pantry drains cannot be provided with a very rapid fall, the congealing of the grease is likely to form a deposit on the inside of the pipe which often obstructs it entirely. To remedy this condition, which will arise no matter how large the drain pipe, the drain should be flushed with a hot four-per-cent. solution of caustic potash or soda several times a week, or, what is far better, so-called "grease interceptors" are placed as near the sinks as possible. The grease congeals in these bowl-shaped stoneware tanks and floats on the surface and can be removed when necessary. The outlet for the waste water being immersed several inches below the surface, the water is allowed to flow off while the grease accumulates on the top of the standing water (Fig. 2745).

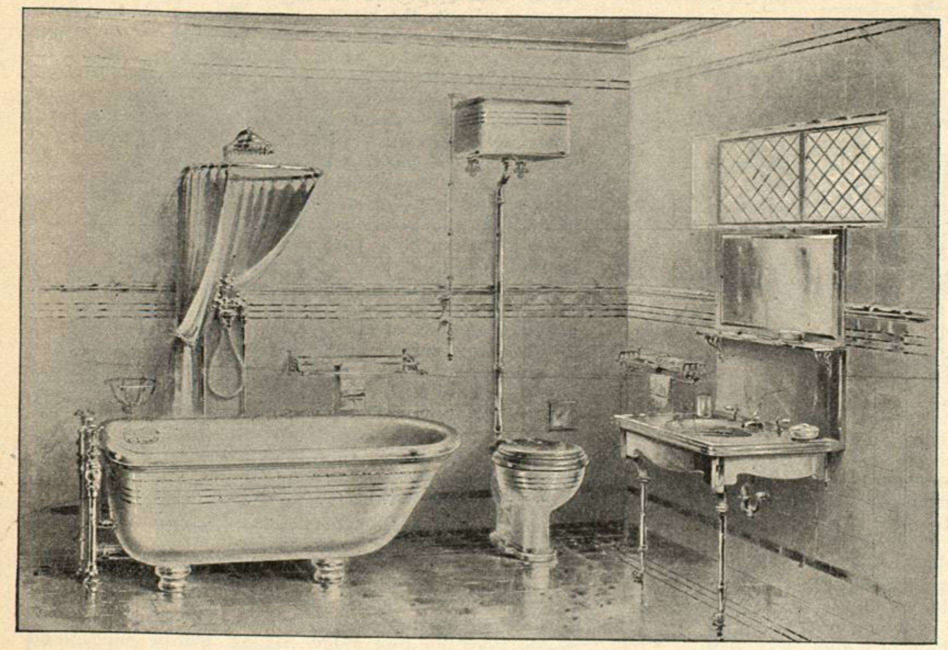

FIG. 2743.—Model Bathroom. (Plate VI.—R, copyright 1900 by the J. L. Mott Iron Works.)

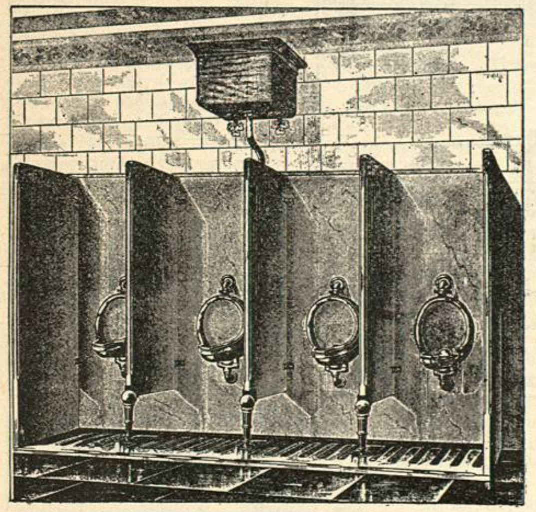

FIG. 2744.—Bowl Urinal. (Munson.)

*Soil Pipes.*—The soil pipe forms a vertical stack inside of the building, extending from the house drain through the roof where it should terminate ten feet away from all windows and chimneys. The soil pipe receives the sewage from the water-closets and the waste water from all other fixtures; it should never be less than four inches in diameter, made of wrought or cast iron and painted with a coat of tar within and without. Special rules are laid down for the construction of the joints between the different lengths; they may be screwed together, or what is more common caulked with oakum and lead and Spence's metal. Screw joints are preferable. In any event they must be air- and water-tight and free from all defects. The proper security of the soil pipe is a point of importance, for if not perfectly secured it may during the settlement of the walls strain one or more of the connecting joints and produce mischief by leakage. The connection between the soil pipe and house drain should be made by means of a rounded elbow and not by an abrupt right angle (Fig. 2746). At this junction a screw plug should be inserted for inspection and cleaning, as obstructions are most likely to occur at this point.

