the walls and circular ventilators at the highest points of the roof. It is also a good plan, in order to prevent rusting, to cover the tin with a coat of mineral paint on the under side. Slate, cement, and tiled roofs, when properly constructed, afford protection against dampness, fire, and heat. In rural districts wooden shingles are still extensively used, and such roofs when treated with creosote and covered with rubber or metallic paint last for about twenty years. Whatever kind of a roof is used, free access to it should be provided by means of stairs or a ladder through a suitable opening, which in summer can be utilized for the escape of hot air. Special attention should be paid to the gutters and rain leaders; the openings of the latter should be protected with a network of galvanized iron, so as to prevent dead leaves, scraps of paper, mortar, birds' nests, etc., from passing through and clogging the conductors. The gutters should be periodically cleaned to prevent accumulation of rubbish and the overflow resulting therefrom. Subsequent leaks and defects should be promptly repaired. A leaky rain spout may keep the entire house damp. Copper or galvanized iron should be chosen instead of tin for gutters and conductors.

Floors.—Hygiene demands that the floors should be impervious to dirt, moisture, and germs, and should therefore be well seasoned, tongued, and grooved, closely matched and laid in white lead. All crevices resulting from subsequent shrinkage should be neatly filled with strips of wood, putty, paint, or wax. There should be a sub-floor of rough pine with a double layer of Florian building paper between; the top floor should not be laid until after the building is trimmed out; it should then be planed off and treated with a mixture prepared as follows: Dissolve by heat one pint of paraffin pared into shavings in two pints of raw linseed oil. To this solution add two pints of liquid dryer and sufficient turpentine to thin it to the desired consistency. This will give a gloss finish. If a dead finish be desired, about one-half of the quantity of paraffin should be used; apply with brush the same as varnish. If a high degree of polish be desired, rub with a polishing brush. One gallon of this mixture will cover approximately two hundred square feet of floor surface.

Oak and other hard-wood parquetry floors are not only attractive but also offer every hygienic advantage. In warm climates cement or "granito" floors may be advantageously used. The latter are really nothing more than a concrete-cement floor, four to six inches in thickness, with chips of marble and granite of various colors embedded in the upper layer and polished. They are prac-

tically insect and vermin proof, especially desirable for kitchens, pantries, and bathrooms, and should supersede the use of linoleum and rubber floor coverings. As a filler for the ceiling space, with a view of deadening sounds and as a protection in case of fire, special hollow bricks, dry cinders, clean dry mortar and peat, impregnated with milk of lime, have been used. Metallic laths are preferable to wood.

Stairs.—The stairway should be so constructed as to afford an easy ascent with risers not exceeding seven inches in height and treads from ten to twelve inches in width. For public buildings and tenement houses iron stairs and fire-escapes are demanded; indeed, even private houses would be better off with these safeguards in case of fire.

Halls.—The halls of a house should be roomy, well-lighted by direct light, if possible, and susceptible of ventilation. In a modern private dwelling the hall on the first floor is five to six feet in width and leads into the reception room, from which proceeds an open stairway to the upper floors. The open stairway should be lighted and ventilated by means of a skylight.

Interior Arrangements.—In regard to the size of the dwellings it is always best if they are simply large enough to accommodate one family. Overcrowding should be avoided, as infectious diseases are more liable to spread in consequence of aerial infection and the more intimate contact of the occupants. Körösi, of Budapest, has shown that out of every one hundred deaths from contagious diseases, there were:

20 deaths in dwellings with 1 to 2 persons in each room.
29 " " " " 3 " 5 " " " "
32 " " " " 6 " 10 " " " "
79 " " " " over 10 " " " "

The following table, prepared by Rohé, shows the relation of death rate to density of population:

City.	Mean number of inhabitants to each house.	Average annual death rate per 1,000 inhabitants.
London	8	24
Berlin	32	25
Paris	35	28
St. Petersburg	52	41
Vienna	55	47

