FIFTY years ago sanitary engineering in this country scarcely existed, even in name. The larger cities were provided with public water supplies and there was a general desire among sanitarians to supply water free from filth. Sewers in combination with storm water drains had been built in the larger communities to a limited extent for several decades. Some of the more progressive engineers were watching the activities of the Rivers Pollution Commissions in England and at Paris, Berlin and a number of other places abroad. The germ theory of disease had not been established. The laboratory man spoke of chemical tests in terms unappreciated by the engineer and of comparatively little aid to him. Bacteriology had not sprung into being. In brief, the history of the past fifty years tells practically all of the substantial accomplishments of the sanitary engineer in advancing the public-health movement on this continent.

I shall outline briefly what the engineer has accomplished along sanitary lines in the field of water supply, water purification, sewerage, sewage disposal, control of streams and the collection and disposal of solid wastes.

WATER SUPPLY AND WATER PURIFICATION

Fifty years ago most American water supplies were muddy, colored, polluted and frequently objectionable as to tastes and odors. Typhoid death-rates were high. The laboratory men were studying hardness, lead-poisoning and methods of measuring dead organic matter in water.

The art of filtration was practically unknown in this country, except in so far as efforts to get clear water in European cities had been revealed by the classical publication of Kirkwood. This engineer, long identified with the Brooklyn Water Department, was sent abroad in 1866 by the city of St. Louis to investigate foreign practice with a view to planning a plant for filtering the muddy water of the Mississippi. Practically the only outcome of this standard book on filtration was the installation in 1872 of two small water filter plants, at Poughkeepsie and Hudson, New York.

In 1884 the late Professor William Ripley Nichols brought back from Europe a few gelatine tubes and explained to engineers in Boston what the Europeans were doing in their efforts to apply new bacteriological methods to water supply matters. A year or two later, the Massachusetts State Board of Health was reorganized. It established in 1887 an experiment station at Lawrence, under the direction of the late Hiram F. Mills, a distinguished hydraulic engineer who had been made engineer member of the State Board. It was here that the first coordinated efforts were made to lift sanitary engineering into a plane whereby it, with aid of the chemist and of the biologist, with his new bacteriological methods, could expedite practical accomplishments.

In the fall of 1893 the water filter plant installed by the city of Lawrence, Massachusetts, under the direction of Mr. Mills, was put in service and the first bacteriological tests of a modern filter installation in America were reported to a convention of this Association then convened at Chicago.

To the engineer there was a wide difference in the water treatment arrange-
ments needed for the relatively clear waters of the New England States, or of England, as compared with the river waters of the South and West, so heavily laden with silt and clay. In 1895 investigations were undertaken at Louisville, Kentucky, under the direction of the late Charles Hermany, whereby the rapid or mechanical filter was tested in connection with sedimentation and coagulation. Subsequent investigations, embracing a co-ordinated set of tests of an engineering, chemical and biological nature were conducted at Pittsburgh, Cincinnati, New Orleans, Washington, Philadelphia and other places. The result was a substantial foundation for effective means of purification for the prevailing types of water encountered in this country. Actual construction of numerous sizable plants dates back some twenty years or a little more. During this interval immense strides have been taken in the installation and operation of water purification plants. In this march of progress the sanitary engineer, as might be expected from his earlier contact with laboratory men and the health officers, has played an important part in securing clean and safe water supplies for the American public through provision of proper works.

There are to-day more than eight hundred filter plants in operation in this country and Canada, serving more than twenty millions of people, or more than one-third of the population resident in cities and towns. In scores of cases heavily polluted sources of supply have been abandoned in favor of new and comparatively unpolluted sources.