*Traps and Ventilation of Soil Pipes.*—It will be readily understood that if the fixtures were simply connected by means of ordinary drain pipes to the soil pipe, the air of the house would certainly be contaminated by sewer air and the more objectionable emanations from the soil and house drains, which are constantly coated with a slimy putrescible mass, giving rise to dangerous and offensive gases.

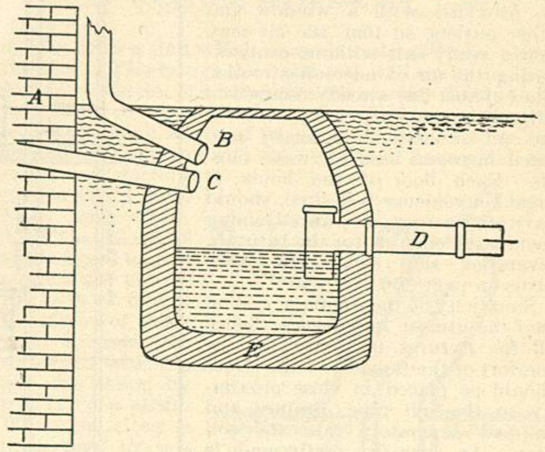


FIG. 2745.—Grease Interceptor. *A*, House wall: *B*, ventilation pipe; *C*, inlet; *D*, outlet.





When houses are artificially heated, this tendency is increased by the diminished density of the air within the house, causing slight inward pressure through all existing openings and fissures. The remedy consists, first, in the use of traps which are certain appliances so constructed as to form a water seal of at least three-quarters of an inch, standing above the highest level of water in the curve of the trap. This water seal prevents the back flow of gases. There are an endless variety of traps in the market, such as the siphon, "Sanitas," midfeather trap, bell traps, etc. (Figs. 2747 to 2753), but of these Figs. 2747, 2748, and 2749 are the simplest and best, because there are no corners or angles for the accumulation of filth and the whole curve is always full of water. The water seal may be broken by evaporation when the fixture is not in constant use; this in warm weather may occur within a few days, and to reduce the danger to a minimum Mr. Putnam invented the "Sanitas trap" which has given excellent results. Evaporation may also be prevented in unoccupied houses by pouring a little oil into the fixtures. It is desirable, however, upon re-occupying a vacated house to flush all the fixtures with water and air the rooms, as sewer air may have entered. Traps may also be emptied by reason of capillary attraction, which is liable to occur if bits of rags and strings have found access to the trap, and one end passes over the further bend while the other remains immersed in the water seal. The water seal may also be broken by a heavy rush of water through it from its own fixture ("*siphonage by momentum*") or by a rush down the soil pipe from a fixture on a higher level, "*siphonage by suction.*" As an additional precaution against the entrance of sewer air and the unsealing of traps by siphonage, the soil pipe and traps should be ventilated. For this purpose the soil pipe is carried above the roof, the top being left open or protected with wire gauze or a ventilating cap, and fresh air is freely admitted to the drain at its lower end on the house side of the trap which connects the system with the sewer. The fresh-air inlet terminates above the ground and must be protected by a perforated iron plate to prevent obstruction, and as the air of the house is generally warmer a constant upward current is thus secured, except when the closet is used, when the current is reversed on account of the sudden rush of water downward through the pipe. For this latter reason and on account of the frequent obstructions placed in the fresh-air inlet by playing children and the obstructions found in the running trap, there has been a disposition to abandon the fresh-air inlet and running trap altogether, and Mr. Charles E. Ball, Inspector of Plumbing of the City of Washington, states that in two outlying districts of the city the concurrence of three conditions—viz.: new clean sewers, recently constructed house plumbing, and the separated location of the dwellings—has justified the omission of the house running trap; indeed, he holds that the objection to open connections with the sewers has little force if the plumbing within each house thus connected has tight joints. The present method of inspections and tests of our plumbing work assure this result in most cities. If the houses are constructed of uniform height, as is usually the case in modern city blocks, or if they are isolated from each other as in suburban localities, emanations from the soil pipe openings cannot injuriously affect the occupants of neighboring premises.

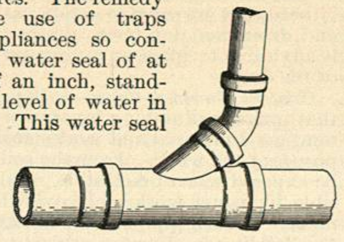

FIG. 2746.—Method of Connecting Soil Pipe with House Drain.

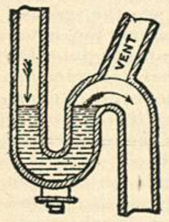


FIG. 2747.—Vented Trap.

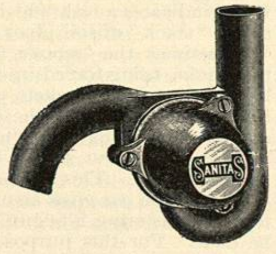


FIG. 2748.—"Sanitas" Non-vented Trap.

