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ENGINEERING EXPERIMENT STATION -- BULLETIN NO. 32 - 1943

CROSS - CONNECTION SURVEY IN CALHOUN COUNTY, MICHIGAN

(Revised Edition)

by

EDWARD LEE STOCKTON

In Cooperation With The
W. K. KELLOGG FOUNDATION
BATTLE CREEK, MICHIGAN

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Submitted in Partial Fulfilment of the
Requirements for the Degree of
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CHAPTER I

INTRODUCTION

Health hazards due to faulty plumbing fixtures and installations have existed since the water-borne method of waste disposal came into common use; but, these hazards were not recognized until comparatively recent times. In 1933 an amoebic dysentery epidemic occurred in Chicago during the World's Fair which was traced directly to faulty hotel plumbing, and this, more than any other single incident, focused the interest of health authorities on the health menace of plumbing.

Since this incident considerable information has been obtained on the mechanics of faulty plumbing, particularly in cross-connections and inter-connections, and the plumbing manufacturers have co-operated in a commendable way in designing new equipment so as to eliminate these dangerous features.

During the past two decades much has been done to improve the quality of our public water supplies. Fortunately this is one of the most important steps that can be taken to safeguard the health of individuals against disease. Unfortunately, however, the supervision of health measures does not end with this accomplished protective measure. Modern law places the responsibility, for supplying pure water at the consumer's tap, on the officials and plant personnel directly in charge of the municipal supply. Therefore, we should not be lulled into a false sense of security by past general improvements in our water supplies. Lack of vigilance in safeguarding public water supplies takes it tragic toll of human lives and suffering, to say nothing of extensive economic losses to the community affected.

Unfortunately, as a result of the general diminishing typhoid fever rate in both the United States and Canada, there has arisen the false impression, in the minds of the general public and to a lesser degree among health and water works officials, that water-borne epidemics are no longer to be feared as they were in the past. With the construction of the modern water purification plant, there has developed among many public officials a feeling that vigilance can be relaxed in matters pertaining to pollution of the source of supply and supervision over the health aspects of the water works system.

One who holds such a viewpoint should heed the toll which water-borne outbreaks have exacted since 1920. Mention is made here of only a few examples.

Two of the largest water-borne typhoid epidemics in epidemiological history occurred in the decade 1910-1929. At Hanover, Germany, in 1926 there were over 2,423 cases; at Lyons, France, in 1929 there were over 2,100 cases.

In their most recent report covering the seventeen-year period, 1920-1936 (see also page 102), Wolman and Gorman list 339 water-borne outbreaks which occurred in the United States and Canada. Thirty-three of these outbreaks occurred in cities of over 50,000 population. It is therefore evident that outbreaks of enteric disease traceable to water are possible, even in larger communities, unless stringent control measures are constantly practiced. The total number of outbreaks accounted for illnesses involving approximately 125,000 persons and almost 1,200 deaths. These facts should serve as a warning to every water works and public health official that water-borne disease is a constant danger.

The vast majority of plumbing installations very likely contain possible avenues for the contamination of water or food by sewage or other wastes. Even modern installations have suffered from mistakes in design and erection. In many cases there is possibility of direct access of either impure water to the pure water system, or of sewage or other wastes to the water system or to food. It is fortunate that most of these plumbing hazards are not dangerous continuously, but become hazardous only under certain conditions which will be discussed in more detail in the body of the report.

The extent of these cross-connections has been pointed out by surveys made in the city of Saint Louis in 1934-35 under the direction of Mr. W. Scott Johnson,[1] now Chief Engineer of the Missouri State Board of Health.

Following the Chicago amoebic dysentery outbreak, a vast amount of survey and experimental work was carried out in Chicago by the Chicago Board of Health under the direction of Mr. Joel I. Connolly,[2] Assistant to the President. The federal government, under the United States Public Health Service,[3] carried out a survey on the public buildings in Detroit and New York which showed that over two-thirds of the fixtures were unsatisfactory from a health standpoint.

Until this investigation, so far as is known, no experimental surveys have been carried out in rural areas or in small urban communities. The lack of information prompted this special co-operative project between the W. K. Kellogg Foundation and the University of Missouri.

The object of the survey was to locate such cross-connections as existed in a typical county and to determine the extent to which these constitute potential health hazards. A cross section of the area was surveyed to estimate the total number of such connections which were present, to find out how the correction of these hazards should fit in with a public health program, and finally, to design a procedure for the elimination of the dangerous connections found.

The W. K. Kellogg Foundation sponsors a program known as the Michigan Community Health Project. Their operations are confined to seven southern Michigan counties, namely; Allegan, Barry, Branch, Calhoun, Eaton, Hillsdale and Van Buren. This Program includes all types of educational studies in cooperation with local personnel and fellowship members from various colleges and universities throughout the United States and Canada.

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[1]W. Scott Johnson, A Survey of Potential Health Hazards Due to Faulty Plumbing, Jr. Am. Water Works Assoc., Vol. 28, No. 2, Feb., 1936.

[2]*Cross-Connection Crimes*, Joel I. Connolly, Engineering News Record, April 21, 1938. See also other publications by the same author.

[3]*Plumbing and Public Health*, Public Health Service Bulletin 256—FS 2.3.256, 1940.

The Foundation's main interest in the present investigation was in finding the health hazards of plumbing that were present in a rural community, in designing a practical procedure for conducting a similar survey, and in eliminating the hazards in this and other small communities which cannot finance such elaborate investigations as have been conducted in the larger cities.

This report, therefore, has been written with the expectation that it may be used as both a technical and non-technical treatise on cross-connections.

The New England Water Works Association[1] has adopted the following definition of cross-connections:

> A cross-connection is a connection whereby a potable water-supply system is connected with another water-supply system, whether public or private, in such a manner that a flow of water into the potable supply is possible therefrom, either directly through the manipulation of gate-valves or because of ineffective check- or back-pressure valves.

While these accepted definitions have been given full credit as stating concisely the exact meaning of the phrase, they have not been strictly adhered to in this report. Specific mention is made in numerous instances of the total number of defects being classified as cross-connections. In this report the term includes not only the physical connections between two or more supplies such as the city supply with an auxiliary river fire supply, city supply with private wells which are either contaminated or are subject to contamination, or city supplies with cistern supplies; but also such plumbing installations as are listed throughout this report through which the safe supply, under certain conditions, is subject to contamination by back syphoning sewage or contaminated waters through improperly designed or installed plumbing fixtures.

Examples of these latter conditions are such installations as flushometer valves on stools with no vacuum-breakers, compressor cooling water discharges fastened solidly to a sewer with no air-gap in the waste lines, many types of hospital sterilization equipment with submerged inlets or waste connections with no fixed air-gaps, loose hoses in contaminated waters, below-rim lavatory supplies, submerged water closet supplies, and many others that are shown on the summary sheets.

Since no specific definitions have been formulated to describe these faulty plumbing installations, they have been included in the term cross-connection. In general, the term cross-connection as used in this report may be defined as any physical connection between a safe and unsafe water supply source or system, or between a safe source of water supply and the contaminated contents of a plumbing fixture.

On the tabulation sheet conditions have been classified as cross-connections if there were submerged inlets such as water closet valves or closed discharge pipes through which sewage could be drawn directly into the supply. An example of the latter is the discharge of cooling waters

[1]Final Report of the Committee on Cross-Connections, New England Water Works Association, Technical Bulletin No. 99, page 98.

fastened solidly to the sewer. Other cross-connection conditions indicated refer to such things as below-rim lavatory and bath tub supplies or installations in which a sequence of events is necessary to create the condition which may subject the supply to contamination, but which under these conditions may present a definite hazard.

The plumbing system of a building includes the water service pipes, the water supply distributing pipes, the fixtures and fixture traps, the soil, waste and vent pipes, the building drain and building sewer, the storm water drainage, with their devices, appurtenances and connections, all within or adjacent to a building.

A plumbing defect is any faulty design, construction, arrangement, or installation of the plumbing system which may result in contaminating a safe water supply.

Some of the results of plumbing cross-connections has been described as follows by the magazine, Domestic Engineering.[1]

"To drink the water from a recently used water closet, to bathe in the waste liquids discharged from a urinal, to plunge into the diluted contents of a bed pan, to purge a wound with the drainage from an operating table, is worse than disgusting. Such conditions may result from the existence of a plumbing cross-connection. Irrefutable records of tragedies stand ready to testify as to the frequency of occurrence of these revolting dangers to the health of the public."[1]

DEFINITIONS

The term "cross-connection" has been considerably misused since its origin, and until the last few years no nationally accepted definition has been recognized. Recently, however, a committee of men, prominent in the water works profession, was established to formulate a definition for this term, and also to report on suggested general policies in regard to plumbing. This definition is now being accepted by most engineers and is stated below.

Quoting from the committee report,[2] "A cross-connection shall be defined as any physical connection between a public potable water supply and any private supply used for auxiliary purposes, for fire protection, for manufacturing processes, or for any other purpose not regularly inspected and approved by the State Department of Health."

A physical connection is one in which any two supplies are connected by means of pipes leading directly from one to the other, flow being prevented by means of gate valves or check valves, removable sections of pipe, swinging joints or any device from which the flow from the unapproved source may possibly enter that which is approved.

While not so comprehensive, a more popular definition is—"Any installation in the water system which brings pure water in contact with impure water, polluting the water which has to be used for human consumption."[1]

[1] "What is a Cross-Connection?," Domestic Engineering, Volume 154.
[2] Report of Committee 8, Jr. Am. Water Works Assoc., Vol. 25.

WATER AND ITS RELATION TO DISEASE [1]

Water is a vehicle for certain infections such as cholera, typhoid fever, dysentery, and other diseases having their primary seat in the digestive tract. It may carry inorganic poisons such as lead. It is responsible for a large group of nutritional and dietetic disorders less well understood. It may lack qualities which bring about derangements of metabolism resulting in such conditions as goiter; further, it may be the medium for carrying infections now not generally regarded as water-borne, or it may lower resistance so as to favor infections not water-borne. It is also occasionally responsible for conveying animal parasites, amoebas, worms, et cetera. From time to time new troubles are disclosed—recently epidemics of infectious jaundice have been traced to water, and it has been demonstrated that fluorine in water is the cause of mottled enamel of teeth.