It would be unfair, however, to attribute this increased death rate solely to overcrowding; other factors must be considered, since, as well expressed by Ogle, "The more crowded a community the greater, generally speaking, is the amount of abject want, of filth, of crime, of drunkenness, and of other excesses." Nevertheless, these mortality statistics demonstrate the baneful effects of tenement houses. With the present rapid-transit facilities in every city, our voice should be clearly in favor of individual homes; and when this is impracticable, we should insist on broad streets and deep yards. No more than sixty-six per cent. of the lot should be covered by the house, and the height of the building should never exceed the width of the street. No field affords better opportunity for philanthropic work than the removal of slums and erection of sanitary houses for wage-earners at reasonable rentals. Acting upon this, the Washington Sanitary Improvement Company was organized in 1897, and Surgeon-General Sternberg prepared plans in which no detail was omitted which would tend to provide the best accommodations from the standpoint of hygiene. Each house has a frontage of 17½ feet and consists of two independent flats, one on each floor, the special feature being that each flat constitutes a complete home, having a separate entrance and exit, separate yard and cellar. The entrance to the flat on the first floor opens into the front or sitting-room, 13.2 by 14 feet; back of this room is a hallway leading to the bedrooms, 12 by 13.2 feet, bathroom 5.6 by 5.6, and kitchen 10 by 12.4 feet. The entrance to the flat in the second story is by a staircase with access through a doorway on a level with the one opening into the flat on the first floor, but at the other end of the front of the house. Each flat has three large closets, and the kitchens are provided with a range, hot-water boiler, dressers, and sinks. Every room receives direct light and air, and the plumbing is the best. These flats rent for $12 per month, with a rebate of one month's rent every year to tenants whose apartments have not required repairs. The company has paid five-per-cent. dividends from the beginning and accumulated a surplus fund at the rate of two per cent. per annum. No officer receives any compensation, and this promotes the philanthropic aspect of the enterprise by providing the very best accommodation from the standpoint of hygiene, and as to comfort the utmost which a given cost will provide. The company was awarded a gold medal at the Paris Exposition in 1900, the only company in the United States to receive that award.

Basements are always desirable, even in small houses, for store-rooms, heating plants, and kitchens; they should be at least eight feet from floor to ceiling, not over one-half below ground, well lighted, and with all precautions taken to prevent the odors of the kitchen from passing into the upper stories. This can be done by a closed stairway and a deep hood over the range, which should conduct the gases into a flue located next to the smoke flue. In the more commodious houses the first floor usually consists of three large rooms, parlor, reception, and dining-room, to which in double houses a library may be added. When practicable, the kitchen should be located in a one-story wing with pantry intervening between the kitchen and dining-room. This isolates the kitchen and odors from the main house, and is preferable in many respects.

The rooms of the first floor, or parlor floor, should be from 10½ to 11 feet high and liberally supplied with windows, while the upper stories may be 10 and 9½ feet in height. Living and sleeping apartments for obvious reasons should not be tolerated in basements. The largest and sunniest apartment in the house should be chosen for the nursery and living room. The bedrooms should also be bright and sunny, and rooms with northern exposure avoided as much as possible for regular bedrooms. In this connection the stimulating effects of sunlight upon tissue metamorphosis and its destructive influence on micro-organisms should be remembered. No room should have a borrowed light, and this can be avoided by the construction of ample air and light wells in city houses which are three or four rooms deep. The windows should be made to open on top and bottom.

Interior Finish and Decorations.—Hygiene cannot approve of decorations or an interior finish which serve as dust and germ traps. In all houses dust is produced by the wear and tear of domestic activities, and our object should be to prevent its accumulation and facilitate its removal. Cornices and projections on ceilings and walls, the mouldings of door and window frames, wardrobes, carpet and cumbersome draperies all tend to collect dust and micro-organisms; they are not tolerated in hospitals and should be abolished in sanitary houses.

When the floors are neatly polished, it is quite sufficient to have a few small rugs which can be easily taken up and shaken and the floors cleaned with a damp duster. Heavy curtains and draperies should give way to light, airy fabrics, which can be easily washed. The bedroom furniture should be light, simple, and limited to the most necessary articles. Every bedroom should be provided with a commodious closet, supplied with clothes hooks, shelves, and drawers, and if the mirror is sunk in the panel of the door, wardrobes and dressing-cases could be conveniently dispensed with. All corners and angles of the inside of the house should be rounded to facilitate the removal of dust.