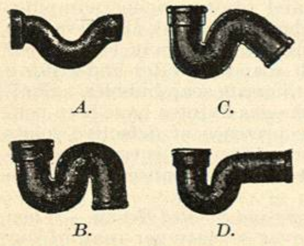


FIG. 2749.—*A*, Running trap; *B*, S-trap; *C*, three-quarter S-trap; *D*, half S-trap.

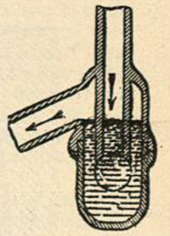

FIG. 2750.—Bower's Trap.

That even more radical opinions than those here expressed are entertained by eminent sanitary authorities is evidenced in a report of the Sewerage Commission of the City of Baltimore, rendered in November, 1896, by Mess. Rud. Hering and Samuel M. Gray, who say:

"The problem of sewer ventilation resolves itself into a provision for maintaining a direct communication between the air in the sewers and the atmosphere and in causing the entrance of pure air and its circulation through the sewers to be as free as practicable.

"The most perfect way of accomplishing the above conditions is to ventilate public sewers through the house drains and soil pipes of the buildings, to omit the main trap along the house sewer which also acts as a retainer of foul matter, and to have perforations in the manhole covers of the public sewers.

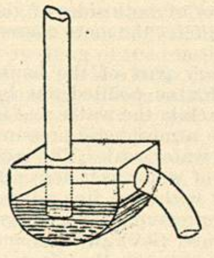

FIG. 2751.—D-Trap. (After Notter and Firth.)

"In this way an abundance of air can enter the system not only from the outfall, but through the manhole covers and circulate through the sewers and out through every premise sewer to above the roof of the buildings.

"Such a method of ventilation, however, requires that the entire plumbing in the house is planned and constructed by responsible parties, so that the work will be first class. It is also necessary to have the house pipes tested after the plumbing is finished so as to be assured of tight joints. This method has been tried in several cities in our country and is the common one on the continent of Europe, but it is not the usual one in our country, for there is in the minds of many a fear that if the public sewer should be ventilated through the soil pipe of their house, some danger might arise through a leak in their own pipes of contracting a disease, the germs of which are supposed to come from the public sewer.

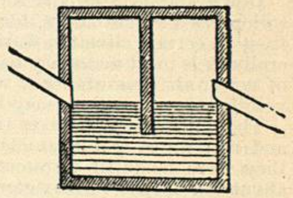

FIG. 2752.—Mid-feather Trap. (Notter and Firth.)

"From experience in our country and in Europe, these fears are not well grounded and there are no facts on record to justify them. On the other hand, the advantages of a thorough draft through the house pipes is considerable and keeps

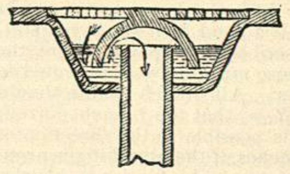

FIG. 2753.—Bell Trap. (Munson.)

them much cleaner than where a trap is placed between the house and the sewer, thus disconnecting the two.

"It has been said that air coming out of soil pipes below windows of adjoining houses might cause offence. But

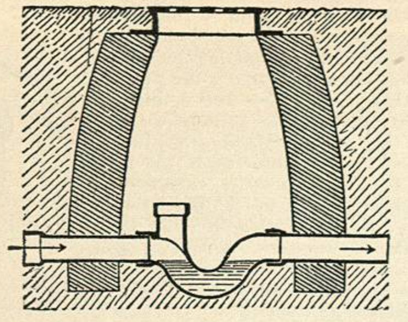

FIG. 2754.—Main Trap and Air-hole for House Drain.

offence could also be caused if there were a main trap and the house pipes were fouled, which they generally are not when used for ventilating the public sewers."

There is much to be said in favor of both sides of the question, and for the present we prefer the more conservative views of Mr. Ball.

The need of draft through every part of the house drainage is not the only reason, for, as pointed out by Mr. Philbrick, it is impossible to retain the water seal in the best forms of traps, unless the atmospheric pressure is freely admitted just below the water seal. The partial vacuum that follows a charge of water as it descends a vertical line of pipe is such that without a free admission of air below every trap, the pressure on the house side of the trap would force the water through them and leave them unsealed. It becomes necessary, therefore, to apply branch vents to each separate trap, for waste pipes more than eight feet in length and less than four inches in diameter. These vents should be extended from the drain below and above the roof or at least be extended and connected to the main soil pipe above the highest fixture. Mr. Putnam and others insist that trap venting does not cure siphonage and simply favors evaporation and necessarily increases the cost of plumbing, and to overcome this fault and still prevent the danger of siphonage, he prefers the "Sanitas trap."

Down spouts from the roof should never be used as soil pipes or ventilators, for apart from the danger of frost in certain climates, during heavy rains, when generally it is most necessary to give a safe exit on account of sewer air pressure, they will be absolutely useless as ventilators and foul air may be forced into the houses.

