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BY

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SECOND REVISED AND ENLARGED EDITION OF SANITARY ENGINEERING

NEW YORK

PUBLISHED BY THE AUTHOR

33 UNION SQUARE

1909

Stanhope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

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I.

SANITARY ENGINEERING: THE PROFESSION AND ITS PRACTICE.

The subject discussed in these pages was, up to within a few years, comparatively unknown. Sanitary engineering — like electrical engineering — is one of the recent branches of civil engineering; sanitary science, the researches of which form its foundations, is a new science, which has, in the past few years, made such rapid strides that its importance is beginning to be more universally recognized.

The general public has but a vague idea of the meaning of the term "sanitary engineering." Many mistaken or narrow views exist in regard thereto, and it is with a view of dispelling these that this book is published.

ARCHITECTURE AND ENGINEERING.

When a science, art, or profession expands to such an extent, both in theory and in practice, that its entire field can no longer be mastered by one mind, it divides itself naturally into departments or specialties. We know this has been the case in law, in medicine, in the fine arts, and in the natural sciences. In fact, ours is the age of specialists in all branches of learning, in all arts and sciences. Such a sub-division has also gradually taken place in the profession or art of engineering; thus it came about that sanitary engineering was made a special and distinct branch of the profession of civil engineering.

Let us glance briefly at the origin, and define the meaning, of this new branch.

Centuries ago the whole science and art of building construction were concentrated in one profession. At that time not even the division into engineers and architects existed. Architecture and engineering were not only combined, but merged together with other professions or arts. In those bygone times a man could be, at the same time, a painter, a sculptor, an engraver, a designer and builder of church edifices, a constructor of fortifications, an engineer of canals. In this connection, our thoughts naturally revert to Michael Angelo Buonarotti, to Leonardo da Vinci, to Albrecht Dürer, and other famous men.

But the complex requirements of modern civilization, the multiplication of human wants, and the exigencies of business competition render it well-nigh impossible for a universal genius or master-mind to rise to success. While there may occasionally be exceptional instances of accomplished men who are proficient in many things, as a general rule those will succeed best who limit themselves to the study and practice of one specialty.

It is now a little over a century ago that in building construction the first division into the two independent professions of architecture and engineering took place. Broadly speaking, architecture deals with the ornamental, whereas engineering embraces the purely utilitarian, branches of construction. While, from a purely business aspect, in the practice of the art, this division exists, the line cannot be quite so strictly drawn as regards the preparation and training required for the subsequent practice of the professions. It lies in the nature of their work that architects must be, to some extent, engineers; they must understand construction in order to be able to design, whereas the reverse of this proposition is not quite so evident, for to find artistic talent and skill in an engineer is rare. To some extent, nevertheless, these two professions have always remained in close touch, and in recent years architects and engineers have once more been drawn together, particularly in such works as pertain to landscape and to domestic engineering.

DEFINITION OF CIVIL ENGINEERING.

The profession of civil engineering has been defined as " the art of directing the great sources of power in nature for the use and convenience of man." The organization of the first State engineer corps occurred in France, in 1791, when the Corps des Ingénieurs des Ponts et des Chaussées was established. As the name implies, the work of these *civil* engineers consisted largely in the development of means for better transportation for passengers, as well as for merchandise, such as the construction of roads, bridges and canals; whereas the *military* engineers constructed works of fortification, and applied engineering construction to military operations.

Soon afterward followed the construction, equipment and management of railways and the improvement of rivers, harbors and other aids to navigation. Other branches were added from time to time, such as the manufacture and improvement of machinery and mechanical appliances; the operating of mines; the establishment of telegraph and telephone lines; the erection of gas works; the application of electricity for producing light, heat and power; the fire protection of buildings; the water supply, sewerage and lighting of cities; the drainage, lighting, heating and ventilation of buildings; the reclamation of marshes and agricultural drainage; the laying out of street and towns, of squares and parks; the construction of piers, docks, sea-dykes, jetties, breakwaters and lighthouses.

Broadly speaking, engineers deal both with structures and with machines, the former being, according to Rankine, combinations of materials, the parts of which have no relative motion; and the latter, mechanical appliances whose function is to perform useful work, and the parts of which move.

This distinction points to one of the chief divisions of the profession, namely into *civil* and *mechanical* engineering. (See also pages 59 and 93.) Still later, we find four principal groups, namely, civil, mechanical, mining and electrical engineers.

ENGINEERING SPECIALTIES.

At the present day we may distinguish the following divisions of engineering, viz.:

- Military Engineering,
- Railroad Engineering,
- Hydraulic Engineering,
- Marine or Naval Engineering,
- Bridge Engineering,
- Mechanical and Steam Engineering,
- Mining Engineering,
- Electrical Engineering,
- Gas Engineering,
- Municipal Engineering,
- Sanitary Engineering,
- Landscape Engineering,
- Fire Protection Engineering,
- Architectural Engineering,
- Agricultural Engineering,
- Irrigation Engineering.

It would be quite impossible for one man to acquire a thorough knowledge and practice in all these branches, and the tendency to specialization leads engineers to devote themselves to some one particular field. Notwithstanding this division into separate branches, made necessary largely by business considerations, the various branches often meet. Much of the work of the municipal or city engineer, for example, refers to sanitary, to hydraulic, and to gas engineering; the landscape engineer and the architect meet in the laying out of country estates, city gardens and public parks; the sanitary and the mechanical engineer meet in the planning and construction of heating and ventilating plants; the sanitary and the hydraulic engineer, in works of water supply or sewerage for cities, villages and institutions; the architect and the sanitary engineer, in all that pertains to healthfulness of habitations; the architect and the bridge engineer, in the iron or steel construction and the foundations of large and tall buildings. These examples might be multiplied, but what is said will suffice to explain how several branches of engineering are often correlated.

DEFINITION OF SANITARY ENGINEERING.

With the above definition of civil engineering as a basis sanitary engineering may be defined as the art and science of applying the forces of nature in the planning and construction of works pertaining to public or individual health. To put it in other words, the purpose of all works of sanitary engineering is the promotion of healthful conditions, the avoidance of disease caused by outside influences which may be brought under control of mankind, and the increase of the duration of life.

In his Presidential address, at the 1907 annual meeting of the American Society of Mechanical Engineers, Professor F. R. Hutton referred to sanitary engineering in the following words: —

"The sanitary engineer is a specialist in hydraulic engineering in the application of water supply and drainage as means to secure the well-being of the community as respects its public health.

"The field expands from that of the wise precautions respecting the piping of the individual house, where it touches the craftsmanship of the plumber, up to the broadest problems of sewage disposal and utilization, and the healthful supply of potable water for cities,

free from bacterial or inorganic pollution at its source or in transit.

" The co-workers of the sanitary engineer are the bacteriologist and the physician. Such men might be grouped with the *civil engineers.*

" Heating and ventilating engineers make a specialty of the sanitary requirements of enclosed building structures as respects their fresh and tempered air supply; they are really sanitary engineers, having, however, an outlook and a relation to *mechanical engineering* in the appliances of their function rather than toward civil engineering."

Obviously, a general knowledge of civil engineering, of architecture and of sanitary science, in all their branches, forms the best basis of the technical education of the sanitary engineer.

I shall make an attempt to outline briefly the course of studies and the special training required, in my judgment, to enable a person to attain the qualifications necessary to practise the profession of sanitary engineering. I shall describe further on and discuss briefly, the principal subjects or problems with which the sanitary engineer deals in his practice. In order to become a competent engineer, the course of study should embrace both theoretical (scientific and technical) education and practical or manual training. The practical education differs according to whether the special branch, which the engineer decides to follow later on, belongs to mechanical, civil, electrical or sanitary and hydraulic engineering.

COURSE OF STUDY IN SANITARY ENGINEERING.

In order to be able to make use of the forces of nature for the promotion of the comfort, health and welfare of mankind, it is necessary to study and to become conversant with them; hence, training in the natural sciences and in mathematics forms the basis of sanitary as well as of all other branches of engineering.

The study should include mathematics (arithmetic, algebra, geometry, trigonometry and stereometry), astronomy and descriptive geometry; likewise, the physical sciences, mechanics and dynamics, hydrostatics and hydraulics, aërostatics and aërodynamics; the theory of heat, optics, acoustics, magnetism and electricity. It is also necessary for the engineer to have some knowledge of meteorology, climatology, physical geography, mineralogy and geology; furthermore, of general chemistry, metallurgy, and, in particular, of chemical technology. The study of botany, of the trees of commerce and of forestry, is also useful in many ways. In none of these studies, however, can the young engineer student expect to become complete master; even in mathematics, which is to the engineer the basis of all learning, he cannot expect to cover the whole field.

He must become acquainted with the properties of the materials employed in engineering structures, and gain a knowledge of the principles of construction, of the theory of strength of materials, and of the stability of structures. Without this knowledge, he cannot attain eminence in his profession.

All engineers should be good draughtsmen, and therefore, students should practise not only general drawing and sketching, but become skilful in particular in mechanical drawing, in the preparation of engineering drawings, and, to some extent of architectural plans, sections and details. They should learn geodesy, surveying, levelling, the laying out and staking out of work, and should aim to thoroughly master topographical and map drawing. All these studies are fully as useful to the sanitary engineer in his practice as they are essential to the civil engineer.

The studies mentioned so far comprise the general or preparatory course in engineering. They should be followed by special courses in engineering as related to commerce, which comprises the means of transportation and communication on land and on water; in engineering as related to agriculture; in engineering as related to manufacturing industries and mining; in engineering as related to buildings, and, finally, in engineering as related to public health. These studies comprise road and street construction, railroad and tramway building, hydraulic engineering, sewerage, water supply, measurement of water power, bridge, roof and tunnel construction, works of drainage and irrigation, canals and locks, river improvements, harbor and sea-coast works, machine construction, and the application of the different classes of motors. A general course in architecture or building construction is also desirable for the well-qualified sanitary engineer, and this should include some knowledge of the trades of carpentry, bricklaying and stone masonry, plastering, blacksmith work, plumbing, gas-fitting and drain-laying.

In addition to these, there should be a course in sanitary science, comprising public and personal health, and a study of the causes and methods of preventing the spread of infectious and contagious diseases.

The course of study in sanitary engineering at the Massachusetts Institute of Technology in Boston is essentially one in civil engineering, with special attention devoted to sanitary chemistry and sanitary biology, and including some practice in the laboratories.

The first year is the preparatory one common to all courses. The second year is the same as for civil engineers, with qualitative and quantitive chemical analysis added. The third year adds to the general course the topics of organic chemistry, general biology and bacteriology, industrial water analysis and heating and ventilation.

In the fourth year the students take up special courses in sanitary and hydraulic engineering and designing, bacteriology of water and sewage, water supplies and analysis, air analysis, municipal sanitation and on sanitary science and public health.

An advanced course in sanitary engineering is given for the fifth year and includes sanitary and hydraulic design, sanitary statistics, sanitation of water supplies, water purification and sewage disposal, sanitation of houses and of public buildings, public health problems, vital statistics and personal hygiene.

A special course of Lectures on *Sanitary Science and*

Public Health, instituted at Columbia University in the City of New York during the college year 1908–1909, comprised the following subjects: —

1. The Rise and Significance of the Public Health Movement.
2. The Great Pathological Discoveries and their Bearing upon Public Health Problems.
3. Sanitary Science: the Control of Environment.
4. Modes of Transmission and Methods of Prevention of Communicable Diseases.
5. The Beginnings of Organization for Public Health Service.
6. Water Supplies and Sewage Disposal.
7. Factors influencing the Health and Death Rate of Cities.
8. Reinforcement of Vital Resistance.
9. Public Health Problems of the Municipality.
10. Public Health Problems of the State.
11. Public Health Problems of the Nation.
12. Milk Supplies and Public Health.
13. Infant Mortality and its Reduction.
14. The Prevention of Tuberculosis.
15. School Hygiene and Sanitation.
16. Street Cleaning, Garbage Collection and Refuse Disposal.
17. Quarantine and Disinfection.
18. Tenement House Sanitation.
19. Diseases of Animals transmissible to Man.
20. Personal Hygiene and the Hygiene of Communities, Gymnasia, Public Baths, Play Grounds.
21. Industrial Hygiene and Sanitation.
22. The Prevention of Alcoholism and Insanity.
23. Visiting Nursing and its Influence on the Prevention of Disease.
24. The Influence of Education on Public Health.

The course of instruction in *Public Health*, recently instituted by the University of Pennsylvania, comprises the following subjects: —

Sanitary Engineering, the subject of water supplies, of sewerage systems, street cleaning and the disposal of wastes.

Sanitary Legislation, the study of the movement for sanitary reform, and of the laws enacted relating to public health, and the methods of their enforcement in the United States and elsewhere.

Inspection of meat, milk, and other animal food products, with a study of the methods of preparation and preservation of the same, the conduct of dairies and creameries, and demonstrations of the diseases of animals transmissible to man.

The sanitary engineering of buildings, including demonstrations of systems of heating, ventilation, plumbing and drainage, the study of plans, etc.

Social and Vital Statistics, an examination of statistical methods and their results, with special reference to vital statistics and to city populations in the United States.

Practical Methods used in Sanitary Work, including water, air and milk analysis, studies in ventilation and heating, soil investigations, methods of disinfection, sterilization, etc.

General Hygiene, as applied to communities, including the causes of disease, exciting and predisposing, methods of prevention, including isolation, quarantine, natural and acquired immunity, protective inoculation, vaccination, methods of house disinfection, means employed

for it, suggestions for the organization of sanitary work, the influence of water supplies and sewage disposal on the public health, etc.

Personal Hygiene, exercise, bathing, air food, cleanliness, hygiene of the schoolroom.

The course of sanitary engineering at Cornell University, Ithaca, N. Y., is essentially a four-year course in civil engineering. It comprises, in the third and fourth years, studies in structural design, hydraulics, hydraulic laboratory, municipal engineering, geodetic and topographic surveys, cartography, water supply, specifications and contracts, electrical engineering, steam machinery, design of sewerage works, purification and control of water supplies, water analysis, besides courses in bacteriology, microscopy, engineering calculations and political economy.

During the term 1908–1909, a special series of lectures on Sanitary Science and Public Health was instituted in co-operation with the New York State Department of Health. Some of the subjects dealt with in the lectures are public health administration, epidemiology, health of rural communities, public health laws, bacteriology, vital statistics, dairy hygiene, health in public schools, insects and the transmission of disease, sanitary science, water filtration and purification, sewage disposal, modern housing, heating and ventilation, and general municipal sanitation.

A fundamental knowledge of anatomy and physiology, so useful to men in all conditions of life, is of paramount value to the sanitary engineer, and a special course in "First Aid to the Injured," as now made a feature in all

German polytechnic schools, should not be forgotten. This will prove eminently useful in the subsequent practice of the engineer, when accidents or emergencies arise, either in the machine shop, on buildings, in railroad disasters, or in sanitary and hydraulic works.

Finally, the general knowledge of languages and of grammar should not be overlooked, because engineers are frequently called upon to write reports. The study of foreign languages will prove useful in travelling and in many other ways. And, finally, there should be added a general knowledge of law, so necessary when drawing up contracts or preparing specifications, the cultivation of business habits, and the faculty of dealing with foremen and workmen in the superintendence of works.

From the foregoing it is seen that the extent of theoretical knowledge and practical acquirements which the sanitary engineer should possess is quite formidable. It has been truly said that "no man in an ordinary lifetime can properly learn engineering," and that "the learning period of an engineer ends only with his death."

Although it follows clearly from what has been said that the foundation for the special study of sanitary engineering should be a regular course in civil engineering, it by no means follows that every civil engineer is also a well-qualified sanitary engineer. In order to become competent for the duties of a sanitary engineer, the civil engineer should — in study as well as in practice — give special attention to, and gain knowledge of and experience in, all those problems which are correlated to, and which influence, public health. It is thus seen that sanitary engineering covers a very wide field, and is a profession requiring years of preparation and hard work.

ACTUAL PRACTICE OF THE SANITARY ENGINEER.

In the following pages will be outlined a very general and condensed review of the various classes of work and of the problems arising in the professional practice of the sanitary engineer. None of these questions or topics can be discussed in detail.

Much of the work performed by the salaried city or municipal engineers is sanitary engineering. A sanitary engineer having a private practice is often called upon to act as consulting or advisory engineer for municipal works; in other cases his work is more in the nature of private architectural engineering and domestic work, such as heating and ventilating of buildings, plumbing and drainage, water supply, sewerage and sewage disposal.

WATER SUPPLY OF CITIES AND OF DWELLINGS.—A problem which belongs both to the sanitary and the hydraulic engineer is the provision of a bountiful supply of pure and wholesome water for cities, towns and buildings.

A project for water works requires investigations as to the quantity needed; as to the quality and available sources of supply; as to the pressure required and the division into pressure districts; as to the means for conducting the water from its source to the places of consumption and the systems of pipe distribution; as to the methods of storing the water, its protection against contamination, and, finally, as to the means of purification.

Water is required for many uses, such as for drinking, cooking, washing, bathing and general ablutions; for cleaning; for sprinkling sidewalks and streets, areas and yards and watering gardens; for fire-extinguishing purposes; for flushing water-closets, drains and sewers; for washing carriages and watering horses and cattle; for feeding steam-boilers; supplying fountains; running hydraulic elevators; for industrial establishments, laundries, dyeing establishments, paper factories, breweries and sugar refineries, etc.

From a sanitary point of view, the chief considerations are the sources of supply, the quantity, the quality, the pressure, the storage of water, the material of the distributing pipes and the artificial improvement of the water (1).*

The sources of a water supply may be rivers and lakes, springs and gathering ponds, which are naturally good, but liable to be polluted by surface washings or by sewage; rain water, which is pure in the country, but contaminated in cities; subsoil and ground water which, away from habitations, is good; shallow wells, which are always open to suspicion, and deep artesian or driven wells, which, as a rule, furnish an uncontaminated water supply. A sanitary examination of the source of supply should always be instituted, and should comprise chemical, microscopical, and bacterio-

* The numbers refer to the books mentioned at end of volume.

logical analyses of the samples, in the gathering of which particular care is required.

The quantity of water required is determined according to the rate of growth of population, and according to the special needs of water for domestic and personal, for industrial, and for public use. The amount of water required per head per diem will naturally fluctuate with the customs, desire for cleanliness, and the social conditions of the inhabitants of a place, likewise with the extent of the manufacturing industries, the number of public baths, public institutions and public fountains, and, finally, according to the mode of supply, *i. e.*, whether this is unlimited or metered. The consumption also varies at different hours of the day, on different days of the week and in different seasons of the year, a fact which must be borne in mind in the design of a water works system.

The quality of the water is a consideration of much importance. The fact needs to be emphasized that clear water is not necessarily wholesome water; and, inversely, water may be good without being absolutely pure from the chemist's point of view. Good water, suitable as a beverage, should be transparent, colorless, odorless, tasteless, moderately hard, and cold and free from organic impurities and disease germs.

The pressure under which water is supplied is of interest mainly from the point of view of fire protection, but also as regards the supply in dwellings, for a deficient pressure points to the need of storage cisterns in houses, and in some places necessitates the use of domestic pumps to lift the water to the tanks.

Deficiencies in quality, quantity or pressure of the water supply may be the cause of disastrous calamities to life as well as property. To guard against these, standpipes or storage reservoirs often form a part of the distribution system. In the reservoirs, the water stored is frequently subject to vegetable growths, or algæ, which impart to it a bad taste or odor, or both.

The method of supply is either constant or intermittent; the former is far preferable for sanitary reasons, and may be either a free and unlimited supply, or the supply may be controlled by water meters. The system of supplying consumers by meter measurement prevents unnecessary waste of water, due to leaky house-fittings or carelessness and negligence in use, and is not, from a sanitary point of view, objectionable, as many suppose.

The supply of water is brought to a city by open or covered gravity conduits, or it is pumped, by hydraulic, electric or steam power, into reservoirs, standpipes, or directly into pressure conduits.

The distribution in the city streets is effected by a network of underground iron pipes, and the domestic water service consists of smaller distributing pipes, the material of which in some cases may have a bad influence on the quality of the supply.

The artificial improvement of the supply is another problem which concerns the sanitary engineer. It may be accomplished on a large scale, either by sedimentation, by sand filtration on filter beds, by distillation, by aëration, or by chemical precipitation processes, which require the addition of substances like alum, lime, or perchloride of iron. In the home, small domestic filters effect some purification, but the majority of household filters merely strain the water without actually purifying it. Unless they are frequently and regularly cleaned and recharged with fresh filtering material, they become worse than useless. There are a few household filters which do remove the germs from the water; but all those which have any merit necessarily filter the water very slowly and require frequent cleaning and occasional sterilizing.

Incidental to the use of water as a beverage is the employment of water in its solid form as ice, for the purpose of rendering the temperature of the drinking water more agreeable. It is a popular fallacy that ice is water purified by freezing. Recent progress in bacteriology has established the fact that germs of disease, such as typhoid germs in drinking water, are not killed by the process of freezing. Danger, therefore, lurks in the indiscriminate use of ice. The business of ice-cutting requires careful watching, and should be under the control of sanitary engineers of municipal or State Boards of Health. The cutting of ice from ponds or rivers subject to organic contamination, and rendered unfit as a source of ice supply, should be prohibited.

Careful householders should, for like reasons, as a matter of precaution, always make use of water coolers so arranged that the ice is kept in a separate compartment, so that in melting it cannot mix with the drinking water, or else they should order their ice supply only from dealers in artificial ice, manufactured from distilled water.

SEWERAGE. — The water supplied to a city from its water works must be removed after use. To accomplish this is one, though not the only, object of a sewer system. Town sewerage, in the wider meaning of the term, signifies the removal, by underground conduits or sewers, of the sewage of a city, which may include a portion or all of the following liquid wastes: house wastes, including excreta and urine; stable wastes, manufacturing wastes from industries using in their processes large volumes of water; waste from water motors and hydraulic lifts; subsoil water; and, finally, surface or storm water, falling on roofs, yards, areas, courts, paved streets and unpaved spaces.

From a sanitary point of view, the continuous and instant removal, before putrefaction begins, of all liquid waste products from habitations, should be the chief consideration in order to avoid the pollution of the soil and air in and about dwellings, and the contamination of the ground-water. In order to design a sewerage system, it is necessary to institute many preliminary investigations, which refer to the present and future extent of the drainage area, the configuration or topography of the city, the geology and physical character of the drainage district, the meteorological observations, particularly as to the rainfall of the place, including the frequency and the amount of sudden heavy showers, the proportion of rainfall, if any, which is to be admitted into the sewers, the character and quantity of the daily and hourly water supply, the size of the population, present as well as prospective, which will derive practical benefit from the sewers, and the comparative density of population in different sections of the city.

A question of prime importance in the establishment of a sewerage plan is the final disposal of the sewage; the location of the sewer outfalls; the nature, volume of flow and velocity of current of the water course intended to receive the sewage, the requirements of pumping stations, or the need of sewage purification works. No engineer can give intelligent advice concerning a proposed sewerage system of a city without having a correct general contour map of the place.

Following the preliminary investigations the sanitary engineer should consider the various sewer systems, the combined and the separate system, the gravity, suction, and compressed air systems of sewage removal, and decide which is best adapted to the locality in question.

Often it is of advantage to admit into the sewers only a portion of the liquid wastes enumerated. In many towns the storm water may be left out of consideration, as, for instance, where it can be taken care of quite sufficiently by open or covered street gutters, or by a few shallow and short rain-water sewers, which can be made to discharge in a straight line into the nearest water-course. Wherever sewage must be pumped to the outfall, and in all cases where it must be purified before discharge into a water-course, the advantages of the separate system predominate.

After deciding upon the system of sewerage which is best adapted to the needs of a community, a general sewerage plan should be developed. According to the topography of the city, various lay-outs for the division into sewer districts may be followed, such as the direct or perpendicular system, the intercepting system, the zone or parallel system, the fan system and the radial system, the details of which need not be described here. The grade and inclination of the sewers, the resulting velocity of flow, the importance of making sewers self-cleansing, the depth at which they are laid below the street level, the sectional forms and sizes, the material and construction, whether cement or vitrified pipe or iron pipe sewers, concrete, brick or stone-masonry sewers — these are matters of importance, which the experienced sanitary engineer has to consider.

In the construction of the sewers many questions of detail arise upon which the ultimate success of the system may depend, such as the trenching, the provision of proper foundations in loose soils, the use of invert blocks, the making of water-tight joints in pipe sewers, the proper junction of sewers, the careful alignment and the adjustment of the grades, the smoothness, hardness and durability of the sewer pipes, and other considerations.

Sound, practical judgment will determine the position and number of man-holes and lamp-holes designed for purposes of inspection and for the location and removal of obstructions; also the advisability of using devices for flushing the sewers, either flushing man-holes, gates or tanks with automatic siphons, and the details of sewer outfalls. Where rainfall is admitted to the sewers, the construction of catch-basins at street corners and of storm overflows, to relieve the sewers in case of sudden heavy showers, must be studied. Where sewage cannot be discharged by gravity, pumping stations and sewage pumps must be designed; finally, the house connections must be provided, in wet soils subsoil drains must be laid in the sewer trenches, and in all cases the sewers must be well ventilated.