Wall Decorations.—The wall coverings should be as smooth as possible, since rough and highly-embossed paper and hangings accumulate an enormous quantity of dust and germs. On the whole, the plain calcimined or painted walls outrank from a sanitary point of view the gorgeous decorations of the palatial homes. Green paint and green-colored wall papers should be rejected; indeed, since arsenic has been found in various colored papers other than green, no paper should be used unless guaranteed to be free from arsenic, as much harm may be done by arseniuretted hydrogen, which tends to produce a chronic form of arsenical poisoning, characterized by conjunctivitis, cough, nausea, and diarrhœa, with colic, cramps, and debility.

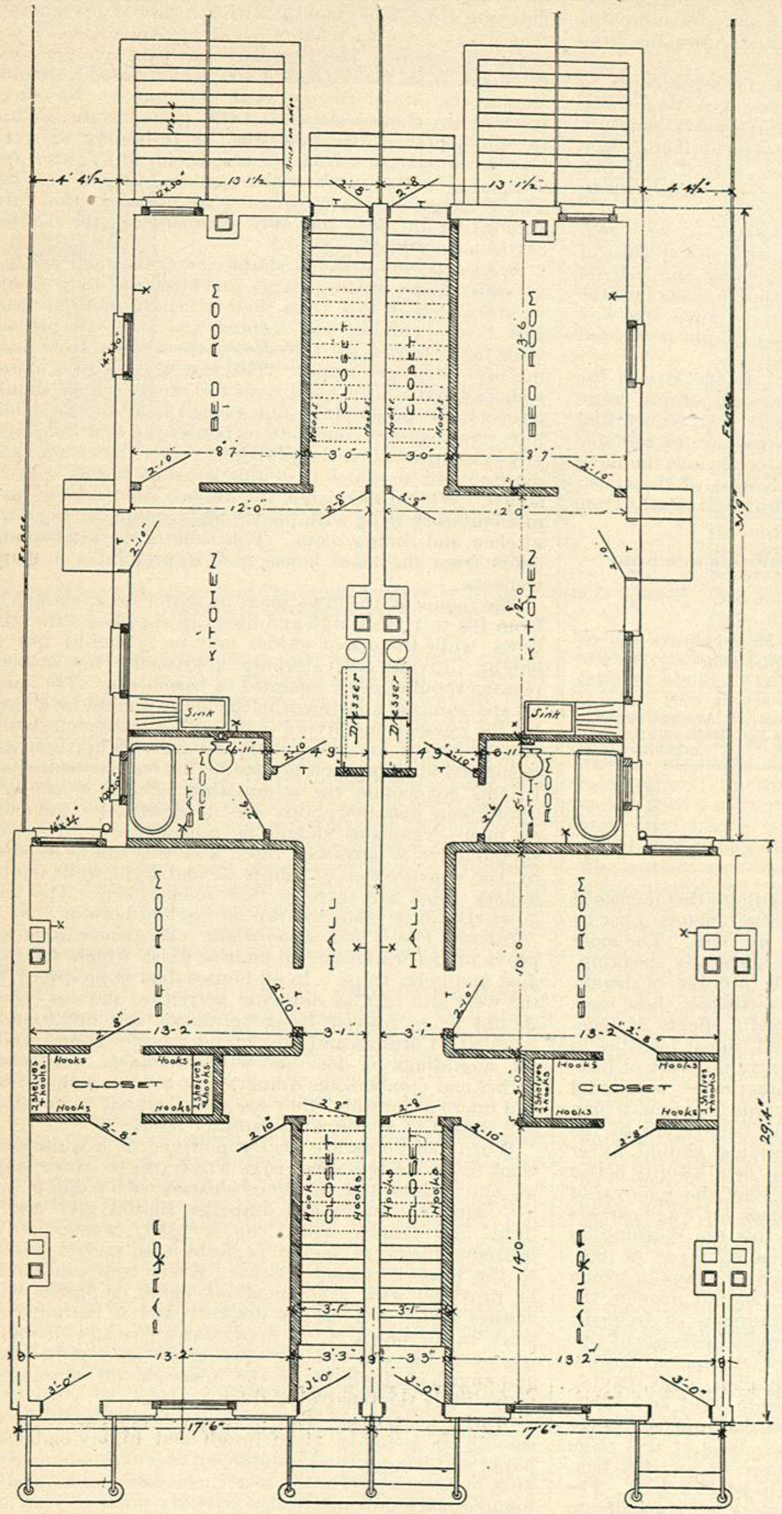

FIG. 2713.—First-Story Plan of Sanitary Houses for Wage-earners in the City of Washington.