The *house drain* receives the discharge from all waste and soil pipes and conducts it to the sewer; formerly they were made of terra-cotta in two-feet lengths and about six inches in diameter laid in cement, but owing to so many fractures caused by the settlement and weight of the walls, the insinuation of roots of trees between the joints, rat burrows, etc., the building regulations very properly require that they also shall be made of cast iron, well-jointed, the diameter depending upon the number of soil pipes and rapidity of the fall. The fall for a four-inch drain should if possible be not less than one in forty, of a six-inch drain one in sixty, and of a nine-inch drain one in ninety feet; this will insure a velocity of flow in each case of between three and four feet per second. A direct line from the house to the sewer should always be chosen; if a bend is necessary a suitable curve should be described; the place where the drain emerges from the house must be well cemented to exclude rats from the sewer. All branch drains should be made to connect with a **Y**, so that the branch current may be flowing as nearly as possible in the direction of the main current; these branches, if the plumbing is properly planned, will be necessary only for large houses.

The water from the rain leaders should when practicable discharge at the head of the house drain, so that the drain may be thoroughly scoured during each rain storm. When drains discharge into a sewer liable to flooding, it is necessary to provide a tide valve between the sewer and drain, and for house drains with insufficient fall it is advisable to place an automatic flush tank at the head of the drain.

*General Considerations.*—It is perhaps needless to insist that sanitary plumbing involves a carefully planned system, good material and workmanship, simplicity and exposure of the work. Even the soil and drain pipes should be exposed when practicable, or at least should be accessible by panel work and covered channels in the basement. No soil pipe should be carried on the outside of the building in climates subject to frost, and to render a house safe from the contamination of sewer air it is necessary, first, that the soil pipe and all traps be ventilated; second, that the water seal in the traps be maintained and the house drain be disconnected from the sewer by the introduction of a running trap and fresh-air inlet in the manner already described, with the exceptions noted on page 765; and third, that the entire system be free from leaks or defects.

*Testing of Plumbing.*—Soil pipes and the general plumbing should be tested for leaks before the house is occupied. This may be done by pouring into the highest point one ounce of *oil of peppermint* in a bucket of hot water. Another person who has not come into previous contact with the oil should inspect the respective floors after a lapse of ten minutes, when the leak will be discovered by the presence of the volatile oil. The man who handles the peppermint must remain on the spot until the investigation has been made below; it requires extreme caution, as a single drop emitted elsewhere will destroy the value of the test. Special glass grenades charged with the oil of peppermint or other pungent chemicals have been prepared for use of sanitary inspectors. The system may also be tested before the water-closets are connected by soldering over the apertures where the traps are connected with the soil pipes and then filling the pipes with water. This is a severe test, but very certain, as any subsidence in the level of the water indicates a leak which can be searched for as long as the "stack" of soil pipes and drain is exposed to view.

Sometimes the "smoke test" is applied from below; the smoke, being forced up the pipes by means of a small bellows or smoke rockets, will be emitted through the leaks and thus lead to the discovery of the defects. Of course all openings known to exist must first be closed and the smoke test should be connected with the lowest possible point. This test is not so reliable as the others named. The *gas pipes* should also be tested before lathing and plastering is begun, otherwise great damage may be done. For this purpose all the outlets are capped except one, to which is attached a tube connected with an air pump and mercury gauge. Air is pumped into the whole system and the stopcock turned, and if after working the pump for some time and stopping it the gauge shows in the course of thirty minutes no signs of sinking, the pipes may be taken as in a safe condition; but if the mercury in the gauge falls, owing to the escape of air from the gas pipes, there is a leak somewhere, which may be discovered by pouring a little ether into the pipes near the gauge and recommencing pumping, while another person searches for the leak at the various joints or outlets. Very minute holes may be detected by lathering the pipes with soap and water and making use of the pipe and pump to create soap bubbles. Similar tests are applied after the gas fixtures have been connected, so as to detect the presence of defective joints and keys; in this instance every burner is turned off except one to which is attached a tube connected with the air pump and gauge.

*Sewage Disposal for Villages and Isolated Houses.*—When we consider the fact that over seventy per cent. of our population reside in rural districts and occupy homes without sewer connections, we see at once why wells and





outhouses are often dangerous neighbors. Mr. Philbrick, of Boston, has described a system of sewage disposal by irrigation which must commend itself as safe and practicable for all small villages and isolated houses, where the land has sufficient slope to afford the requisite grade. The requisites for this system, as stated by him in Parkes' "Manual of Practical Hygiene," vol. ii., p. 484, are as follows:

"First, land adapted to grass nearly level or gently sloping at the rate of one-fourth of an acre for a single family, or an acre for a combination of eight to ten families, if provided with a constant water supply under pressure. If the water supply is limited to what may be pumped by hand one-half of the above area will be ample.