The problem of sewer ventilation presents many practical difficulties. The prevailing method, by means of perforated man-hole covers, is open to objections, particularly in narrow streets or courts, and the alternative of untrapped catch-basins aggravates the evil, owing to the proximity of the latter to the windows of dwelling houses. Among the various other methods suggested from time to time, I mention ventilation by means of the rain-water pipes of buildings, which is objectionable, first, because during rain-storms, just when the sewers require a free vent, owing to the displacement of the air by water, the rain-water conductors cannot act as ventilators; second, because the joints of outside metal leaders are rarely tight; and third, because rain-water leaders often terminate under windows of living rooms or sleeping apartments.

Ventilation by lamp-posts or special columns rarely accomplishes much, because they are of too small diameter. The carrying of special sewer vent pipes along the outside of buildings would be somewhat more effectual, but the method is difficult to enforce, expensive, and often troublesome in case of adjoining buildings of various heights. Ventilation of sewers by connection with chimney shafts or boiler flues involves the possibility of explosion, or is objected to by the owners, as it may injuriously affect the chimney draft. Special tall shafts, at the upper ends of sewer lines, are, to some degree, effective, but very expensive.

Other propositions include charcoal ventilators in the top of man-holes, which require frequent renewal, or material placed in sewers to absorb gases, and the passing of disinfecting vapors or chemical gases into sewers. Unfortunately, most of the devices suggested are costly or difficult to apply, and the problem is by no means satisfactorily solved. One other method deserves special mention, it being a successful feature of the separate system; this is the omission of the running trap on all house drains, thus making use of the house soil and vent pipes which are carried up to the roof. With a well-flushed, well-arranged and well-maintained sewer system, under complete control of the municipal engineer, this simple method is perfectly feasible, and gives good results, provided the drainage works of the houses are absolutely air-tight.

A public water supply and a sewer system are improvements which usually go together, and exercise a marked sanitary effect upon the general health of a community. The problem becomes more difficult when there is a water supply without sewerage, in which case the filthy and health-destroying cesspool, or the vault, are the usual receptacles of the sewage pending removal by cartage. Where there is neither sewer nor a water supply, the disposal of filth must be accomplished by dry removal systems, such as the earth or ash closets, or the pail system.

Finally, there are certain special systems, such as the pneumatic systems of Liernur and of Berlier, and the mode of pumping sewage by compressed air by the Shone system, of which a practical application was made at the World's Fair in Chicago, with all of which the sanitary engineer should be quite familiar. Of all systems, that one will be by far the best, from a hygienic point of view, which effects cleanliness by a constant, systematic and quick removal of all manner of liquid organic refuse from houses, streets and towns.

PREVENTION OF POLLUTION OF WATER-COURSES. — From the earliest periods, rivers and water-courses have been utilized as the natural outfalls for the sewage of towns. As the amount of town sewage increases, owing to the growth of the population, and of its industrial establishments, the streams and water-courses become more and more polluted, to the great detriment of the people living further downstream.

River pollution, in numerous instances, has been the result of improved town sanitation by sewerage. Too much reliance has often been placed in the assumed self-purification of rivers. In many instances, furthermore, clear streams flowing through the heart of a city have been made the receptacle of all its liquid wastes, with the result of turning a once pure water-course into an extremely foul open sewer, contaminating the air of the town. This offensive practice cannot be too strongly condemned from a sanitary point of view.

The experienced sanitary engineer will uphold the axiom that in cities all natural water-courses should be kept unpolluted. Even the smallest open streams should, under no circumstances, be covered or arched over and used as sewers. Filth should be prevented from reaching these open streams, and they should be kept pure with plenty of water and by a free circulation of air, and may, by proper rectification, be used to serve as a natural embellishment of a city.

As regards the larger water-courses which flow past a city, the question whether or not the sewers may be permitted to discharge directly into them depends upon a number of factors which should be carefully considered by the engineer. A certain amount of self-purification is, no doubt, always going on, due largely to the sedimentation or subsidence, to oxidation and aëration and to dilution; and with this in view there is a certain degree of permissible pollution.

Speaking generally, the larger the volume of the water-course, and the greater its velocity of current, the more sewage can be admitted to it without the danger of an undue pollution. The condition of the water-course before it reaches the town should also be considered, but the chief question will always be whether the water of the river is, or may in the future be, used at a point below the sewer outfall as a source of potable water. In that case the direct discharge of unpurified sewage should never be permitted, for the preservation of the purity of the water used for a public water supply is of paramount importance. We may even go a step further and demand a certain amount of purification of the sewage, before its discharge into rivers or lakes, in order to keep these inoffensive even when they are not drawn upon to supply the drinking water. The required degrees of purification can be made variable according to the circumstances of each case.

Small lakes, stagnant ponds, coves, bays or inlets should never be used as receptacles for town sewage. In manufacturing districts difficulties often arise from the chemical wastes, and from the fact that the volume of water of the stream is considerably reduced on account of the flumes which divert part of the water to use it as motive power. On the other hand, artificial dams, like rapids and natural waterfalls, form an aid to the purification of the sewage by aëration and oxidation.

SEWAGE DISPOSAL. — The question of the proper disposal of the sewage of populous places is one of the most important, and often difficult, problems which the sanitary or municipal engineer encounters. In many sewered cities of Europe, particularly in the case of inland towns, sewage purification systems have long ago been devised and adopted, while in the United States the difficulty is only beginning to be appreciably felt with the increasing pollution of our rivers.

A direct discharge of sewage into a water-course or into lakes and tidal rivers is seldom permissible. Even the casting away of crude sewage into the sea can only be countenanced under special conditions, as it quite often leads to a defilement of the beaches, and tends to create mud-bars and silts up the navigable channels at the entrance of harbors. Frequently the argument is used against this method of disposal, that it is a waste of fertilizing materials. It should be said, however, that none of the methods of sewage disposal can be carried out with a view to financial gain. The purification of the sewage is, in all cases, the chief object.

The methods of purifying sewage may be divided into natural and artificial methods. To the former belong the simple sedimentation or subsidence, filtration through soil and broad surface irrigation. Among artificial methods, I mention the simple straining of the sewage, mechanical filtration, chemical precipitation, aëration processes, and the purification by electrical currents. To these have been added in recent years the bacterial methods of treatment, in septic tanks, in contact beds and in trickling filters. Quite often a combination of two of these methods is adopted, and it is impossible to say, in a general way, which is the method that will yield the best success. The sanitary engineer must study each problem separately and use sound judgment in selecting a method best adapted to the existing conditions. Certain scientific experiments, however, and the actual experience gained in cities which have various processes in operation serve as a useful guide.

Simple sedimentation or subsidence is a slow method, which rarely effects more than a mere clarification of the sewage, and removes none of the matters in solution. This is also true of the cruder methods of straining or filtering sewage in mechanical filters. These processes may be considered useful preliminary methods, to be followed by broad irrigation or intermittent downward filtration.

Chemical precipitation consists in the addition of certain chemicals, such as lime, or sulphate of alumina, or salts of iron, which act as precipitants, causing the suspended matters and a part of the dissolved impurities to be removed. The precipitation takes place in large sewage tanks, and is effected in a variety of ways. In some the sewage comes to a complete rest for several hours, and this method requires, therefore, a large number of tanks. Or the sewage, after the addition of the chemicals, is made to move slowly through shallow tanks, or it is compelled to follow up-and-down movements in the same. Finally, instead of large shallow tanks, deep upright tanks, cylinders or wells, placed either above or below the ground, are used in certain chemical precipitation processes.

None of the numerous chemical processes effect a complete removal of all foul matters, and where the effluent is required to be very pure, the chemical method is often supplemented by irrigation over, or filtration through, soil. In all precipitation processes a new difficulty arises on account of the unavoidable accumulation of sewage sludge, which contains a large percentage of water. This sludge must be dried, either by spreading it out on well-underdrained land, or by pressing it in filter presses. The sludge cakes have some value as manure, but a financial return from their sale is seldom realized. In some cities the solid house and street refuse is mixed with the sludge and burned in garbage-cremating furnaces.

In the natural methods of sewage disposal, sewage is made to flow either over or through land prepared for the purpose, and an excellent degree of purification is usually attained. Sewage irrigation over cultivated land is assisted during part of the year by the vegetation, for the cultivation of certain crops on the sewage disposal field is perfectly feasible. The difficult feature of the system is the need of large areas of well-drained land. Near cities these are not always available, or when they are to be found they require a large outlay of money. Irrigation and filtration through soil also involve the constant need of manual labor.

Aëration processes are seldom adopted, although the oxidation of the organic matters in sewage, either by forcing air through it, or by causing it to run over a series of terraces or waterfalls, or by dripping it down on wire meshes, appears to be practicable.

The treatment of sewage by electricity was introduced experimentally in England several years ago; more recently it has been tried in the United States on a small scale, but sufficient practical experience is not yet available to permit definite conclusions to be formed as to the results to be attained by the process.

The modern bacterial methods of treatment distinguish two stages in the purification of the sewage. The first stage deals largely with the solids in suspension, and effects a clarification and liquefaction. It is accomplished in scum or sludge tanks, which are also designated as putrefaction or septic tanks; clarification may also be attained by using upward flow filtration or cultivation tanks, and finally by means of coarse contact filter beds. The effluent from any of these septic processes contains but little suspended matter, but requires a further treatment to get rid of the polluting matters held in solution.

These are dealt with and removed in the second stage by oxidation and nitrification, and purification is accomplished either in contact filter beds, or by means of trickling filters, followed sometimes by a further purification in sedimentation basins, or by land irrigation.

The purifying action, which takes place in the two stages of sewage treatment mentioned, is due to different kinds of bacteria, known respectively as the aërobic, the anaërobic and the facultative bacteria. None of the methods of treatment mentioned are absolutely automatic, and all require intelligent management and constant supervision (1).

STREET PAVEMENTS. — Roads and streets serve for purposes of intercommunication and traffic; in cities the streets fulfill the further object of providing light and air to the adjacent houses; incidentally they are utilized as receptacles for a network of underground pipes, conduits, and wires which afford drainage and sewerage facilities and furnish water, gas, heat, light, steam, and electric power, telephone service, etc., to the buildings.

Both the country roads and the city streets should not be dusty in dry weather, nor muddy and impassable in wet seasons. For obvious reasons these requirements should be much stricter for city streets, in which our habitations, offices, and places of work are located. As far as the topic of this book is concerned we are interested chiefiy in the sanitary aspects of street construction, or the paving of its surface.

The essential requirements of a good city street pavement are quick surface drainage, good foundations, impermeability and hardness of surface, avoidance of slipperiness, least resistance to traffic, cleanliness and noiselessness. From a sanitary point of view, impermeability and noiselessness are the chief desiderata. There is plenty of medical testimony available tending to prove that the ceaseless noise, from early morning till late at night, due to vehicles passing over rough stone pavements, affects the nervous system and reduces the duration of life.

A street surface should be as water-tight as possible, to prevent a downward soakage into the ground of liquids, or the retention of filth in the joints and cracks of the paving stones. The street surface should drain off quickly, and there must be no depressions or inequalities where water can stagnate and become offensive. A street pavement should also not be slippery, as this causes horses to fall, and is equally dangerous to life and limb of pedestrians. Cleanliness of pavements is essential to prevent dangerous exhalations and illness due to polluted air. Finally, paved streets should be noiseless, for the continuous jarring and rumbling of heavy vehicles, the shaking of the foundations and the accompanying vibrations of window panes, doubtless affect the nerves of town-dwellers, disturb sleep, aggravate the suffering and retard the recovery of the sick.

For these and similar reasons the selection and construction of a good street pavement is a sanitary problem of much importance. Leaving out of consideration some of the pavements which are not used to any great extent, the choice lies between macadam, wood, cobblestone, granite block, and asphalt pavements.

Macadamized roads are not well suited for city pavements. Under a heavy street traffic the broken stones — particularly if the softer limestones are used — are quickly ground to powder, causing clouds of disease-breeding and irritating dust in dry weather, while in wet weather the dust is quickly changed into the worst kind of soft mud. The surface of macadamized roads wears out very quickly, and almost the only advantages worth mentioning are that such roads are noiseless, and that they afford a firm footing for horses.

Wooden pavements have formerly been employed, to a large extent, in American cities, but, in recent years they have been given up, partly, no doubt, on account of the growing scarcity of timber, due to the barbarous destruction of our forests. From a hygienic point of view, wooden pavements, unless the blocks are impregnated to prevent decay, offer several important objections. In the first place, wood absorbs not only dampness, but likewise putrefying matter, and exhales bad odors, and, being alternately wet and dry, the surface soon rots. It is a well-known fact that decaying wood is detrimental to health. Wooden pavements, on account of their elasticity, are more noiseless than stone pavements, but they are expensive to maintain, and their surface soon becomes quite unequal, except when the precaution is taken to lay the blocks on a concrete or sand foundation.

Cobblestone pavements are of a very inferior character, on account of the uneven surface, due to the absence of a proper foundation and the rough joints and numerous pockets, due to the irregularity of the stones. The joints of such pavements soon fill up with putrefying street filth and create obnoxious odors; they are very difficult to maintain in a clean condition, and, taken altogether, they are unfit for the thoroughfares of large cities.

Granite pavement, if composed of stones of regular size, evenly laid, well bedded on a good concrete foundation, and with the joints carefully filled with sand or cement or tar and gravel, forms a good city pavement in streets where a heavy traffic occurs. The stone blocks should not be too hard, as they otherwise become quite slippery from abrasion, and the evenness of the pavement is usually disturbed by the frequent tearing up required for underground pipe connections. Improved stone pavements, with well-filled joints, have one disadvantage, namely, that of causing increased vibration of buildings.

The best pavement, from a sanitary point of view, is without doubt the asphalt pavement. This is destined to become the favorite pavement for streets with light traffic. It is water-tight and quite impermeable; it prevents soakage into the subsoil; it is free from the noxious odors so often found on pavements with joints; it is durable, smooth, and very readily cleaned; it renders the traffic noiseless, does not cause jarring or vibration of buildings, and creates no dust due to abrasion and wear. Its only disadvantage is its liability to become slippery when the pavement is damp or greasy, as during foggy weather, or where soft mud is carried to it from adjoining stone pavements, by horses' hoofs, pedestrians' shoes and carriage wheels. It is principally adapted to the residential parts of cities, where there is no heavy traffic; owing to its noiselessness it is also preferred in the neighborhood of courthouses, schools and hospitals.

Other durable pavements are the vitrified paving blocks, the asphalt blocks and brick pavements, in the laying of which particular care should be given to the filling in of the joint spaces.

Footpaths and sidewalks are paved with flagstones or with artificial stone, with bricks laid flat, or with asphalt. They should be laid so as to afford good drainage into the gutters, and should be constructed so as not to become slippery. Gutters should be constructed with care, to avoid leakage of storm-water into the subsoil and into the cellars of houses.

I have already alluded to the fact that city streets serve also the purpose of receptacles for many pipe conduits. In our large cities the number of different pipe lines buried under the street surface is constantly growing. We have not only one or several street water mains, gas mains, sometimes separate mains for fuel gas and lighting gas, sewers for rain-water and house-wastes, and in the "separate" system two lines of sewers, but also electric light conduits, telegraph wires for commercial uses, for fire alarm system, and for police telegraph; telephone wires, pneumatic conduits for mail, parcel delivery and telegraph messages; electric or pneumatic conduits for synchronized clocks; compressed air mains, cables and trolley line wires, steam conduits, hot-water pipes, pipes for cooling purposes, and what not. At street intersections the network of pipes is particularly crowded, for here we find, in addition to the above, the sewer man-holes, the catch-basins, the shut-off valves for water and gas, and the man-holes on subways for electric and telegraph wires.

In order to avoid the endless tearing up of streets and pavements, and the incidental disturbance of traffic, caused by repairs or connections to the various conduits, it has been frequently suggested to build subways or underground galleries in the more important streets, and to place in them all the above-named complicated network of engineering conduits and pipes. This would, doubtless, tend to secure a more permanent street surface, but it involves a very large outlay of money for construction, and the remedy suggested is by no means free from objections. Some of the most experienced municipal engineers have been opposed to the construction of subways. Much may be said on both sides of the question, but it would lead me too far to discuss the subject in detail. It is doubtless true that the maintenance of a permanent street surface is rendered difficult owing to the continued and repeated breaking up of the pavement for the connections of water, sewer, gas and electric conduits.

STREET CLEANING. — In the foregoing I have pointed out how necessary good street pavements are, not only from the traffic point of view, but more especially from a sanitary standpoint, for the maintenance of the health of a city. But the advantages of well-paved streets count for nothing if the pavements are not thoroughly cleaned at regular and frequent intervals.

Street cleaning, in the widest sense of the term, includes the sweeping of roadways, sidewalks and gutters, the collection and removal of the road dirt, the sprinkling of streets, the removal of snow, the cleaning and disinfection of public conveniences, the cleaning and flushing of sewer catch-basins, and the removal of house refuse. Leaving the removal of garbage out of present consideration, as it will be referred to further on, I shall restrict my remarks to a discussion of street dirt.

The maintenance of city streets, and the scientific administration of street cleaning in large cities, require a great deal of engineering knowledge, practical skill and judgment, besides not a little executive ability. It is not often, however, that the matter is considered in this way. Many instances are on record where in municipal administrations politicians are placed in charge of the street-cleaning bureau, no doubt because street cleaning, like the construction of a State capitol, often involves the employment of a large force of laborers whose political vote may thus be controlled at election time.

Street cleaning may legitimately be considered one of the important problems of sanitary municipal engineering. Viewed in this light, the appointment, by a reform mayor, of an able civil and sanitary engineer of high reputation to the position of street-cleaning commissioner in the city of New York deservedly received the highest commendation.

The quantity and the composition of street dirt depend upon a great many points, such as the character and material of the pavement, the width of the street, the density and class of population, the nature and size of the traffic, the condition of the weather and other factors. Road detritus is composed chiefly of abraded particles of stone, wood, iron and shoe leather; gravel, sand or mud from the sub-surface; the horse-dung and urine of animals, mixed together with house refuse, ashes, street and yard sweepings, more or less garbage, dead leaves and other vegetable matters.

Some of this dirt, and particularly that of animal origin, becomes absorbed in the joints or cracks of ill-laid or ill-kept pavements, where it keeps the subsoil damp and contaminated, putrefies and causes noxious smells and disease-breeding emanations. A part of the street dirt is breathed directly into our lungs or enters the alimentary canal, and thus may cause disease. When the March winds blow, and in dry seasons generally, the dust and dirt of the streets are wafted about in the air, become injurious to the eyes of pedestrians, and are driven or blown into the houses, where they soon settle on the skin and the clothes of persons, on furniture, draperies, curtains and carpets. To avoid this, windows are kept closed, and thus the rooms of our houses do not receive the necessary change of air. The street dust is also highly injurious to tradesmen's and shopkeepers' goods.

When wet, the dirt is changed into street mud, which is destructive to people's clothing, shoes, and to carriages. Muddy and greasy streets are also a source of trouble by becoming slippery, and causing, on sidewalks, street crossings and in the carriage-ways, numerous accidents to life and limb, to men and horses. As a rule street dirt or mud is particularly bad about the public hack-stands, on open squares, near hotels, theatres and railway stations. Regarding the comparative quantity of street dirt from different pavements an English engineer is authority for the statement that one cartload of street mud is, on the average, removed from 344 square yards of macadam, from 500 square yards of granite, from 1666 square yards of wood and from 4000 square yards of asphalt pavement.

Streets kept in a bad condition are an obstruction to traffic, and necessitate a waste of energy and tractive force. We are accustomed to consider muddy streets as an annoyance, and we condemn unclean streets principally on account of their untidy appearance. Very few people, however, take into consideration that, owing to the air and soil pollution caused by accumulation of dirt and refuse matter and soakage of liquid impurities, there is a powerful influence on the public health which by far outweighs all other disadvantages.

It is a fact that clean and well-kept streets cause a marked reduction in the death rate of large cities, particularly from malarial and pulmonary ailments. Children playing in unclean streets are more or less affected, being often much more susceptible than adults; the same is true of invalids, and people not in robust health.

Sanitation, therefore, requires that the street surfaces be made impermeable and that all thoroughfares be kept scrupulously clean. Near children's schools, near institutions, and near hospitals the streets should, for obvious reasons, be swept with particular care, and be arranged with a view to perfect drainage. In all advanced schemes for the ventilation of buildings the fact that street dirt is injurious to health is taken into consideration by providing special means for screening and filtering the air supply from outdoors, or by washing out its impurities. Dirty and dusty streets exercise at all times indirectly a baneful influence upon the salubrity of habitations, because they prevent the free ventilation of living or sleeping apartments by the opening of windows.

We have yet much to learn from European cities, which are far ahead of ours in the matter of street cleaning. This fact is generally conceded by those Americans who have travelled with open eyes through Europe, and who have admired the tidy and well-kept streets of its capitals and of many of the smaller cities and towns. It is a matter beyond comprehension to me how the mayor of a large American city, after returning from a trip to England and the Continent, could have stated, as the newspapers reported, that, in the matter of street cleaning, American cities had nothing to learn from cities like Paris, London, Berlin, Dresden or Vienna.

The work of street cleaning presents difficulties which are not easily surmounted, chiefly on account of the enormous quantities of street refuse to be removed daily. The cleaning is accomplished by scraping, sweeping, washing and flushing. The sweeping may be done by hand labor with brooms, or else by the use of special machinery. Owing to the greater rapidity with which work is done there is economy in using the best machinery, implements and tools available. Mechanical sweepers should displace hand labor at least on all well-maintained street pavements; street cleaning by hand is from three to six times as expensive as cleaning by the aid of machines. It is a curious fact that the first street-cleaning machine, devised by Sir Joseph Whitworth, was rejected "as interfering with the labor for poor people." Street sweeping should always be done without stirring up dust and dirt, hence water is needed in street-cleaning operations, and the streets should be sprinkled before sweeping.

Carelessness in street sweeping should not be tolerated. In all large cities the cleaning of the principal thoroughfares should be largely done at night-time. The method of cleaning streets by washing the filth and dirt into the gutters and catch-basins, and thence into the street sewers, cannot be approved, except in special instances, as it simply transfers the dirt from the street surface to the catch-basin and the sewer. Dry removal of street dirt in large, well-built, covered carts is much to be preferred.

Horse-droppings on important thoroughfares should always be picked up at once and removed with brushes into hand-bags. The fact should be noted that the extensive application of steam and electricity to replace horse traction in surface roads tends to reduce the amount of organic street dirt. The ultimate disposal of the collected street refuse is a problem which presents difficulties in large cities with many miles of pavements.

REMOVAL OF ICE AND SNOW. — A problem which, in winter time, taxes the ingenuity of the engineer of a street-cleaning department to the utmost, is the removal of a sudden fall of snow, particularly when the snow-storm is accompanied by high winds, causing the snow to collect in drifts. The snow which accumulates on sidewalks and on footpaths should be swept off by the adjacent householders, and fines should be enforced for a noncompliance with the city ordinances. The snow is best removed as soon as the storm subsides, for when hard-trodden the mass is more difficult to handle. Sidewalks in front of vacant lots or unoccupied houses should be, under all circumstances, included in the city regulations, and if their owners are negligent, the cleaning should be done by the city, and the cost assessed upon the property.

The removal of snow from the carriage-way is difficult to accomplish when the fall is heavy. Few persons realize the enormous quantities to be removed. Street railroad companies, after using the snow-plough

to clear their tracks, should, by city ordinance, be required to remove that portion which they pile up outside of the tracks.

The mode of disposing of the snow varies according to the location of a city. In districts which adjoin a river, a canal, or a harbor, the snow may be dumped from the carts into the water. In some cases it is thrown into the sewer man-holes. Owing to the fact that snow from frequented thoroughfares is generally mixed with street mud and road scrapings, the former method is often objectionable, as it causes the harbor or water-course to silt up, and necessitates dredging; and the second method should only be adopted if the sewers are simultaneously flushed with large quantities of water, otherwise it leads to deposits of mud in the sewer inverts.

Melting the snow by fires or by steam jets has been tried, but it is a slow and expensive proceeding. The use of salt to hasten the melting of snow is quite objectionable, as it causes a deep slush, and should only be tolerated when the slush is at once swept into the street gutters. Salting sidewalks or car tracks is very objectionable, from a health point of view, as the mixture causes much cold dampness, ruins pedestrians' clothing and shoes, is injurious to horses' hoofs, and causes the feet to be severely chilled, inducing colds, pneumonia, or the grippe.

STREET SPRINKLING.—**In summer time, and in dry weather generally, city streets should be sprinkled, to cool the air in hot weather and to keep down the** street dust with its many annoyances and inconveniences.

Street sprinkling is usually accomplished by means of watering-carts or vans, but sometimes hose jets are used, or the street is watered by means of perforated pipes on wheels, attached directly to the street hydrants as may be seen in Paris. The latter method is particularly adapted for well-kept, impermeable asphalt pavements.