While water has an established place among the carriers of certain infections, it has not a supreme or exclusive place, and this should be kept carefully before us. The tendency to exaggerate the importance of water as a bearer of disease and death has sometimes led to overstatement. The facts are bad enough and do not require extravagant language to emphasize their importance. The greatest danger in water is pollution from human sources. All discharges from the body: urine, feces, expectorations, secretions from the nose and washings from the skin, find their way sooner or later into our streams, especially where modern water-carriage systems are installed for the disposal of wastes. All sewage-polluted water must be regarded as dangerous, whether there are any known cases of disease on the watershed or not. It is highly probable that the sewage of large communities always contains typhoid bacilli in larger or smaller numbers, because in large communities typhoid fever does not die out completely at any time, and carriers and missed cases are always liable to be present.

Water differs in several essential particulars from any other article of diet. Above all, it is usually used in its raw state, while perhaps 90 per cent of all our other food is disinfected by cooking before it is used. Again, it is a vehicle which comes in contact with many objects spread over broad acres, and it is the natural vehicle for the removal of wastes from these areas.

The relation of water supply to sickness and death has clearly shown in many cities, notably at Lowell and Lawrence, Massachusetts; in Albany, New York; at Jersey City and Newark, New Jersey; at Philadelphia and Pittsburgh, Pennsylvania; at Chicago, Illinois; and abroad at London, Paris, Hamburg, Altona, Berlin and many other cities.

Impure water is responsible for disorders other than the specific gastro-intestinal infections, but these disorders are often obscure or overlooked. It is not always plain just what quality or what impurity in the water is responsible for these nonspecific disorders, and the diseases themselves may present a vague and ill-defined clinical picture. The relationship has been worked out in only a few instances.

A turbid or malodorous water may not in itself be particularly injurious to health, but, on account of its unattractive appearance or repulsive condition, less of it may be used than is necessary for the maintenance of good health. In this way water may be indirectly responsible for harm. A common dietetic error is that too little water is consumed.

While a polluted water may not carry specific germs, it is conceivable that it may so undermine health or lower resistance as to favor infections

[1] Preventive Medicine and Hygiene, Rosenau, 6th edition, pp. 1082-85.

not usually associated with the digestive tract. This may bear hardest on the young, the old, or the enfeebled. There is always a possibility that gastro-intestinal disturbances may be due to bacterial or chemical irritation by sewage polluted water.

From the nature of the case the effects of an impure water cannot always be measured by gross results, but the cumulative or separate action of small effects often repeated may result in deranged digestion, altered metabolism, irritation of delicate membranes or sensitive organs and structures, which may lead to or hasten the course of chronic diseases.

The organic matter in the quantities usually contained in a natural water is not of itself harmful. This organic matter, however, does not stay in its native state, but soon decays and it is suspected that some of the intermediate products of decomposition may have toxic potency. Ordinarily these toxic substances are in minute quantities, or at least in great dilution, but under certain circumstances they may accumulate in noticeable concentration. Further, while persons habitually taking such toxic substances may soon become immune, the newcomer will not be so fortunate. The case against organic matter in water is not clear and sanitarians have ever erred on the safe side in condemning waters containing much organic matter. It is generally believed that if the organic matter is not derived from sewage it is probably harmless. However, in the case of organic matter of vegetable origin, Mason[1] has been able to find but few cases of illness traceable to peaty waters. In such instances the patients suffered from a mild, transient form of diarrhea, the cause of which is uncertain.

As far as the inorganic impurities usually found in water are concerned, the chlorides, carbonates, sulphates, silicates, lime, magnesia, and aluminum can scarcely be harmful in the amounts ordinarily found. In fact, most of the mineral matter carried by water is needed by the body, especially lime. The trace of iodine in water is our main source of this element in the diet. It is commonly stated that water containing 500 parts per million, or 30 grains per gallon, of clay and silt is unfit for drinking purposes on account of its irritating effects upon the gastro-intestinal tract; but beyond this probability, turbidity is of no special sanitary significance, unless the water also contains metallic poisons or other objectionable qualities.

An attempt has frequently been made to correlate the formation of urinary and biliary calculi with the inorganic salts in hard water. We now know that biliary calculi usually form about a colon bacillus or a typhoid bacillus or about some pathological particle as a nucleus, and that urinary calculi probably have a similar pathogenesis. There is no known relation between these concretions in the body and the inorganic salts in water, even those in very hard water.

It is stated that a change from a soft to a hard water causes diarrhea, particularly when the water contains magnesium salt.

[1]Mason, W. P., *Examination of Water*, Wiley & Sons, New York, 1931, 6th edition.

CHAPTER II

DEFECTIVE PLUMBING AND ITS RELATION TO DISEASE

Since the advent of water-borne waste disposal, the effects of defective plumbing in relation to the transmission of disease organisms have become of major importance.

The principal water-borne diseases are typhoid fever, cholera, and dysentery. Instances of water-borne epidemics involving each of these diseases are at hand from the most remote to the most highly civilized parts of the world.

Wolman and Gorman in their report[1] on water-borne outbreaks for the period 1920-1936 state:

> Contamination of water in distribution systems enroute to consumers caused 43 outbreaks in the United States and 11 in Canada. Over 90 per cent of these were due to cross-connections. There were 2,330 cases of typhoid fever in the United States caused by pollution in public water distribution systems. In Canada, 9.5 per cent of the typhoid fever cases and the illnesses of 4.7 per cent of the total persons affected in water-borne outbreaks were caused by contamination of the water in the distribution system.
>
> The elimination of water-borne outbreaks resulting from the interconnection of polluted and potable water systems is one of the major problems facing water works and public health officials today.
>
> The second most frequent cause of water-borne outbreaks was "cross-connections with polluted water systems" with 40 cases reported. This was the leading cause of typhoid fever cases, totaling 2,122, or 16.9 per cent of all cases reported. It also rated fourth in total persons affected.

One of the most notable epidemics occurred at Chicago in 1933. Excerpts from the report[2] of this outbreak are given below:

> EPIDEMIOLOGY
>
> 1. An epidemic of amebic dysentery had its origin in Chicago during the summer and fall of 1933. It was the first recognized water-borne outbreak, and the only known extensive epidemic of this disease in a civilian population.
>
> 2. During the period of the epidemic, June 1, to December 31, 1933, there were approximately 8,500,000 out-of-town visitors to Chicago, with resulting unusual congestion of downtown hotels and public eating places.
>
> 3. Chiefly involved in the epidemic were two neighboring large downtown hotels, here designated 'X' and 'Z'. They had in part a common water supply.
>
> 4. During the epidemic period approximately 160,000 persons had contact with these hotels. Slightly over one-half were registered guests, including approximately 300 who resided there more or less permanently. Some 2,300 were employees and the remainder visited the hotels for meals, beverages, or both.
>
> 5. During the period, June 1, 1933, to June 30, 1934, evidently incomplete reporting brought to light a total of 1,409 cases. Slightly more than two-thirds of those infected were out-of-town visitors to Chicago. Approximately 75 per cent had had contact with one or both of the hotels, but less than one-half of the infected Chicago residents reported such contacts.

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[1]Water-borne Outbreaks in the United States and Canada and Their Significance, 1939, pp. 21, 22, 23.

[2]Epidemic Amebic Dysentery, National Institute of Health, Bulletin No. 166, 1936.

. . . .

26. The opinion is held that the principal if not the sole means of spread of this epidemic was through water polluted within one of the hotels. A contributing factor was the progressively increasing number of carriers of *E. histolytica* among the employees and probably of transients. Thus, any pollution of the water with hotel sewage would become progressively more hazardous.

ENGINEERING

1. The two hotels involved in the epidemic, while among the older ones in Chicago, were well patronized by reason of a long-established reputation. An unusual service relationship existed between these hotels in that one (hotel 'Z') was, in part, supplied with electricity, steam and water from the other (hotel 'X').

2. The sewers in both hotels were overloaded to an unusual degree during the period of the epidemic. This was due to the high guest occupancy of rooms and also occasionally to excessive rainfall.

3. In providing modern conveniences, especially in connection with plumbing, drainage loads were placed on sewer lines in excess of their safe carrying capacities. This was especially true of one gravity sewer in the basement of hotel 'X', with which the two principal points of possible pollution of the water supply common to both hotels were associated.

4. The two major points of possible pollution which are considered to have resulted in water-borne infections in the two hotels were:

(a) Two cross-connections in hotel 'X' which joined an overhead sewer to condenser-water discharge pipes. This water which had been first used for cooling purposes was distributed throughout hotel 'X' and to the upper floors of hotel 'Z'. The pollution of this would account for the observed parallelism of the incidence of infection in the two hotels.

(b) An old rotting wooden plug in an overhead sewer which permitted leakage into the cooled drinking-water tank below. This would account for infections among guests and patrons in hotel 'X' only because this water system was limited to that hotel.

5. Both sources of pollution probably were operative intermittently during the period of the epidemic, the influencing factors causing peaks of infection being (a) overloading the sewers, (b) restriction of sewer capacities due to flooding of the city sewers during heavy rainfall, (c) conditions surrounding the operation of the condensers and (d) probably the use of the cross-connections for disposal of condenser water through the sewers.

6. The leak over the cooled drinking water tank probably was the principal cause for high infections among guests at hotel 'X' on June 29 and 30, 1933, due to pressure in that hotel's sewer, accompanying the flooding of city sewers during and following a short period of excessive rainfall.

7. The infections attributed to the cross-connections appear to be related, especially in August and September, to the intermittent operation of the condensers in hotel 'X'.

8. Flooding of a portion of the basement of hotel 'X' occurred during an unusual storm in the early morning of July 2, 1933, from a break in two sewers under an ice storage room. This temporarily created a potentially hazardous situation, but does not appear to have contributed to the spread of amebic infection; in fact the relief of pressure in the sewers due to the rupture was a fortunate occurrence since it probably prevented a repetition of the pollution of the cooled water which apparently occurred 3 days previously.

9. While other potential health hazards were found by detailed inspection at both hotels, they are not considered to have contributed to any considerable degree, if at all, to the epidemic.