Typhoid fever annual death-rates of representative cities on this continent ranged, twenty years ago, from about fifteen to fifty per hundred thousand population. In a number of large and well-known cities these figures reached seventy-five to one hundred or more. To-day the death-rates have dropped in many of those same cities, largely as a result of preventing or removing the pollution of public water supplies, to nearly one-tenth of the rates prevailing twenty to thirty years ago. Sanitary engineering has not been the only factor in bringing about this result. It is necessary to recognize the accomplishments in other fields of public health and to appreciate the results of the teaching of improved personal hygiene. Mention must also be made of antityphoid inoculation and other advances in the art and science of preventive medicine. Annual typhoid fever death-rates in large American cities for the past forty years are shown in the table on the following page. It is hardly necessary here to speak of technical matters in detail, to explain how slow sand filters have been preferred for some water supplies comparatively free of turbidity, or how sedimentation and coagulation in connection with mechanical or rapid filters have sprung into almost universal use for the treatment of muddy waters, so generally found in this country. Laboratory control is an important element in practical accomplishments in controlling the purity of public water supplies, and many of the sanitary engineers of to-day have been well schooled at college and by practical experience in the need of bringing the results of practical laboratory tests to the aid of those who have charge of the quality of public water supplies.

Algae growths have produced offensive tastes and odors at intervals in many American water supplies. The removal of the microscopic growths themselves and of products originating with them can be effectively accomplished by means of aération in conjunction with filtration.

Some twenty years ago the use of copper sulphate in controlling the growth of microscopic life in surface water supplies was introduced by Dr. George F. Moore. This step was of much practical help and continues to be so from time to time in many places.
About a dozen years ago the so-called sterilization or chlorination or disinfection of water supplies was proposed by Col. George A. Johnson, as a means of removing objectionable bacteria. Its use has become widespread, particularly as a factor of safety to be applied in connection with filtration processes. In many cases, however, its use has resulted in a falling off of the quality of filtered water, largely for the sake of economy during the war period, so that instead of being a factor of safety, chlorination has quite frequently become a substantial portion of the process for the elimination of objectionable bacteria. Undoubtedly the pendulum swung too far, and there is now a pronounced reaction whereby higher accomplishments are demanded of filter plants themselves. This affects the size of sand used in filter beds; the quantity of coagulant; the skill with which filter plants are operated, and other technical details which are receiving deserved attention though not discussed here.

ANNUAL TYPHOID FEVER DEATH RATES FOR VARIOUS AMERICAN CITIES IN DEATHS PER 100,000 POPULATION

| Year | Chicago | Milwaukee | Detroit | Cleveland | Ohio | Buffalo | Boston | New York* | Jersey City | Philadelphia | Baltimore | Washington | Pittsburgh | Cincinnati | Louisville | New Orleans | Minneapolis | St. Louis | Kansas City | San Francisco |
|------|---------|-----------|---------|-----------|------|---------|--------|----------|-----------|-------------|-----------|------------|---------|------------|-----------|------------|-------------|-------------|----------|-------------|-------------|
| 1880 | 34      | 37        | 44      | 42        | 25   | 34      | 25     | 34       | 25        | 34          | 34        | 34         | 34      | 34         | 34        | 34         | 34          | 34          | 34       | 34          | 34          |
| 1890 | 105     | 47        | 99      | 67        | 56   | 38      | 38     | 38       | 29        | 34          | 34        | 34         | 34      | 34         | 34        | 34         | 34          | 34          | 34       | 34          | 34          |
| 1899 | 53      | 32        | 75      | 68        | 57   | 32      | 12     | 74       | 12        | 74          | 74        | 74         | 74      | 74         | 74        | 74         | 74          | 74          | 74       | 74          | 74          |
| 1893 | 62      | 25        | 65      | 34        | 32   | 24      | 32     | 49       | 29        | 49          | 49        | 49         | 49      | 49         | 49        | 49         | 49          | 49          | 49       | 49          | 49          |
| 1894 | 96      | 31        | 60      | 42        | 64   | 34      | 29     | 51       | 71        | 34          | 34        | 34         | 34      | 34         | 34        | 34         | 34          | 34          | 34       | 34          | 34          |
| 1895 | 78      | 38        | 28      | 32        | 40   | 23      | 37     | 64       | 64        | 37          | 37        | 37         | 37      | 37         | 37        | 37         | 37          | 37          | 37       | 37          | 37          |
| 1897 | 90      | 31        | 65      | 52        | 44   | 34      | 26     | 78       | 78        | 34          | 34        | 34         | 34      | 34         | 34        | 34         | 34          | 34          | 34       | 34          | 34          |
| 1898 | 47      | 42        | 46      | 47        | 49   | 43      | 24     | 74       | 42        | 47          | 47        | 47         | 47      | 47         | 47        | 47         | 47          | 47          | 47       | 47          | 47          |
| 1899 | 48      | 28        | 31      | 74        | 30   | 43      | 24     | 83       | 71        | 47          | 47        | 47         | 47      | 47         | 47        | 47         | 47          | 47          | 47       | 47          | 47          |
| 1900 | 90      | 41        | 19      | 69        | 40   | 35      | 92     | 64       | 112       | 132         | 129       | 130        | 129     | 129        | 129       | 129        | 129         | 129         | 129      | 129         | 129         |