The beneficial effect of street sprinkling upon the street air is very marked; the air is washed of impurities, it becomes refreshed, and a feeling of relief is experienced similar to that after a thunder shower. It is debatable whether street sprinkling should be done by the city from a general improvement fund, or by private firms or corporations paid by the owners of property abutting on such streets. In my judgment street sprinkling should be looked upon as a part of the general street-cleaning system, because the general traffic and pedestrians are benefited by it quite as much as the owners of the property bordering on the street.

It has been suggested in seaboard towns to water the streets with sea water, and the matter seems well worth trying, as it reduces the demand made upon the general city water supply in periods of drought, and also because salt water keeps the street surface damp for a greater length of time.

CLEANSING FOOTWAYS AND SIDEWALKS, STREET CROSSINGS AND GUTTERS. — The sidewalks of streets should be kept scrupulously neat and clean. Mud should not be permitted to accumulate because it tends to make the sidewalks slippery. In winter, snow should be regularly removed, and when ice forms it should be covered by the householders with sand or ashes to prevent accidents and to avoid damage suits.

Street crossings need the particular attention of the street cleaners. They should be cleaned, swept, and the mud raked off, and during snowfalls they ought to receive attention first, so as to re-establish the regular street traffic with as little delay as possible.

The maintenance of the street gutters is particularly important from a sanitary point of view. In hot weather filthy gutters are a source of danger and the cause of noxious odors. They should be swept daily, and kept unobstructed, to secure a rapid drainage of the street surface. There should be no pools of stagnant, offensive liquids in the gutters; they should be kept impervious, to avoid leakage into the subsoil or into cellars, and they should have a continuous grade to the nearest sewer inlet. After snowfalls, gutters and inlets of catch-basins should be kept clear, so that when a thaw occurs there will be no flooding, which causes the street crossings to become impassable.

REMOVAL OF REFUSE; GARBAGE DISPOSAL; SCAVENGING. — While sewers are intended to remove from habitations all liquid and semi-liquid organic matters, the solid refuse of city houses and streets, comprising ashes, offal, garbage, house-sweepings and street refuse, should be removed by cartage. Sir Robert Rawlinson, one of the foremost sanitary engineers of England, called scavenging one of the important features of city sanitary engineering.

In dealing with this problem distinction is often made between regular and special refuse. Without going at length into the question, what constitutes ordinary house refuse, I shall merely state that house refuse should be divided into two distinct kinds, the garbage and the ashes, the former largely organic, the latter inorganic masses.

Scavenging deals not only with house refuse, but also with street refuse; with stable, garden and trade refuse; with market refuse, builders' rubbish, and with the mud accumulating in street or catch-basins.

House refuse, paper and litter, should never be deposited into the roadway, nor should any of it be thrown into sewer man-holes or catch-basins. Pending removal, house garbage and rubbish should be stored in dust-bins or in barrels and ash-cans, and it is essential, and by no means difficult to enforce, that separate vessels be provided by householders for the garbage or swill, and for the ashes and sweepings. Large fixed receptacles for the temporary retention are not as desirable as small portable pails or cans, except, possibly, for large tenement houses (1).

The garbage pails should be of non-absorbent material, and ash-cans should not be of wood, but of iron, to avoid danger of fire from hot ashes. All such receptacles should be provided with tight-fitting covers, so that, when they are placed on the sidewalk near the curb just before the scavenging cart arrives, the ashes may not be scattered by the wind, and the swill and offal may not offend the senses of passers-by when exposed to the rays of a hot July sun. The removal should be done at regular hours at all times, and garbage should be more frequently removed in summer than in winter, to avoid the emanations due to rapid decay.

The city should, of course, provide separate garbage and ash carts of solid construction and fitted with covers to avoid a street nuisance during transportation. In summer time, householders may help to reduce the amount of offal to be disposed of by drying, carbonizing and burning some of the house garbage in the kitchen range (1).

Regarding the ultimate disposal of city refuse, it is found by experience that much of it may be utilized, after sifting and separating the coarser from the finer materials. This sorting of the contents of ash and garbage barrels should never be permitted to be done in the streets. The city refuse dumps are the places to which ragpickers should be relegated.

All dirt, as Lord Palmerston has said, is merely "matter in the wrong place." While ashes, cinders, and clinkers may be utilized for the filling up of sunken lots or for making river banks or roads and pathways, garbage should not be so used or mixed in any way with ashes. Horse droppings from streets are salable as manure, and some part of the house offal can be disposed of to farmers for like uses. Whatever cannot be utilized in some way should be removed by rail or by water.

In harbor towns, the city refuse is taken in specially constructed hopper barges far out to sea, and dumped into deep water. This mode of disposal is not always desirable or feasible, as it sometimes leads to a defilement of the beaches and bathing resorts near the city. There is little doubt that destruction of garbage by the all-purifying element — fire — is one of the best, if not *the* best, method from a sanitary point of view. Various refuse cremators have been contrived, which are operated successfully without causing a nuisance by the smoke and gases from the furnace. The ashes resulting from cremation have some value as fertilizers, particularly where sewage sludge or nightsoil is mixed with the refuse.

The cleaning of earth closets, privies, ash-pits, cesspools, vaults, and sewer catch-basins is also a part of the city scavenging, which need not be discussed further.

THE LAYING OUT OF CITIES AND TOWNS. — The municipal and sanitary engineer's services become of paramount value in the laying out of cities and towns. This complex problem arises:

(1) When new towns are founded.

(2) When, owing to the tendency of men to congregate in cities, these grow so quickly as to require the extension of their limits by the addition of new outlying districts.

(3) When the alteration of the older parts of a city becomes necessary, because of the increased internal traffic which requires the extension or widening of the streets, or when, as in European cities, the abolishment

of fortifications in old towns and the tearing down and planing off of fortified walls causes a sudden growth and expansion of the town, and calls for a reconstruction of its narrow streets, simultaneously with the building up of its outer districts.

In such cases the actual work of extension, in whole or in part, should always be carried out under a general, well-considered plan, and under the guidance of certain practical as well as æsthetic principles (2).

SANITATION OF TOWNS. — The general sanitation of towns embraces problems like the following: the avoidance of outdoor dust, the prevention of the pollution of the town air by smoke and gases, the planting of trees in streets, the laying out of gardens, squares, and city parks, the means of transportation, storage and sale of the food supply, and other topics. Other sanitary problems refer to city graveyards, cemeteries, mausoleums, crematories and other modes of preservation and disposal of the dead, to the drainage of swamps and malarious districts, the prevention of inundations and storm-floods and of drought, the sanitary influence of forests, the benefits due to forest culture, and the objects of city and village improvement and sanitary associations, all of which will at some time engage the sanitary engineer's attention.

SANITARY ENGINEERING IN RELATION TO HABITATIONS. — The sanitary engineer's duties in relation to habitations and the problems arising therefrom are many and complex ones. The sanitation of the dwelling (3), the protection of buildings against the elements, the problem of housing the poor, tenement-house reform, the sanitary features of schoolhouse construction (4), the proper planning and arrangement of hospitals, of prisons, jails, and military barracks, the establishment of people's baths (5) in populous city districts to further bodily cleanliness and health of the working people, the arrangement of markets and of abattoirs, the disposal of dead animals, the construction of mortuaries and city morgues, the sanitation of bakeshops and of public laundries, the fire protection of buildings and of cities, the safety of audiences in theatres (6), and general theatre hygiene — these are all matters pertaining in whole or in part to sanitary engineering.

Industrial hygiene, the sanitation of workshops, the prevention of machinery accidents in manufacturing establishments, the regulation of noxious and offensive trades, the abolishment of public nuisances, the healthfulness of summer hotels, summer resorts, and camps, and the fight against malaria and mosquitoes, against typhoid fever and flies (1) present problems which it is often the business of the sanitary engineer to solve.

The hygiene of the travelling public requires, not only provision of comforts and conveniences, but, above all, of safety and cleanliness. In hotels this means unobstructed fire escapes and fireproof stairs, located, not around, but away from, the elevator shafts; perfect cleanliness of rooms, beds, and bedding; bathing facilities, well-kept toilet rooms, safety from sewer air in sleeping

apartments, freedom from coal gas due to stove dampers, avoidance of gas leaks due to defective gas fixtures (7); and the filtering of the water supply, and in particular of the table water.

RAILWAY AND SHIP SANITATION. — **Public conveyances, in which travellers are often carried for long distances huddled close together, require sanitation as much as our homes. Subway, street, and elevated railroad cars should be thoroughly washed, cleaned, and aired every night. The ventilation of railroad coaches, of sleeping cars, of railroad tunnels, of ferry-boats, and of steamship state-rooms and berths afford sanitary problems which are not always easy to solve. The luxurious sleeping-cars, in particular, could be much improved if more attention were paid to cleanliness and sanitation rather than to decoration and embellishment. Means of ventilating the cars are often absent, or, where they are provided, they are not effective, because they are not rightly handled by the train hands.**

Among the more palpable defects I mention defective lighting, overheating, lack of cleanliness and of ventilation; unclean water tanks, with ice and water of doubtful purity, and often mixed together; bad arrangement of car hoppers, objectionable water-supplied pan closets in compartment cars of vestibule trains, etc. There is in all cases some danger of the transmission of disease, such as typhoid fever, or consumption, by the sputum of invalids.

Railway and ship sanitation really include much

more than this, as the readers will admit when I recall to them the disgraceful and unsanitary condition of many railroad stations and ferry houses, and when I remind them of the crowded steerage quarters on emigrant vessels.

SANITARY INSPECTION OF BUILDINGS AND BUILDING SITES; SANITARY ORDINANCES.—A large part of the practice of the sanitary engineer refers to sanitary inspections, whether examination of houses, or inspection of future building sites for institutions, or sanitary surveys of cities and towns (8).

His acquirements also render him well qualified to assist in drawing up building laws and sanitary ordinances, to see to their proper enforcement in the position of sanitary, or building, or factory inspector, or to prepare in the office sanitary maps, profiles, and diagrams of mortality in its relation to meteorological and sanitary conditions.

THE SANITARY ENGINEER AS EXPERT IN THE COURTS.—Another part of the sanitary engineer's work consists in rendering expert services in cases of litigation pertaining to sanitary works or sanitary patents. To give testimony as an expert witness in court is not always an agreeable duty, particularly under the custom prevalent in the United States, under which experts are engaged by both the plaintiff and the defendant. It is far preferable, to my mind, that experts be retained by the court only, as is the rule in some European countries.

I hold the opinion that it would be better if experts in sanitary engineering cases were confined to testifying to facts only, and not required to answer hypothetical questions. In any case, they should limit themselves to testimony relating to sanitary engineering questions, and decline to enter into a discussion of problems belonging to sanitary science or the germ theory of disease.

Even a well-qualified and learned sanitary engineer should not offer opinions in court cases as to what may or may not be injurious to health. He should leave this to the medical officers, to the sanitarian or the biologist, and he should confine himself to the constructive side of such works as health officers require for the prevention of illness or for the increase of salubrity. Viewed in this light there is quite a distinction between a sanitary engineer and a sanitarian, which, in cases of litigation, the judge, as well as the attorneys who plead the case, should recognize.

Sanitary Engineering in Case of Epidemics, in Time of War and in Sudden Calamities. — Brief mention should be made of the special work and duties of the sanitary engineer in case of sudden outbreaks of epidemics, or of sudden calamities or great disasters in civic life, such as earthquakes, river floods, and destructive conflagrations; and of the services which may be rendered by sanitary engineers in time of war, such as the erection of temporary hospitals for the wounded, the housing of soldiers in tents, the maintenance of cleanliness in the camp, the sanitation of battlefields and the prevention of war pestilence.

This work is of so much importance and so timely that I have discussed it in a separate chapter.

THE TITLE "SANITARY ENGINEER." — The foregoing brief statement of what constitutes the practice of the sanitary engineer will give the readers a tolerably clear insight into the numerous duties of the new profession. Having defined sanitary engineering and thus gained some knowledge of the education and the practice of the sanitary engineer, and of the problems which engage his attention, we are in a position to answer the question: "Who is not a sanitary engineer?" in the true sense and meaning of the term.

No one should be entitled to the name of "sanitary engineer" unless he is amply qualified, by study, special training, and practical experience, to offer sound advice in all problems arising in his profession. The mere fact that a man is qualified in a single special branch — for instance, in house drainage or in the plumbing work of buildings — does not entitle him to be regarded as a sanitary engineer.

I am quite aware of the fact that, in making this statement, I am stepping on dangerous ground, and that there are some who do not agree with me. I do not believe in mincing such matters, and I do prefer always to call things by their right names. Misuse of terms is misleading. A builder or contractor is not an architect, but the architect may, in certain cases, be a builder. A druggist or apothecary is not a doctor, though an educated physician may be, at times, a dispensing chemist. So likewise, a man who does the plumbing work of buildings, or who takes contracts for laying drains or sewers, or who confines himself to repairing or altering defects in house drainage, is not thereby qualified to be considered a sanitary engineer, but a sanitary engineer may, and often does, plan or carry out works of house drainage and interior plumbing arrangements.

A man does not become a physician by the mere act of hanging out a sign on which he styles himself "M.D."; neither does a man become a sanitary engineer by merely adding these words to his trade sign after having obtained a license to run water pipes or to lay sewers, or an appointment as inspector of nuisances. The innocent public, however, may oftentimes be misled by signs of ambitious tradesmen, such as "Plumber, Gasfitter and Sanitary Engineer," or the still more pretentious sign, "Plumber and Consulting Engineer for Hydraulic and Sanitary Works."

I do not wish, however, to be misunderstood, nor have my words misinterpreted or misquoted.

Nobody has a higher appreciation of intelligent and skilled mechanics and craftsmen than I, and it is far from me to underestimate the good work done by conscientious tradesmen. But I hold that the difference between a trade and a profession cannot be bridged over or eliminated by devices merely calculated to deceive the public. It is just as erroneous to call a man, or to take a man to be, a sanitary engineer, who has had no general engineering training, and whose knowledge and skill are confined to house drainage and plumbing, as it is to think a man cannot be an engineer because he does not build or run engines.

To go a step further, physicians, who have made a special study of preventive medicine and sanitary matters, should likewise not be considered sanitary engineers — the term "medical engineer" has even been coined for the purpose — for they lack the technical experience and training absolutely required to qualify them for carrying out works of sanitary engineering.

Summing up, I claim that just as in medicine the eminent specialist must be a physician proficient in general medicine, so in the profession of engineering *the sanitary engineer should be a well-trained civil engineer.*

General Qualifications of the Sanitary Engineer. — Let me say a few words in regard to the general qualifications of the sanitary engineer. To my mind he should be a man with the broadest possible general culture. Only a person combining a liberal education with broad views can expect to attain a high position in modern life. While these qualifications are to some extent influenced by the training which a student receives during his college years, many of them are acquired only after some practical experience in his professional duties.

An engineer should not only have a thorough knowledge of his profession, but he should combine with it good business capacity. To be cultured, an engineer should not merely be expert and skilful in some branch of the profession, it is necessary that he study problems of economy, that he possess executive ability and be a good manager of men; that he should have acquired not only knowledge, but also experience, training, and sound judgment; that he should possess tact and refined manners, which are the evidences of good breeding. The requirements of conscientiousness, trustworthiness, truthfulness, honorable conduct, blameless character, and business integrity are almost self-evident. The engineer should respect his brother engineers in order to win their respect.

President Humphreys, of the Stevens Institute of Technology, recently remarked that "the engineer must be more of a man of business than he has been in the past. It is not enough that the technically trained engineer should be practical in his ability to meet business men on their own ground. Some engineers fail to secure success because they carry too large a proportion of science; some because they have not enough, and others because they fail to recognize that commercial efficiency must outweigh theoretical efficiency. The training of the future engineer should be a harmonious blending of science, practice and commercial judgment."

Opportunities and self-education will help the engineer in acquiring a broad general culture, which is so necessary in dealing intelligently with many of the engineering problems of the present day.

The following "Specifications for a Good Engineer" are taken from an engineering paper: —

"A good engineer must be of inflexible integrity, sober, truthful, accurate, resolute, discreet, of cool and sound judgment, he must have command of his temper, must have courage to resist and repel attempts at intimidation, a firmness that is proof against solicitation, flattery, or improper bias of any kind; he must take an interest in his work, must be energetic, quick to decide, prompt to act, he must be fair and impartial as a judge on the bench, he must have experience in his work and in dealing with men, which implies some maturity of years; he must have business habits and a knowledge of accounts."

"Men who combine these qualities are not picked up every day. Still they can be found. But they are greatly in demand, and when found, they are worth their price; rather they are beyond price, and their value cannot be estimated in dollars."

In order to win universal respect an engineer in practice for himself should avoid sensational writing or advertising; he should confine himself, if he is building up a practice and is obliged to seek work, to legitimate advertising, but only to such as the insertion of a professional card in the engineering journals; he should utilize opportunities which offer themselves to him to demonstrate his qualifications and skill in works designed and superintended by him; or become known by original contributions to the technical and engineering press, or by the dissemination of essays, or by lectures.

Much of the sanitary engineer's work is necessarily of a missionary character, as the public must be educated to appreciate the benefits of sanitation. Not a little of his work requires constant patience and perseverance. It is, as a rule, uphill work until success and the merited reward of a widespread reputation are attained. In this strife for recognition, do not permit discouragement to overtake you, and above all "do not confound success and acquisition of wealth, for some of the world's most successful men have been poor."

The Sanitary Engineer in Public Life and Municipal Government. — The sanitary engineer who has established a reputation should be much more closely identified with public affairs than has been the case in the past, for among the learned professions engineering justly occupies the foremost rank. Speaking of the relation of engineering to progress and civilization, Professor Hutton has pointed out that "the civil engineer lays out roads, canals and railroads; the mechanical engineer applies the motive power by water and by rail, and thus men and goods are conveyed with increasing celerity and certainty between their objective points. If the flying machine is to make communication as free as air it will be by the engineer that its work will be done. It is unfortunate for the engineer that his work, fundamental to so much which makes the comfort and civilization of the day, should be concealed and disregarded simply because it underlies. Without the engineer, life in cities would be impossible, where there was no gas, no water supply, no sewerage, no food supply except by wagons, no motive power but human muscles."

By reason of their special training, sanitary engineers are exceptionally well fitted to be represented in City, State, and National Boards of Healths, in Boards of Education and of Charities, in City Councils, and in City Improvement Societies and citizens' committees.

In the appointment to municipal offices or boards of public works, the fact should never be lost sight of that engineering is not politics. Reforms in municipal government, such as were so happily inaugurated some years ago in New York City, can only bear good results if politics and engineering are kept strictly apart.

II.

THE WORK OF THE SANITARY ENGINEER IN TIME OF EPIDEMICS, IN TIME OF WAR, AND IN SUDDEN CALAMITIES IN CIVIC LIFE.

In the present age of keen business competition, and in the stern realism of modern life, one is far too apt, in choosing or in pursuing a profession, to consider purely the business aspect involved, or, in other words, the expected financial gain. One usually forgets the humanitarian side incident to every professional man's career.

In the everyday life of a nation, of a State, or of a community, contingencies are likely to arise at any time which require the exercise of the faculties acquired in the pursuit of a business, trade, or profession in order to apply them — at such times — in the interests of humanity. Among such contingencies are outbreaks of epidemics, war, and great disasters in civic life.

I propose in the following to discuss briefly what services and aid the professional man, who has chosen "sanitary engineering" for his calling, can render in such extraordinary events to the cause of humanity.

I. *Work of the Sanitary Engineer in Case of Sudden Outbreaks of Epidemics.*

"Mankind is accustomed to the ceaseless and regular work of death, to the slow removal of human beings from its midst. One may compare it," says a German writer, "to the leaves of a tree, which, after changing color in autumn, drop off one by one as the winter comes. So also, one by one, will men sink into their graves, while new generations arise, only to meet the same fate in the end. This is the inevitable decree of destiny, of the order of things in nature. But the aspect of death changes when an epidemic breaks out. It is then more like the sudden uprising and uproar of a storm, which in its mad fury breaks off delicate branches and twigs, and uproots strong and healthy trees. It is death, again, to be sure, which we see all around us when an epidemic rages, but death in a different form, clad in a strange and dismal raiment, which shakes the nerves of the strongest and bravest men." At such times the people begin to feel that perhaps the wholesale dying need not have taken place, that the causes which led to the calamity might have been avoided — in short, that death in epidemics, far from being a dispensation of Providence, is the result of man's own carelessness, neglect, or indifference in sanitary matters.

When an epidemic threatens, the work of the sanitary and municipal engineer consists principally and first of all in *measures of prevention.*

He should pay particular attention and care to all hygienic municipal work, such as the public water supply, the sewerage, the scavenging and street cleaning, the sewage and garbage disposal, the public bath and wash-houses, market-houses, abattoirs, and public comfort stations. Increased cleanliness is required for public conveyances, hacks, cabs, street-cars, elevated and steam railroads, as well as ferry-boats, and stricter attention should be paid to railroad depots and stables, to hotels and public lodging-houses.

It is well, at such times, to institute a sanitary survey of the city,* including a house-to-house inspection, with particular regard to the tenement districts. Temporary hospitals for the reception and care of infected patients should be planned, located, and arranged. Speaking broadly, the problems which in such a case arise for the sanitary or municipal engineer consist in stricter and closer attention to the sanitation of the soil, the air, the water, the food supply, and the dwellings of a city.

If an epidemic actually breaks out, the extraordinary duties of the sanitary engineer embrace mainly the following work — viz.:

1. Measures for the protection of those who are not sick.
2. Measures for the proper care of the sick.
3. Measures for the prompt and safe removal and disposal of the dead.

While some of the work to be performed is of a medical nature, not a little of it, particularly as regards preventive measures, belongs to the province of the engineer. Both the physician and the sanitary engineer should therefore work hand in hand, and assist and supplement each other. Physicians, however, are

* See Gerhard, "Guide to Sanitary Inspections," 4th Edition, revised and enlarged, 1909.

rarely sufficiently educated in technical details of sanitation, and it seems at least doubtful, if it would not be a serious mistake, to put all preventive measures in the exclusive charge of health officers. A division of the work would be, to my mind, far preferable, and would offer considerable practical advantages.

Among *measures for the protection* of those who are well, the preservation of the purity of the drinking water is of greatest importance. Regular periodical chemical and bacteriological examinations of the water supplied by the city water-works should be instituted. The sanitary engineer should have a sufficient knowledge of the noxious components of water, and of the methods of detecting these impurities or contaminations, in order to be able, if not to perform the analyses himself, at least to interpret correctly the results of the chemist's and microscopist's work. In addition to this, it is essential that all public wells in streets or squares, as well as those in private grounds, be watched with care. It is advisable to close up at once all suspicious wells. Rain-water cisterns should be cleaned and purified, and where filters are used, the filtering material should be sterilized or renewed. It is better still to avoid entirely during epidemics the use of filters, and to make it a practice to boil the water used for drinking purposes. The ice supply should be watched, the sale of all impure ice, or ice cut from contaminated ponds prohibited, and the householder cautioned to use the ice which is intended for the cooling of beverages in vessels with separate compartments, so that the melted ice cannot mix with the water.

The sanitary engineer should look after the city sewers, and should take the necessary steps to insure that they are well flushed and ventilated, and that the catch basins and street gutters are kept clean. If necessary, he should apply disinfection to the sewers. Medical men should make it a strict rule that the discharges of the sick be disinfected before they are thrown into water-closets or slop-hoppers to pass away through the house sewers.

The police and sanitary department should prohibit during epidemics the throwing of any evacuations into rain-water inlets, gutters, catch-basins, or privy-vaults. Where there is a sewer in the street, the connection of houses to it should be made compulsory.

Houses without sewerage facilities, depending upon privy-vaults, earth-closets, and cesspools for the liquid wastes, require at such times more than ordinary attention. Old or badly constructed sewers, generally filled with a mass of putrefying deposits, are particularly capable of propagating an infectious disease through the house connections, the street catch-basins, and the open or ventilating manhole covers. Such sewers will require a thorough disinfection with either milk of lime or with sulphur. Next to a system of water-carried sewerage, a well-arranged system of dry removal by pails is during an epidemic the best; but the removal should be well organized and occur regularly, and the pails should be well cleaned and disinfected. It is advisable not to empty privy-vaults or cesspools during an epidemic without having their contents thoroughly sterilized by germ-killing disinfectants.

Where the town sewage is regularly purified before discharge into a water course, the sanitary engineer should watch with care the sewage field or the sewage purification tanks. All sewage should reach the irrigation field before it has begun to putrefy. In the disposal field or the sewage beds it should be evenly distributed, and stagnant pools of sewage should be removed.

The utmost cleanliness should be maintained in the streets of the city. All paved surfaces should be regularly swept clean, and the cleaning up of back and front yards, of courts and alleys and street gutters, should not be forgotten. The streets should be moderately sprinkled to lay the dust, which, if scattered, may carry disease germs into dwellings; if necessary, disinfectants should be added to the water in the watering-cart.