"Second, the highest part of the land devoted to this purpose should be at least five feet below the level of the top of the drain where it leaves the house.

"Third, the soil should be thoroughly under-drained, if not resting on a dry and porous subsoil by nature. Under-drains are often needed in clayey or retentive soils and should be laid at least four or five feet below the surface, at intervals of about twelve feet, with a free outfall.

"Fourth, the land should be graded, unless tolerably smooth beforehand, so as to avoid sudden inequalities. A surface that is adapted to smooth mowing by hand is good enough for this purpose.

"Fifth, the soil must be entirely free from roots of trees and shrubs. These would choke the pipes in a few weeks. . . ."

If house drainage is conducted directly into porous tiles laid under the surface, the fluid parts will escape at every joint while the solid matter is apt to cling to the interior and gradually fill them, so as to render them practically useless, hence arrangements should be made to discharge the sewage by means of properly trapped and ventilated drains into a water-tight cesspool, where it will macerate and liquefy, and to discharge the contents periodically with such a rush as to fill the whole system of distributing pipes at once and brush away slight obstructions which may have been left by former discharges. This can be accomplished by providing a stopgate in the outlet pipe where it leaves the tank to be opened by hand when the tank is full and closed again when empty, or by providing a siphon or float to discharge the tank automatically whenever filled.

Mr. Philbrick has modified Field's siphon to be used in connection with these sewage tanks. One of the objections to this plan of subsoil irrigation, while excellent in principle, is the possibility of the roots entering the porous tiles and choking them; there is also danger from frost, and if laid deeper than one foot the vegetation cannot assimilate the very matter we wish to dispose of; for these reasons the writer favors the disposal by surface irrigation along the furrows of growing vegetation or in winter on the same garden spot.

Fig. 2755 shows such a method which Mr. Philbrick says has been in use for several summers at a house used only as a summer resort, and has been attended with complete success. There is an overflow pipe from the cesspool which is perfectly tight, indicating when it is full. The gate in the outlet pipe is then opened, and the whole contents are distributed on the kitchen garden in ten minutes. If an opportunity is selected when the wind is blowing from the house to the garden, no offensive odors are perceived and the growing crops soon absorb the fluid, much to their advantage.

When a proper slope cannot be had, we must of necessity fall back upon either the earth closet, tonneau, or pail system for the collection of excreta, while the kitchen slops and refuse waters from the house should be conducted to some garden spot if practicable and disposed of by irrigation. The ordinary privy pits and open-box privies should never be tolerated; the undue prevalence of typhoid fever in rural districts is largely due to the use of these makeshifts and neglect in the disinfection of the excreta. The history of every sewered city shows a lessening of the typhoid death rate subsequent to the construction of the sewers and that the typhoid rate is always higher in sections supplied with privy pits and open receptacles. The only reasonable explanation for this is, that sewers carry away the filth and germs that otherwise would contaminate the soil and ground water. But even if there were no wells these makeshifts are still a source of danger, in so far as they favor the transmission of the infection by means of flies; nor can the possibility be ignored that the germs in leaky or overflowing boxes may reach the upper layer of the soil and with the pulverized dust gain access to the system. These conclusions were enunciated by the writer in 1895, and appear to have found ample support in the experience of the late Spanish-American war.

*House Diseases.*—Special reference should be made to some of the insanitary factors likely to produce disease.

Dampness of the basement and walls is certain to render the air of the house damp; this not only leads to undue abstraction of animal heat, but also influences the cutaneous functions and favors the development of micro-organisms. The air of habitations may be vitiated not only by the products of respiration and by exhalations of the skin and mouth, but also by the products of combustion, by putrid gases from decomposition of organic matter (more especially sewer air), and last, but not least, by the household dust. Dr. Charles Smart, in his able article on air and its impurities, pp. 147–155, Vol. I., has fully set forth the nature and effects of these impurities. Severe outbreaks of acute tonsillitis, marked by great inflammatory swelling of the tonsils, foul tongue, gastric derangement, severe headache, intense depression and high temperature, have been attributed by some authorities to the entrance of sewer polluted air into the habitations. Cases of typhoid fever, gastro-enteritis, diarrhœa, and dysentery have been attributed to the same cause, and Parkes tells us that in general and lying-in hospitals in which the air of wards was liable to pollution from drains, surgical fever, erysipelas, pyæmia, septicæmia, and puerperal fever were quite prevalent and fatal. Since sewers receive the excreta of patients suffering from intestinal infections and also the wash-water and secretions from persons and clothing of other infectious diseases, it may be presumed that they contain the carriers of many diseases, but it is not so easy to explain the liberation of micro-organisms from the sewage. Some believe that there is always a possibility of particles of sewage becoming dried and as particles of dust gaining access to the air, while others contend that during evaporation or from the bursting of bubbles of gas when the sewage is putrefying, the germs may be projected from the liquids into the sewer air, and may then in consequence of defective traps or joints in the drains be blown into the house. While there is ample room for speculation on the subject, in the present state of our knowledge we may conclude at least that whether sewer air contains specific organisms or not, its constant inhalation cannot fail to lower the power of the system to resist the invasion and effects of pathogenic germs, and that the emana-