1 Filtration effective for city.
2 Sterilization of water supply begun.
3 Drainage canal in service.
4 New intake.
5 Coagulation introduced.
6 New York includes Borough of Manhattan only through 1888. Since 1889 Greater New York.
7 After 1899, B'D of F. & W. Conn's, Kansas City, Mo.
DRAINAGE, SEWERAGE AND SEWAGE DISPOSAL

Drainage is an important element in relation to the public health, as shown by the fact that the drainage works installed some twenty years ago at New Orleans had a more beneficial effect upon the health of that community than did the installation in subsequent years of modern sewerage and modern water supply works. In northern climates the engineer has had to deal with drainage to eliminate the mosquito and thus keep under control those diseases that require an insect as a vehicle for their transmission.

Most American cities are now provided with moderately complete arrangements as to sewerage, but after household wastes have been collected the problem of their disposal has been a perplexing one with which sanitary engineers have wrestled in association with other workers in the public-health movement.

A great impetus was given to the installation of sewers some forty years ago as a result of investigations made by Dr. Rudolph Heri for the National Board of Health of this country. Those investigations embraced a comprehensive study of European practice and a clear statement as to fundamental principles involved in the art of properly removing the spent water supply from a community. The undertaking had its origin largely as a result of frequent outbreaks of yellow fever in the Southern cities. While sewerage was thus investigated in connection with an inquiry into the causes of a disease later found to be attributable to other factors, real good was performed in putting under way modern arrangements for removing household and other wastes in a suitable manner.

Water supply is a product which all householders desire and are willing to pay for, but the spent product, after its usefulness has been served, has engaged the attention of comparatively few, and these have seldom included the taxpayer, who frequently considers that money is spent needlessly when devoted to the sanitary disposal of the liquid and solid wastes of the community.

In Eastern states a good deal of attention was devoted to the investigations, commission reports and legislative acts adopted in England forty to fifty years ago. A few scattering sewage disposal plants were in operation in this country before 1890, but it was practically a lawsuit, instituted or threatened by property owners, which alone prompted substantial steps in the field of sewage purification. Here again the Massachusetts State Board of Health, with its experiment station and its sanitary engineers working in conjunction with chemists and biologists, did much to solve the problem of sewage disposal for conditions more or less similar to those in Massachusetts. The Lawrence reports also stimulated inquiries and investigations by numerous other workers both in this country and abroad. It is thirty-four years since the Lawrence Experiment Station was founded and fortunately we have a statement prepared for the engineering congress held in St. Louis in 1904 indicating the progress made up to that date in sewage disposal. Thus we have an opportunity of comparing roughly the progress made during the first seventeen years with that of the second seventeen-year interval since 1887.