All street dirt, house refuse, and garbage should be removed with particular regularity, for they may contain the germs of the disease. Householders may assist the municipality by burning litter and refuse in the house fires whenever it is possible to do so. Manure pits of stables require careful attention. In times of epidemics, the destruction of the city refuse by cremation appears to be by far the safest mode of proceeding. The disposal of the garbage by removal offers considerable difficulties even in ordinary times; but during an epidemic the question of removal is apt to be particularly embarrassing, for the very act of removal may cause a further spread of the dreaded disease, and quarantine laws will in many cases render a removal to an out-of-town place utterly impracticable. On the other hand, the sanitary engineer should avoid at such times the accumulation of large masses of putrefying garbage and offal at any point within the city limits; hence sanitation by fire seems about the only solution of the problem.

Mosquitoes and flies have recently been recognized as the carriers of certain infectious diseases. In the case of a threatened epidemic of yellow fever, it is a matter of the utmost importance that the patient's bed and the sick room be screened, so that he may not be bitten by the stegomyia mosquito, which might by its next bite transmit the disease to other persons. Rainwater cisterns or barrels and cesspools should be screened in order to prevent the breeding of these insects. In the case of an epidemic of typhoid fever, the kitchen, pantry, and store room for food should be protected by screens so that flies may not contaminate the food or the milk by the germs which they may carry on their feet and bodies after having crawled over the dejecta of patients sick with the disease. Food stuffs, and in particular those eaten raw, like fruit, salads, celery, etc., should not be exposed for sale by grocers on open stands, but should be at least screened from flies, and preferably protected against street dust. For like reasons the screening of camp sinks, earth closets or latrines is an important preventive measure.

The battle against filth diseases requires the maintenance of absolute purity of the soil, the air, and the water. While general cleanliness, light, air, and water are the best available general means of disinfection, it is necessary during epidemics to provide well-appointed places for a proper disinfection by steam of all wearing apparel, and of the washing of those who have been taken sick. Disinfecting stations for persons, such as were used in Stettin in 1870–71, and exhibited by Professor Petruschky, of Königsberg, at the Berlin Hygienic Exhibition of 1883, are to be recommended. In these the persons take an ablution with antiseptic soap under a shower or rain-bath, while their clothing is disinfected for about twenty minutes by steam. Following the douche, the bath attendants wash the whole body of the bathers thoroughly with a permanganate of potash solution.

If proper care is exercised in the maintenance and management of public baths, it is not always necessary to close these places when an epidemic occurs, for it would deprive many people, who have no facilities for thorough ablutions at home, of the chance to keep their bodies clean, a measure which in itself tends to prevent infection. The public wash-houses, however, should be closed, and physicians should insist that the dirty linen of all patients be sent to the disinfecting station.

The municipal engineer must also see to it that water-closet conveniences and urinals of public comfort stations be kept scrupulously clean, well flushed, and disinfected, while the sanitary engineer in private practice will be kept busy with inspections and with tests of plumbing work in dwellings, office buildings, stores, and institutions, and with the more or less extensive alterations of the plumbing and drainage, with a view of making the same safe from a hygienic point of view.

A sanitary survey of the city and a house-to-house inspection enable the sanitary engineer to know beforehand the actual condition of the worst city districts, generally the tenement quarters of the poor population. Efforts should be made to improve the obtaining conditions, particularly in regard to overcrowding and cellar habitations. Public lodging-houses should be put under close surveillance. In hotels those rooms which may have become infected by a patient ill with the disease should be properly disinfected, and the carpets, furniture, and bedding destroyed. Attention should be paid to public vehicles, particularly to cabs in which patients may have been transported from the houses to the hospitals. This should always be avoided by providing separate ambulances for the infected.

As a further measure to protect those who are not sick, it is advisable to close, at the very beginning of an epidemic, all public halls and places of amusement, likewise the public schools, colleges, and boarding or private schools. Should the epidemic spread, it may be better to close up the factories and workshops. The shipping of freight should be stopped, travellers' baggage should be disinfected, and railway-stations, railroad-coaches, sleeping cars and steamship berths should be inspected.

Then, again, there must be efficient *measures for the isolation and care of the sick:* first, in order not to endanger those who escaped the scourge; second, to cure the sick. An efficient ambulance service should be organized, largely composed during epidemics of volunteer emergency corps, of firemen, policemen, and militia soldiers, as the regular hospital service of a city will at such times prove insufficient.

The sanitary engineer may be called upon to provide temporary tent or barrack hospitals, where the city hospital accommodations do not suffice to care for the sick. As the school-houses are closed, such buildings may be utilized for hospitals, but if this is done great care is necessary in the disinfection of such buildings after the epidemic ceases. Military barracks and stables may often be used for the same purpose, while theatres and churches are not so suitable. The temporary barracks, while constructed of woodwork, should be arranged in a manner to keep out the cold. Besides provision for heating, they should have hot and cold-water service, bathing facilities, sewerage, and electric lighting. The location for hospital barracks should be carefully chosen. In case of an epidemic it is far better to keep them within a short distance of the crowded city districts, rather than locate them at the outskirts of large towns.

Finally, the dead must be cared for. These should be quickly removed from the hospitals and from the poorer and crowded city districts, using extra precautions against infection during removal and transportation. During epidemics, the final disposal of the dead bodies by cremation offers important advantages.

In case of sudden pestilence, many people who are able to do so leave the infected city and fly to camps of safety, erected with refuge huts and refuge tent hospitals. In these, too, the sanitary engineer may find opportunity to assist in maintaining sanitary conditions by attention to those requirements which at other times form together what is known as "camp hygiene." Such "tenting out" always necessarily involves more or less exposure to the vicissitudes of the weather, and may cause sickness of a preventable nature.

Whenever possible, one should prepare beforehand for the emergencies likely to arise during an epidemic. When the writer was in the Prussian military service, thirty-three years ago, as a volunteer in an engineering regiment of the Imperial Guards at Berlin, he was ordered for a few weeks to the headquarters of the general military staff, under General Moltke, and he well remembers how he assisted then in preparing beforehand the railway time-tables required for the quick moving of the bulk of the German Army to either the French or Russian frontier in case of a future war. In a similar way should the sanitary engineer and the health officer lay out beforehand all the plans required to assist in the fight against infectious disease, so that when an epidemic does occur, it may not find them unequipped and unprepared.

II. *Work of the Sanitary Engineer in Time of War.*

In case of an outbreak of war, the civil engineer will be chiefly concerned with the provision of proper means for the speedy and safe transportation of large masses of troops, including the necessary ammunition; with the laying of temporary railroad tracks and the erection of temporary bridges or the construction of pontoons over streams; or with the destruction of the enemy's railroad lines or rolling stock and the burning of bridges. The work of electrical engineers will consist in the erection of signal stations, the laying of military telegraph lines, and the provision of portable electric-light apparatus for the search of the dead, the aid of the wounded after a battle, and for the disinfection of the battle-field.

The duties of the sanitary engineer in time of war will embrace something like the following — viz.:

1. Providing proper facilities for the temporary housing of soldiers, and selection of proper sites for military camps.

2. Enforcement of cleanliness in the camp; examination of sources of water supply; purification of water and provision of an ample supply for the troops and horses; drainage, removal of wastes and garbage, and erection of latrines; also safety measures against fire.

3. Provision and transportation of a proper food supply.

4. The first aid to the wounded on the battle-field and at the dressing-stations.

5. The care of the wounded; erection and fitting up of temporary field hospitals, and means for heating and ventilation and electric lighting; transportation of the wounded from the battle-field, and organization of a field ambulance service.

6. Care of the sick in tent or barrack hospitals.

7. Sanitation of the battle-field and care of the dead soldiers; also the cleaning and disinfection of camps, the destruction of temporary hospitals, and the disinfection of putrefying battle-fields.

The sanitary engineer, through his practice in times of peace, is rendered particularly qualified to assist in the housing of an army of troops in the field, to give aid in the care of the sick and wounded, and to prevent in military encampments war pestilence, or diseases and deaths due to deficient sanitary conditions, by enforcing sanitary preventive measures.

In his interesting book, "The Real Triumph of Japan," Dr. Louis L. Seaman, late Surgeon-Major United States Volunteer Engineers, states: "It must never be forgotten that in every great campaign an army faces two enemies — the armed forces of the opposing foe, and the hidden foe, always found lurking in every camp, the grim spectre ever present, the far greater silent foe — disease."

Statistics record the fact that for every soldier who dies from bullet wounds in or after a battle, there are from two to four who fall victims to disease, and that for one soldier discharged as disabled and wounded, there are three who are more or less permanently disabled by disease. At the Shipka Pass, during the Russo-Turkish War in 1877, the daily losses from bullets were far exceeded by those from frostbite.

Ours is not a military nation, and during peace we do not keep a large standing army; but those European nations who are obliged always to be on a war footing pay, since the Crimean War, a great deal of attention to sanitation. After the battle of Balaklava and during the siege of Sebastopol, in the Crimean War of 1854, the English Army suffered immense losses from sickness in the camp. It is stated that of 100 sick soldiers in the hospitals, only 11 were soldiers wounded in battle; 46 per cent of the sick died from fevers. It was then that England sent the well-known Miss Florence Nightingale with 40 assistants to the seat of war, and she succeeded in reducing the mortality of the English troops by enforcement of practical measures of sanitation.

In the South-African Boer War the English losses from disease were frightful, and in the Spanish-American War the ratio of those dying from disease to those dying from bullets is said to have been as 14 to 1.

In contrast with these figures are the records of the Russo-Japanese war of 1905, for while 12,000 soldiers died from disease, 53,000 died from wounds received in battle. This surprising result was due in a large measure to the most excellent system of sanitation in the field instituted by the Japanese, and to their constant vigilance against disease in camp.

Military camps should offer to the soldiers shelter against sun and heat, against rain and damp, against wind and storms. In order to be healthful, such camps require an elevated site and a dry subsoil, with good drainage facilities and means for a pure water supply. In choosing and locating camps, the sanitary engineer can render efficient service by making preliminary topographical surveys and avoiding all unhealthy sites, the neighborhood of marshes or swamps or alluvial river bottoms, subject to overflow, which tend to foster malarial conditions. If compelled to erect a camp in such a situation, it should be placed well to windward of all suspicious grounds.

Old camp grounds should be avoided on account of the likelihood of a previous soil contamination and the possible incidental danger of infection. Hills and woods serve as protection against winds, and the woods also for shade in warm climates.

Cleanliness and healthful conditions must be maintained in camps. Dryness of soil is essential, hence the first care of the sanitary engineer should be to arrange for proper surface drainage, and to provide against floods or excessive rainstorms. He should also make provision for a good water supply, arrange for the disposal of slops and waste water, and erect suitable latrines or plain earth closets, and have them well screened against flies. Facilities for performing bodily ablutions, including simple bathing arrangements, should be contrived, as well as means for washing the underwear and cleaning the clothes and blankets of the troops. For although the out-door life of military service, and the camping out under the open sky tend in general to favor healthful conditions, the want of cleanliness, particularly in the field or during and after long marches, may be a fruitful cause of disease.

The camp should be inspected daily. A regular system of scavenging should be instituted, order and cleanliness must be maintained, and the danger of fire must be guarded against. The latrines must be carefully looked after and kept well screened; kitchen refuse should be removed daily to a safe distance or buried. The stable manure of cavalry or artillery encampments should be carted away regularly, and dug into the ground. Soil pollution by the voiding of urine in other than the designated places should be prevented by strictly enforced regulations. Finally, a small field hospital should be erected, either of log-huts or of tents, to care for the sick.

When a battle has taken place, humanity demands the early search for, and the immediate first aid to the wounded, to friend and foe alike, and considerations for the health of the surviving as well as piety require the burial or disposal of the soldiers who fell in battle and of the horses killed. Warm weather and moisture combine to create very soon conditions of war pestilence dangerous to health, unless immediate attention is given to the sanitation of the battle-field.

After the battle of Solferino, on June 24th, 1859, not less than 40,000 wounded covered the field, lying exposed to the hot summer sun, which soon changed all into a mass of putrefaction and pestilence. Henry Dunant, a citizen of Geneva, Switzerland, witnessed these shocking sights a day after the battle, and described them in his book, "Un souvenir de Solferino," which gave the first impetus to the founding of the Red Cross Society, at Geneva, on October 26th, 1863. Colonel Naundorff, in his book, "Under the Red Cross," gives a similar vivid description of the horrors of the Königgrätz battle-field. It took, after the battle of Gravelotte, in the Franco-Prussian War of 1870–71, four days to remove the wounded and dead, and after the battle of Sedan it took six days to accomplish this. Nowhere, however, have the hardships of war and the horrors of the battle-field been depicted with a greater master hand, more vividly and realistically, than in Verestchagin's world-famous war paintings, the scenes of which are taken from the Russo-Turkish War. The sights which he saw in actual military service were so forcibly impressed upon his mind that the paintings which he created after the war speak eloquently for themselves. The message conveyed to us by his works cannot fail to teach a lesson and to awaken sentiments in opposition to warfare; at the same time they point to the urgent necessity of civil aid upon the battle-field.

What may be accomplished at such times by civil aid has been well illustrated in the excellent work done by the United States Sanitary Commission in the War of the Rebellion of 1861–64. The barrack or pavilion system of hospitals was originated by this commission, and has had a powerful influence in changing the general plan and arrangement of hospitals, and in emphasizing the importance of securing ample ventilation to such structures. The well-known German surgeon, Professor Frederick von Esmarch, made a powerful appeal for civil aid in his famous essay, "The Battle of Humanity against the Horrors of War," published in 1869.

In England John Furley founded in 1877 the St. John Ambulance Association of London, and Esmarch followed soon after in Germany by the establishment of

"Samaritan Societies," which he aptly calls the "Pioneers of the Red Cross."

In addition to the aid given on the battle-field by volunteer emergency aid corps, the regular military hospital and field ambulance corps attend to the wounded during and after a battle. It is usual to distinguish three series of stations — viz., the first dressing station, near the line of battle, where the wounded receive the first aid, and where the temporary bandaging of wounds is done; second, the field hospitals, composed of tents or barracks located from two to three miles behind the line of battle, to which the wounded are removed in field ambulances, and finally the general war hospitals, which are stationary but usually temporary structures, located at greater distance from the seat of war, and to which the wounded are transported by hospital railway trains or sometimes by hospital ships.

After the battle the dead must be cared for, generally by interment in large common graves, and sometimes by cremation. The introduction of the movable electric-light wagon in the military service has aided greatly in accomplishing this more quickly; at the same time it may render useful services in the early disinfection of the battle-field to avoid war pestilence.

The Medical Corps of the National Volunteer Emergency Service is intended to provide a trained body of physicians and pharmacists, available for emergencies of all kinds, but more in particular for service with troops in case of war.

III. *Work of the Sanitary Engineer after Sudden Calamities, Catastrophes and Great Disasters in Civic Life.*

Many opportunities offer themselves to the sanitary engineer for rendering useful service in case of accidents or sudden calamities, like earthquakes, floods and freshets, destructive conflagrations, tornadoes and cyclones, forest fires, collapse of buildings, machinery accidents, boiler or powder explosions, railway disasters, and accidents in mines.

After a storm flood, caused either by river overflows or by the breaking of dams or water reservoirs, the entire flooded district must be drained, and its habitations must be rendered healthful by artificial drying; but as this requires considerable time, it is often necessary to erect temporary barracks for shelter, as many people will suffer from lack of homes. All dampness must be removed, disinfection applied whenever necessary, and in houses with deafened floors the wet filling-in material should always be removed, as it may breed disease. After deplorable calamities, such as the flood at Johnstown, Pa., in 1889, caused by the breaking of a dam above the town during an extraordinary rainfall, or the Galveston flood in 1900, or the almost entire destruction of the city of Szegedin, in Hungary, in March, 1879, by a river freshet, all of which caused much loss of life, the services of sanitary engineers can be put to good use.

Similar aid may be rendered after destructive forest fires like the one at Chisholm, Minn., on Sept. 6th, 1908, after earthquakes such as the one in Charleston in 1886 or the one in San Francisco in 1906, or after great conflagrations like the one of Baltimore in 1904, or devastations by cyclones, typhoons or tornadoes, as at St. Louis in 1896. Panics and fires in theatres, or in orphan asylums or hospitals for insane, are terrible calamities, often accompanied with appalling loss of life. The Iroquois Theatre fire in 1903 caused the death of 571 persons, nearly all in the audience. Here, again, the knowledge of sanitary engineers can be applied and efficient services rendered, first of all, in providing measures for preventing the recurrence of such catastrophes and, second, in rendering aid when such accidents have happened.

Speaking of the disaster of Galveston, a writer in the *New York Times* stated that it perhaps exceeded in the number of the dead and injured, in the loss of property, and in the horrors of the conditions following the destruction, any other disaster to an American city (except the more recent one at San Francisco and abroad that of Messina, Italy, in which both the earthquake and the subsequent conflagration due to it caused an appalling havoc — W. P. G.). Galveston was confronted with a water famine and the danger of pestilence. In none of the previous disasters was the demoralizing, paralyzing effect of terror so great. The imagination staggers before the frightful picture of the night of horror in the raging water at Galveston. After such an experience, the sturdiest community must be in need of aid. In such disasters the National Government always renders prompt aid to the homeless, but this is not enough, and the great bulk of assistance should come from the people and from Volunteer Emergency Corps.

The following table shows the loss of life and destruction of property in eight recent large public calamities:

	City or Town.	State.	Population.	Area.
1	Charleston	S. C.	55,807 (1900)	——
2	Johnstown	Pa.	35,936	——
3	St. Louis.......	Mo.	630,000 (estim.)	61½ sq. m.
4	Galveston......	Texas	37,789 (1900)	13 sq. m.
5	Chicago	Ill.	1,698,557 (1900)	190 sq. m.
6	Baltimore	Md.	600,000 (estim.)	32 sq. m.
7	San Francisco ..	Cal.	342,782 (1900)	47 sq. m.
8	Messina, Reggio, etc.	Italy	abt. 300,000	——

	Nature of calamity.	Date.	Number of persons killed.	Destruction of property in value.
1	Earthquake	Aug. 31, 1886	Scores of people	8,000,000 Dollars
2	Flood	May 31, 1889	2,235	10,000,000 "
3	Tornado	May 27, 1896	306	13,000,000 "
4	Flood	Sept. 8, 1900	6,000	17,000,000 "
5	Theatre fire (Iroquois)	Dec. 30, 1903	571	80,000 "
6	Conflagration	Feb. 7, 1904	——	70,000,000 "
7	Earthquake and fire	April 18, 1906	500	300,000,000 "
8	Earthquake, fire and tidal wave	Dec. 28, 1908	about 200,000	many hundred millions

Then, again, we have a large number of accidents, such as the collapse of buildings or grand stands, railway disasters and bridge accidents, injuries in industrial or manufacturing establishments and in workshops, due to unprotected machinery in motion or to defects of hoisting apparatus; blasting accidents, fire-damp explosions in mines, caving in of trenches in earth excavations for sewers or water-pipes, suffocation by escaping illuminating gas in laying mains, collapse of tunnels; steam-boiler explosions, and explosions of gunpowder or dynamite.

In the construction of architectural as well as engineering structures, accidents to the superintendents, to masons, bricklayers, roofers, and other workingmen are of frequent occurrence. There are injuries due to falling stones, brick, or timber, falls from scaffolds or ladders, derricks and hoisting accidents. In carrying out large railroad or other public enterprises, like the Panama Canal, it is usual to provide beforehand temporary barrack hospitals for the care of those who may become in any way injured or who succumb to disease.

The National Volunteer Emergency Corps proposes to organize in each State a brigade, under appropriate command, to be known as the First Aid Corps. "This is intended to furnish every community and neighborhood with the means of transporting the sick or injured to home or hospital, and to furnish sufficiently trained persons to supervise such removal."

In the Army and in the Navy officers and men receive training to render first aid; manufacturing and mining industries and some of the principal railroads instruct their employees in first aid to the injured. The new Emergency Corps is to spread similar knowledge among the public.

In view of the frequency of accidents in architectural and engineering works, a general course of instruction of first aid in emergencies and accidents has been introduced at all the German Polytechnic Schools and Technical Universities. While it is true that the knowledge of how to render the first aid in injuries until a surgeon arrives should be a part of every man's general education, and while it is by no means claimed that the engineer is specially qualified to render such service, the matter is mentioned here because, through the nature of his work, he is apt to be frequently present at, or to be brought into immediate contact with, such accidents when they do occur, and it is desirable that he should in such emergencies know what to do to make the injured person as comfortable as possible until medical aid arrives.

The engineer should, therefore, know the rudiments of anatomy and physiology of the human body, and be conversant with fractures, sprains, dislocations, contusions, crushes and lacerations, and bleeding or poisoned wounds. He will meet cases of torn limbs, of splinters, wounds, and hemorrhages, sun and heat strokes, frostbite, foreign bodies in the eye, as well as cases of drowning, of suffocation with smoke or illuminating gas, or bad gases at the bottom of wells or vaults. He may be called upon to treat burns, scalds, or in chemical works cases of eschars or poisoning. He should also be familiar with the extemporized means of transporting injured persons, when accidents occur in places far away from doctors, as in surveys in the woods, in the climbing of mountains, on the ranches in the far West, on board of ships or trains, or in mines.

No one has done more efficient service in popularizing this useful knowledge than Professor Esmarch, who founded the German Samaritan Society, of which the writer is a life member. In February, 1882, he delivered his first course of lectures on first aid to the injured, which have since then been time and again repeated by others. In Vienna a Volunteer Aid Society was founded a day after the terrible fire of the Ring Theatre, on December 8th, 1881.

In England valuable work is being done by the St. John Ambulance Association, founded by John Furley, Esq., and in Scotland a similar society exists and is known as the St. Andrew's Ambulance Association.

In New York City the Society for Instruction in First Aid to the Injured was founded many years ago, while in Brooklyn a similar society, known as the Red Cross Society, is doing excellent work in the instruction of police and firemen, railroad employees and laymen.

After the formation of a United States Committee of the International Red Cross Society, whose work was until then confined to civil aid on the battle-field and in the war hospitals, it was proposed and advocated, largely by Miss Clara Barton, that the usefulness of the Red Cross Society might be increased by relief work in cases of calamities *other than war*. This accepted amendment to the constitution of the Red Cross Society is known as the "American amendment," and by it the aid of the society is now extended to sufferers by flood, pestilence, tornadoes, and other great disasters in civic life.

The National Volunteer Emergency Service, a civilian body under military organization, was established in the United States in 1900 " for the purpose of combating all emergencies threatening the health of the community or of the individuals, whether in peace or in war." The author is a member and engineer-general of its public health corps.

III.

A HALF-CENTURY OF SANITATION.

(1850–1900.)

The beginning of the twentieth century seems to be a fitting occasion for making a halt in the hustle so characteristic of our modern business and professional life to consider one out of the many magnificent achievements of the past century. Just as a wanderer on a long journey rests occasionally in order to cast a look backward over the road which he has left behind him, and to contemplate the path which lies before him, so I shall ask the reader to pause, like the traveler, and to take with me a retrospective glance over the past, and in particular over the second half of the nineteenth century.

THE CENTURY OF GREAT INVENTIONS. — This is destined to be described by future historians as the era of wonderful practical progress of mankind in the application of the sciences to inventions. Indeed, the progress made in this century in the industries and in the applied arts, as well as the changes in the mode of our living, resulting from this progress, have been so vast that only the older living people can realize thoroughly and appreciate what stupendous results have been accomplished in this comparatively short period of history.

Although the use of steam in the steam-engine originated with James Watt near the close of the eighteenth century, all important applications of steam were inaugurated after the beginning of the nineteenth century. Consider for a moment what the railroad and the locomotive have done for mankind, what immense progress in speed, safety and comfort of traveling has been achieved, how completely travel on land has been revolutionized, from the slow stage-coach to the mile-a-minute trains; how a similar progress has taken place step by step in steam navigation; how both have served to extend trade and commerce, and to spread knowledge; how nations have been brought closer together; how famines have been reduced in severity and wars shortened in duration, by these improved means of communication on land and on water.

Again, consider the truly wonderful way in which the conveyance of thought has been revolutionized by the railway and ocean mail systems, by the electric telegraph, by the telephone, the submarine cable and the wireless telegraphy. Contemplate the changes which have occurred in the modes of obtaining fire and light, the radical departures from old-time methods of interior and outdoor illumination by gas-lighting and by the electric light.

Look at the numerous, now practically available, inventions in labor-saving machinery, of which I will only mention a few, such as the agricultural implements and machines, the sewing machine, and, more recently, the typewriting, typesetting and type-distributing machines. And again in the science of light, how wonderful are the inventions of photography, of spectrum analysis, and the discovery of the Roentgen or X-rays.

These marvelous accomplishments and a great many more, which I shall not stop to mention, belong, one and all, to the nineteenth century; they constitute one reason for our superiority over former generations, for they have enabled us to make better and more extended uses of Nature's powers in the interest of mankind.

It is not with these, however, that I wish to occupy the attention of the reader in this brief essay.

Birth of Public Sanitation. — Many of the discoveries, inventions and engineering achievements named belong to the first half of the nineteenth century, but its second half has been distinguished, perhaps more than in any other respect, by the birth of public sanitation and of applied sanitary science.