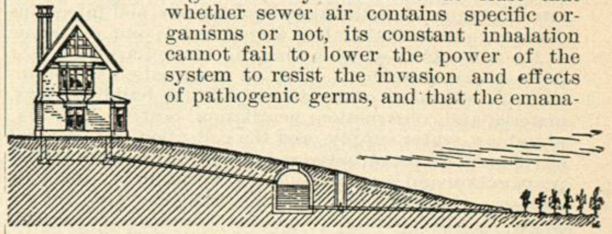

FIG. 2755.—Disposal of House Drainage by Surface Irrigation.

tions from choked house drains are more injurious than those from sewers. The inhalation of household dust, apart from the mechanical irritation of the mucous membranes produced thereby, may also be the means of carrying infection; since the tubercle and influenza bacillus and the pneumococcus are doubtless often conveyed from dried and pulverized sputum or mucus deposited in the room. When we recall the bad effects of deficient sunlight, of dampness, impure air, and excessive summer heat, we can appreciate why some of these factors should be especially potent in unsanitary dwellings in the production of certain typical house diseases.

*Scrofula*, or more correctly speaking a chronic form of tuberculosis of the glandular system, is especially common among children brought up in dark, gloomy, and damp habitations. These children are anæmic and as puny as plants reared without the stimulating effects of sunlight. Add to this fact that dampness favors the development of catarrhal conditions which render the system more vulnerable to tuberculous infection, and we have a reasonable explanation why this disease, as well as *pulmonary tuberculosis*, prevails especially among inmates of damp and dark basements and back-to-back houses. The death rate is often double and treble that of other localities, and while there are doubtless other factors which determine this frightful mortality, none are more potent than deficient sunlight and ventilation, especially in view of the fact that the ubiquitous tubercle bacillus clinging to floors and walls in carelessly expectorated sputum, may retain its vitality and even proliferate in damp and badly lighted rooms. For similar reasons *diphtheria* and *cerebro-spinal meningitis* are also more frequent in unsanitary dwellings. *Acute* and *chronic rheumatism* and *bronchial affections* are likewise of more common occurrence in damp houses, and in recently constructed houses which have not been sufficiently dried and aired. Here again the continued abstraction of animal heat lowers the vitality of the inmates and favors the development of these affections, and a bronchial catarrh thus produced may render the mucosa vulnerable to the invasion of the tubercle bacillus.

*Infantile diarrhœa* is more frequent and fatal among the inmates of the upper stories; this is doubtless due to the enervating effects of heat and the more speedy decomposition of food, especially the milk, in the heated atmosphere; at all events, Meinert has shown that the mortality from cholera infantum, at Dresden, was 11.27 per cent. in the top stories as compared with 9.13 on the second and 3.98 on the first floors. Similar observations have been made at Berlin, which also developed the fact that still-births occur in a larger proportion among the occupants of the upper stories of houses. Whether this condition is due to the causes already mentioned, to sociological conditions, or to stair-climbing, remains to be determined.

*Sanitary Inspection of Buildings.*—The eradication of preventable diseases is the highest aim of scientific medicine, and the time may come when the public is willing to compensate the physician "to prevent by watchful foresight so far as is consistent with the progress of human knowledge" the outbreak and extension of such diseases. Indeed even now it is the duty of health officers and medical officers of the public services to examine into the cause of outbreaks of contagious and infectious diseases, and it is therefore desirable to point out some of the subjects to which an intelligent sanitary inspector pays special attention. Such an examination should include the character of the site and soil, the building plans, material and construction, ventilation, heating, lighting, plumbing, water supply, and the collection and disposal of refuse, and presupposes a knowledge of the causes of propagation and best methods of prevention of infectious diseases; also a knowledge of sanitary chemistry, microscopy, and bacteriology in order to determine the impurities in air, water, soil, food, etc., the prompt and accurate diagnosis of disease and the efficient use of disinfectants; —in fact, a good sanitary inspector must possess a general knowledge of the subject under discussion, good common sense, the habit of accurately observing facts, and the power for reasoning from causes to effects and by way of exclusion.

Before beginning the examination of a building or locality proper it will be well to gather all the information possible from all persons likely to throw light on the subject of bad water, offensive odors, and many other details, for, as remarked by Mr. Frederick N. Owen, "he will often find that this testimony will be uniform in a certain direction and will save him much time and labor in the investigation he is about to make, by directing his attention to some one point as the probable cause of the trouble." There are thousands of houses, clean and well-kept inside, which are steeped in the foul exhalations rising from cesspools and vaults in the immediate vicinity; if, therefore, offensive odors are noticed only when the wind is from certain directions, the inspector would do well to look for the nuisance in that direction. The inspector should be systematic in his methods and all the observed facts should be carefully noted in a memorandum book.