CONTROL

1. Efforts were made to control the outbreak by the elimination of carriers of cysts of *E. histolytica* from among the food-handling staffs, but there is no evidence that these efforts were successful. The experience in this respect is not to be regarded as an indication either of the value or lack of value of the procedure under some other conditions.

2. The measures required to prevent the recurrence of such an epidemic are: (a) Effective supervision of the installation of plumbing in new buildings and of changes in old ones; (b) reasonably frequent inspections of the water and sewage systems of buildings, especially of the older ones; (c) particular attention to the elimination of hazardous cross-connections, through preventing their installation and through detecting and removing existing ones.

3. Institutions serving the public, particularly those providing residence, meals, or beverage, should be encouraged, aided, and required to provide adequately for the protection of the public health. Properly trained sanitarians should more commonly be included in the personnel of such organizations.

Herman N. Bundensen in his article "Plumbing in Relation to Infectious Diseases"[1] gives a good account of cross-connections in hospitals and the diseases associated with defective plumbing.

Regulation of plumbing was first begun as a health measure before the time of Pasteur. Early enactments were aimed more at proper trapping and venting, to prevent the escape of sewer air into houses, than at prevention of water contamination. With the advent of modern bacteriology, examinations were made of sewer air, which indicated that, because of its relative freedom from dust particles, the air in sewers usually contained fewer bacteria than the air of the streets above.

Then losing sight temporarily of the health aspects of toxic gases often found in sewer air, health workers generally discredited plumbing inspection as a public health measure, and many even advocated the transfer of such activities to other departments, or relegated them to the background when they retained supervision.

Plumbing inspection was like Cinderella in the family of health activities—the unwanted child.

But, like Cinderella, it has experienced an almost magical change. Plumbing control is again beginning to be regarded as a proper activity for Boards of Health, due largely to the growing recognition that plumbing defects are responsible for outbreaks of water-borne diseases.

A careful examination of sterilizing equipment of all the hospitals in Chicago was instituted shortly after Major Joel I. Connolly, chief of the bureau of public health engineering, had demonstrated to a group of hospital and health authorities how infective bacteria could pass through water pipes from utensil sterilizers or toilets into the sterile water tanks.

Subsequently, the Board of Health conducted demonstrations of these dangerous possibilities at a number of scientific meetings, among which might be mentioned the annual meetings of the American Hospital Association and the American College of Surgeons in 1928 and 1929, The American Public Health Association in 1928 and the American Water Works Association in 1930. A survey of hospital plumbing throughout Kansas was made since by the Board of Health of that state. Its report, presented to the Kansas Medical Society, shows that conditions there and in Chicago hospitals were much alike.

Samples of supposedly sterile water collected in hospitals showed that

[1]American Journal of Tropical Medicine, Volume 15, No. 4, July, 1935.

far too often the water was not sterile.

One hospital in Chicago was found to have eight separate cross-connections between sterile and unsterile water supplies, and one between the drinking water pipes and a sewer. Is it any wonder that this institution had a great many post-operative infections, or that the water, actually drawn from the sterile water tap during an operation was found to be not sterile? A simplified working model of the plumbing system, made of glass, to illustrate how contamination of the sterilized water occurs through cross-connections, was operated by the Chicago Board of Health throughout the meeting of the American Hospital Association held in Atlantic City in June, 1939, in order to acquaint those present with the hazards from this source.

As the result of our findings in hospitals, the manufacturers of sterilizing equipment brought out new designs, so that hospitals built or newly-equipped during the last six years have been able largely to avoid these dangers. Older hospitals should have a study made to determine what corrections should be made in their plumbing and sterilizers to eliminate danger of infections through the water supply. Hospitals in several cities, outside of Chicago, have also been visited by members of my staff, and have been found to have defects similar to those formerly existing here. Inasmuch as the entire breadth of the country from coast to coast was representated by the hospitals visited, it is apparent that this is not simply a local problem, but rather one of nation-wide importance.

The principles of modern aseptic surgery voiced by Lord Lister cannot be adhered to in any hospital where dangerous plumbing arrangements permit the contamination of the sterilized water used for washing the wounds, for making physiological salt solutions, for lap sponges, and the like.

A practice often noted is the connection of stills for distilling water for hospital use directly to the drain pipes. In one such case, our inspector found the still filling with water much more rapidly than it could possibly be distilled in apparatus of that size. The nurse operating the still said it acted that way once in a while, and she couldn't understand why. The inspector found the drain valve slightly open. The vacuum produced in the still by the condensation of steam was sucking sewage up into the distilled water from the drain pipe below. If a proper installation had been made of the drain by a competent plumber, this could not have occurred.

As water sterilizers are often installed, the same sort of thing may occur. The blow-off valves in the bottom of the sterilizing tanks are often found to be connected directly to the drain. Sewage may be drawn into the sterilized water through this connection if the valve is not absolutely tightly closed, because of the vacuum produced in the tank as the steam condenses after sterilization is completed. Devices for breaking the vacuum customarily provided with the sterilizer do not always work, and even when they do, it may be too slowly to prevent contamination of the sterilized water.

Any device in which a vacuum is produced has possibilities of trouble, if it be directly connected with a drain pipe. For example, not long ago, an investigation was made of the cause of several deaths of babies which occurred simultaneously in a large hospital. Among other things, it was found that the autoclave in which the babies' nursing bottles were sterilized had a drain pipe leading to a slop sink in another room. This drain was constantly filled with water because, for most of its length, it was lower than its outlet in the slop sink. Our engineers discovered that each time the autoclave was used, the vacuum produced by condensation of steam after sterilizing the nursing bottles, sucked about 300 cubic centimeters of water lying in the drain pipe back through the leaky check valve into the sterilizer.

This water ran out the door of the autoclave when it was opened, into a pan on the floor beneath and, undoubtedly, it frequently contaminated both the nursing bottles and the hands of the attendant, who took them from the autoclave and filled them with milk. Whenever the outlet of the slop sink or the drain below it became stopped up, the outlet of the autoclave drain would become submerged in the contents of the slop sink and the siphoning action of the vacuum in the autoclave would carry such sink contents into the drain pipe, thus contaminating the water constantly filling this pipe. Such contaminating materials would find their way from the sink into the autoclave and to the nursing bottles and attendants' hands. This occurrence emphasizes the unreliability of check valves and the need for proper supervision of plumbing installations.

Of course, we ordered this condition rectified at once. The practice of having the nurses change diapers and then put nipples on bottles shortly afterward was also changed at the same time. The intestinal disturbances which caused the deaths of the babies then disappeared.

The faulty plumbing conditions observed in the hospitals during the present investigation substantiate the article quoted above in that similar defects were found. In one hospital some newly installed instrument sterilizing equipment provided proper protection against back siphonage, but many plumbing defects still exist at this institution such as those on bed pan washers, flushometer stools and urinals, autoclaves, et cetera. Recommendations were made to install proper equipment to eliminate the hazards as soon as possible.

In another instance the installation of a pressure recording gage disclosed a negative water pressure of six inches of vacuum in at least two instances and exceptionally low pressures during the entire period of the pressure recording. There were numerous other typical hospital plumbing defects in this building, but one particular defect is well worth noting. The hot water supply lines to the third floor delivery room were so filled with encrustation that hot water for a delivery had to be brought from the operating rooms across the hall. Also, sewer drain serving the delivery room sink is and has been partially plugged for over seven years. As a result, the practice of laundering bloody linens, following deliveries, in this room permitted bloody water to traverse the waste pipe to the basement only to be retarded by the partially plugged sewer in the basement. This stoppage of flow resulted in the backing up of waste water into a kitchen sink in the basement which was connected to the same sewer. Since that time the linens have been washed in the operating room, leaving the plugged drain line stopped up. The reason for the lack of maintenance in this case was not investigated.

Early provision should be made to remove the cause of stoppage from waste lines, install new water service lines and vacuum-breaker valves on the water and instrument sterilization units, eliminate the submerged inlets on the X-ray tanks, equip all stools with vacuum-breaker valves, and eliminate other defective plumbing. A complete list of faulty errors may be obtained from the original investigation blank.

In a hospital where practices of sanitary housekeeping and supposedly sterile operations are always required, it is a hideous crime to permit such insanitary conditions to exist.

To eliminate such public health hazzards several large municipalities or organizations have conducted cross-connection surveys in relatively recent times. After the Chicago amoebic dysentery outbreak that city instituted the most noteworthy and extensive survey of its kind ever to be conducted, at an expenditure of $1,000,000.

Since 1933 similar surveys have been undertaken in other cities by various agencies. The Federal government conducted a cross-connection survey in all Federal buildings in New York and Detroit which was the results of which were announced early in 1938. At present such a survey is being carried out in Cleveland, Ohio, at an original estimated expenditure of $1,081,830.

Many plumbing errors have been discovered in these surveys. As a result efforts are being made to eliminate the hazardous conditions.

In smaller communities such as the one surveyed, public health is none the less important. For this reason all communities should conduct a survey of the immediate locality to determine such hazards as do exist and to institute a program for their elimination.

Due to the size of larger cities, the cost of financing such a survey has been a staggering figure as viewed by smaller communities. Perhaps this accounts for the lack of such surveys in smaller communities. They believe that the cost would be excessive and the community could never benefit proportionately.

In any county health unit a well-trained public health engineer can be of invaluable assistance in conducting such a survey and designing methods of eliminating the errors. As visits or inspections to various places in the community are made he can be on the alert for cross-connections. A person must have a fundamental background in the principles of hydraulics and back-siphonage to conduct such a program. In view of these facts, no community served by a sanitary or public health engineer can excuse itself for lack of knowledge of the plumbing hazards that surround it.

CHAPTER III

THE DANGERS OF CROSS-CONNECTIONS

EXAMPLES OF CROSS-CONNECTION HAZARDS

One of the most recent and large scale hazards to occur from a cross-connection was at Rochester, New York, in December, 1940. (See article on page 83. Because a workman inadvertently opened a wrong valve, approximately 4,000,000 gallons of contaminated water from the thaw-high Genesee river had poured into Rochester's drinking water. This hazardous condition existed for 17 hours before it was discovered and corrected.

Herman N. Bundensen,[1] President of the Chicago Board of Health, 1934, relates four outbreaks of disease within the city which occurred during the previous year and a half. The salient facts may be of interest.