The air of habitations differs from the exterior air in this, that unless precautions have been taken it may contain the elements of ground and sewer air; but even in the best-appointed houses the air is vitiated by the products of respiration, combustion, and decomposition of organic matter. As a matter of fact we always find an excess of carbonic acid, as much as 5.88 volumes per 10,000 having been determined in basements, 4.59 on the first floor, 4.50 on the second floor, and 4.19 on the third floor. We also find an excess of organic matter, most probably derived from the lungs, mouth, and skin of the occupants. Some authors deny that the skin and lungs in perfect health give off anything impure, but experience points to the fact that even the cleanest and healthiest persons exhale an organic substance which clings to bedding, clothing, carpets, and walls, and imparts that peculiar close and offensive odor to bedrooms and other inhabited apartments. Indeed, Uffelmann never failed to find ammonia nitrates in the air of his rooms, amounting to from 0.108 to 0.072 mgm. as compared with 0.025 mgm. per cubic metre in the outer air.

We also find more dust and germs than in the open air. If on a wind-still day we expose two glass slides moistened with glycerin, one in the outer air and the other indoors, we shall find at the expiration of twelve hours that the slide exposed indoors will contain a larger amount of dust, and that the organic constituents which in the outer air amount to about thirty per cent. are present to the extent of about fifty-seven per cent. It has also been shown that when the exterior air contained only 6.5 mgm. of dust per cubic metre, the air of even well-ventilated houses contains an average of 16.8 mgm. per cubic metre.

The number of micro-organisms in the air of even the better class of houses is invariably greater than in the open air, and depends largely upon whether the dust has been stirred up or not. Thus Uffelmann found the outer air thirty-nine inches above ground to contain 250 germs per cubic metre; one of his rooms during a perfect calm to contain 7,500 per cubic metre, and one, after shutting two of the doors vehemently, 27,000 per cubic metre.

Cellar air contains usually more organic matter and CO_2, and the degree of humidity amounts often to complete saturation; but

the number of germs is less than in other parts of the house.

The *relative humidity* of the air of habitations when not heated is usually quite constant. It is, of course, influenced by the exterior air, but the fluctuations are never so marked as outdoors. This is probably due to the fact that the walls and furniture absorb moisture and give it off to less hygroscopic substances.

The *temperature* of habitations, with the exception of the upper floor, is also very much more constant than that of the open air. The maximum temperature in summer usually occurs five hours later than in the open air; for this reason our houses are hotter about six o'clock in the evening than at twelve or one o'clock. The thickness and construction of the walls determine this to a great extent. Houses constructed with walls having a four-inch air space are cooler in summer and warmer in winter.

Ventilation.—When we consider that an adult individual exhales on an average 14.4 cubic feet of CO_2 during twenty-four hours, and recall the other polluting factors, such as the products of combustion and decomposition, and that the presence of individuals tends to vitiate the air with dust, germs, and organic matter from the skin, mouth, and lungs, while the watery vapor eliminated by the lungs and skin, amounting to about 550 grains per hour, is sufficient to saturate 90 cubic feet of air at a temperature of 60° F., we see at once the necessity for the renewal of air in our habitations. Since it would be neither prudent nor expedient to wait until the air becomes literally unfit to breathe, it is self-evident that the dilution of impure and diffusion of pure air should be constant and gradual. The next question arises, How much fresh air is required to renovate the vitiated air? It has been found by careful observation and experiments that no appreciable organic odors are perceived in the air of inhabited rooms until the volume of CO_2 exceeds six volumes per 10,000. "When the carbonic acid amounts to seven volumes, a want of freshness is observed on entering. When nine, ten, or more volumes are present, the organic odor becomes manifest" (Smart). We know, of course, that this volume, or even double the quantity, of carbon-dioxide is not in itself harmful, but as it goes hand-in-hand with an increase of organic matter it is an index of the amount of organic impurities, and its estimation, according to Smart, affords the best means of testing the efficiency of the ventilation. Our object should be, therefore, to supply a sufficient amount of pure air so that the volume of CO_2 may not exceed six volumes per 10,000. From careful calculations (see Dr. Smart's excellent treatise on *Air*, p. 152, Vol. I.) it has been found that in order to accomplish this result, an average adult requires about 3,000 cubic feet of fresh air per hour. It is evident that the supply of fresh air can be introduced only by a movement of the air, which is brought about either by a diffusion of the gases or by the difference in weight of masses of air of unequal temperature and the pressure resulting therefrom. It is well known that gases have the property of penetrating or spreading and mingling with others in every direction, and this diffusion takes place through all porous substances, even a