1. The examination of the site should include its relations to sources of soil, water, and air pollution, such as proximity to marshes, factories, and other nuisances, the presence of ponds and stagnant pools with special reference to mosquitos as carriers of malaria. Attention should be paid to the elevation of the site and its relation to adjoining lands as regards drainage; to the amount and duration of sunlight, prevailing winds, and the character and amount of dust; and to the influence of trees close to the house in causing dampness by shutting off sunlight and air. The examination should also be directed to the cleanliness of the yards, outhouses, and the character of the diseases in the neighborhood. The writer in 1895 recorded a number of house epidemics of typhoid fever in which the infection was doubtless carried from privies to the food supply of neighboring houses by the agency of flies.

2. The examination of the soil on which the house stands, with special reference to dip of strata, porosity, and soil pollution, height and fluctuations of the ground water as determined by the water level in neighboring wells. A porous soil like sand, unless upheld by a stratum of clay, is usually dry and salubrious; clay and rock are impervious to moisture, and the water usually flows along the surface to some lower point; situations at the base of a hill are especially objectionable, as the ground water from higher levels generally comes here near the surface and renders the soil and air by capillary attraction and evaporation more moist than at any other point, and this dampness may extend to the walls of the house unless special precautions have been taken in the manner described on page 752 ("Construction of the House").

3. The examination of the plans, number of stories, construction and interior arrangement of the house should include the permeability and hygroscopic properties of the building material. Our general knowledge of the relative permeability of different kinds of building material will enable us to form an opinion, but for exact determinations the use of a poroskop, or gasometer and manometer becomes necessary. The capillary attraction may be determined by drying a suitable piece of the material, placing the lower end in water, and noting the height to which the moisture ascends. The effective humidity of certain building materials is determined by weighing a certain sample and after drying it at a temperature of 100° C. to weigh it again. The loss in weight indicates the amount of moisture. The relative capacity of certain building materials for parting with their moisture can be determined by placing two equal-sized pieces in water until completely saturated, and then, after wiping them off rapidly, exposing them to a uniform current of perfectly dry air. From the length of the time consumed in drying, the capacity for evaporating moisture may be calculated. The material, character, and condition of the roof, gutters, and rain leaders should receive careful attention.

4. The examination of the air in the interior is important. Here we should remember that whenever the volume of $CO_2$ amounts to seven volumes per 10,000, with a proportionate increase of organic impurities, a want of freshness is observed, and when nine or more volumes are present the organic odor becomes quite perceptible, although, as pointed out by Dr. Smart, Vol. I., p. 153, the continued occupancy of an apartment may give rise to organic odors, clinging to the walls and other surfaces, when $CO_2$ may not be present in large quantity. Before





entering into a systematic examination of the air for the determination of its impurities (see *Air*, pp. 147–155, Vol. I.) as regards carbonic acid, organic matter, ammonia, hydrogen sulphide, carbon monoxide, micro-organisms, and humidity, and for the determination of cubic air space for the occupants, it will be well to note the character and habits of the inmates as regards cleanliness, the amount of household dirt and dust which has accumulated on the walls, floors, and furniture, and to examine the closets, slop-pails, garbage, and ash receptacle, as well as the condition of the water-closets. The latter are often found with no connection with the outer air, being located in the middle of the house. Most of the private dwellings have no other way of changing the air than through doorways, windows, transoms, and the seams of imperfect workmanship.

5. We should study the arrangement of rooms, their length, breadth and height, floor and cubic air space for each occupant, distribution of light, number of doors, transoms and windows, sufficiency of ventilation, the size of fresh-air inlets and outlets, their cleanliness and freedom from obstruction. We should also test the humidity of the air in different stories by means of a reliable hygrometer, remembering that a humidity of 60°, saturation being 100, is the limit for healthy dwellings in this country. If the house is found to be noticeably damp, we may find the cause in imperfect cementing of cellars or basements, in the absence of damp-proof courses in the walls to prevent capillary attraction, in leaking downspouts, house drains or water-pipes, in ash heaps piled against the wall, absorbing and retaining moisture, in obstructions to air and sunlight, etc.

6. The methods of heating, as by stoves, open fireplaces, steam, hot water, or hot-air furnaces. If the house is heated by a furnace, the position of the fresh-air inlet with reference to sewer drains, underground ducts, and other impure sources should be noted. The very place which should be well cemented to exclude ground air—namely, right under the furnace—is frequently neglected. Basements and cellars must be cemented to exclude not only dampness but the equally objectionable ground air with its excess of $CO_2$ and other impurities. We should also note the character of fuel, the provision of dampers and presence of coal gas, the amount of heat obtained, and the quality of the air.