> In June, 1933, the foreman on the eighth floor of a factory asked for more water. The engineer of the building sent an ignorant workman, not a licensed plumber, to make a connection to a city water pipe to supply the additional water. He thought he could save an hour by doing the work contrary to his instructions, and unknowingly, he made a direct cross-connection between the city water and a pipe carrying an industrial water supply taken directly from the sewage-polluted Chicago River. An outbreak of diarrhea immediately followed. Owing to the color and taste of the water, a cross-connection was suspected by the factory management. They investigated, found it, and removed it after it had been in place for three days. On one of these three days the factory operated, and it was shut down on the other two, which were Saturday and Sunday. Nothing was reported to the Board of Health at the time, either about the diarrhea and nausea, or about the cross-connection.
>
> A little later, we heard of the outbreak, but no cross-connection could be found, the factory having already removed it. The trouble was blamed by the factory upon decaying fish in a dead end street main nearby.
>
> On July third, one of the employes came down with typhoid fever. Knowing that dead fish couldn't be the cause of this disease, we demanded the truth, and a confession was made by the factory superintendent about the former existence of the cross-connection. The patient died on July 10. A subsequent examination of stool speciments from all employes, for *Endamoeba histolytica*, indicated that a considerable proportion were carriers and one active case of amebic dysentery developed.
>
> The other factory outbreak occurred in December, 1933, The diarrhea and nausea affected the greater part of the force of 375 employes, but was not reported at once. Five days after it commenced, an employe asked to have the drinking water tested, and upon being questioned as to the reason for his request, the existence of the epidemic was learned. Within the next three hours, the plumbing inspector I sent there had discovered a cross-connection between the city water and the river water supply used for cooling and fire protection. Three typhoid fever cases and one amebic dysentery case developed among the employes.
>
> Although, during the summer of 1933, our inspectors had discovered a priming connection from a city water pipe to the pump handling river water and had required it to be removed, the engineer of the factory didn't take

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[1]*Plumbing in Relation to Infectious Diseases,* American Journal of Tropical Medicine, Volume 15 No. 4, July 1935.

much stock in the idea that cross-connections were dangerous. Therefore, when it was necessary to shut down the river water system during the first part of December, to install some new screens in the intake at the river, he cross-connected the city water system with the river water pipes, in order to fill the boilers and be ready to operate on the following Monday. Then, when the river water pump was started, the sewage-polluted water passed through this cross-connection into the drinking water. Because of his inability to learn safe practices and his indifferent attitude, the engineer of the factory was replaced with a more up-to-date man. Here, also, an examination of stools from all employes was made between January 8, and 16, and 73 carriers of *Endamoeba histolytica* were found. In addition, all the food products made in this factory during the time the cross-connection existed, which were likely to be eaten without further cooking, were required to be reprocessed, in order to assure that disease could not be spread through them to the consumers.

In both of these factory outbreaks, proper observance of the plumbing code would have prevented the disease outbreaks.

(The third outbreak discussed is the Chicago Epidemic. See Chapter II, page 21).

The fourth recent outbreak of water-borne disease is one of typhoid fever and amebic dysentery which occurred among firemen and spectators at the great stock yards fire in May of this year. Sixty-nine cases of typhoid fever with 11 deaths, and 11 cases of amebic dysentery with 1 death, occurred from drinking water used ordinarily only for cattle. This water was known by the employes of the stock yards to be unfit to drink, but people not aware of this fact used it with tragic results. The source of the contaminated water has been abandoned as the result of that experience.

That valves on connecting piping between a potable and an unsafe source of supply do not afford positive protection is exemplified by the experience at the Golden Gate Exposition on Treasure Island in San Francisco Bay. A summary of this case, as reported by J. C. Geiger,[1] is presented below:

Cross-connections between the potable water supply and a contaminated salt-water fire supply were made at 4 points in the distribution system of the Golden Gate Exposition on Treasure Island. The connections were made over the protest of the San Francisco Department of Public Health. Only separation of the supplies at 3 points was by means of double, manually operated gate valves. A 5-alarm fire occurred on August 24, 1940. It was claimed that all of these valves were closed promptly after the alarm and before any fire pumps started operation. Nevertheless, heavy concentrations of salt water were detected in the domestic water system within 3 hours after the original alarm. Coliform contamination was subsequently found. Prompt action was taken by the San Francisco Health Department in warning consumers and disinfecting both distribution systems, with the result that domestic water service was restored within 15 hours after pollution had been detected. The alertness of the health department may have prevented a serious outbreak of disease. This incident is one more telling argument for complete separation of potable and unsafe water supplies.

[1]J. C. Geiger, Pollution of Drinking Water Through Cross-Connection with Fire Lines, Jr. Am. Water Works Assoc., Dec. 1940.

Public health and water works literature is full of such reports, all adding to the evidence that protection of the source of supply alone is not sufficient to insure freedom from water-borne outbreaks. The following examples were reported by the U. S. Public Health Service.[1]

> Several years ago an investigation at a railroad coachyard involving a connection between the company raw water supply and the treated municipal supply disclosed the fact that the single valve between the two supplies was partially open and that the raw water meter was registering a flow of 265 gallons per minute while the treated water meter was running in reverse. Meter readings of water consumption indicated that the defective valve condition resulting in reverse flow had existed for at least thirteen hours, resulting in a serious contamination of the clean supply. The connection was promptly eliminated.
>
> Another interesting example bearing out the old proverb, 'Eternal vigilance is the price of freedom', concerns a cross-connection at a Florida seaport, discovered fortunately before serious damage could take place. While a fire hose conveying fresh water from a pier hydrant to a vessel was in place, the vessel crew engaged in a fire drill. The fire system pump on the vessel operating at a higher pressure than that of the city forced contaminated water from the harbor into the city system. Luckily the presence of the salt water in the city mains was discovered when a short section of pipe blew out. The mains were promptly flushed and sterilized with chlorine. Since the harbor was grossly polluted by sewer outfalls near the point where the ship was loading, it is quite possible that serious contamination might have been introduced into the mains.
>
> Close cooperation between the sanitary officers and the local water department official will usually be the means of discovering numerous unprotected cross-connections. When the dangerous potentialities of cross-connection are explained to the private interests concerned, a large proportion of these conditions will be eliminated or at least adequately protected until final severance becomes possible.

CONDITIONS WHICH MAY CAUSE CONTAMINATION

Water is a relatively non-compressible fluid that flows in accordance with well-established principles. Polluted water such as sewage or other wastes submits to the same rules as drinking or fresh water. Either potable or nonpotable fluids flow from areas of higher pressure to areas of lower pressure at rates which are dependent upon the amount of friction they must overcome and the hydraulic gradient or difference in pressures.

The average person is obsessed with the erroneous idea that flow in waste lines is always away from the source of such wastes, and that water always flows out of, and not into, water lines. Any one of a large number of reasons such as stoppages or overloading may cause sewage to back up in waste lines and flood the fixtures connected thereto. Such reasons as those listed in the following paragraphs may be the cause for the failure of water pressure or the creation of partial vacuum in supply lines.

A familiar plumbing fixture is a lavatory to which are attached a hot and cold water connection and a waste connection. When the drain plug

[1]The Health Officer, U. S. Public Health Service, November 1939.

is pulled, a person expects the dirty water to be carried off through the waste connection. Since there are no devices on the waste line to prevent reverse flow, dirty water, sewage or other wastes may flow backward through this same pipe and into the basin. One expects water to flow when the faucets are turned on, and this usually happens. But it is not an uncommon occurrence on "wash days" when large amounts of water are being used in basements to open faucets on upper floors and hear only a "woosh" of air as it rushes into the pipes to relieve a partial vacuum. Or another phenomenon, which most people have experienced at one time or another, is to open the faucet and have it spit out air and water. Does one ever stop to think where this air might have come from? Seldom, if ever. A person would have only to reflect for a moment before he would realize that this air came through some outlet when the line was under partial vacuum. To consider the possible sources from which this could have originated might be an astonishing revelation.

Reduced pressure or partial vacuum within the pure water system may be caused by any of the following factors or by a combination of several of them:

1. Shutting off the supply for maintenance of the street main or repairs to plumbing within the building. This is the single most frequent cause of partial vacuum and occurs when the water service is shut off. Immediately after the supply has been shut off, the faucets on all branch connections should be opened to relieve the partial vacuum.
2. Excessive demand from mains for fire fighting purposes.
3. Failure of supply system due to main break, damaged pumps, power shut-off, deficient water supply, or labor difficulties.
4. Freezing of mains or services in extremely cold weather.
5. Excessive friction caused by too small pipe lines, or by deposits of scale in lines which reduces the effective pipe diameter.
6. Occurrence of water-hammer.
7. Condensation of steam within boilers, hot water systems, or such units as hospital sterilization equipment.

PLUMBING DEFECTS IN CALHOUN COUNTY

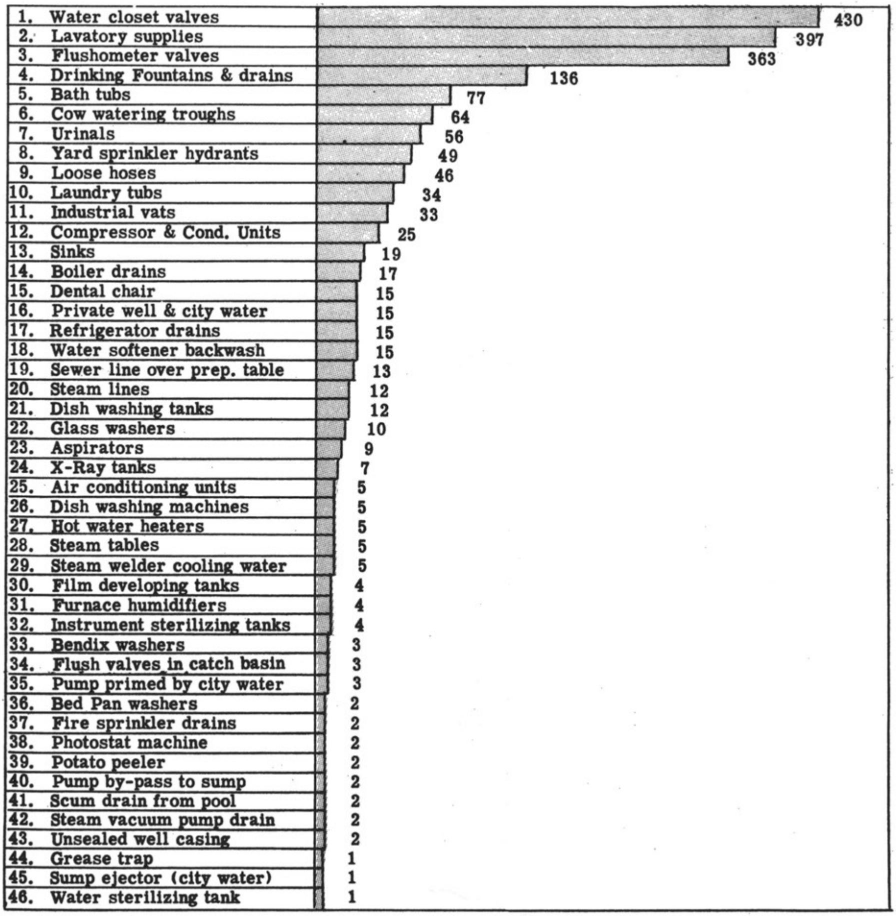


Fig. 1.