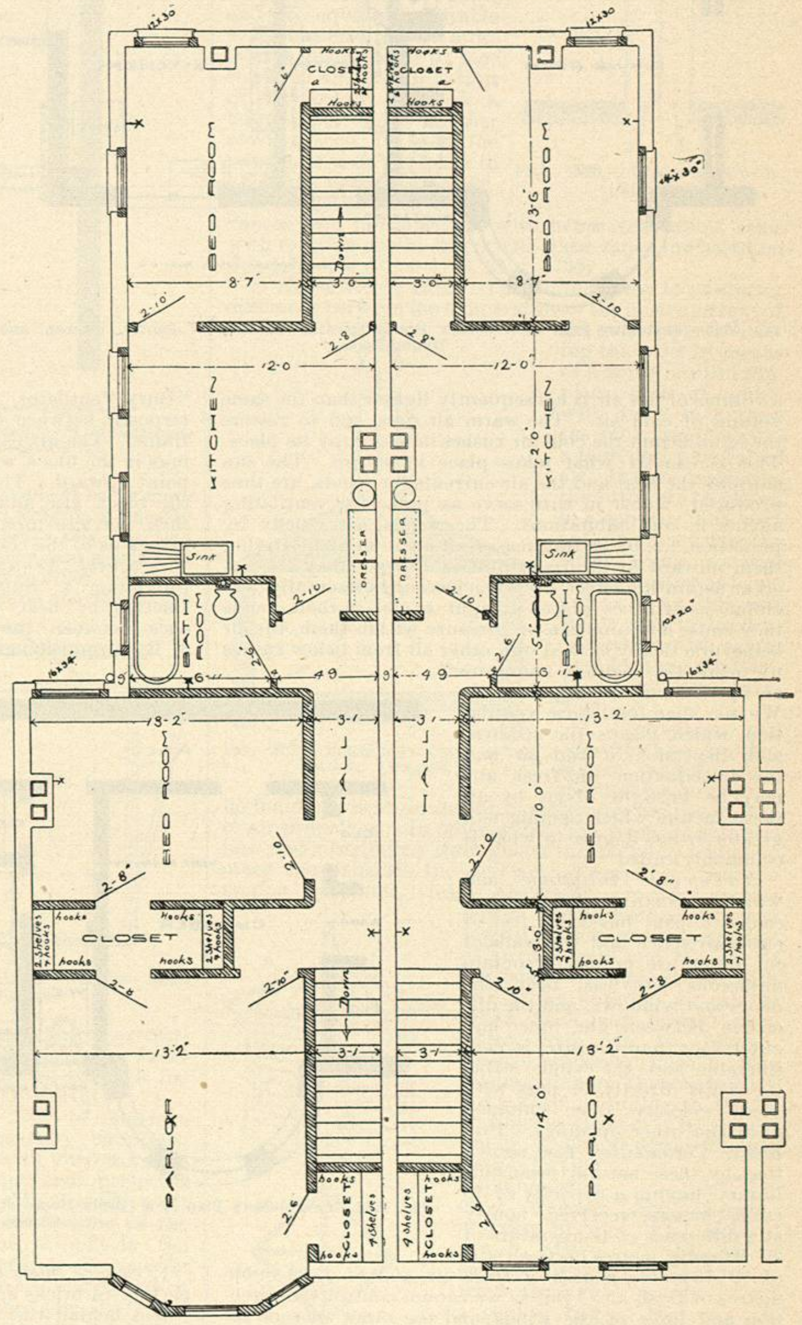

FIG. 2714.—Second-Story Plan of Sanitary Houses for Wage-earners in the City of Washington.

dry brick or stone wall. If it were not for this power of diffusion, CO_2, by reason of its specific gravity, would sink to the lower part of the room.