Sanitation in History. — In saying this I do not mean to convey the idea that there has been no sanitation before. It is well known that many of the nations of ancient history practised sanitation, and, with their limited means, tools and knowledge, erected many great works which served the interests of public health. The Hindoos and the Parsees were practical sanitarians; to them both the water and the soil were holy and the pollution of either was a punishable offense. One of the teachings of Zoroaster was that the purity of flowing water-courses should not be defiled.

The Romans built gigantic aqueducts, canals and works for the supply of water to their cities, both at home and in their provinces. Many ancient cities had a system of sewers. Some of the cloacæ of old Rome have been well preserved and are still in use at the present day. History records also that the Romans, the Assyrians and the Babylonians made use of tubular pipes for drainage purposes. The Grecian houses had sanitary conveniences and bathing arrangements, and the public baths of Rome, built during the time of the Emperors, were magnificent and costly structures, devoted to recreation, personal cleanliness and health.

Following this period of advanced civilization, however, came an era of decay and retrogression. During the Middle Ages the arts and sciences declined, and with the decay of civilization sanitation was also more and more neglected, until it became a lost art. Personal cleanliness was not thought of, the practice of bathing was given up, clean clothing became almost unknown; in fact, owing to the ascetic practices of the monks, uncleanliness of the body became identical with sanctity. During this dark period of history, happily gone by, knowledge was largely confined to the priests and monks, who purposely kept the masses of the people in ignorance, and who exerted such a dominant influence upon them that their example of uncleanliness was blindly followed.

In this period of sanitary neglect and decay the noisome cesspool appeared, being first used at monasteries and subsequently at feudal castles. In both classes of buildings the sanitary appliances, according to investigators, were of the most primitive kind. The cities and towns of this period likewise presented the worst imaginable appearance of sanitary neglect. No wonder that plague and pestilence made their appearance in Europe in the fourteenth and fifteenth centuries, that as the inevitable consequence of the disregard of sanitation entire populations were decimated, and that the death-rates of towns became appallingly high!

In order to thoroughly appreciate the benefits due to modern sanitation let me picture briefly the condition of cities and towns a century or more ago, as we find them described by historians.

Nearly all cities were badly overcrowded, this being in many instances due to the fact that the fortification works prevented the growth or development of a city beyond its walls. The houses were built of wood and the roofs thatched with straw; their interior was dark, ill-ventilated, unsanitary, and often full of foul air; the floors were of earth, covered with rushes, which were generally saturated with filth and incumbered with refuse. Cesspools were commonly located underneath the houses, or placed in the ill-aired courts in the rear. The shops where the people carried on their trades were also generally unhealthy, and dirt in one form or another was to be found everywhere.

The streets were narrow and darkened by the overhanging stories of the buildings; they were unpaved, except perhaps the main town thoroughfares, which were paved with the coarsest quality of cobblestones. No sidewalks existed: pedestrians were compelled to walk through the mud and the dirt; slops and solid refuse from the houses were thrown upon the streets, generally at night-time; no attempt was made to remove this filth or to clean the streets by any system of scavenging; at night the streets were dark, and few people ventured out after sunset. The crevices of the pavements retained the solid filth, while the liquid soaked into the ground and contaminated both the subsoil and the public wells, which were the only means of water supply available to the habitations. Large heaps of mud, dirt and refuse accumulated in the streets, and hogs were running about in the public squares.

Open water-courses, flowing through the town, and serving at first as sources of water-supply, soon became polluted with sewage to such an extent that the fetid emanations compelled the authorities to arch them over and thus to convert them into objectionable sewers of deposit. The water used in the houses was generally drawn from wells, located in the public squares. It had to be carried by hand, hence it was used but sparingly, and the ablutions of our forefathers were usually confined — so we are told — to the face and the hands, while a frequent change of underwear was not yet practised, owing to the expense of the linen and cotton garments, and the cost and trouble of washing.

Much sickness and unhealthiness were also due to the poor quality of the food available to the lower classes of the population. Because of the unimproved and generally bad condition of the country roads, fresh supplies arrived at the towns irregularly and at long intervals; vegetables and fruit were scarce. There were no public markets, no public slaughter-houses, and no sanitary control of the food supply existed.

Such was the state of sanitary neglect which cities presented one or two centuries ago!

Early in the nineteenth century a better sanitary era began, but all large and systematized public efforts for the improvement of the sanitary condition of communities date only from the beginning of the second half of the century. The earliest sanitary works, such as water works and town sewers, were rather the outcome of necessity; they were built to fulfil requirements of comfort and convenience, to provide necessary commodities, or to guard property against conflagrations. The health point-of-view, which in such works is of prime importance, was not, as a rule, considered or appreciated.

With the advent of modern sanitary science it became more generally recognized that the creation and the maintenance of healthful conditions in a community depend to a great extent upon the carrying out of large and important municipal sanitary works, assisted in turn by individual efforts of householders to establish sanitation in the dwelling-houses and places of work.

Three professions have chiefly contributed to secure the grand results of which, at the close of the 19th century, we may justly be proud, viz., the engineer, the chemist and the biologist. If in the following I say but little about the valuable achievements in sanitary science which are the outcome of the labors of the chemist and of the biologist it is because this essay is written chiefly for civil engineers, and also because, being myself an engineer, I am little qualified to speak with expert knowledge of the work and the successes of the other professions mentioned, invaluable as they have been to the sanitary engineer in his recent practice. I shall confine myself, therefore, to a brief and general review of the work done by engineers in the interest of sanitation.

WORKS OF ENGINEERING. — Speaking generally, works of engineering relate, (1) to commerce and transportation, or to means of communication by land or water; (2) to agriculture; (3) to manufacturing and mining; (4) to buildings and to architectural construction; (5) to public health; (6) to warfare.

Ours is an age of specialization in all professions, and a man can, as a rule, distinguish himself only by concentrating his energies in one special branch. It thus came about that we have nowadays a very large number of engineering specialties. The scope of the work of all branches of modern engineering comes under one or the other of the above-mentioned divisions.

SANITARY ENGINEERING. — Sanitary engineering has been defined as the branch of civil engineering which is devoted to works by which the public health of communities or nations is promoted, and disease prevented; it is a recent and in many respects most important branch of civil engineering; it originated practically, and certainly became developed entirely, in the great epoch of history embraced in the past fifty years. Its importance is characterized by the utterance of a prominent statesman that "The greatness of a country is dependent more than anything else upon the physical constitution of its inhabitants, and everything which is done to improve the state of public health forms the foundation for the strength, the power and splendor of a nation." (Disraeli, Earl of Beaconsfield.)

The sanitary engineer, guided by the results of the researches of the biologist, the chemist and the sanitarian, carries out in practice, in the design of public sanitary works, the requirements of sanitary science, and thus he creates sanitation. Systems of sanitation originated from the time when sanitary science and the germ theory of disease taught us that there are preventable deaths and preventable illness arising from a polluted water supply, from contaminated air, from bad food, from an impure soil, from filth accumulations and from a general neglect of cleanliness. The true foundation for all works of modern sanitary engineering is the now well-established fact that pure air, water, soil, and food are the chief essentials of personal as well as public health.

Speaking on the "Progress in Sanitary Engineering," at the Congress of the Sanitary Institute in 1896, Sir Andrew Noble remarked that "no man of ordinary intelligence could avoid paying some attention to such vital questions as were involved in sanitary engineering. Indeed, the strides which had been made by that science in recent years were so remarkable as to thrust themselves upon the notice of even the most careless or the most absorbed." . . . . "Before the year 1848, no serious attention was given to sanitation, and what was done in that direction was done entirely by rule of thumb. Since 1848 certain architects, engineers and mechanics were led to devote special attention to the practical methods of ameliorating the public health, and thus proved to be the forerunners of the sanitary engineers as we have them to-day, a class as necessary, as able, and as much appreciated as any in the community."

WATER SUPPLY. — A pure and abundant water supply constitutes one of the chief sanitary requirements of modern cities, and the important problem how to provide it belongs to both the hydraulic and the sanitary engineer. It was known even to the early nomadic races, who located their tents near springs or rivers, that water is a necessity to both man and beast, even more so than solid food. Water is required for ablutions and personal cleanliness, and likewise for the maintenance of cleanliness in the houses, in the streets, and in the public squares; it is necessary for the sprinkling of thoroughfares, so as to avoid unwholesome dust; it is required in the "water-carriage" system of sewerage for flushing both the sanitary appliances in buildings and the street sewers. Many cities of ancient history were provided with a system of water supply, but during the Middle Ages no waterworks were built, and, in fact, the works of the older cities were permitted to decay.

In our century, waterworks construction received a great impetus, particularly after the closing up of those town wells which were found to be the cause of epidemics by reason of being polluted from cesspools, privies, or leaky sewers. The rapid growth in the number of cities and towns provided with a public water supply dates from the time when the art of casting iron pipes, which originated at the close of the last century, was perfected. Cast-iron water-pipes were used in London for the first time in 1809, and consisted of pipes only 3 and 4 feet long, and not larger than 12 inches in diameter. Before that period, wooden logs were often used for supply mains.

According to Professor Merriman, there were only 5 public water works in the United States prior to 1800, and prior to 1851 there were only 68 water works. In 1880, 629 waterworks systems were in operation; in 1888, 1598; in 1890, 2,037, and according to the "Manual of American Water Works" for 1897, there were in existence in the United States in that year 3,196 works. On the Continent of Europe likewise, all central waterworks systems originated practically since 1850. These figures speak eloquently for the fact mentioned heretofore, that the era of sanitation began with the second half of the present century.

No town or city can expect to grow or prosper without a public water-supply. Once water is introduced, all town wells should be closed and the service connections with the houses should be made compulsory. When cities begin to expand in area and population, or when they become thriving manufacturing centers, additional works and more abundant supplies are often required.

Water introduced under pressure is used more lavishly in American than in European cities, and this is partly accounted for by our generally wasteful habits. Simultaneously with the problem of providing an additional supply arises the question of how to check the waste of water, without in any way reducing the sanitary advantages derived from the system.

Often the source of supply becomes slightly polluted, and epidemics of typhoid fever warn the authorities that works for the purification of water are required. The prevention of contamination and the purification of a water supply on a large scale are two great sanitary problems which have only recently attracted public attention. Only a few cities of the United States have so far arranged filtration works. These consist of either natural filtration by filter galleries, along the banks of rivers, or of artificial filtration in filter beds of sand, or of mechanical filtration through batteries of filters, which generally operate under high pressure and pass quickly very large volumes of water. Owing to the very satisfactory results obtained where water derived from open streams is purified by filtration, particularly in the reduction of the death rate from typhoid fever, this great sanitary problem will undoubtedly command a large share of the attention of municipalities during the years to come.

In the past fifty years nearly every large city, both in Europe and America, has either introduced a water supply or enlarged its works. Paris has a double system of supply, the river water being designated for public use, while water for drinking and other domestic uses is conveyed to the city from distant springs and mountain sources by means of large aqueducts. Some of these works were completed in 1865, others in 1874, and quite recently another additional supply was completed in 1894. The city of Hamburg derived its water supply from the River Elbe, and after the severe epidemic of cholera in 1892, which was caused by polluted water, established large sand filter beds, which have been in operation since 1893.

Vienna conveys its supply of pure mountain spring water from the Alps, a distance of eighty miles. As a result of a violent cholera epidemic, a new public water supply for Naples was completed in 1885, and this has materially bettered the sanitary condition of that city. For years the question of a more abundant supply has been agitated in London, and one of the schemes proposed is to bring the water to the Metropolis from Mid-Wales. It is only a few years since New York completed the second aqueduct, which increased its daily supply by many million gallons, and a new and extensive storage reservoir was completed at Quaker Bridge. But even this did not suffice long, and at the beginning of this century additional works were undertaken, designed to furnish a large supply from the Catskill Mountains. Other proposed schemes contemplated a supply for Greater New York and the towns in the Hudson River Valley from Lake George and the Adirondack Mountain regions.

Instances are multiplying rapidly where large towns find themselves under the necessity of spending vast sums of money to tap distant uncontaminated sources of water supply. Owing to the contamination of the Hudson River water by the sewage of cities located upstream, the city of Albany was obliged to construct large sand filtration works. Similar works have been carried out for the Schuylkill River water at Philadelphia, for the Allegheny River water at Pittsburg, and for the Ohio River at Cincinnati and Louisville. St. Louis has for many years suffered from an insufficient capacity of its waterworks and not less from the muddy condition of its water; new works have now been put in operation and filtration of the river water is contemplated. In this connection mention should be made of the valuable researches on sand filtration of water, made by the chemists and biologists of the Lawrence Experimental Station of the Massachusetts State Board of Health, and of the Louisville and Cincinnati experiments on mechanical pressure filters.

SEWERAGE. — The progress in sewerage works has been much slower than that in works of water supply. This can be, in a measure, explained by the fact that taxpayers are nearly always willing to pay a small annual tax for water, and hence the financial success of such a scheme is rarely in doubt, whereas a sewerage system does not yield an annual revenue, but, on the contrary, causes sometimes large operating expenses, for instance when the sewage must be purified before it can be safely discharged into a water-course. It is, therefore, a much more difficult matter to induce communities to introduce a sewer system. On the other hand, it is a well-known fact that the introduction of a public water supply has generally been a stimulus to sewer construction.

Sewers were originally built with a view of removing the storm water from the street surfaces; the introduction of liquid household wastes followed only incidentally, and the removal of human excreta by water carriage is of still more recent origin. While the construction of sewers by civil engineers dates from the beginning of the last century, and even from earlier times, the sanitary features and functions of a sewer system and the benefits to public health derived therefrom have been but recently studied and recognized.

Prior to the year 1850, few, if any, cities had a regular system of sewerage, built in accordance with a well-studied general improvement plan. We do find, however, in the older cities underground conduits, built by unskillful mechanics in a haphazard manner, without any attempt to make them water-tight, or to construct them in the way in which conduits for the removal of foul water and excrements should be built. Before the year 1815, the introduction of fæcal matters into the sewers of London was prohibited; it was made compulsory in that city only in 1847. In St. Louis, a similar condition existed up to the year 1842, while in Baltimore and Paris this is the case even at the present day. The use of modern pipe sewers was advocated first in England by Edwin Chadwick, in 1842; they were actually used first in modern times by John Roe and Sir Robert Rawlinson in England.

Since 1850 the organized efforts of City Boards of Health have been directed nearly everywhere against the continuance of cesspools and privy vaults in cities, and, as the best sanitary substitute, the construction of sewers for the removal of household wastes and excreta was urged.

After the great conflagration in 1842, Hamburg was the first city of Germany to introduce a well-designed sewerage system, which was built under the direction of the elder Lindley. Dantzic was sewered by Baurat Wiebe, assisted by Baldwin Latham, in the years 1869–71. Then followed Berlin, in 1870–80, under plans by Hobrecht, and more recently Frankfort-on-Main, the well-built sewer system of which was planned by W. H. Lindley, the son of the above-mentioned English engineer. The first modern main sewer was built in Paris in the Rue de Rivoli in 1851, and in 1856 the new sewer system, planned by Belgrand, was adopted, which comprises several large intercepting sewers. A well-known feature of many of the Paris sewers is their construction as general subways for water and compressed-air pipes and for the telegraph and telephone wires. After the great cholera epidemic in 1884 the city of Naples, Italy, introduced a general scheme of sewerage; and though Rome had the ancient cloaca maxima, which still performs its functions as a drain, modern sewers were not introduced until the year 1871.

In London, the old lines of sewers discharged directly into the Thames at low-water level. Many serious evils resulted; owing to the sewers being tide-locked, deposits occurred in them and the basements of buildings often became flooded. The sewage which emptied into the river was carried upstream with the rising tide and oscillated to and fro, causing the river to become extremely polluted and offensive. It was in the years 1850–1875 that Sir Joseph Bazalgette carried out the main sewerage scheme of London, which consisted of a series of high and low-level intercepting sewers, conveying the sewage partly by gravitation and partly by pumping, to a distance of fourteen miles below London Bridge. On the Northern and Southern banks of the river two sewage reservoirs were located to hold back the sewage. From these it was discharged through the two outfalls during only a brief period of time after high water. But even this did not mitigate the evil of the growing pollution of the lower Thames, and a chemical treatment of the sewage, assisted more recently by bacterial treatment, was carried out with favorable results. The chemical treatment and the removal of the resulting sludge to the ocean alone cost London about seven hundred and fifty thousand dollars annually.

In the United States, the majority of city sewerage systems were introduced after the year 1850. In 1857 Mr. James P. Kirkwood, then waterworks engineer, appointed Mr. Julius W. Adams to prepare plans for the sewerage of Brooklyn. Mr. E. S. Chesbrough planned and designed the sewerage of Chicago, his first report being issued in 1858. Mr. J. Herbert Shedd laid down the guiding principles for the sewerage of Providence, R. I., in his report of 1874, while Mr. S. M. Gray designed a scheme for the ultimate disposal of the sewage of that city in 1884.*

* See Report of the results of examinations made in relation to sewerage in several European cities, in the winter of 1856–57, Chicago, 1858.

See J. Herbert Shedd's "Report on the Sewerage of the City of Providence, R. I.," 1874.

See "Proposed Plan for a Sewerage System and for the Disposal of

Within the past twenty-five years our best sewerage engineers have been kept engaged in the preparation and in the carrying out of plans of sewer systems. In many cases, the American engineers were in consultation with European engineers, like Thos. Hawksley, Wm. Haywood, Sir Robt. Rawlinson, W. H. Lindley, Wiebe and others, or else, like Colonel Waring, Rudolph Hering, E. Kuichling, Samuel M. Gray and others derived benefit from personal visits and inspections of recent European sewerage systems.

The main sewerage of Boston was planned in 1876–77, and executed in the following years by Jos. P. Davis and Eliot C. Clarke, and a larger scheme for the drainage of the Metropolitan district, including many of the outlying towns, is now being carried out. I confine myself here to the mention of some of the older plans and reports on sewerage, which are not so readily accessible, assuming that the readers are familiar with the more recent plans and reports. No less an engineering authority than Sir Benjamin Baker declared in a report in 1891 that "the existing mass of literature on sewerage and sewage disposal was of quite unmanageable bulk," hence it will be appreciated how difficult it is to give in this essay a brief general outline of the subject.

Quite an impetus to sewer construction in this country was given when the late Colonel Waring constructed,

the Sewerage of the City of Providence," by S. M. Gray, City Engineer, Providence, 1884.

See Report by a Commission, consisting of E. S. Chesbrough, Moses Lane, and C. F. Folsom, M.D., 1876, and Report on Sewerage by Jos. P. Davis and Eliot C. Clarke, 1877.

in 1880, after the yellow fever epidemic of 1878, a small pipe sewer system for the city of Memphis, Tenn. This resulted in making the town healthful, and stamped out, possibly forever, the fever. The introduction in the United States of the "separate system" of sewerage, so ably advocated by Colonel Waring,* created quite a spirited discussion in engineering circles, and owing, probably, to the fact that Colonel Waring had taken out a patent on certain details of the system, the debate was not always free from personalities. The fact, however, remains undisputed that a very large number of smaller cities, towns, and even villages took advantage of the lower cost of a system of "sanitary" sewers, advocated by Colonel Waring, to introduce a sewerage system, and thus were enabled to derive the sanitary benefits from the measure which they probably could or would not have done, if the experience of Memphis had not proved conclusively the feasibility of the scheme.

COLONEL WARING THE PIONEER OF SANITARY ENGINEERING IN AMERICA. — The name of Colonel Waring and the Memphis sewer system are closely associated together, and lead me to pause for a moment, in my review of sanitation, to pay a tribute to the memory of my late friend, Colonel George E. Waring. To my mind, no American engineer has done more for the cause of public sanitation in this country than he. For several years, as his principal assistant, I had

* See Geo. E. Waring, Jr., "Sewering and Draining of Cities," 1879, "Sewerage of Village-Cities," 1879.

unusual opportunities to become acquainted with his life work, as well as with his personality. And while I could not at all times agree with his views, nevertheless his noble enthusiasm for sanitation, his keen knowledge of the subject, his untiring efforts toward the attainment of better sanitary conditions in our dwellings, in our streets, in our towns and cities, and last, though not least, his able literary style, have always commanded my highest admiration.

His masterful organization and his honest and efficient administration of the street-cleaning department of the Metropolis of America and the creditable results attained are matters of so recent event that I need not dwell upon them further than to express the sincere hope that the time may soon come when the reforms begun by him may again be carried out in the spirit with which he imbued the cause.

And as his whole life work was devoted to public sanitation, so his pathetic and almost sudden death, on October 29, 1898, from yellow-fever, which he had done so much to eliminate, occurred in the midst of his studies of the problem, how to design measures to make the island of Cuba healthful, and to prevent for the future any danger to health threatening our shores from this neighboring island.

All fair-minded engineers will agree with me that Colonel Waring rendered to this country the same invaluable services which men like Sir Edwin Chadwick and Sir Robert Rawlinson gave to England. Those of us who remain to carry on, wherever it may be required, the good work commenced by him should never lose sight of the fact that it was he who was the "pioneer of sanitary engineering" in this country.

River Pollution. — The question of the pollution of rivers by sewage is another important sanitary problem which has only arisen during the past fifty years.

From the earliest time it had become the custom in the United States, as well as in Europe, to consider the water-courses flowing through, or adjacent to, towns as the natural receptacles for the liquid and solid refuse. When town sewers were first constructed their principal mains were accordingly laid out on the line of the shortest available course to the river. This unsanitary practice soon led to the pollution of the water-courses, and with an increase in the population the resulting evil became of such magnitude as to call for urgent relief measures. While it was contended at first that rivers and streams possessed the power of self-purification, it soon became a matter of observation that the purification thus obtained was insufficient in the case of the majority of streams.

The problem was thoroughly studied in England, where a Royal Rivers' Pollution Commission was appointed in 1868. The results of the labors of the Commission were given in several voluminous reports, and in 1876 a Rivers' Pollution Act was passed in Great Britain, which made it illegal to discharge crude sewage into any water-course, and intrusted Government Boards, like the Thames Conservancy Board, with the duty of preserving the purity of the streams. France appointed a similar Commission in 1874 to investigate the growing pollution of the River Seine. In Germany, an Imperial Health Board has more recently issued very stringent laws, excluding crude city sewage from rivers and streams.

In the United States, the same question came up first in the State of Massachusetts, where rivers had for some time been grossly polluted with city sewage and manufacturing wastes. The investigations of the Massachusetts State Board of Health, and the Rivers' Pollution Committee of the American Public Health Association, which are not yet concluded, give promise of a satisfactory solution of this troublesome problem.

Our present knowledge of the matter may be summed up as follows: sewage discharged into a river will sometimes become purified by dilution, by oxidation, by subsidence and also by the aid of aquatic plants, of small animalculæ and some fishes, where the sewage is in a fresh condition when discharged. To secure a sufficient dilution, there must be a certain proportion between the average volume of dryweather flow of the stream and the maximum volume of sewage, and to secure oxidation there must be a certain minimum limit of current. The degree of permissible pollution depends chiefly upon whether the water-course is to be used by populations farther downstream as a source of water supply. The problem becomes still more complicated when the discharge takes place into a tidal river.

SEWAGE PURIFICATION. — As a result of the enactment of laws against river pollution the question of sewage purification has during the last twenty-five years forged to the front. At first the problem was taken up from the point-of-view of sewage utilization, either in an agricultural way, by land irrigation and application of town sewage to vegetation, or else by subjecting the sewage to various chemical treatments, intended to convert it into a solid manure.

Many costly experiments in chemical precipitation were made, numerous patents were taken out and companies were formed in the expectation of realizing handsome profits from the sale of the products of chemical treatment. The lesson derived from the many instances of failures is that sewage treatment does not yield a financial profit, and that the expenditures required for purification works should be considered as necessary and legitimate in the interest of the health of a community.

Many large cities, as for instance London, New York, and Boston, disposed of the problem by discharging their sewage into the sea. The city of Chicago has constructed, at a cost of many millions of dollars, a drainage canal to get rid of its sewage, and to preserve the purity of its water supply, which is obtained from Lake Michigan. A similar gigantic drainage scheme has been proposed for Manchester, England, by which the sewage was to be carried a distance of 15½ miles, partly through an underground conduit, to empty into the estuary of the River Mersey. Other cities, like Paris, Dantzic and Berlin, and a great many small towns in England, have, since 1870, established sewage-farms where the sewage is purified by land irrigation.

It is of historical interest in this connection to note that Bunzlau, a small town in the eastern part of Germany, offers the first example of sewage irrigation, dating as far back as 1531, and in Scotland sewage irrigation has been practised on the Craigentinny meadows, near Edinburgh, since the year 1750. Many towns in Europe and a few in the United States purify their sewage by a process of filtration similar to that adopted for water purification, but differing from it in that the filtration is carried on intermittently instead of continuously.

Our knowledge of the subject of sewage purification by filtration, either through natural soil or through artificial filter-beds, has been greatly advanced by the results of studies made under the direction of the Massachusetts State Board of Health at the Lawrence Experimental Station, which was established in 1888. In this department of sanitary engineering great progress has been made since the recent researches of biologists have increased our knowledge of the functions of the bacteria.