PLUMBING DEFECTS IN ALBION

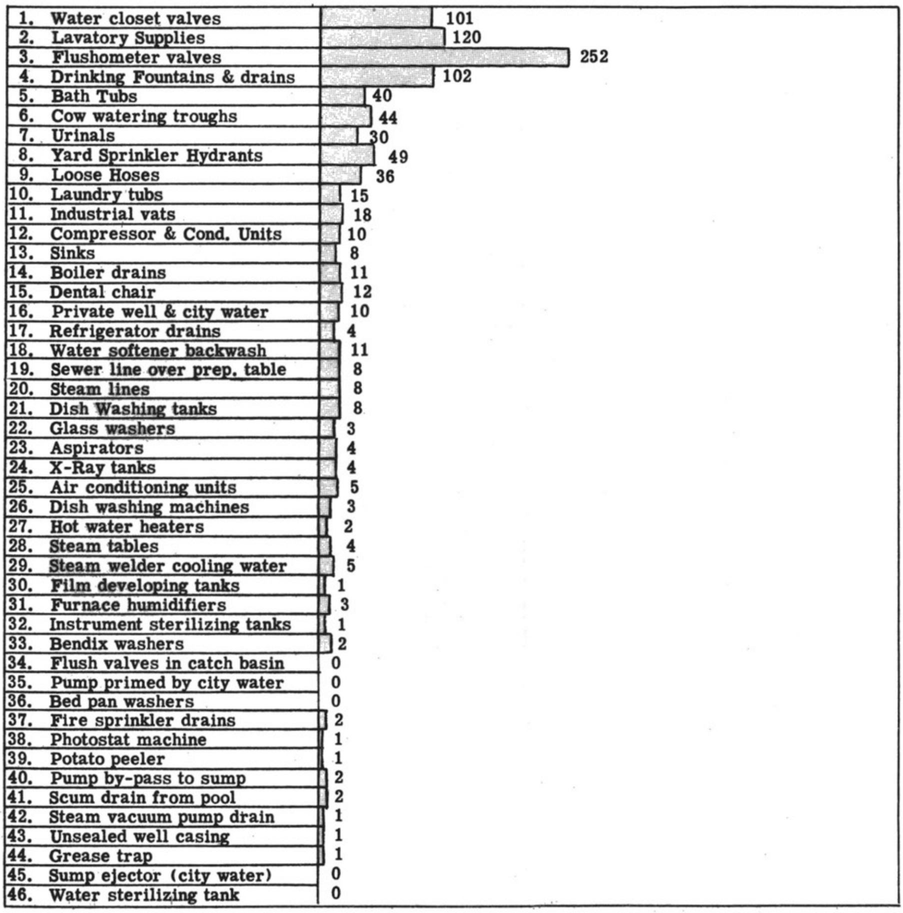


Fig. 2.

PLUMBING DEFECTS IN MARSHALL

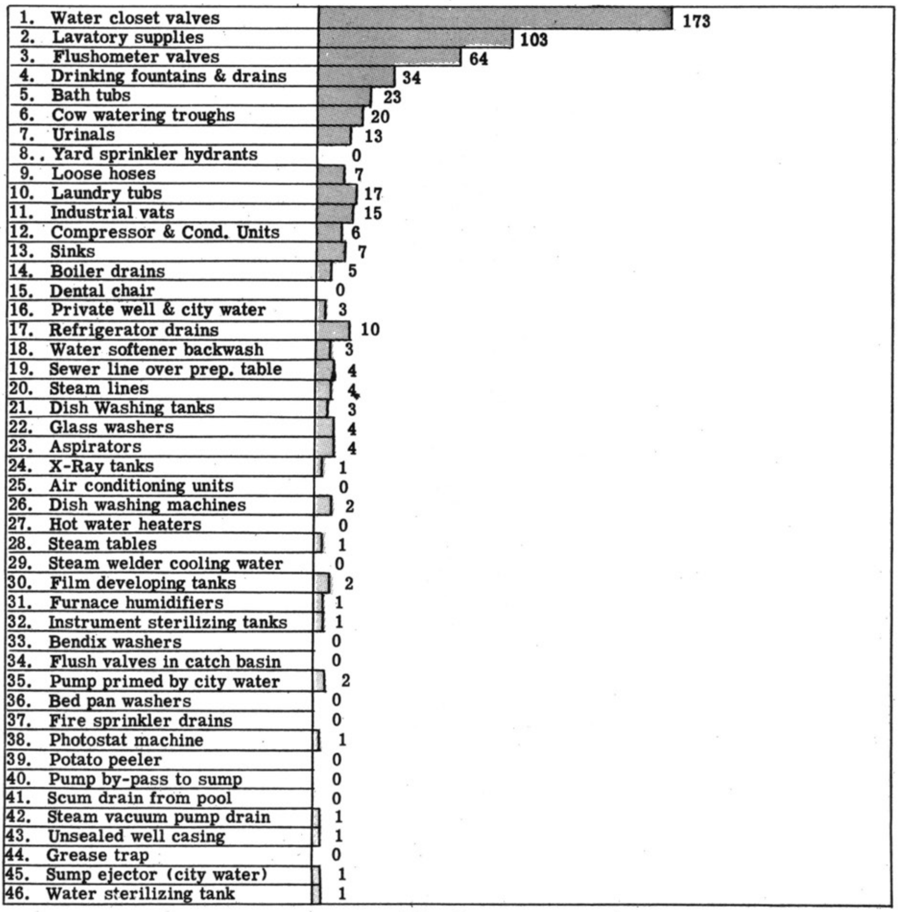


Fig. 3.

PLUMBING DEFECTS IN BATTLE CREEK

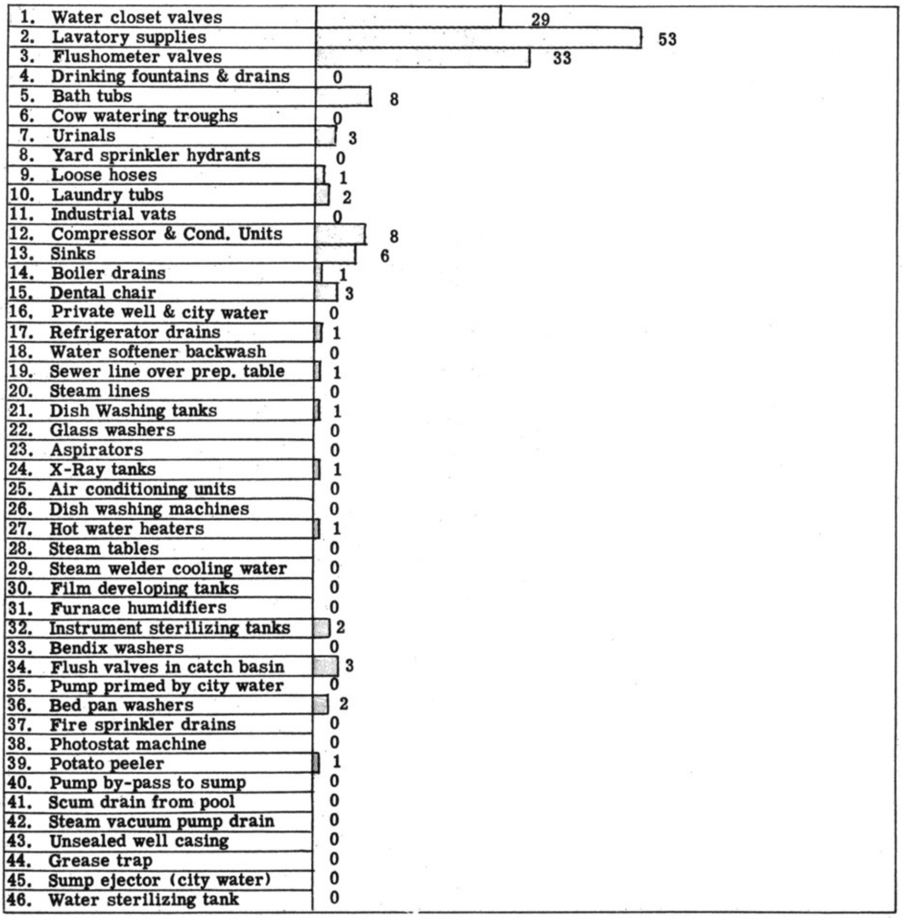


Fig. 4.