An unequal temperature produces a difference in weight of masses of air. When air is heated it expands;

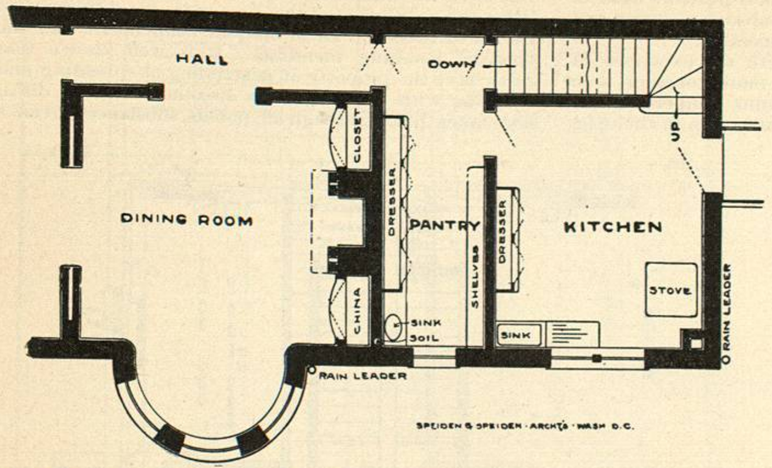

FIG. 2715.—First-Story Plan of a Corner House Showing Location of Pantry, Kitchen, and Dining-Room.

a volume of hot air is consequently lighter than the same volume of cold air. The warm air rises, and to restore the equilibrium the cold air rushes in to occupy its place. This is exactly what takes place in nature. The sun supplies the heat and the air currents, or winds, are thus produced, which in turn serve as powerful ventilating agents in our habitations. The winds act chiefly by perflation, *i.e.* by setting masses of air in motion, driving them onward by an irresistible *vis à tergo;* they also exert an aspirating effect, for when passing horizontally over chimneys or tubes placed at right angles to their course they cause a diminution of pressure within them, the air being practically sucked out, other air from below rushes up to fill the vacuum, and thus an upward current is produced. We see therefore, how ventilation, which means the removal and dispersion of bad air and the introduction of fresh air, may be brought about by all these factors which operate to a greater or less degree in what is commonly called

Natural Ventilation, and which is usually sufficient when each occupant has 1,000 feet of cubic air space and the walls of the house are porous or contain numerous crevices near the doors and windows, and the difference between the inner and outer door temperature is considerable and the winds strike the walls directly or pass with great velocity over chimney flues and other openings. Professor Pettenkofer has shown that by these natural means his library, having a capacity of 75 cubic metres, received hourly at a difference of temperature of 20° 92 cubic metres of fresh air, of 19° 75 cubic metres of fresh air, and of 4° 22 cubic metres of fresh air. But as we cannot control the direction and force of the winds, and the other factors referred to, we should provide additional means for ventilation, and one of the simplest and most efficient plans is to flush the room with fresh air by opening windows or doors on opposite sides of the room. No other method can take the place of this periodical airing for a thorough ventilation of the dead corners and the removal of an immense amount of dust. The objection to this method are the cold draughts in winter, and it should therefore be relied upon chiefly in summer or during the absence of the occupants. In rooms heated with direct radiation, the fresh air should be admitted above the heads of the occupants, either by means of a register in the wall or by the insertion of a louvered or swinging window pane (Fig. 2718) in one of the windows, an upward direction being given to the air so that it may impinge on the ceiling, mix with and be warmed by the heated air in this situation, fall gently into all parts of the room and be gradually removed by means of the chimney flue or any other outlet. Another simple plan is to bore standing holes in the bottom rail of the window sash, or to insert a "Pullman Ventilator" in the bottom rail of the lower sash, or to employ the "Bury Ventilator," which consists of a wooden block interposed between the bottom of the lower sash and the frame. The air passes into the room through the openings in the block which, as in the "Pullman Ventilator," point upward. The separation of the sashes caused by the block also adds to the fresh-air inlet. The use of these devices practically invades the domain of and brings us to the consideration of

Artificial Ventilation, which may be secured by providing, 1. Suitable inlets and outlets; 2. By extraction by heat, or the creation of a decided difference between the inner and outer temperature, and 3. By propulsion and aspiration.