7. The question of natural and artificial light should receive consideration, and the average amount and duration of sunshine should be noted. Thus, for example, the proportion of window to floor space should be one-sixth or one-fifth, and in temperate climates direct sunshine should reach, when practicable, all parts of the room. The sufficiency of artificial lighting may be approximately determined by observation, and quite accurately by the employment of Bunsen's photometer. In this country, the unit adopted for the measurement and comparison of lights is a No. 6 sperm candle, burning 8 gm. per hour and giving out a light known as "one-candle-power." Such a candle, according to Munson, contains, on analysis, carbon 80 per cent., hydrogen 13 per cent., oxygen 6 per cent. The quality of the air and the temperature of the room lighted with ordinary illuminants should also receive attention.

8. The inspection of the plumbing is one of the most important features of a sanitary inspection. If an offensive odor is perceived in the basement it will suggest the possibility of a leaking drain pipe; and if inquiry reveals the frequent presence of rats, we may infer that the house drain is in direct communication with the sewer and that the traps and lead bends are likely to be gnawed and leaky. Unfortunately, in most buildings the pipes are hidden behind woodwork and underneath floors, and the owner never appreciates the importance of exposed work until the workmen have to tear up floors and walls to permit of the necessary inspection and repairs. Of course this should not be done until a general examination and the tests for plumbing already referred to indicate defective work. Very often, too, the owner has not the faintest idea of the location of the house drains and soil pipes, and this suggests the necessity of a law compelling every householder to preserve a set of drawings, showing the location of drains and vertical soil pipes.

The inspection of plumbing should begin with the main drain and proceed upward to all the ramifications, special attention being paid to imperfect caulking of joints, open connections, putty joints, holes plugged with corks, rag-patches, spots of corrosion, lead pipes gnawed open by rats, etc.

The fixtures should be carefully examined and their traps or water seals tested in order to learn their efficiency against the entrance of sewer air; this unsealing, unless special precautions have been taken, is sure to occur if the fixtures remain unused for a certain time and the water in the traps has evaporated. To make this test Mr. Owen suggests that "all the basins, baths, and other fixtures above the traps to be tested and on the same line of piping should be filled with water and then discharged simultaneously, care being taken that all the pipes are free from obstruction. The fixtures below the trap should then be filled and discharged in the same way. If the trap retain its seal under these tests, it is safe to assume that it is an effectual barrier to the entrance of sewer air." For the detection of pin holes in the pipes, etc., which cannot be seen by the naked eye, the "peppermint," "smoke test," or some other pungent chemicals should be employed in the manner described on page 766.

The following list of defects in plumbing and drainage have been encountered by Mr. Owen, and numerous specimens illustrating these defects have been observed by the writer in the Museum of Hygiene, in the City of Washington:

1. Earthen-pipe drains, either broken or with leaky joints, laid under the cellar floor, saturating earth with sewage. 2. Section of earthen pipe drains completely obstructed by the insinuation and growth of the roots of trees. 3. Pipe drains without sufficient grade or with the fall in the wrong direction. 4. Drains without running traps admitting sewer air from sewer or cesspools to the pipes in the house. 5. Drains without a free current of air. 6. Rat burrows from sewers and along drains undermining floors and admitting foul air to the house. 7. Section of soil pipe, the lumen of which was completely obstructed by urinary deposits, because of the exposure of the soil pipe on the outside walls of the house in cold climates. 8. Soil or waste pipes without any or sufficient ventilation. Defective connections between fixtures and waste pipes. 9. Lead pipes and traps gnawed by rats. 10. Water-closets, cistern with overflow joined to soil pipe or drain. 11. Safes under closets or basins connected to soil pipe or drain. 12. Two or more fixtures with unventilated traps on the same line of pipe, siphoning each other when used. 13. Sink overflow pipes joined to soil pipes untrapped or with trap liable to siphon. 14. Overflows from fixtures connected with waste pipe on sewer side of trap admitting foul gases to rooms. 15. Faulty traps and fixtures without traps. 16. Water supplies to sinks taken from water-closet or other contaminated tanks and used for drinking purposes. 17. Rain leaders used as soil pipes or ventilators to drains, delivering foul air to bedroom windows or under eaves or roofs. 18. Ash pits near larders and pantries, or liable to soak moisture to walls. 19. Defects of drainage and rat burrows from neighboring houses, especially from those located on a higher level. 20. Cesspools near houses, wells, or cisterns, polluting the drinking-water.

If an outbreak of contagious or infectious disease is being studied, and up to this point the inspector has not reached any conclusion, it is desirable to consider the possibility of the germs being carried by flies, mosquitos, and other insects. Our investigation should, of course, extend to the water supply, milk, food, and even the ice supply.

The general principles set forth in the foregoing pages are equally applicable to the inspection of public buildings, schools, hospitals, prisons, barracks, asylums, etc. (For inspection of dairies, etc., see *Milk-Borne Diseases*.)

*George M. Kober.*