PLUMBING DEFECTS IN HOMER

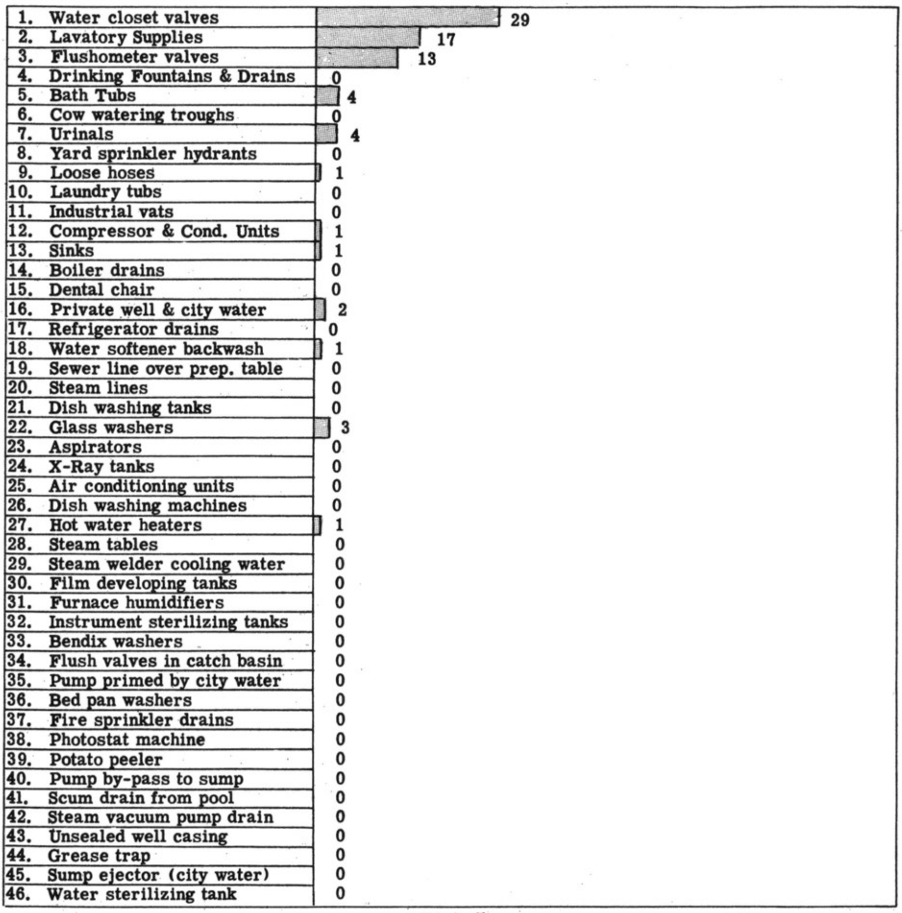


Fig. 5.

CHAPTER IV

THE CALHOUN COUNTY CROSS-CONNECTION SURVEY

SUMMARY OF DEFECTS

The investigation of sanitary conditions in a limited number of buildings, which were chosen from a cross-section of the area, revealed certain conditions needing correction. The survey shows a recorded list totaling 1935 defects which are either cross-connections or cross-connection conditions whereby drinking water could become contaminated from one source or another. Following is a report of the cross-connections and cross-connection conditions recorded during the investigation.

Most items in the list are self explanatory. The heading "Public Buildings" included a variety of establishments which are post offices, court house, county jails, county health department, American Legion Hall, churches, bus stations, railroad stations, city halls, theaters, Masonic Temple, Leisure Hour Club, athletic field, and Community House.

A more compact picture of the findings can be acquired if the list is divided into the following classifications:

Cross-connections found (direct)	1208
Cross-connection conditions found (indirect)	727
	1935

In any building where two supplies exist, one safe and one unsafe, there is always the danger of direct cross-connections. The possibility of hazardous conditions becomes increasingly likely with one or more connections between the two supplies. Even in the event that both supplies are safe and potable, no direct connection should be made between the two systems unless both systems are supervised and maintained in a sanitary manner. Certain manufacturing processes and expensive machinery may sometimes be ruined in the course of operation provided an auxiliary supply is not immediately available. In these cases some states will permit a direct cross-connection provided two bronze check-valves with drain cocks are properly installed and maintained on the safe supply line. These check-valves should be inspected at least once a month for defects.

It cannot be overemphasized that any such connection is a dangerous practice. Check-valves, gate-valves, globe-valves or any other valves on such cross-connections are not to be trusted to safeguard the health of those using the drinking water supply. Too many instances stand ready to testify that valve combinations, intended to segregate and prevent the intermixing of the two supplies, have failed. A slight pressure differential in favor of the polluted supply permits unsafe water to enter the potable water lines through malfunctioning check-valves.

Not infrequently waste water from cooling devices runs directly into the sewer system. Several defects were discovered where the water line was piped directly into cooling devices such as an air conditioning unit, the cooling coil of a refrigeration system, the cooling head on a motor or compressor unit, and the cooling section of steam welding machinery; and then discharged through a closed system into a sewer line. Such installations constitute direct connections between the water lines and the sewer system. Should the water pressure fail, sewage could gain entrance to the water supply through this closed system.

Other formidable defects are flushometer type hospital bed pan washers, flushometer valves on stools, and certain styles of siphonic urinals. These, as with dual supplies, can and should be corrected to safeguard the water supply from gross pollution.

Mention is made here of only a few of the defects. From the summary sheet one can obtain a visual picture of the different types of faulty plumbing or fixture designs. In Appendix B diagrams may be found which depict the errors in design or installation and suggested remedial installations.

LIST OF DANGEROUS CROSS-CONNECTIONS

The following is a partial list of dangerous cross-connections that may be found in an average community:

1. Air-conditioning equipment with dual safe and unsafe water supplies or with direct sewer connection for waste water.
2. Aquariums with below-the-rim connections.
3. Aspirators as used in funeral homes for operations.
4. Automatic devices for sealing floor drains.
5. Bathtubs with below-the-rim connections.
6. Bar sinks with submerged inlets.
7. Bendix washing machines with submerged inlets (or similar type).
8. Bird baths with submerged inlets.
9. Boiler drains solid to sewer.
10. Cellar drains of the water-ejector type.
11. Cisterns cross-connected to pure water lines.
12. Closets with drip waste to sewer or polluted ground area.
13. Closets of the hopper type with manual or automatic flushing apparatus.
14. Closets equipped with flush valves attached to bowl.
15. Coffee urns with submerged inlets.
16. Combination faucets with one safe and one unsafe supply.
17. Cookers with submerged inlets.
18. Cow watering troughs with submerged inlets.
19. Cross-Connections between safe and unsafe supplies, sprinkler systems and the like.
20. Cuspidors with water supply connections.
21. Dental chairs with submerged inlets.
22. Dish washers with water inlet below the rim or with direct sewer connection on waste line.
23. Drinking fountains with submerged inlets, water supply connections

through waste lines, or waste lines directly connected to sewer.

24. Dual water supplies, such as hot water supply from an unsafe source.
25. Egg boilers with common waste and supply lines, submerged inlets, or waste lines directly connected to sewer.
26. Ejectors actuated by direct water connection.
27. Faucet flush valve in catch basin.
28. Filters with waste connected directly to sewer line.
29. Fire supply from unsafe source directly connected to pure water supply.
30. Fire supply from safe source directly connected to sewer.
31. Fish ponds with submerged inlets.
32. Floor drains with flushing connections.
33. Flush-boxes with submerged inlets.
34. Flush valves not protected by siphon breakers.
35. Foot tubs with submerged supplies.
36. Fountains with submerged supplies or supplies connected through waste lines.
37. Frost-proof closets with bleeder line connected to sewer or polluted ground area.
38. Furnace humidifier boxes with submerged inlets.
39. Glass tumbler washers in beverage sinks with submerged supplies.
40. Hot water heater drain directly connected to sewer.
41. Ice cream scoop washers with submerged supplies.
42. Industrial vats with submerged supplies.
43. Instrument sterilizing tank with submerged supplies or direct sewer connections.
44. Integral flush-box and toilet bowl.
45. Kitchen equipment with common waste and supply lines, with submerged inlets, or with waste line direct connected to sewer.
46. Laundry tubs with submerged inlets.
47. Lavatories with submerged inlets or with hose extending below rim, such as barbers' and beauticians' hair-washing apparatus.
48. Lawn sprinklers with subgrade outlets.
49. Leaky water mains or services near sewers.
50. Photostat machines with submerged inlets.
51. Pumps used for dual purposes with one safe and one unsafe supply.
52. Pumps used for unsafe materials and having a direct connected water supply for priming.
53. Pump pits with drain connected to sump or sewer line.
54. Refrigeration equipment with water cooling.
55. Rubber hose connections extending water lines to below the overflow rim of sinks, lavatories, tanks, tubs, and the like.
56. Sealing rings on sewage pumps with direct water connections.
57. Scum drains from swimming pools directly connected to sewer.
58. Sewage lifts with direct water connections.
59. Sewers or waste lines running over open pure water tanks, ice water

vats, or food storage or food preparation benches and equipment.

60. Showers with one safe and one unsafe supply.
61. Sinks with below-the-rim supplies.
62. Soap kettles with submerged supplies.
63. Soda fountain sinks with submerged supplies.
64. Steam tables with common waste and supply lines, with submerged supply lines, or with waste lines directly connected to sewer.
65. Steam welding unit cooling water directly connected to sewer.
66. Steam vacuum pumps directly connected to sewer.
67. Swimming pools with direct water connections.
68. Siphon flush-tanks with water connections below the overflow rim.
69. Siphon-jet toilet bowls with flush valves directly connected.
70. Tanks with submerged supply or below-the-rim supply.
71. Therapeutic baths with submerged inlets.
72. Urinals with flush valves not protected by siphon breakers.
73. Vats with inverted supplies or below-the-rim supplies.
74. Vegetable peelers with direct-connected waste lines.
75. Washers with common waste and supply lines, with submerged inlets, or with direct-connected waste lines.
76. Waste lines from cooling equipment; condensors or water jackets directly connected to sewer or submerged in slop sink, floor drain or other fixture.
77. Water cooled grease interceptors with direct water connection.
78. Water coolers improperly designed and using toxic refrigerants that may pollute the water supply.
79. Water softeners with direct sewer connections or with submerged inlets to solution tanks.
80. X-Ray tanks with submerged inlets.
81. Yard hydrants so constructed that polluted water may drain into the water supply lines.

FIELD PICTURES TAKEN DURING THE SURVEY

The following photographs are presented to illustrate some of the defects which were observed during the survey. These by no means represent all the different types of cross-connections that exist in a rural community. It is hoped that by observing the following defects a working knowledge of cross-connections may be obtained.

The pictures are to be used only as illustrations of some cross-connection or plumbing hazard and in no way are to be used discriminantly against persons or establishments.