We now know that the sewage purification by filtration through land is not merely a chemical or mechanical process, but principally a biological one, and that the action of certain bacteria is required to break up the putrefying organic matter into harmless elements, which in turn become food for plant life. Valuable experiments confirming these observations were carried out at one of the London outfall sewers in 1895 by W. J. Dibdin.

Recently experiments in sewage treatment were carried out on a moderate scale at Exeter and Sutton in England, at the Sewage Experimental Station of the Massachusetts Institute of Technology, in Boston, and on a larger scale at Columbus, Ohio, and Baltimore, Md., in the United States.

In septic tanks, air and light are carefully excluded, whereas in the coarse bacterial filters air is very freely admitted, yet by both processes, which are diametrically opposed to each other, the production of sewage-sludge appears to be partly avoided. As to the value of either method, professional opinions are not by any means unanimous. Quite recently a bacterial process, based upon the theories of Dibdin, has been tried at Gross-Lichterfelde, near Berlin, by Schweder, with a part of the sewage from the city of Berlin, and the report of a commission of experts, who investigated the process, expresses some doubts as to the successful application of the system, and as to its economy in first cost when carried out for the purification of the sewage of larger cities.

Still more recently, however, a large sewage disposal system by sedimentation basins, trickling filters and gravel filters was installed for Berlin-Wilmersdorf, a part of the Greater Berlin.*

While much progress has been made in the scientific treatment of sewage, the ultimate solution, owing to the difficulties involved in the problem, is still left to be solved by the scientific investigators of the present century. For a number of years a Royal Sewage Commission has

* See the author's illustrated description in *Engineering News* for March, 1908.

investigated the problem in England, and while it has issued from time to time some reports, it has not yet published a final summary of its investigations and conclusions.

Removal and Disposal of Garbage. — The removal and disposal of the solid refuse and garbage form part of a well-arranged sanitary system of a city. Until recently the removal of garbage was usually accomplished by contract, and its disposal in the case of cities located on a stream or at the seashore was accomplished by simply discharging the refuse into the water-course, or by carrying it and dumping it far out at sea. Both methods have in many cases proved to be objectionable.

It is scarcely more than twenty years since it began to be recognized that the problem is one intimately connected with the town sanitation, that it belongs to the province of the municipal engineer, and that it is one of the most important problems with which municipalities have to deal (1).

Many cities of Europe have distinguished themselves by systematic efforts directed by engineers, and more recently American engineers are paying considerable attention to the subject. Its solution is now sought for by two methods, namely, first, by the cremation of the garbage in furnaces or destructors, and, second, by its reduction by steam-heat, whereby marketable products such as grease and powdered manures, are obtained, the sale of which is expected partly to cover the large cost of the process.

Garbage-cremating furnaces were introduced in England about the year 1880, and in this country about 1885, since which time dates the increased attention paid to the problem. In both processes efforts are made to avoid the generation of offensive odors, and much mechanical skill has been brought to bear upon the construction of furnaces, intended to consume the garbage without creating a nuisance in the neighborhood. Experiments in this direction were undertaken first by some inland American cities, for which no other method of disposal seemed available, because the spreading of city garbage on the fields in the country was found to be objectionable.

It is a matter of regret that the late Colonel Waring, in his position of street-cleaning commissioner of New York, was not allowed to continue in office, to complete the work so well begun, for he had just commenced to introduce plans concerning city garbage, and no one appeared better qualified than he to find a solution of the problem which would be at once practical, economical, and sanitary.

STREET-PAVING AND STREET-CLEANING. — The paving of city streets and the maintenance of cleanliness in streets and squares are problems of municipal sanitation which have an important bearing upon the health-rate of a city. In the last twenty years many cities of Europe and of this country have made vast progress by laying street pavements with durable foundations and with water-tight surfaces. The sanitary and other requirements of city pavements constitute subjects of prime importance, but space forbids my making more than a passing reference to the subject.

A few words regarding street-cleaning, may, however, not be amiss, particularly because it is only within a very few years that this problem has been considered worthy of being placed in the hands of engineers.

The capitals and larger cities of Europe have for many years distinguished themselves by efforts to maintain their principal traffic thoroughfares in a sanitary condition, and the reduction in the annual death-rate of many European cities has, without doubt, been effected partly by the well-organized efforts to clean the streets, the gutters, and the sewer catch-basins. Leaving aside a few isolated instances of good work accomplished in the United States in this direction, I am within the limits of truth when I state that Colonel Waring's well-known recent efforts in this cause set a standard which many of the smaller cities are now following.

Some degree of improvement in the condition of city streets has already been effected by the substitution on the street-car lines of electric motive power in place of horses, and a further reduction in the amount of street dirt and dust may doubtless be looked for in the near future with the more general introduction of automobile vehicles. I believe that the new century will be distinguished by many important reforms in street-cleaning. Whether such work be undertaken by contract, or be carried out by the municipality, vigilant engineering superintendence is required in either case. Judging from poor results obtained by the contract method, and comparing these with the splendid achievements of the New York system under Colonel Waring, one is inclined to form the conclusion that street-cleaning should not, at least in American cities, be given out to contractors. Be this as it may, however, one of the lessons which we have learned, and which may with advantage be applied to other branches of municipal engineering and sanitary work is, that no work upon which the health and welfare of a city are dependent should be in any way associated with politics, or be directed by politicians.

PUBLIC ABATTOIRS, MARKETS AND FOOD INSPECTION. — Another municipal sanitary problem, which I must briefly review, relates to the provision of healthful food-supplies, and to a proper and efficient food-inspection. In the beginning of the last century open markets were replaced by large covered structures. This innovation was inaugurated in Paris by Napoleon I. In 1811, the planning of the now famous Halles Centrales was commenced, but they were only completed in 1878. In the past thirty years many of the larger cities of Europe and a few in the United States have erected imposing architectural structures, in which the sale of food-provisions takes place. Their chief advantages are the protection which they offer to the market-people and to the public against the weather, the fact that the provisions are not damaged by rain, snow, heat, cold or street dust, that fresh market products are obtainable daily, and that the control of the food supply is facilitated.

Market-houses require well-arranged traffic connections with the railroads, rivers, canals, harbor-docks, and good roads leading to the country districts. They thus offer many sanitary, architectural and engineering problems (4). In recent years much attention has also been devoted, particularly in England, to the sanitation of bakeries, which have been brought under the supervision of the health boards.

Intimately connected with the public markets are the slaughter houses or municipal abattoirs, which do away with the nuisance of private slaughtering, and facilitate the important inspection of the meat (4). In Europe, municipal abattoirs were inaugurated first by the great Emperor Napoleon, who by his decree of 1810 prohibited all private slaughtering, and thus did away with a formidable sanitary evil in cities. Since the middle of the last century nearly all large European and a few American cities have built centralized abattoirs, located remote from the crowded city districts.

Many architectural and engineering questions are involved in the planning and construction of such structures. Their sanitary and mechanical equipment, the provisions for water-supply, for ventilation, for the purification of the waste water and blood, the installation of cold-storage plants, hoisting machinery and other labor-saving devices, the paving and drainage of roadways and yards, and the provision of suitable rail and water connections must be judiciously considered.

The trades connected incidentally with the slaughtering of animals, such as rendering, fat-melting and bone-boiling establishments, are now likewise brought under sanitary control. Modern abattoirs are fitted up with complete bacteriological laboratories for the microscopical inspection of diseased or suspected meat. With the system formerly in vogue of having small slaughtering establishments scattered all over a city no efficient inspection was possible. In the last twenty-five years American cities have profited much in this branch of municipal sanitary administration by the experience of the older cities of Europe.

City Improvement Plans. — Since 1850 another very important municipal problem has arisen in many of the older towns of Europe. I refer to the enlargement of the cities and the partial reconstruction of their system of streets and thoroughfares. The progress of modern industries, the extension of commerce, the movement of population from the rural districts into the cities, and the doing away with many of the old fortifications and walls, which protected but also hemmed in the cities and prevented their growth, have created new and important municipal problems (2).

Many cities and towns of Europe have at the end of the past century undertaken magnificent and comprehensive works for the transformation of their street traffic, for the building-up of new urban districts, and for the laying out of parks and squares. The reconstruction of Paris, under the era of Baron Haussman, is a familiar example. In the period from 1852 to 1871 many new boulevards and grand avenues of communication were laid out with rows of shade trees, parkways and garden strips, while Mr. Belgrand, the distinguished engineer of Paris, planned and executed its now famous underground works. In Vienna the old fortifications were destroyed after the year 1857, and the famous Ring-Strasse, or belt street, a magnificent boulevard lined with costly palaces, museums, theatres and other public buildings, became the principal feature of the city-improvement plan.

In Germany, the recent transfiguration of many of the historical and mediæval towns has been most remarkable. The old, narrow and crooked streets, with their dark dwellings and warehouses, have disappeared, and have given way to widened and straightened avenues with modern residences or stores; new suburbs have been laid out with engineering skill and provided with water and sewerage facilities; towns situated on the banks of rivers have had their water frontages improved for commercial purposes or for the embellishment of the city. Wherever one goes, one finds municipal sanitary improvements, such as sewer systems, works for the purification of both water and sewage, city hospitals, magnificent public schools, public bath-houses, market buildings, cattle-markets, and abattoirs.

In the last five years the subject has been taken up in the United States, and a considerable interest has been aroused in the question of civic improvements for the beautifying of cities. The next fifty years will doubtless see a large amount of work of this nature accomplished. The fact that the past has not been distinguished by works for the enlargement and embellishment of cities is doubtless due to the comparative youth and rapid growth and development of our cities.

THE TENEMENT-HOUSE QUESTION. — In those large American cities which are more than one hundred years old, the question of providing decent and sanitary homes for the poorer population in the crowded city districts has arisen, just as it did in Europe. In England, interest in this problem was first aroused by the report of Sir Edwin Chadwick, "On the Condition of the Laboring Population," published in 1842.

In 1856, the first Committee was appointed by the State of New York to inquire into the condition of the tenements, and its report was issued in March, 1857. The tenement-house question has ever since remained one of the municipal problems of large cities. About twenty-five years ago, the well-known Peabody workingmen's buildings were erected in London, likewise the improved industrial dwellings of Sir Sidney Waterloo. On a large scale, the problem was successfully solved in Brooklyn in 1877 by Mr. Alfred T. White, who erected the Riverside apartments and other model tenements. In New York, the Improved Dwelling Association, the Tenement House Building Company, the City and Suburban Homes Company, and other similar organizations of more recent date attempted the solution.

The city of New York proper offers, largely owing to the unfortunate and arbitrary limit of the ordinary city lot, the best example for the study of the evil effects of the tenement-house system. From time to time citizens' associations and legislative tenement-house commissions have devoted much time and study to the inspection and to suggestions for the improvement of tenement-houses. In this connection the "Model

Tenement-house Competition," organized in 1878 by the *Sanitary Engineer* (now the *Engineering Record*), under co-operation of several public-spirited citizens, deserves special mention. Many of the plans submitted by architects in this competition showed great improvements, but still the conclusion of the competition committee was that it was impossible to secure sanitary results in the erection of a tenement on a narrow lot.

The progress of recent years is due to the passing of the Tenement-House Act, in May, 1879, which limited the space of the lot to be built upon, required all bedrooms to have outside windows for direct admission of light and air, and gave to the Board of Health increased powers to regulate the question. A vast improvement in the character of the plans for tenement-houses submitted to city departments has been noticeable since this Act became law, and further progress followed the labors of the various Tenement-house Commissions (3).

HOUSE SANITATION. — The last fifty years have witnessed such vast improvements in the construction and sanitary features of dwelling-houses that it seems impossible, in a limited space, to give even a general outline. One important result of the efforts in the interest of sanitation was that the details of drainage, ventilation, water supply, lighting (7) and general sanitation, and the installation of sanitary appliances is now in many cases intrusted to sanitary engineers, who make a specialty of domestic engineering. The field of their practice is a large one, and the progress made in the past fifty years has been far-reaching.

To show by only a single example what has been accomplished in this era of sanitation I may mention that, while water-closets were invented a hundred years ago, all really sanitary types were introduced within the last twenty-five years. At the middle of our century the much-condemned pan-closet was universal. Prior to the year 1850, not a single house fitted with plumbing conveniences had any kind of vent-pipe carried up to the roof for ventilation. At the close of the nineteenth century the fundamental principles of house-drainage and sanitation were well and firmly established and in nearly all cities and towns the installation of plumbing became regulated by Health or Building Department rules and regulations, and the work subject to municipal inspection (3), (8).

HOSPITAL, SCHOOL, THEATRE, CHURCH AND PRISON SANITATION. — The benefits due to sanitation have not been confined to our dwelling-houses. Marked improvements in the planning, construction and equipment of hospitals, schools, prisons and military barracks are noticeable in all civilized communities (4). Many novel engineering problems have sprung up with the advent of the modern tall office-buildings.

In hospital construction, the old block plan, with crowded and insufficiently ventilated wards, has been superseded by the pavilion system, for sanitarians are agreed that it is better to extend buildings for the care of the sick over large areas rather than to pile up story upon story. Even the large cities of Europe locate their new hospitals in the suburban districts and provide a great number of one or two-story detached wards, sometimes connected by covered corridors, and thus secure plenty of light, air, avoidance of dirt and the maintenance of fastidious cleanliness.

In New York and a few other American cities of metropolitan character the high price of land in all sections of the city compels adherence to the old system, and there is, perhaps, still a tendency to give too much attention to purely ornamental features.

The State care of the insane offers another example of the improvement in sanitary administration for the mentally sick patients, which is a result of the last ten years of the nineteenth century.

A vast improvement is also noticeable in the construction and equipment of public school-houses, it being now recognized that healthy minds can only be formed in healthy bodies. Much attention has accordingly been given to the problems of heating and ventilating the classrooms, of providing decent and inoffensive sanitary conveniences, and of encouraging personal cleanliness of the pupils by establishing free school baths.

Our prisons and jails have also been vastly improved and prison sanitation has been the outcome of modern sanitary science. Formerly dark and unventilated cellars of court-houses, towers and castles, and underground cells in convents and monasteries, were used for the confinement of the prisoners, and epidemics of typhus fever or other contagious and infectious diseases were common, and often threatened even the health of judges, jurors and court-officers. In the improved modern structures the influence of imprisonment on the health and the nervous system of the convicts has been reduced to a minimum.

The States of Europe which compel their citizens to perform military duty have become conscious of the moral obligation resting on them of providing healthful military habitations. The modern military barracks differ as much from the older barracks erected in fortified towns centuries ago as do the private dwelling-houses of our period from those of the citizens during the Middle Ages.

Sanitation has also been introduced in the modern theatre as well as in churches and places of worship, and both kinds of buildings have been rendered much safer from the danger of fire and panic (6).

Much might be said on this subject, but I can only make a passing reference to these branches of municipal improvement (4).

PUBLIC BATH-HOUSES. — The erection within the past twenty-five or thirty years of an annually increasing number of public bath-houses in cities and towns, both in Europe and more recently in the United States, forms another illustration of the fact that all large sanitary municipal improvements originated after the year 1850. Before this date, the practice of bathing was not a general one; it was confined almost entirely to river and sea baths, but these are available only during a few months in the year.

England set the example in 1842 for municipalities in providing public baths for the people, and since 1850 the principal cities of the Continent, particularly in Germany, have imitated it.

In the United States much interest has been awakened in this subject, and the State of New York was the first to pass an act (in 1893) making the erection of free public baths, open the year round, mandatory upon all cities of 50,000 or more inhabitants. Without going into details I will mention that for the attainment of bodily cleanliness the rain or spray bath is considered to be much superior to the swimming-bath, though I do not wish to be understood as underestimating the improvement of the general bodily health which is due to the athletic exercise in the swimming-bath.

In my judgment, it is just as necessary that a municipality should provide public baths as it is that they provide public schools, well-paved and clean streets, public sewers, and fire and police protection. Many valuable and interesting reports on public baths have been prepared, and a number of large people's rain-baths have been in use for some years in New York and elsewhere; Buffalo, Boston, Chicago, Philadelphia, Pittsburgh, and other cities have, within the past ten years, erected such baths, and even the smaller cities are making a good progress in this direction (5).

Drainage of Swamps and Malarial Districts. — Much work of a sanitary character has been accomplished in the past years in rendering malarial districts healthful. As an instance I mention the Roman

Campagna, which, according to the investigations of Professor Tommasi-Crudelli, became malarious, because the old Roman drainage-works became stopped up. A part of this beautiful tract of land has again been made healthful by re-establishing the former efficient drainage of the subsoil, which renders its pores free from excess of water, and thereby permits air to enter them to oxidize the impurities.

In this country there are numerous vast tracts of land which form swamps and which should be reclaimed by a similar process of drainage.

According to a bulletin of the United States Geological Survey, "the drainable swamp lands cover more than 100,000 square miles of area of the United States. The possibility of reclaiming these swamp lands has been under consideration for over half a century."

"The possibility of drainage is a matter of practical engineering, the preliminary requirements being in no way different from those governing the irrigation of arid lands, the construction of inland waterways, the prevention of floods, the conservation of water, or any other important engineering work. Such projects all involve engineering and physical problems, the solution of which may affect areas far beyond those immediately under consideration. The work of construction must be preceded by topographic surveys, by investigation of geologic conditions, by studies of streams, including measurements of flow and determination of channel capacities, and by careful consideration of all the related climatological data."

"Preliminary work of this character has been done for many years by the United States Geological Survey. Over 400 topographic sheets, published by the Survey, show swamp areas scattered throughout all the States."

"The drainage of swamp lands involves the providing of means to accelerate the rate of run-off, and the water drained from them must be discharged into streams or rivers. No project for the drainage of wet lands can be successful unless the work is based upon careful preliminary hydrographic investigations."

In this connection should also be mentioned the efficient work of mosquito extermination, which was recently inaugurated (1).

SMOKE PREVENTION. — In the past twenty-five years many other important sanitary questions have sprung up, which I can only scan very briefly. Among these I mention the question of smoke-prevention in cities. Smoke and city fog are in many ways injurious to health; the atmosphere of cities is defiled by the carbonic oxide and the sulphuric acid; the smoke becomes hurtful to persons with delicate lungs; it likewise interferes with the free ventilation of the dwelling-houses, and it causes buildings and sculptural monuments to be disfigured.

The difficulties involved in the question of smoke abatement were recognized as early as the eighteenth century, and Benjamin Franklin, James Watt, and Count Rumford studied the problem. Some of the remedies suggested are the use of hard coal, the application of smoke-consuming appliances in the boilers, the use of gaseous fuel for cooking, heating and for small motors, the better firing of the boilers, and, lastly, the removal, as far as possible, of large manufacturing industries to the suburbs, or at least to parts of the city away from the crowded districts.

PUBLIC SQUARES, PARKS AND RECREATION-PIERS. — Town sanitation includes also, according to Fred. L. Olmsted, the provision for, and laying out of, public parks, boulevards, open squares and playgrounds for the population. It is now well recognized that one acre of trees and grass and shrubbery in the heart of a city is of far more sanitary advantage to the town-dweller than hundreds of acres outside of the city limits, and not within easy reach. In city blocks a considerable improvement may be effected by changing the rear of the building-lots into gardens with low dividing fences; it is still better to omit fences altogether. A recent sanitary improvement, in the cities of New York and Brooklyn which is worthy of mention, is the establishment of recreation-piers at the river-fronts. These are a step in the right direction, and further efforts should be made to improve the water-fronts, as well as the condition of public water-courses (2).

WASH HOUSES AND DISINFECTING STATIONS. — The sanitation of public wash-houses and steam-laundries, the establishment of disinfecting stations, and the sanitary questions involved in the disposal of the dead, are other sanitary problems which attract considerable attention at present, but they belong more to preventive medicine than to engineering.

Work by State Boards of Health. — The work done in the last thirty-five years by State Boards of Health has been important and far-reaching. In the year 1849, the Massachusetts Legislature passed an act appointing three commissioners to prepare for a sanitary survey of the State. Their report called attention to the awakening of sanitation in England, but was received with general apathy.

Twenty years later, 1869, the first State Board of Health was established in Massachusetts. The first report of this Board was issued in 1870, and ever since its annual publications have been eagerly sought by sanitarians and sanitary engineers. In Michigan, a State Board of Health was created in 1873, in New York State in May, 1880.

Very few States of the Union are now without this useful institution. Matter of considerable and permanent value is found in the annual reports of these Boards, of which I shall mention only the valuable results achieved by the Lawrence Experimental Station, established in Massachusetts.

City Boards of Health, Sanitary Commissions, and Sanitary Associations. — In 1866, a Board of Health was created in the city of New York. To-day nearly every city or town has its Board of Health, its labors being chiefly devoted to the cause of town sanitation. Valuable features of their work comprise the preparation and publication of vital statistics and of sanitary maps, profiles and diagrams exhibiting the relation between the location of old water-courses, of sewers, of the density of population, and the mortality in various city districts.

Valuable results have also been accomplished by Sanitary Commissions, such as the one appointed in England in 1885, during the war in the Crimea, and in this country by the United States Sanitary Commission of 1861.

In many English and a few American cities sanitary protective inspection or assurance associations have been formed for the annual inspection of dwelling-houses, and much good has come from their labors.

The recent introduction of sanitary science at the universities, and of special courses in sanitary engineering at some technical colleges, both in Germany and in the United States, is another step in the right direction. A great deal of good has likewise been accomplished by the scientific and literary press, which is laboring indefatigably to establish and spread the knowledge of sanitary principles among both professional and laymen.

Cities and towns have adopted building-laws and framed sanitary ordinances intended to regulate not only safe construction and protection from fire, but also healthful building-construction and healthful modes of living. The width of the streets, the height of the houses, the size and height of rooms, the position and number of windows, the details of heating and ventilation, of plumbing and sewerage, of prevention of dampness, surface-drainage, avoidance of defective gas-piping and others are now regulated by law.

INFLUENCE OF MODERN SANITARY WORKS UPON PUBLIC HEALTH. — In all engineering works the results attained by the expenditure of large sums are of immediate interest to the public. Statistics gathered in different countries give proof of the marked beneficial effects upon the public health of municipal sanitary measures, such as sewerage, water supply, drainage, street cleaning, etc. Some epidemics, which in former times appeared periodically, are now practically extinguished in certain sections of the country, and banished entirely from some cities. The decreased death-rates of cities, as shown by annual statistics, form the best evidence of the good influence of sanitary works.

Take, for example, the case of London: at different periods of history the death-rates were as follows: from 1660–79 the annual death-rate was 80 per 1,000; 1681–90, 43; 1746–55, 35.5; 1846–55, 24.9, and in 1871 the rate had decreased to 22.6 per 1,000.

In Croydon, near London, the rate was as follows: 1848–55, 24.03 per 1,000; 1855–75, 19.56; 1876–80, 17.07.

In Brussels the death-rate in 1876 was 25 per 1,000, and in 1894, 18.1.

In Vienna the death-rate was: 1848–57, 42 per 1,000; 1878–88, 28.6; 1893, 24.3; 1894, 22.8.

In Buda-Pesth the figures were as follows: 1876, 41 per 1,000; 1892, 27.9; 1895, 24.4.

In Milan, Italy, the death-rate was 30 per 1,000 before 1880, and was reduced to 21 in 1894.

In Copenhagen the rate was: in 1884, 24 per 1,000, and in 1894, 18.7.

In Stockholm, Sweden, the figures were: 1877, 28.7 per 1,000; 1884, 24.6; 1894, 18.3.

German cities present even more striking examples of the benefits derived from sanitation.

In Hamburg, for instance, in the period from 1838–44, before the sewerage system was introduced, the rate was 48.5 per 1,000. In the period from 1845–53, during the construction of the sewer system, the rate of mortality was 39.5; 1854–61 (the first eight years after the sewer system had been put in operation), 29.9; 1862–69, 22; 1871–80, 18.3.

In Dantzic the rate was as follows: 1863–68 (before sewerage), 38.4 per 1,000; 1869–71 (during construction), 34.6; 1872–80 (when sewer system was completed), the death-rate fell to 28.8.

Regarding deaths from typhoid fever, the following figures are instructive: the mortality in Munich from typhoid fever was, prior to 1859, 24.2 per 10,000 deaths; 1860–65, when there was no sewerage, 16.8; 1866–73, when there was partial sewerage, 13.3; 1875–80, after the sewer system was completed, 8.7.

In Frankfort-on-Main the typhoid mortality was 8.7 from 1854–59, when there was no sewerage, and during the period from 1857–87, after the sewerage was completed, the rate of the mortality fell to 2.4 per 10,000.

To mention just a few examples taken from statistics of American cities: in St. Louis the annual death-rate in 1860 per 1,000 was 32, and in 1865–70 it became reduced to 20.

The City of Memphis had formerly a death-rate reaching as high as 109 per 1,000, and in the year 1897 its rate had been reduced to 23.56.

These examples might be multiplied, but the figures given are sufficient to prove the good results due to sanitation and sanitary measures introduced during the past fifty years.

* * * * *

In conclusion, I wish to emphasize once more the fact that a greater progress in municipal sanitation has been made in the last half-century than in all preceding centuries combined. This incomplete essay may serve a useful purpose by indicating that whenever in any period of history civilization advanced, some sanitary measures were carried out; whenever, on the contrary, general culture and refinement declined, sanitation became neglected.