In 1904 there were about ninety sewage treatment works in operation in cities and towns of 3,000 population or more, of which the total number in the United States in 1900 was 1,524. At that date about 1,100, or roughly about 75 per cent, of the cities and towns had more or less complete sewerage systems. The 1904 statement as to municipal plants does not include several hundred disposal plants in smaller towns, hotels, institutions and industrial establish-
ments. In 1915 there were over 600 treatment plants for municipalities on this continent and about 300 institutional and private plants for hotels and industrial works. War activities interrupted municipal activities but several important plants have been completed since 1915. Progress was much more rapid during the ten years prior to the outbreak of the Great War than in any decade prior thereto. Not only were many more plants built during the period from 1905 to 1915, but works were provided for larger cities, such as Baltimore, Columbus, Rochester and Toronto, with substantial beginnings made at Milwaukee, Indianapolis and several other larger communities. Since the armistice there has been much activity in the preparation of preliminary reports and completion of other arrangements looking to an active period of building sewage disposal works as soon as financial programs are completed.

Sewage disposal arrangements vary widely in type, depending upon a variety of geological, climatic and stream conditions. Legislative requirements also vary in different states and provinces, but practically all departments of health are now exerting their influence in the direction of clean water courses.

Notwithstanding the systematic efforts towards “river cleaning,” the predominating method of sewage disposal has continued to be the dilution method. Within certain limits that are reasonably well understood, and when accompanied by suitable preliminary treatment, this method is fairly satisfactory, although frequently abused and misused.

Seacoast cities and towns, particularly those located near bathing beaches or shellfish layings, dispose of sewage now much more effectively than was the case twenty years ago. Recognition of the transmission of disease by infected oysters and clams and a general demand on the part of the public for clean bathing beaches have had much to do with the adoption of state and provincial laws looking to adequate control of sewage pollution. In general, this betterment has been accomplished by the use of screens, sedimentation tanks, long outfall sewers and by disinfection.

In New York Harbor and in some other tidal estuaries extensive investigations have been made as to dissolved oxygen in the water, a reasonable margin of which is considered important in maintaining clean harbors. Much has been done on the New York and New Jersey side of New York Harbor towards getting under way arrangements for correcting pollutions now found in such a conspicuous degree in certain arms of local waters.

The United States Government at present has very little control over sewage disposal matters. Its jurisdiction is limited practically to preventing the shoaling of navigable waters by sewage solids, and to the protection of government property which it may own on or near the waters in question. The United States Public Health Service has undertaken a comprehensive study from various angles of the pollution of the Ohio River, but the oncoming of the war interrupted steps in the direction of a federal waterways commission.

American rivers in many instances are fortunately very large, but they have not as yet received the benefit of adequate treatment of the sewage or industrial wastes entering them. Sanitary districts or joint sewage disposal projects have been created in quite a number of instances, but not to the comparative extent found in some European districts where river conservancy boards or drainage districts are established on a basis of facilitating real accomplishments.

Along the Canadian border, an International Joint Commission has done much during the past decade in seeking to prevent the pollution of these boundary waters to an extent such that life and property on one side of the boundary is injured by sewage pollution entering the waters from the other side. The
World War, however, interfered largely with practical accomplishments arising from the application of tentative rules of practice.

The so-called "land treatment" was the prevailing method of sewage disposal in New England for over twenty-five years, and still is such in some northern districts where deposits of coarse sand in place are found. Away from the glacial drift formation, sand filtration has been out of the question on account of cost, although in a few instances sewage has been treated in artificial sand beds. Sewage farming or the disposal of raw sewage by broad irrigation, even in semiarid regions, has not been very satisfactory. The sewage when not needed is frequently diverted to streams or allowed to pool on limited areas, resulting in incomplete purification and offensive odors. Of about seventy such installations, mostly in California, nearly all produce odor nuisances and are sources of net expense due to one or more of the following causes, namely: lax management; unsuitable soil; insufficient preliminary treatment of sewage before its delivery; unsuitable location with respect to isolation; and insufficient land to permit of satisfactory treatment.