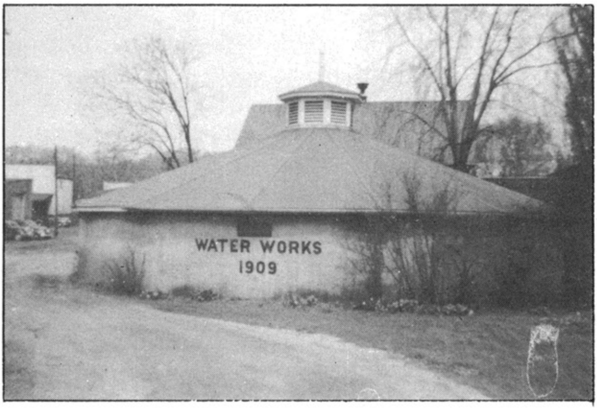


Fig. 6.—A picture of a municipal water supply reservoir.

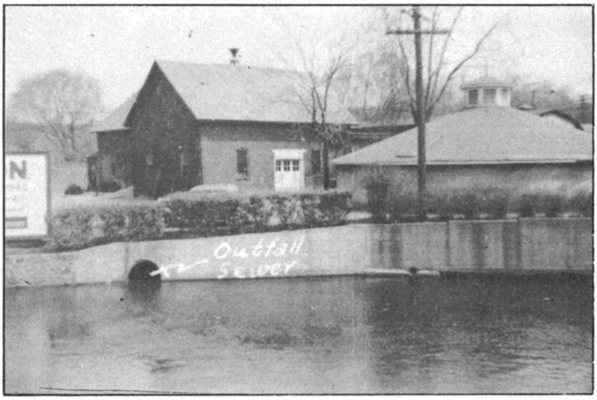


Fig. 7.—A three-foot outfall sewer from the city which carries some sewage in addition to storm water to the river in the immediate foreground.

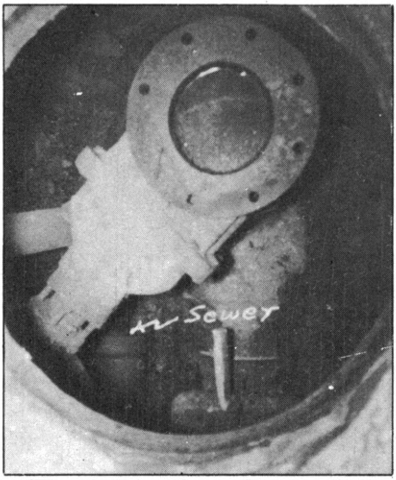


Fig. 8.—A view of one of the well supplies to the reservoir which is located in the interior of the pumping plant. Observe the sewer line in the well pit below the gate valve.

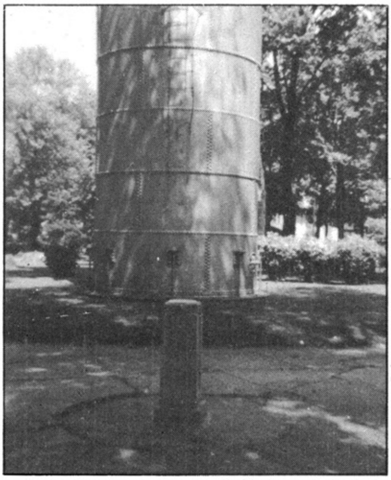


Fig. 9.—A view of the standpipe for the city to which water is pumped every hour.

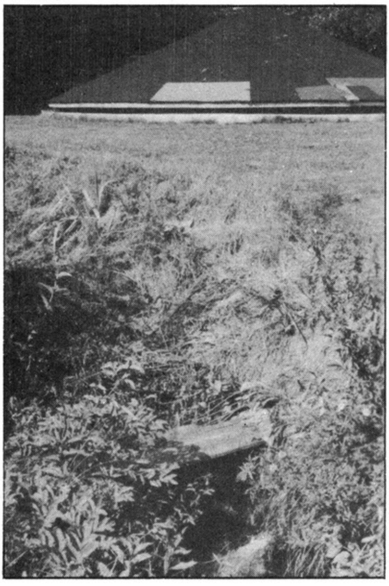


Fig. 10.—A drain in the foreground. This is the point at which the effluent from a septic tank on the premises unites with the overflow drain from the water supply reservoir shown in the background.

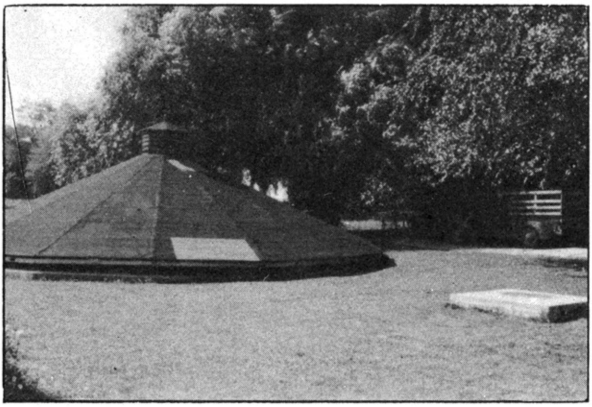


Fig. 11.—A view of one of the wells which supplies the reservoir. (Concrete block near right edge.) The reservoir is supplied by four four-inch wells in the bottom of the reservoir and one eight-inch well outside, each of which is 85 feet deep.

On August 30, 1940, the sanitarian and one of his assistants drilled some test holes outside the walls of the reservoir. With all pumps in operation, the maximum reservoir drawdown was 8 feet, but the water in the test hole fluctuated as much as 24 inches. This indicated that the reservoir is a large dug well with pervious walls. The septic tank effluent is 15 feet from the reservoir. See diagram 3, Appendix B for plan view.

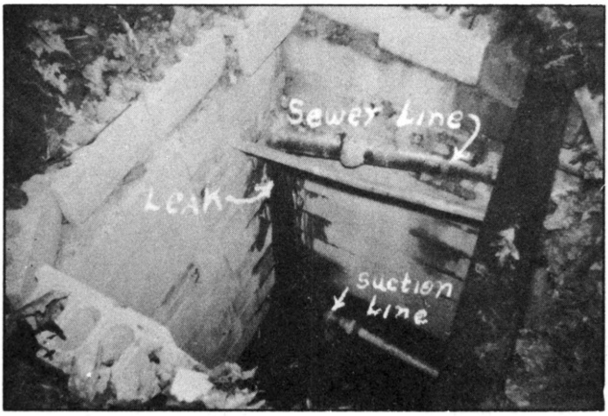


Fig. 12.—An example of gross pollution of a privately owned municipal supply. This well supplies 21 homes in the immediate vicinity. One of the residents requested that a water sample be taken and analyzed because her children were always complaining about stomach aches. This is the phenomenal sight that presented itself. A vitrified tile sewer line passes through the upper corner of the well pit (see arrow), and leaked every time the toilet was flushed. (Note the leakage down the wall). When this picture was taken, approximately a foot of sewage was standing in the pit. There was no seal between the drop tube and the casing of the 90 foot drilled well. When the pump inside the house operated, sewage lowered in the pit into the well water supply and distributed to these 21 homes. Analysis on the water sample showed 10 B. Coli per 100 cubic centimeters. The homes are now supplied by city water.

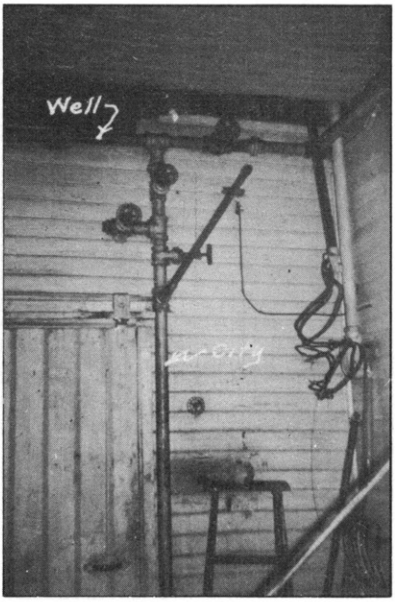


Fig. 13.—A cross-connection between a private well water supply and a city supply.

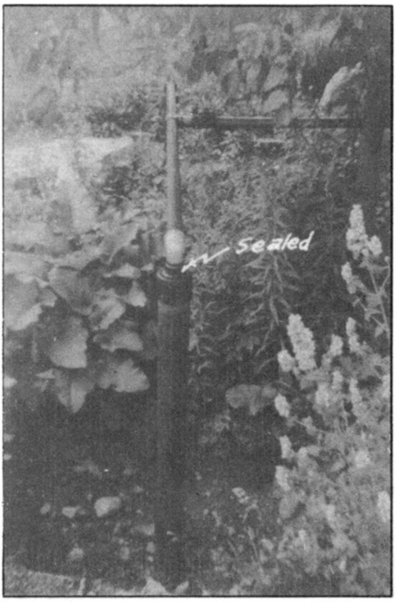


Fig. 14.—The private well.

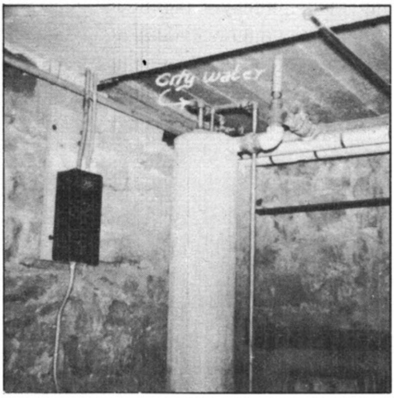


Fig. 15.—A cross-connection between another private well supply and the city supply.