Civilization and sanitation are so closely allied that one cannot exist without the other. As an evidence of this progress, advanced sanitarians seem now to be agreed that *the prevention of disease is the highest aim of modern medical practice.*

As regards the prospects of sanitary reform in this country, an encouraging feature is the ever-increasing interest, taken by the press and by the general public, in questions which have a bearing upon the welfare and health of communities, and in which engineers are so largely involved. The twentieth century will, doubtless, witness a still further advance in all the branches of work outlined herein.

The work of sanitary engineers is to a large extent unostentatious and inconspicuous, for much of it is underground and concealed. Their plans, suggestions and ideas are often unpopular and not looked upon with favor, because they burden the community with heavy expenses and necessitate special taxes. But I am convinced the day will come when sanitary works will be universally appreciated, and when sanitary engineers will be more generally honored and esteemed.

I also venture to predict that in the coming century the memory of our school-children will not be taxed with dates of ancient wars and of battles in history so much as with dates from the history of civilization, of discoveries and inventions, and of the progress of civil engineering. And that will also be the day when nations will not seek glory so much in wars as in proudly showing the largest amount of those public engineering works which, by the amelioration of sanitary conditions, reduce preventable sickness and death in communities.*

* This essay has been enlarged from a lecture given by the author before the Brooklyn Engineer's Club, in 1899.

IV.

SANITATION IN GREATER NEW YORK.

LOCATION AND CLIMATE. — The city of New York enjoys many natural advantages due to healthful location, for it is surrounded on two sides by wide and deep rivers, and on the third by the Upper Bay or harbor; it is also only a few miles away from the ocean. The climate of the city is generally mild, though it may be best characterized as very changeable, there being much hot and humid weather in summer, and some severe cold, and a great deal of damp, raw, and changeable weather in winter. Notwithstanding these natural advantages, New York has in by-gone times repeatedly suffered from outbreaks of epidemics, particularly of yellow fever and of cholera.

AREA AND POPULATION. — The area of Greater New York comprises 313 square miles. Its population in 1908 was estimated at 4,493,118. The city has 6,587 acres of parks, 1,900 miles of paved streets, 1,829 miles of sewers, 1,993 miles of water mains, and over 350 miles of water front. The daily consumption of water amounts to 475 million U. S. gallons.

EPIDEMICS. — In the year 1731, at which time the city contained about 1,400 houses, a very disastrous epidemic of smallpox prevailed. Yellow fever epidemics occurred in 1703, 1741, 1791, 1795 (732 deaths), 1798 (2,086 deaths), in 1799 and 1805 (about 230 and 270 deaths). It appeared again in 1819 and in a much severer form in 1822, when 388 persons died from the disease. In this year a general panic prevailed, which totally interrupted business. One result of this last epidemic was the quicker growth of the city northward, for "many of the exiles from the lower part of the island retained their suburban homes after the fever had passed."

"New York was a dangerous town to live in on account of the frequent presence of epidemic disease. The prevalence of smallpox was not chargeable to any defect in the crudely organized system for protecting the public health; yellow fever, however, was a practically preventable disease, which, partly through ignorance and partly through carelessness, was suffered to work great havoc here. When a committee of citizens, of physicians and of the corporation investigated the cause of one of the epidemics, they reported that the spread of the fever was encouraged by the deep, damp cellars, sunken yards and unfinished water lots, public slips containing filth and stagnant water, burials in the city, narrow and filthy streets, and inducements to intemperance, offered by more than a thousand tippling-houses, and the want of an adequate supply of pure and wholesome water. . . . . "

YELLOW FEVER EPIDEMICS. — "Yellow fever seems to have been epidemic for the first time in New York in the summer of 1703. It was not recognized as yellow fever, and is referred to in the records of the times as the 'great sickness'; but from the description given of it, coupled with the fact that the infection was traced to a ship come in from St. Thomas, there is little reason for doubt in regard to the nature of the disease. The mortality was so considerable that a panic seized upon the inhabitants of the city, and they fled to the country for safety — thus establishing the habit fixed so firmly a century later. Again, in the summers of 1742 and 1743 there was a malignant epidemic strongly resembling the yellow fever in type, which caused upward of two hundred deaths in the latter year."

"But the most severe yellow fever summers of the last century came close together in its final decade. Of these the first was 1791, in which the death-rate was comparatively low; the second, 1795, was more severe, the deaths rising upward to 700; while in the course of the third, 1798 (when more than 2,000 deaths occurred and the city was forsaken by its inhabitants and commerce for a time was crushed), the fever became an overwhelming calamity. While the panic lasted, not only Greenwich, but all towns and villages round about, were crowded with refugees. The epidemics of fever which appeared with great frequency during the first quarter of the 19th century culminated in the direful summer of 1822 — when under stress of the worst panic ever caused by fever in this city, the town fairly exploded and went flying beyond its borders as though the pestilence had been a bursting mine." (From Thos. A. Janvier, "In Old New York.")

Cholera Epidemics. — Several times in its history the city of New York was ravaged by cholera epidemics. The first appearance of cholera was in 1832, and it "raged to a fearful extent, almost depopulating the city"; 3,513 deaths occurred, and the death-rate of the city rose to 45 per thousand. Two years later, in 1834, there was another, less serious outbreak (971 deaths), and again in 1849 cholera reappeared in a severe form, claiming 5,071 deaths, and raising the general death-rate of the city to 46.70 per thousand. Since then there have been two further epidemics, one in 1854 (2,509 deaths, rate 46.96), and the last one in 1866, the epidemic causing 1,137 deaths.

Healthfulness of City. — Since that period the healthfulness of the city has been steadily improving, notwithstanding the fact that the tenement-house population increased at a tremendous rate. Improved sewerage methods, a better water supply, a stricter control of the tenements, and of the markets and abattoirs, improvements in the sanitary condition of schoolhouses, establishment of parks and public squares, and greater attention in the last few years to better methods of street paving and street cleaning, — these, taken together, were the factors which brought the average death-rate of the city gradually down to below 20 per thousand.

From the official records, kept by the bureau of vital statistics, I quote a few figures, which exhibit the population and the death-rate in different years: —

Year.	Death-rate per 1000.	Population, estimated or by census.
1804	28.72	72,557
1805	30.22	76,022
1832	45.00	227,920
1834	34.90	255,230
1849	46.70	484,043
1854	46.86	607,603
1866	34.92	767,979
1870	28.81	943,300
1875	29.39	1,044,396
1880	26.41	1,209,191
1885	25.56	1,396,079
1890	24.88	1,611,851
1894	22.77	1,808,244
1895	23.11	1,851,060
1896	21.52	1,934,077
1897	19.13	1,990,562

The annual death-rate in Greater New York was 19.3 per thousand in 1908.

All matters pertaining to public health and general sanitation are under the immediate control and charge of the Department of Health. This has at various times in the history of the city been reorganized and given greater power.

TENEMENT-HOUSES. — One of the most important questions with which the health department dealt was the control and improvement of the tenement-houses.

The first tenement-house in New York (and in the United States) was built in the year 1838 in Cherry Street; twenty-five years later (in 1864) there were 15,309 such buildings in the city, housing 495,592 persons. The tenements increased at a rate of over 1,000 new buildings for some years; in 1867 there were 18,582 tenements; in 1883 there were 18,996. In 1888 the total population was 1,526,081, of which 1,093,701 lived in 32,390 tenements. On December 31, 1891, the census showed 34,967 front and 2,391 rear tenements, holding 276,565 families, with 1,225,411 persons. In 1893, finally, the tenement population amounted to 1,332,773 persons, out of a total population of 1,891,306, so that it appears nearly 70 per cent lived in tenements (of which four-fifths were real tenements, and one-fifth so-called flats and apartment houses).

A Legislative Commission was created in 1856 to investigate the sanitary condition of the tenement-houses. They described the evils of the system and the bad overcrowding in a report published in March, 1857. In 1864, the Council of Hygiene and Public Health of the Citizens' Association rendered a report, as a result of which the Metropolitan Board of Health was created in 1866. The efforts made towards improvements resulted in much good: dark bed-rooms and halls were lighted up, privies were ventilated, and numerous cellar dwellings were ordered vacated.

The Board of Health was reorganized in 1873, and in the following years its efforts were directed toward a municipal control of the tenements. This resulted in the enactment of the first tenement-house law, of 1879, which required that the plans for all new buildings of this kind be approved by the Board of Health. At this time light and air shafts, of small size, for all interior rooms, were first required, also special separate shafts for the water-closets. Two years later, the plumbing Law of 1881 gave the Board of Health more power to prevent plumbing defects, by requiring the filing of plans for drainage and plumbing.

In 1884, a further great improvement was effected by requiring all vent shafts to be open and continuous brick courts. This was further amended in 1887 by making the minimum size of the light shafts 265 square feet. In the same year the plumbing law was changed and required the use of extra heavy soil, drain, waste and vent pipes.

In 1884, a Tenement-House Commission was created, which rendered valuable service to the cause; in 1894 a second similar Commission issued a voluminous report containing important suggestions for the improvement of this class of buildings; a third Commission was created in 1900.

The tenement-houses erected during the past ten years are a vast improvement over the older forms, and include some model tenement-houses, built by the Improved Dwelling Association, the Model Tenement Building Company, and similar organizations.

An interesting Tenement-House Exhibition was held in New York City in May, 1900.

PLUMBING AND DRAINAGE OF BUILDINGS. — From the year 1881 up to 1893 the Health Department exerted control over the plumbing and drainage work in houses, but in 1893 this control was transferred to the Building Department, where it remains at the present time.

Food Supply. — A separate division of the Health Department controls the food supply of the city; it supervises and inspects the public markets, the slaughter-houses and the bakeries.

Street Cleaning. — The regular cleaning of streets and the removal of garbage, ashes, and other refuse from houses has in New York received fully as much attention as in other American cities, though the results, owing to the defects in the system pursued, have not until recently been satisfactory. It is historically interesting that in 1657, when the town of New Amsterdam had only about one thousand inhabitants, the first short street was paved with cobblestones, a gutter being left in the middle of the roadway for the surface drainage; a few other streets were paved soon after, but at that early period there were no sidewalks. In 1675, under the administration of Mayor Wm. Durvall, "the streets of New York were ordered cleaned every Saturday; and in 1784 the streets were cleaned by contract at an annual expense of $750."

Until 1881, the cleaning of streets was in charge of a special bureau of the Police Department, and it is stated that "the work was done very unsatisfactorily to the people." A special Street-Cleaning Department was created in 1881, and the work was let out, partly by contract. Enormous sums were spent annually by this department, the total expenses amounting to $1,890,376 in 1892, $2,036,812 in 1893, and $2,366,419 in 1894. Owing, however, to the fact that the men were appointed to the force not for fitness, but for political reasons, New York enjoyed the distinction of "being one of the filthiest cities in the world."

In 1894, the Mayor appointed a special committee to study the garbage and street-cleaning question, and its recommendations included the following:

(1) The dumping of city refuse into the waters of the harbor or the lower bay should be prohibited; (2) Garbage or kitchen refuse and ashes should be kept strictly separate; (3) All house refuse should be collected in galvanized iron vessels with tight metallic covers; (4) The garbage should be removed daily and (5) disposed of by a reduction process producing commercial grease and fertilizers; (6) Ashes and refuse should be removed separately and disposed on waste land; (7) The removal should be by metal water-tight covered carts; (8) The carts should be regularly disinfected and cleaned and (9) All streets should be sprinkled before sweeping, to avoid the dust.

In 1895, the late eminent sanitary engineer, Col. George E. Waring, Jr., was appointed Commissioner of the Department. He reorganized it completely, introduced a uniformed force — the so-called "white wings" — and by the enforcement of strict discipline, by skilful organization, by proper superintendence and the application of business methods to municipal affairs, he made New York a clean city. He abandoned the use of street-sweeping machines, and introduced improved methods of hand sweeping. Manhattan

Island was divided off into a number of sections, each in charge of a foreman.

63½ miles of streets were swept once a day,
283½ miles twice a day,
50½ miles three times, and
35½ miles four or more times a day.

He recommended to householders the household process of the destruction of garbage; ashes were collected and removed in bags, tied in the houses, thus doing away with the objectionable practice, common in many cities, of exposing garbage and ashes on the sidewalks in barrels and boxes. The garbage was treated by a reduction process, a large plant being established on Barren Island, and the defilement of the beaches near New York by garbage and refuse ceased. In 1896, the cost of keeping New York clean amounted to $2,776,749, and in 1908 this had increased to $7,418,299 for the entire city.

PUBLIC BATHS. — Another public measure, which reduced the mortality, particularly of the tenement-house districts of New York, was the establishment of public baths.

In April, 1849, an association was incorporated, entitled "People's Bathing and Washing Association," and in 1867 the Metropolitan Bathing Association was organized, but their efforts met with little success. The Metropolitan Board of Health, in their report for the year 1866, pleaded for public baths. As a result of the agitation, two floating baths were opened in the summer of 1870. In the early part of this century a floating bath was kept by a notable character, Dr. Robineau, who for twenty-five cents (for children at half price) furnished two coarse pieces of burlap or crash, dignified with the name of towels, and a bath, where the younger population were at liberty "to plunge, dabble and swim, to their heart's content."

Several additional floating baths were added, so that the number increased to fifteen a few years ago. Useful as they were, they could be kept open only during the summer season.

The first Tenement-House Commission of 1884 accordingly recommended that the city should establish free winter baths throughout the tenement-house districts. The second Commission, of 1894, reported that "out of a tenement-house population of 255,033 persons only 306 (by actual census) had access to a bath." Out of a total of 480 houses it was found that only 17 had bathrooms. Out of a population of 28,996 persons (5,912 families) only 1,888 persons had access to a bath, and 93½ per cent were deprived of any means of taking a bath. They advised that "bathing establishments be constructed and that in addition to the free floating baths for summer use the city should open in the crowded districts fully equipped bath establishments on the best European models."

In 1892, the New York State Legislature passed the Free Bath Act, which permitted cities and towns to borrow money to erect public baths. In 1895, the law was changed so as to be not merely permissive but mandatory, and provided that "all cities of the first and second class shall establish and maintain such number of free public baths as the local Board of Health may determine to be necessary; each bath shall be kept open not less than 14 hours for each day, and both hot and cold water shall be provided."

Previous to the passing of the above law, about the year 1891, several public baths were built in New York City; they were either free or made a nominal charge of five cents (for soap and towels). The New York Association for Improving the Condition of the Poor erected the first public bath, open all the year round, in New York. These baths proved to be a great success, as is attested by the figures giving the attendance following, viz.: —

From —	To —	Men.	Women.	Children.	Total.
Oct., 1891	Sept., 1892	42,722	7,460	9,258	59,440
Oct., 1892	Sept., 1893	52,624	8,267	7,738	68,629
Oct., 1893	Sept., 1894	59,908	10,757	9,872	80,537
Oct., 1894	Sept., 1895	65,517	12,581	10,636	88,734
Oct., 1895	Sept., 1896	69,428	14,096	10,284	93,808

In the same year, the Baron de Hirsch Baths, constructed and equipped under direction of the writer,* were opened. These furnished in three years 159,323 baths to men, 39,985 to women, or a total of 199,308, besides baths to children, of which no record was kept; and from 1895 to 1896 they furnished 57,779 baths.

The Demilt Dispensary Baths, also installed by the writer, were opened in 1891, and from November, 1892,

* See Gerhard's "Modern Baths and Bath Houses," 1908.

to 1895 34,618 men and 3,442 women took baths; in 1895, 15,826 baths were given; in ten months of 1896, 13,247 baths.

Another public establishment, known as the "Riverside Baths," was opened in 1895, and gave from February, 1895, to October, 1896, 56,416 baths. They have since been somewhat enlarged, and are well patronized.

In March, 1897, the report of the Mayor's Committee on Public Baths and Comfort Stations recommended the erection of a number of public bath houses, also "that spray baths be equipped in the basements of public schools where practicable." Following the European examples, all public baths are fitted up with "rain or spray" in place of bath tubs, the former type having advantages as regards simplicity, economy in cost, and cleanliness. At the present time there are a large number of such people's free baths in operation.

WATER SUPPLY AND SEWERAGE. — It would be an impossible task to give in a brief sketch an adequate description of these important municipal engineering works as planned and arranged in the boroughs of Manhattan, Bronx and Brooklyn, of New York City. For this reason they are omitted from consideration, but the fact should be pointed out that the many improvements in these departments have had a perceptible influence in lowering the death-rate of the metropolis.

. . . .

BROOKLYN: LOCATION AND CLIMATE. — The borough of Brooklyn, formerly a separate city, is located on the western extremity of Long Island, and is separated from New York by a narrow tidal channel, the East River; on two other sides it borders on the harbor, the bay and ocean, and thus it receives the ocean breezes, while on the fourth side it adjoins a prosperous farming district, which contains largely garden land and which is unusually free from unsanitary influences. The natural advantages of location and topography are therefore highly favorable and warrant the expectation of a healthful settlement. The climate is much the same as that of New York, though it is in parts somewhat more exposed and cold. The area of the city before consolidation with Manhattan was 77 square miles, with thirteen miles of water front. The population of the borough was 1,515,926 in 1908; it has 670 miles of paved streets, 806 miles of sewers and 850 miles of water mains. The average daily water consumption amounted in 1908 to 138 million U. S. gallons.

EPIDEMICS. — In the first half of the present century Brooklyn was frequently visited by epidemics, chiefly of yellow fever and cholera. Yellow fever occurred in the years 1804, 1809, 1823, 1856, 1858, and the last one in 1860. In 1885 and again in 1887 there were quite severe epidemics of typhoid fever. The four cholera years were 1832, when the city had a population of only 17,000, and when 274 deaths occurred; 1849, when there were 650 deaths; 1854, when the number of

deaths reached 656, and finally, for the last time, in 1886, when 564 deaths occurred.

DEATH-RATE. — **Brooklyn's death-rate has been quite low since 1880, as the following figures will show:**

Year.	Estimated population.	Death rate.
1880	567,000	23.3
1885	683,000	22.5
1890	854,000	23.2
1893	990,891	21.2
1895	1,100,000	20.5
1896	1,125,000	20.0

BOARD OF HEALTH. — **A Board of Health, with a Health Officer as chief executive officer, was created in 1824. Later on, the Department of Health was organized with a Commissioner of Health as the head. It has charge of the vital statistics of the city, of all municipal sanitary questions, of the abatement of public nuisances, and it controls the health of the city by a code of sanitary ordinances.**

PLUMBING AND DRAINAGE OF BUILDINGS. — **Numerous complaints were made prior to 1881 about the defective plumbing in dwelling-houses; the health commissioner, having no legal remedy, urged legislative aid as a means of relief. But " the idea was new, and was not only not well received, but was publicly and persistently denounced." As the city had grown very rapidly, since 1870, in number of inhabitants and number of dwelling-houses, this evil grew and soon** threatened to become a "formidable menace to the public health," as stated in the report of the department for 1886. The plumbing law was passed in 1881 and has been enforced since 1882. In 1895 and 1896 the Department of Health organized a special Bureau of Plumbing and Drainage, under charge of a sanitary engineer, and of which the writer was for two years honorary consulting engineer. In later years, plumbing inspection became so well appreciated that, to use the words of one of Brooklyn's Health Commissioners, "few, if any, persons now think of having first class property or modern private residences, without being thoroughly satisfied that the plumbing is sanitary and safe."

STREET CLEANING. — The cleaning of the streets, and the removal of garbage and ashes in Brooklyn was under joint control of the Department of City Works and the Department of Health, and the work was given out by contract. Up to within a few years ago, the garbage was carried out to sea in barges and dumped in deep water. This method did not prove satisfactory, and was prohibited in 1896 by the United States Government, owing to the resulting shoaling up of the outer harbor. Subsequently the city tried both the cremation and the reduction processes for the garbage disposal.

TENEMENT-HOUSES. — Compared with New York, there are not many tenement-houses in Brooklyn, the city being, much like Philadelphia, a city of homes.

Credit is due to the public spirit and enterprise of one of Brooklyn's citizens, Alfred T. White, for having erected a number of well-built and sanitarily arranged model tenement-houses in 1878 and 1890; he also inaugurated the experiment of building, in 1877, a number of workmen's dwellings, consisting largely of two-story small houses.

PUBLIC BATHS. — In the borough of Brooklyn there have recently been erected five public spray or rain baths, and several more are planned or in course of construction. In summer time a number of swimming baths are available, located on floating docks at different points of the river front. The bathing beaches at Coney Island are within easy reach from any part of the city, hence there is perhaps less need in Brooklyn of river baths than in other cities, but in winter time the cheap or free public baths are always well frequented.

V.

SANITATION IN RUSSIA.

In order to show, by contrast with conditions as described in the preceding chapter, the lack of sanitation still existing in some countries of the far East, I have translated the following notes and observations, made by D. Wilcke, Army Surgeon, of Dresden, during his journey through Russia, in 1896, which were published in a weekly medical journal appearing in Munich.

The author's trip included the larger part of the country of European Russia. Starting from the Russian-German frontier, he traveled by way of Warsaw, to Odessa, on the shore of the Black Sea; from here he took a steamer and traveled along the picturesque coast of the Crimea, and the grand landscape sceneries of the coast of the Caucasian Mountains, to Batum, and thence to Tiflis. He also visited some mineral baths in the northern part of the Caucasian Mountains, going from there by way of Rostow, on the river Don, Charkow, Kursk, and Tula to Moscow. From this city he went to a little provincial town, Gshatsk, on the road from Smolensk to Moscow, where he stayed several weeks to study the habits, customs and modes of living of the smaller provincial townspeople and of the Russian peasants; and also to learn something of their sanitary conditions. Finally he visited Smolensk and Minsk, where, being taken for a

German spy, he had some unpleasant experiences with Russian gendarmes and police authorities, which determined him to leave the country sooner than he had expected. His visits to a number of small towns and villages enabled him to gain considerable knowledge regarding the interior arrangements of the Russian dwelling houses.

It is erroneous to suppose that travelers in Russia do not require a knowledge of the Russian language because "nearly all Russians are familiar with either German or French, or both." Only in the highest social circles one finds Russians able to read, write and to converse in these languages. The people of the middle class, as a rule, lack these acquirements, and the moment a traveler leaves the beaten tracks to study Russian country life, it is imperative that he should be somewhat familiar with the Russian language.

Omitting other introductory remarks which the author makes, let us see what facts and experiences he has gathered regarding the hygienic conditions of the habitations.

The Russians are alike everywhere as to their physical features and character traits, and their habitations and dwellings are also generally built according to one type. The villages always have a wide main street, on each side of which are located, closely huddled together, the gloomy gray cottages or huts, separated from each other by small, ill-kept vegetable gardens. As a rule, there are no cross streets, and a narrow alleyway between the houses affords the only means of reaching the fields and meadows located in the rear of the huts. The vegetable gardens, which are surrounded by miserable board fences or low hedges of birch twigs, usually present a dreary and neglected appearance. Cabbage, onions, radishes, and perhaps a few potatoes, but principally thistles and other weeds cover the ground. Flowers are rarely to be seen, except possibly the mallow and the tall sunflower, the seeds of which are used to prepare the fasting oil, of which, owing to the great number of fasting days, a large quantity is required. It is exceptional to find trees in these gardens, but occasionally a solitary birch or a fir tree, a wild apple or pear tree are seen; these are not planted, but grow up because the Russian peasants are too lazy to cut them down.

On the whole, Russian villages, with their weatherworn huts and thatched roofs of a uniform gray color, have a very monotonous, sometimes repulsive and inhospitable appearance, and this is not even lessened by the bright-looking white village church, with its green roof and high separate belfry-tower.

To visit a peasant hut is not difficult, because the Russian peasant is good-natured, hospitable and talkative. In fact, hospitality to strangers is a prominent trait of character of the Russian people. The author never left peasants' cottages which he visited without having been offered some light refreshment, such as milk, eggs, tea and bread.

A peasant's hut or cottage consists of stout logs, placed horizontally over one another, the joints being stuffed with oakum and straw as a protection against wind and cold. There is usually a wide hallway in the center of the hut, with a doorway at the rear, and the hall separates the living-rooms, one intended for winter, the other for summer use. The floor level of the rooms is generally a little higher than that of the hallway, two or three ascending steps being provided. A sort of cellar under the living rooms is used for storage of vegetables and for keeping poultry. The dimensions of the living-rooms vary somewhat, but they are seldom larger than ten to eleven and one-half feet square, while their height averages eight to ten feet. In many instances the living-rooms are again subdivided by a board partition not reaching to the ceiling, and the resulting compartments are extremely narrow. This is particularly true of the winter room, where the immense brick stove, which answers also as a bake oven, occupies at least one-quarter of the floor space of the two compartments. The floor and ceiling are usually boarded, though in the smaller huts there is often no ceiling other than the thatched roof.