Sanitary authorities have taken a strong stand against the use of sewage in an untreated condition for irrigation of lands on which are grown vegetables that are eaten uncooked. Furthermore, objection has been made to sewage irrigation on the basis that disease germs may be transmitted by flies for a considerable distance from the sewage farms.

Chemical precipitation works, which were adopted so frequently in England some thirty years ago, and also by quite a number of American cities, have been largely abandoned on the ground of high cost for results accomplished. New works of this type have not been installed in recent years unless industrial wastes made such a step advisable.

Much progress has been made in methods of clarifying sewage by fine screens and sedimentation tanks in order to prevent rivers, lakes and tidal estuaries from suffering through offensive conditions, due to floating sewage solids and to the decomposition of banks of sewage sludge.

The removal of sewage solids is not the whole story, however, as regards either the disposal in a sanitary way of the sludge or solids themselves, or the purification of the non-settling substances, such as the dissolved and colloidal organic matter and the objectionable bacteria of intestinal origin. Non-penetrable effluents, substantially free of objectionable bacteria, can be secured by the use of several available processes when the plants are not too restricted in their arrangements.

Without going into details of methods now in vogue, it may be noted that in the results accomplished at numerous plants for treating sewage, either in single or two-story septic tanks or by stone beds, which financial considerations have necessitated as substitutes for sand beds, one is frequently surprised with the difficulty of getting efficient results uniformly in an inoffensive way. In part this is due to lax arrangements in the system of collecting sewers; in part it is due to inadequate or overtaxed disposal plants; and in part it is due to inadequate attention in the management of plant operations.

There is no cure-all in the field of sewage disposal. Screens, tanks, sand beds, contact beds, trickling filters, chlorination, activated sludge process are methods, of which each has its place in the satisfactory accomplishment of desired results. Each problem should be solved with due appreciation of local conditions and with the recognition that high grade performance of sewage disposal works involves a cost both for plant installation and for operation on a rather greater scale than was considered necessary a few years ago. This is true, notwithstanding the marked variations in price trends and the cost of both building and operating.
works at present as compared with pre-war conditions.

Activated sludge is the newest method. It is a process which makes feasible a more complete purification of sewage than is readily secured by any other method than sand filters. It requires conscientious supervision, but I am beginning to believe that since few, if any, sewage disposal plants are fool-proof, it is perhaps an advantage, rather than a disadvantage, to the process to call for frequent and efficient supervision. During the war, when very high prices prevailed for fertilizers, it was hoped that the drying of activated sludge would produce a commercial product that could be sold to the fertilizer trade for a price which would offset the cost at least of handling the sludge itself. This is not certain under present circumstances, but again we must recognize that this is not necessarily a fatal drawback, and that if real accomplishments in treating sewage are to be effected in a sanitary way, the price must be paid in both money and intelligent direction. Experience shows that results can be produced to equal any reasonable demand, but the price of an adequate plant for the most suitable process to meet the given demand must be paid.

Progress in sanitary engineering in the field of sewage disposal is more associated with availability of funds than perhaps is generally realized. As already intimated, it is more difficult to secure funds for disposing of these waste products than it is to get funds for water supply improvements, or a new hospital, or new playgrounds, or new street pavements. There have been tendencies toward the formation of two groups of sanitarians with respect to sewage disposal. One of these sought quite complete purification at the outset and the other group sought a more gradual or piecemeal program, whereby funds would be applied in the right direction and with a continuing program of actual construction and plant expansion in accordance with comprehensive plans. Prior to the war the latter method was generally considered the more effective on the basis that if funds on too big a scale were sought nothing at all was accomplished in a practical way. The war upset the situation as to progressive betterments, with the result that numerous sewage disposal plants are now greatly overtaxed and funds are not immediately in sight for improving them.