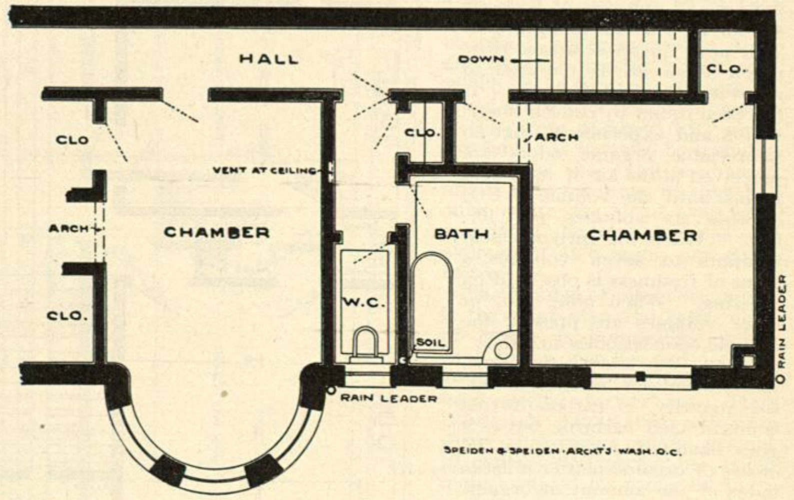

FIG. 2716.—Second-Story Plan of a Corner House Showing Location of Bath-Rooms and Water-Closets.

1. *Special Inlets and Outlets.*—For the admission of air, perforated bricks are sometimes built into walls and concealed behind the washboard. When unwarmed air is to be admitted, the *Sheringham valve* is very commonly

used. In this apparatus (Fig. 2719) the air passes through the walls by means of a perforated iron plate and is then directed upward by a valved plate with side

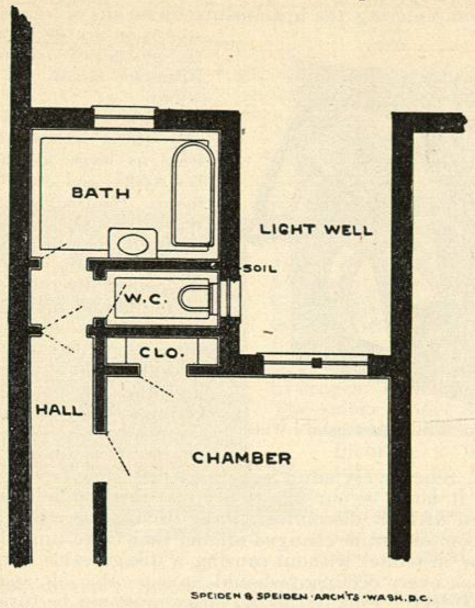

FIG. 2717.—Second-Floor Plan Showing Location of Bath-Rooms, Water-Closets, and Chambers on an Inside Lot.

checks. This plate being hinged is capable of being more or less completely closed by a balanced weight; it usually measures three by nine inches. *Watson's tube* has two chambers placed alongside of each other, one serving as an inlet and the other as an outlet (Fig. 2720). *McKinnell's ventilator* consists of two cylinders, one inside the other, and of different lengths; the longer tube projects above and below and serves to conduct the impure air, while the outer cylinder having a larger sectional area serves as the inlet. The outlet is protected on the top with a cowl; both tubes can be regulated by valves. They are especially useful for the ventilation of one-story buildings, churches, theatres, kitchens, and pavilion hospitals. The gas burner may be placed immediately under the extracting tube; as the warm air escapes through the inner tube, a corresponding volume is admitted through the interspace between the two cylinders (Fig. 2721).