The furniture consists of an oblong table of rough timber and of a wide wooden bench, which runs along the entire side of the room; there are no chairs, and bedsteads are likewise the exception, for the top surface of the immense stove answers for a bed, and where there are too many occupants, those who cannot find room on the stove sleep on the wooden bench. The garments answer for a mattress; a horse blanket and one or two pillows are also used, and a sheepskin fur as a cover. Of other furniture the author mentions the cradle, which is never lacking because of the many children in Russian families.

The rooms contain some dirty vessels, old, half-broken and blackened clay pots, a rack with a few glasses or cups, an earthen wash basin, a towel, hung from the wall, which is usually very finely embroidered but indescribably dirty, and which the hospitable peasant uses to wipe out the dirty tea glass which he offers to the visitor; a few milk and other vessels, and finally, in the corner opposite the door, the picture of a saint, with a light constantly kept burning in front of it.

Besides the occupants of the cottage, who surround the visitor with an air of curiosity, one finds in the rooms some chickens, and sometimes a sheep pokes its head through the door, for the hut must answer in winter time as a stable.

In summer time, there are thousands of annoying flies, which constitute a formidable nuisance not without importance from a sanitary point of view, because the flies may form the medium for the conveyance of all sorts of disease germs, such as tuberculosis which is very frequent in Russia, of diphtheria, of typhoid fever, etc. *

In daytime the huts are lighted by two small windows, with glass panes which are never cleaned, and which often are broken and patched up with paper, pasted over the cracks. At night the rooms are lighted by tallow

* It is interesting to note that this was written in 1896, more than two years previous to the similar observations made in the camps of the United States Army in the war with Spain.

See also notes on Mosquitoes and Flies as Carriers of Disease in W. P. Gerhard's "Sanitation, Water Supply and Sewage Disposal of Country Houses," 1909. See also Bibliography on same subject, by Wm. P. Gerhard, in Entomological News for Feb. and May, 1909.

candles; not once did the author see even the simplest kind of a lamp.

A small court in the rear of the hut is inclosed by sheds and small stables, where domestic animals are kept. The court and the hut form a space which is generally square in shape, and which is covered over by a thatched roof, pitched to the four sides. The roof has a small square hole in the center, which serves to light and ventilate the court, which is ill-kept and used as a depository for all manner of filth.

The conditions of habitations in smaller provincial towns are not much better than those of the village huts; they seem to be everywhere alike in appearance and arrangement.

The Russian cities and towns are subdivided into four classes, viz.:

(1) Capital cities, like St. Petersburg and Moscow;
(2) Governmental or provincial cities, where the seat of government is located;
(3) District towns and
(4) Cities without courts or local government.

Each city or town has a municipal council, which consists of a lower house, composed of citizens in good standing, of an upper chamber (duma), composed of elected aldermen, and of the mayor, who is appointed by the aldermen. This municipal council has the general control of the city affairs, of the health matters, and of the hospitals, charitable institutions and schools.

As a type of a provincial Russian town the author describes the small town of Gshatsk. The principal quarter of the town, which is situated in a very level country, and is surrounded by swamps, consists of two streets, planned in the shape of the letter T, at the intersection of which the large market place is located. The two main streets are partly paved and have a sidewalk, but the stone paving is miserably done, and the larger portion is only macadamized. The market square is not paved, and hence after market days, which occur twice a week, it forms an almost impassable pool, owing to the numerous peasants' conveyances with small horses, and the large number of cows, sheep and pigs which are kept there for sale.

Around the center of the town, where the houses are usually built in blocks, are grouped a number of wide side streets, each up to 130 feet wide, and each forming, as it were, a small village in itself. These side streets are not paved at all, but are simply dirt roads, having in dry weather many deep ruts cut by the vehicles, while in rainy weather the surface is so wet or damp as to resemble a swamp, on which walking is most difficult. The worst spots in the road are usually filled with planks or tree branches, in order to afford firmness to the feet. These tree branches are laid irregularly and the twigs are not cut off; they project in dry weather sometimes as much as two feet, and hence impede the foot traffic seriously, while in wet weather a soft mud covers the twigs, causing frequent stumbling. One or two planks laid side by side form a sort of sidewalk in the swampy portions of the road, but the wood is generally rotten and walking on these planks is anything but easy.

The cleaning of the streets is done only in front of some of the better houses; even on market days it is not considered worth while to remove the large masses of dung and scattered straw, due to the numerous horses and cattle. Dependence for cleaning is placed solely upon the rain and the wind, the latter blowing away the dry straw particles, while the rain changes the organic refuse into a homogeneous semi-liquid mass, a part of which is eventually carried by means of the gutters — where these exist — into the small river or creek which runs through the town. Garbage and compost pits do not exist, and all household refuse, meat remnants, bones, and particles of food left over are either stored in the courts or simply thrown upon the streets, and thereby add to the amount of street refuse.

The common building material for houses of provincial towns is wood; stone houses are found only in exceptional cases along the main streets, or on the market square. In plan the houses are usually a rectangle, with the small side placed parallel to the street. The better houses are two stories high, with a ground floor and an upper floor; they present quite an attractive appearance, being painted blue, red, yellow or green, with red or green tin roofs, and having wood carving along the cornices and windows. But in the side streets the exteriors of houses are usually coarse, and, like the village dwellings, present, with their old, weather-worn wood or thatch roofs, a very monotonous appearance.

The interior of the houses is subdivided by board partitions into a number of smaller rooms, which are but moderately well furnished, even when owned or tenanted by well-to-do citizens. The walls are left rough, or covered with a few cheap colored pictures, either bought or torn from picture books and pasted to the wall. A simple, old lounge, a few rickety chairs, a table and the immense tile stove complete the list of interior furnishings.

In the houses of wealthy families the rooms are larger, more comfortable, and arranged after European patterns; the walls are papered and the furniture is of a better quality, though the general impression remains a rather poor one, according to our notions of comfort. The mode of living is far inferior to that of similarly situated families in Germany.

In the rear of the dwelling is the rather narrow and long court, which is surrounded by a shed which has a roof, but is open toward the court. The latter is not paved and serves as a depository for such of the house refuse as is not thrown on the streets.

Even those cities of Russia which are the seat of the government of the provinces are on the whole not much better than the provincial towns. In their central portion they present a more European or civilized appearance; the houses form compact blocks, are generally built of stone, and from two to three stories in height. Many houses have on the first floor elegant and well-appointed stores, with large and wide show-windows. Monumental buildings, palace-like mansions and attractive apartment-houses with dignified facades, as may be seen in German cities, where often entire streets or city districts are lined with them, are seldom found in Russia. The suburbs, even in the capital city of Moscow, present the same appearance as the smaller provincial towns, and the interior arrangement and furnishing of the houses does not differ much from them.

Speaking of the larger cities of Russia, an important matter which has for a long time occupied the attention of the Russian Health Boards should be mentioned, namely, the constantly increasing overcrowding in dwellings, due to the quick growth of the cities, in particular of those where the larger part of the population is composed of Hebrews. In the town of Grodno, a dwelling composed of three or four rooms often holds twelve families, and the appearance of such habitations is generally extremely squalid. In Berditschew, a town of the province Old Poland, with a large Jewish population, there were in 1890 only 1,545 one-story dwellings for a total of 60,000 inhabitants.

The conditions are not much better in the ill-reputed Jewish quarters of Warsaw, in the Jewish quarter of Wilna, and other towns, largely inhabited by Jews, and in general, in nearly all cities and towns of what was formerly Great Poland, and now West Russia, particularly in the districts around the river Vistula.

Even in cities with other than a Jewish population, the overcrowding and lack of habitations has increased enormously in the past twenty-five years. This was caused principally by the radical changes originating in 1861, when the entire urban life underwent a transformation. Large numbers of people, peasants without homes and farms, rural workmen, and agricultural laborers, emigrated from the country villages into the cities. The growth of manufacturing industries in these was another cause for the overcrowding.

The condition and maintenance of the streets in the larger cities leaves much to be desired. There are, of course, a few exceptions, notably the streets of Odessa, a city in Southern Russia, which in many other respects shows much municipal sanitary progress.

The author quotes at length some statistical data from the official report for 1894 of the General Imperial Board of Health, according to which more than one-third of all Russian cities have no street pavements whatever; only in one-sixth of them is more than half the total street surface paved, while the rest of the streets are simply dirt roads.

During the past years, however, much work has been done in street improvements, and the total area of newly paved streets is increasing each year. The fact is that in at least a part of the Russian Empire there is a lack of good street-paving materials, and the maintenance requires a very large outlay of money. The Northern part of Russia is richly wooded, and thus affords opportunity for making use of wood for street paving; this is done principally in the Vistula provinces and in many towns of Western Russia. Some asphalt pavements have also been laid in recent years in a few of the principal cities.

In provincial towns, the cleaning of the streets is often very imperfectly accomplished. This is generally made the duty of the owners of buildings fronting upon the streets, though the municipal government has the right to have it done at the expense of the city;

in most provincial towns the latter system prevails. In a few cities, as in Odessa, sprinkling carts drive through the streets during the day, and the sweeping is done with painstaking accuracy. In other cities, street cleaning is restricted to the main streets in the center of the city, while elsewhere the refuse remains heaped up as described heretofore.

Town sewerage, up to now, is scarcely known, and cannot be expected as yet on a large scale, because a town water supply by a central system or works, which is the chief condition upon which a sewer system depends, is almost unknown. Even in places which have waterworks, and where logically the construction of a sewer system should have followed, no sewers have been built. In the capitals of Russia, St. Petersburg and Moscow, the construction of sewers has only quite recently been begun.

Two good features existing in many Russian cities are worthy of being specially mentioned, namely, a large portion of the streets are planted with rows of handsome shade trees, and there is in every town, no matter how small, a city park or garden, which is well kept, and which affords to the citizens an opportunity for recreation and rest after working hours. The city of Odessa is a notable example, for the larger portion of its beautiful, wide, well-paved streets is adorned with splendid rows of trees, and notwithstanding the fact that the soil of the city was originally a dry prairie soil (Russian steppes), a beautiful vegetation has been created in the course of years in the ornamental parkways. In some other cities good landscape architecture may be seen, as for instance in Charkow, Sebastopol, Moscow, and a few others. The Russians do not care for long walks into the country; they are naturally lazy, and prefer either to drive or to walk in the shaded public gardens or parkways.

The weakest points in house sanitation in Russia are the privies and the system for the removal of the human excreta. In a very large number of towns and likewise in many villages there are no privies or conveniences of any kind. They are at best but sparsely provided, for instance, in Ostrowez, a town of 8,000 inhabitants, there were, in the year 1891, but two privies. In many towns the inhabitants use secluded corners of the courts of houses for the call of nature, and when the accumulated excreta form too large a heap, a new corner is simply selected.

Occasionally, one finds a dug pit, and in some instances a simple form of wooden privy shed with seat is provided. As a rule, however, the privy sheds are kept in such a horrible condition that even the inhabitants, who are used to filth and uncleanliness, prefer to make use of some corner near the privy. Whoever wishes to learn personally about such unsanitary practices need not go to the smaller towns, for even the large provincial cities offer plenty of opportunities to witness such disgraceful scenes. In Tula, for instance, there were in 1891 only 1,037 privies for 11,271 houses; in Ssaratow, only about one-half of the dwellings had privies, and in Smolensk, with 38,000 inhabitants, there were scarcely any privies.

Even in the second capital of Russia, Moscow, one may often observe the same unsanitary conditions, so vividly described by Count Leo Tolstoi in giving the pen picture of the court of a large tenement-house inhabited by the poorer population. "In this court," says Tolstoi, "a strong bad odor was noticeable. It emanated from a privy, around which, whenever I happened to pass, many persons were crowding, waiting for their turn. This privy, however, was not made use of, but simply marked the place about which people squatted down."

In the larger cities, such primitive conditions are exceptional, and there one finds privy vaults attached to many of the houses. The vaults are built in masonry, but are neither cemented nor water-tight.

The removal of excreta is accomplished in as primitive a manner as is their storage. Municipal rules and regulations regarding the removal exist only in the larger cities. Whenever the landlord, who in smaller towns and villages is also, usually, a farmer, requires manure for his farm lands, or when the heap of excreta becomes too large, and the odor from it too strong for his usually little-sensitive nose, a certain quantity is carted away in open carts, which are also used for other purposes, and so it goes on, until another accumulation calls for removal. There is no urgent need for a separate removal of the urine and slop water, for these run off to the street either in a deep open gutter, or on the graded surface of the court, and often soak away in the street mud.

In several larger provincial towns, where the municipal government has a somewhat better understanding of sanitary questions, the removal of the excreta is accomplished in closed barrels of various constructions, into which the excreta are discharged by pumps. The contents of the barrels are emptied into immense manure pits, located outside of the city limits, from where they are distributed to farm lands and fields. Often such pits are located too near the town, with the result that with certain directions of the wind a very objectionable odor penetrates the entire town; or the pits are located immediately adjoining a water-course, and are the cause of a bad pollution of the river.

There are some isolated instances where water-closets and sewers are used, but these are confined usually to a few streets or blocks of buildings. In Warsaw, for instance, 5 per cent of the privies are connected with the sewer system. But even this method of removal appears to be of doubtful value, for the sewers are not constructed with a view of accomplishing this removal; they have insufficient grades, and cross sections ill-adapted to the purpose, and their dimensions are usually too small. The discharge of sewage and excreta into adjoining water-courses is not without serious sanitary detriment to the districts of the city lying below the sewer outfalls.

Sewage irrigation fields were found only in Odessa, which city enjoys in every respect superior sanitary conditions. The author did not visit the sewage farm, and his impression is that only a part of the city sewage is utilized for irrigation, the larger bulk being discharged directly into the sea.

The water supply of towns forms another weak point of Russian public sanitation. In the year 1890, only 18.9 per cent of all cities had a public water supply; in the Baltic Sea provinces the percentage of cities with water works was 39.0, and in the district of the river Don, 33.3, in the provinces having municipal councils, 23.3, in those without such, 9.2, and in the Vistula provinces, only 6 per cent.

The waterworks of Russian cities are very imperfect as regards both construction and management. The water supply is derived principally from the adjacent rivers or else from ponds, both of which are often very much polluted with all kinds of organic matter and refuse from manufacturing establishments. As a rule, the water is not filtered, and where filtration is adopted, it is carried out very imperfectly.

The water is often turbid, full of organic impurities, ill-smelling and frequently of a nauseating taste, which boiling does not remove. The hygienic value of the waterworks, particularly in reference to infectious diseases, like typhoid fever, dysentery, malaria, and cholera, is accordingly a relatively small one, and it is not surprising that physicians of towns where there are waterworks, insist that the drinking water should be boiled, wherever possible.

Another frequent mode of water supply is from wells. The construction of these wells is the same all over Russia. They are lined with trunks of trees, which are provided at the ends with joint-like incisions to fasten them together. In section the wells are always built square, each side measuring about 39 inches. The depth of the wells varies according to the height of the ground water or the level of the water-bearing stratum. The lining of the wells is usually carried from 13 to 18 inches above the level of the ground. The level of the water is often quite close to the surface, sometimes even within from 3 to 5 feet, and the wells are usually left uncovered at the top.

The water is lifted from the well by means of a reel or windlass with chain or rope, at both ends of which a bucket is suspended, or the lifting is done with buckets hung on ropes attached to long pump poles, which are counterbalanced and pivoted. The long end of the lever is usually 9 to 13 feet long, and often reaches above the roof of the neighboring houses. This form of well lift is the most common. Well pumps are seldom used. The author found these in use only in some of the larger towns, and in the vicinity of some railroad depots.

The quality of the well-water is usually very unsatisfactory. The nearness of the ground-water level to the surface, the insufficient water-tightness of the well lining, the swampy character of much of the ground water, and the position of the wells directly adjoining the manure heaps of farmhouses or in the middle of dirty streets and squares, in consequence of which each rain storm washes large quantities of street and house refuse into the well, the rotten character of the wooden well-lining, which causes the water to smell and taste badly, and finally the insufficient cleaning of the well and the use of dirty vessels for lifting the water — these circumstances, taken together, explain sufficiently why the quality of the well water is bad, as a rule. The wells are, therefore, quite often the cause of epidemic sickness, which generally ceases immediately upon the closing up of the well by the authorities. The student of epidemiology may find in no other country better and more material for bacteriological studies than in Russia, where a number of outbreaks of epidemics occur yearly in nearly all provinces, traceable to polluted well water.

Up to the present time but few artesian wells exist, though their use is increasing from year to year, particularly in those larger cities where the construction of waterworks has been attended with difficulties. The water furnished by artesian wells is, as a rule, quite clear, pure, free from organic impurities and of a good taste, particularly where the wells are not sunk to too great a depth. The quantity yielded is also generally very large and sufficient to supply entire villages and city districts.

A large number of towns derive their supply by direct haulage from rivers or from ponds. This method is prevalent in Poland, and in West and Central Russia, where the country is so well provided with flowing water-courses and ponds that nearly every town is located adjacent to one of them. The water is drawn by special water carriers, who cart or carry the water by hand to the houses of the consumers. They generally drive a small, two-wheeled cart, drawn by a horse. A large barrel is placed on the cart, and is filled at one of the fords of the river, usually in the center of the town. Immediately adjoining the place where the water is taken, people bathe in the river, and horses and cattle are watered, while ducks and geese swim about. The waste water from the houses bordering on the river, which often has but a sluggish current, flows into it, and may be distinguished for a long distance by the brownish discoloration of the water; trucks which pass through these river fords stir up the muddy bottom of the ill-smelling river or creek, while some yards upstream washerwomen are perhaps occupied in rinsing in the same turbid water a large quantity of very dirty clothes. This very water, befouled as it must be, is taken into the water barrels and drunk by the inhabitants. Only a person who has been compelled to depend upon drinking water of this kind for a length of time can judge how nauseating the taste, smell and color of the water are even when taken in the form of tea, coffee, or cocoa. The frequent epidemics of typhoid fever, dysentery and cholera prove sufficiently the danger in the use of such water; in a number of instances, bacteriological examinations showed the presence of the cholera bacilli and proved conclusively the relation between polluted drinking-water and cholera. The author quotes instances of a pollution of the river Kura, in the city of Tiflis, and of the western branches of the river Bug.

The question naturally arises: Are the sanitary authorities taking any action to regulate the problem of water supply? Some laws have been passed, within recent years, forbidding a pollution of the water at the points where it is drawn for use; the police authorities and municipalities are likewise in duty bound to prevent river and well pollution. But in the majority of cases, while the laws exist, they are not enforced. A health officer, whom the author questioned as to why the sanitary and police authorities did nothing in the matter, replied: " It would not do any good, the people would continue to draw the water where they can do so most conveniently."

The author relates a few observations about bathing, which are of interest from a sanitary point of view. No Russian can be without his bath, and the poorest peasant, even, tries to obtain a bath at least once a week. In the largest villages, hamlets and towns, one therefore finds in almost every street one or more bath houses, from the simplest to the most elegantly fitted up. The sanitary condition of these bath houses, however, is often all but satisfactory. In the cities of Moscow, Charkow, Kursk, and the majority of the provincial towns, the public bath houses, intended for the lower classes of the population, consist usually of two large halls, the one intended for men, the other for women. These are, as a rule, kept tolerably clean and neat. On the other hand, in the majority of the smaller towns the bath houses are indescribably filthy, particularly the bath houses for the Jewish population.

Bathtubs are used in Poland and in the Baltic Sea provinces, while in all other parts of Russia a steam, hot air, or vapor bath is preferred. While the people's baths are usually kept in an unsanitary condition, the bath houses for the well-to-do in larger cities are always neat and clean and fitted up very comfortably, though the price of admission is often quite high, viz., three rubels, or about two dollars, and sometimes even more.

The waste water from the bath houses usually runs directly into the nearest river, and often causes a serious pollution of the drinking water. Frequently the drainage is insufficient or defective and causes a bad pollution of the subsoil. The bath houses of Russian towns are also important from the point of view of sanitation, because almost without exception they constitute places for sexual vices, and consequently form a principal cause for the distribution of syphilis, which, as is well known, is very frequent in Russia. The above is also true of river baths where the sexes bathe promiscuously, the feeling of modesty being very little known.

Of other sanitary institutions, the author mentions the abattoirs, the care and maintenance of which is entrusted to the municipal governments. They also decide whether private slaughtering places may exist in addition to the public abattoirs, and whether the killing of animals in butcher shops may be permitted. The majority of cities, and even the smaller towns, have special abattoirs, which are partly under the management of the city authorities, but which in many cases are let to butchers. In addition to these there are nearly everywhere some private slaughter houses. Well-arranged abattoirs are found only in a few of the larger provincial cities, among which Odessa again requires favorable mention.

The abattoirs of the smaller cities are kept in an almost indescribably filthy and neglected state. As a rule, they consist of large, simple, wooden sheds, sometimes located near a river, and lack even the most ordinary means and equipment for facilitating the maintenance of cleanliness. Many do not even have a supply of water for flushing, while others have no drainage whatever. Owing to its absence the waste water and blood from the slaughtering process cannot flow away, and the result is a thorough saturation of the surface, which is seldom paved, and of the subsoil with blood, which soon putrefies and emits a noxious and penetrating smell, noticeable at a great distance away.

The worst imaginable conditions of this kind were discovered in the town of Jelez (30,000 inhabitants) in the province of Orel, which are described as follows: "The pen refuses to give even a faint picture of the horrid places in which the animals are killed. A large pool of putrefying, coagulated blood flows, mixed with dung and excreta, down to the spring, from which the city waterworks take water. A foul mixture of semi-liquid refuse, in which entrails and other waste matters float, takes our breath away, and in the midst of all this nastiness pigs are fed. Slaughtered calves lie on tables which, owing to the rotting of the wood, have a greenish appearance. The carcasses of the slaughtered animals are placed where the refuse lies, amid putrefaction and decomposing matters. They are loaded on dirty carts, which remain uncovered, and which bring the meat to the butcher shops. These often constitute small slaughter houses, for the smaller animals, calves, sheep and poultry are slaughtered here. The blood and the useless entrails are thrown upon the public meat market in the center of the town, where they create a fearful stench."

The butcher shops are often so vile as to resemble the "stables of Augias" of mythological fame; the odors which are due to the putrefying meat offal and to the decomposed blood adhering to the meat tables and which greet one on entering these pest holes is such that one loses for a long time all appetite for meat. Notwithstanding the fact that slaughtering in public abattoirs is in many cities prescribed by law for hygienic reasons, much of the killing of animals is done in the butcher shops, where the control and inspection of the cattle to be killed is more difficult or quite impossible to carry out. In the town of Charkow, for instance, 36 secret private slaughter houses were discovered some years ago, where about one hundred animals, often in a diseased condition, were killed daily, and from where enormous quantities of decomposed and unhealthy meat were sent to the markets.

The markets and stores for the sale of food supplies, such as the small grocery stores, the bakeries and fish stores, are not in a much better sanitary condition. The state of uncleanliness which the author found, particularly in the fish-stores of Batum, in some stores of Moscow, and in other towns, was worse than anything similar seen by him. Yet the control of the sale of food supplies forms that part of the work of the Russian sanitary police, to which health boards are said to pay very much attention.

The control of the food supplies is a part of the duties of the town physicians, but in many cities it is in direct charge of the health board and their specially appointed medical officers. There were in 1891 in the whole Empire of Russia only eight microscopical laboratories for the inspection of pork; and but eleven chemical laboratories or testing stations located in the cities of Warsaw, Moscow, Charkow, Odessa, Tula, St. Petersburg, Dorpat, Riga, Lods and Tiflis. A well-appointed hygienic and bacteriological laboratory is attached to the military hospital in Warsaw. According to the reports issued by these laboratories, the adulteration of food supplies is quite frequent.

In conclusion the author casts a glance upon the Russian burial and cemetery system. In larger cities and in provincial towns the cemeteries present a dignified and solemn appearance; they are adorned with beautiful trees and with some very fine sculptural monuments and tombstones. As a rule, the cemeteries comply with the sanitary requirements which call for a distance of 700 feet between city habitations and the cemetery. The rules also prescribe that cemeteries should be surrounded or fenced in with hedges, ditches or stone walls, that they should be planted with trees, that the graves should have a stated size and depth, namely about six feet, and that they should be kept a certain distance apart. The Armenian cemeteries in the Caucasus, particularly the cemetery in the city of Tiflis, form the only exception: they have neither fences nor trees, but are entirely barren and desolate and only partly covered with a spare growth of prairie grass.

The majority of village cemeteries are kept in a very neglected state, particularly in Western Russia. Their exterior presents a gloomy and dismal appearance.

Nowhere is a wall or hedge to be seen surrounding the barren resting place of the dead. The only ornaments of the individual graves — if ornaments they can be termed — are the tall, primitive, warped wooden crosses, formed of peeled pine branches, which are rocking to and fro in the night wind, and which, particularly when viewed from a distance, present a ghastly appearance.

Worse than these æsthetic drawbacks of village cemeteries is their unsanitary condition. As a rule, they are placed too near the village, sometimes even in the very center of the same, often in rocky or swampy soils; the graves are dug very shallow, so that the coffins and even the human bodies become visible after a time. In times of epidemics chiefly, but also at other times, a single grave is used for receiving several bodies, and this is particularly detrimental when the grave is not dug sufficiently deep, or where a swampy muck forms the soil of the cemetery.