STREET CLEANING AND DISPOSAL OF SOLID WASTES

These subjects are properly included in the scope of sanitary engineering and in this country progress has been substantial. Accomplishments for the most part have followed European precedents, but have not attained as satisfactory results, generally speaking, as found in the better known European cities. A good résumé of developments as to garbage and refuse disposal is to be found in the Proceedings of this Association, containing reports of a committee of which Dr. Hering was chairman for many years, beginning in 1887.

The epidemic of infantile paralysis in 1916 and the outbreaks of influenza during the war stimulated street cleaning in some cities to a substantial extent; but depleted funds and restrictions in capacity of water supply works have caused some municipalities to fall back to a standard of accomplishment lower, rather than higher, than that prevailing just prior to the war.

The United States Food Administration during the war made a strenuous effort to avoid waste and secured comprehensive data as to garbage utilization from cities of 10,000 population or more.

These data were summarized in Engineering News-Record, October 17, 1918, by Mr. M. N. Baker, who is now chairman of the committee of this Association dealing with refuse disposal.

Garbage collection was systematically handled in 1918 in 526 of the 785 cities. It was found that 382 cities, with a com-
bined population of nearly 30,000,000 were then feeding garbage to hogs, or re-
claiming from it fats and fertilizer by means of reduction works. Reduction 
plants were operated in 37 cities having a population of about 18,500,000, so that 
garbage was fed to hogs in 345 cities with a total population of about 11,000,-
000.

Of the 316 cities not utilizing their garbage, 102 incinerated it in furnaces, 
and 214 reported what has been design-
nated as the “burn, bury, or dump” ar-
rangement, which varied widely in its de-
tail and included both land and water 
dumping.

Since the war, with a marked drop in 
the price of hog meat and of grease and 
of fertilizer, things have changed mate-
rially and again the problem has become 
one, generally speaking, of avoiding a 
nuisance. Prospects of substantial profit 
sarcely exist at present.

The most effective way of avoiding a 
nuisance from solid wastes from the 
viewpoint of the sanitary engineer is now 
by incineration. In this country low 
temperature and high temperature fur-
naces have been used. The former have 
predominated and the performance de-
pends largely upon the temperature ob-
tained through the addition of fuel.

The high temperature incinerator is 
the most reliable method for disposal of 
solid wastes in a sanitary way. The gases 
may be used profitably for firing steam 
boilers, particularly if additional boilers, 
fired with other fuel, are also provided.

The sanitary engineer is able to bring 
about in an effective way the sanitary 
disposal of solid wastes. Overtaxing of 
plants and difficulties from odors have 
been more pronounced than should have 
been or need be the case. Even in gar-
bage reduction works the control of odors 
by passing the released gases through 
combustion chambers maintained at a 
very high temperature and their passage 
through curtains of water spray are 
things which the engineer knows about 
but which have not ordinarily been put 
in practice.

In conclusion, it may be said that sub-
stantial accomplishments in sanitary en-
geering during the past fifty years have 
been made in plant installations, in co-
ördination with the efforts of other work-
ers in the public-health movement. Much 
has been accomplished also in developing 
sound bases for procedure; but much yet 
remains to be done, especially in prac-
tical application in the rapidly growing 
portions of our country.

THE WIDER DEVELOPMENT OF STANDARD METHODS

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In the world of machinery the United 
States is the leader in the development 
of standardization of methods and of 
manufactures. The interchangeability of 
parts and the consequent ease of repair 
in case of injury has had much to do with 
our mechanical preëminence. This has 
become so much of a habit that we are 
often accused of standardizing men into 
machines, and at times the accusation is 
well enough founded.

There are still places in our scheme of 
development in which this principle can 
be carried further, and it is of one of 
these that I wish to speak to-day. It is 
somewhat paradoxical, yet none the less 
true, that while laboratory methods are 
much in need of improvement in this 
direction, yet they are at the same time 
among the most difficult to handle. The 
constant comparison of work in one 
laboratory with similar work in another,