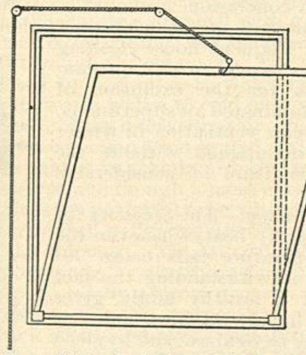

FIG. 2718.—Swinging Window Sash. (Munson.)

The *Ridge Ventilators* consist (Fig. 2722) of openings through the ceiling and roof of one-story buildings, with louvered sides and ends protected with a small roof; the opening of the air shaft in the ceiling is usually provided with a movable shutter to regulate the outlet. The fresh air is admitted by inlets running underneath the floor between the joists and discharging through a register near the stove, or it may be admitted by Sheringham's valves. Of the various methods used in artificial ventilation which contemplate a change of the weight of air without heating, attention is again directed to the perflating and aspirating effects of winds, which are so extensively utilized in the ventilation of ships, and are equally applicable to habitations. Here a large cowl is placed so as to face the wind and the air is thus driven below through a large pipe, whilst another cowl placed to back the wind acts as an aspirator to draw the bad air from below. A great many contrivances seen in connection with house ventilation, some with rotating cowls, others with fixed vanes, are based on this principle (Figs. 2723, 2724, 2725).

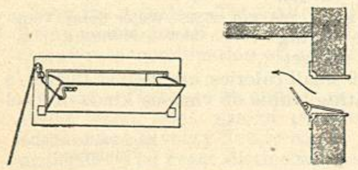

FIG. 2719.—Sheringham Valve. Front and sectional view. (Munson.)

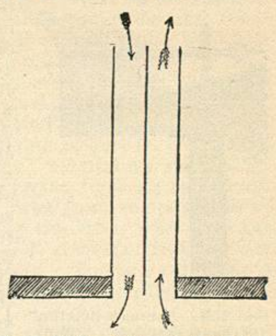

FIG. 2720.—Watson's Tube. (Munson.)

2. *Extraction by Heat.*—The simplest way to produce a difference between the temperature of the inner and that of the outer air is by heating the room by means of a stove or open fireplace, both of which will serve to extract the foul air and secure a thorough renewal of air. In some instances, the outlet can be placed in a separate flue next to the chimney flue; the latter being warmed creates an upward current. Gas jets and lamps may be used in connection with shafts used for the extraction of air by heat (Fig. 2726).

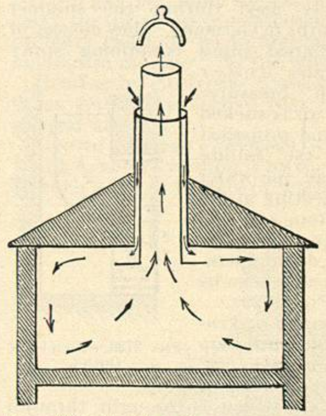

FIG. 2721.—McKinnell's Circular Ventilator. (Munson.)

3. *Propulsion and Aspiration.*—Another system especially adapted for large public buildings is to set the air in motion by the use of fans or air propellers. In other words, the fresh air is forced into and distributed throughout the building while another fan exhausts the foul air. These fans are set in motion by water, steam, electricity, or other motive power. This method presents several advantages: the amount of air delivered and the rate of movement can be regulated with nicety, the entering air can be taken from any desired pure source and can be filtered, washed, warmed or cooled. The Madison Square Theatre, in New York City, according to Dr. D. F. Lincoln (Parkes' "Hygiene," vol. ii., p. 472), is one of the best ventilated buildings of its class. The air is taken at a tower above the roof; is filtered through a conical bag of cheesecloth forty feet long suspended in

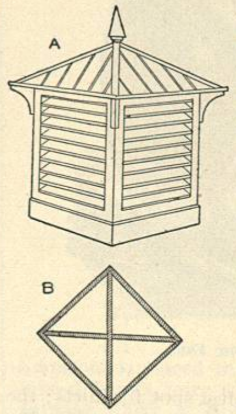

FIG. 2722.—*A*, Muir's Ventilator; *B*, transverse section of same.

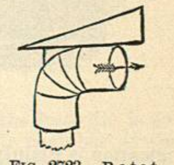

FIG. 2723.—Rotating Cowl for Aspiration. (Munson.)