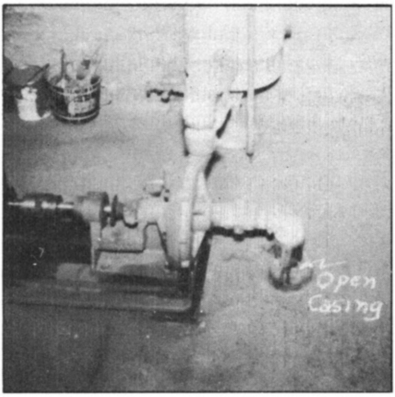
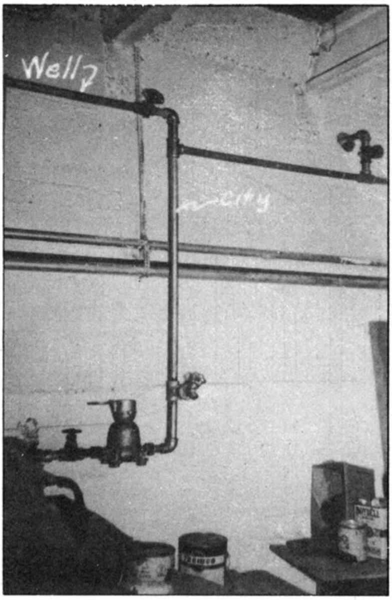
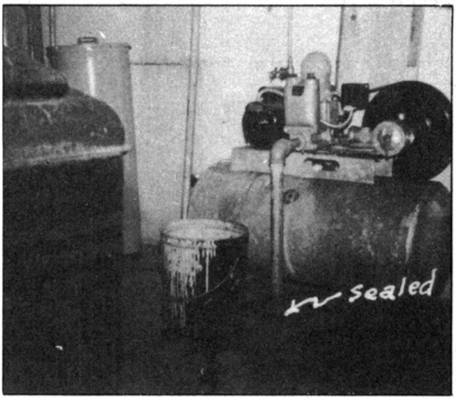


Fig. 16.—The unsealed well casing at the floor level—an unsafe supply.





Figs. 17 and 18.—A private well at a funeral home cross-connected with the city supply. Both views from the same building.

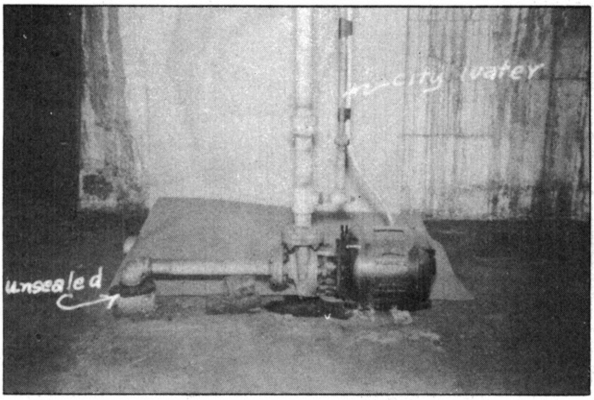


Fig. 19.—A city water supply cross-connected to the discharge side of a pump on a private well, for the purpose of priming the pump. The pump supplies water to an air conditioning unit at a theater and discharges to the city sewer through a closed system.

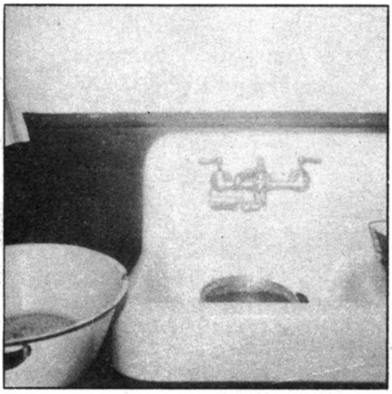


Fig. 20.—"Three-way" valve supplied with cistern and city water. This is the valve mentioned earlier in the report. The middle valve has "Drink" engraved on it, but is supplied by cistern water.

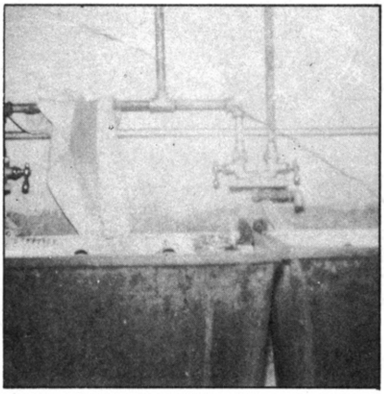


Fig. 21.—Basement of the home, Fig. 20, where the two supplies are again cross-connected.

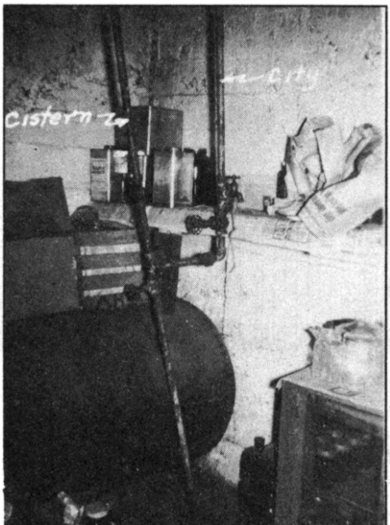


Fig. 22.—Another typical cross-connection.

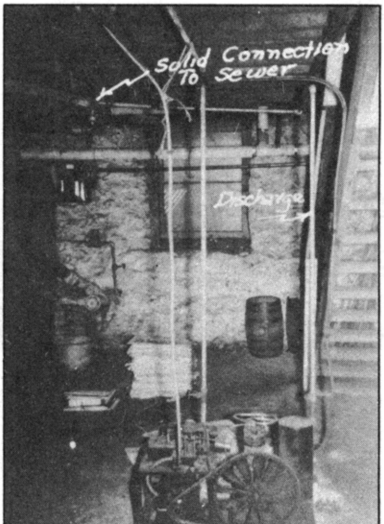


Fig. 23.—A water cooled condenser unit with unbroken connection to sewer.

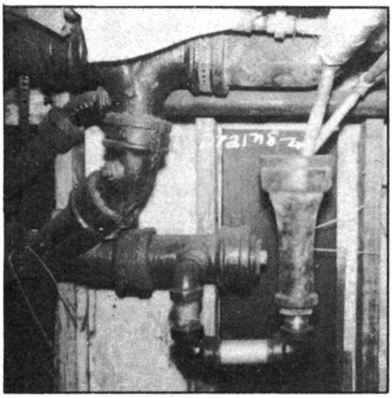


Fig. 24.—An unbroken connection between air conditioning cooling water and sewer.

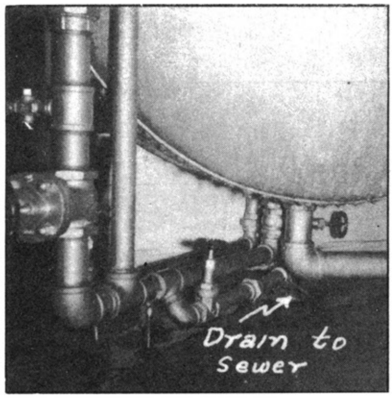


Fig. 25.— Awater supply tank at hospital cross connected to sewer.

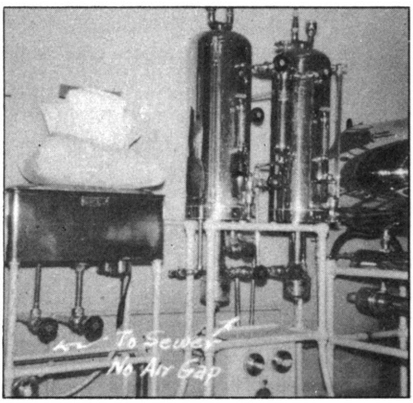


Fig. 26.—Unbroken connections on drains for sterilization equipment at a hospital.

Fig. 27.—A view of the operating room displaying an expensive bank of lights by which to operate. Post-operative infections have occurred in numerous cases from such installations as shown in Fig. 26. This is the hospital, mentioned earlier, in which there is a plugged sewer line and water supply lines which are heavily encrusted.

Question: Which is more important, expensive lights or sterile instruments?

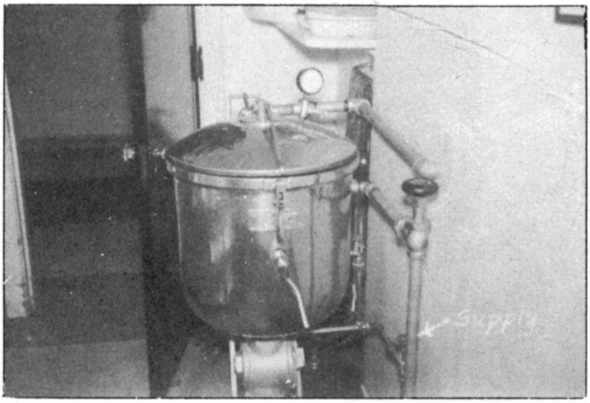


Fig. 28.—A bed pan washer at a hospital with submerged supply. These are always to be considered a definite hazard to the water supply when installed in a manner similar to that shown.

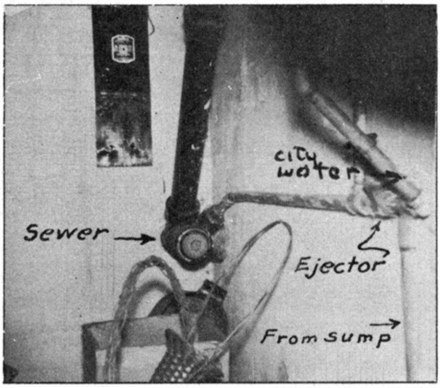


Fig. 29.—A water operated sump ejector. The water supply has two contaminated sources on the other side of the control valve; one is the sewer, the other the sump.

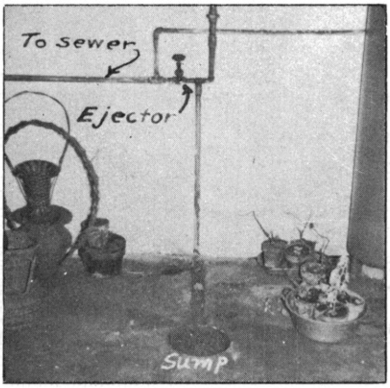


Fig. 30.—Another view showing the sump.

Fig. 31.—A flushometer valve at a school with no vacuum breaker.

Fig. 32.—A side spud flushometer valve at a church with no vacuum breaker.

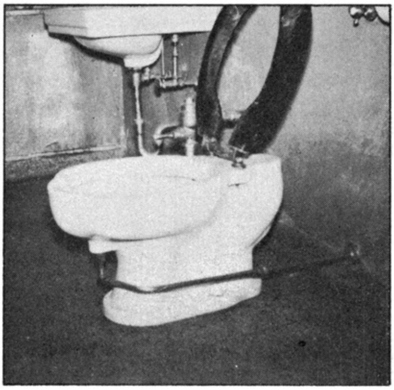


Fig. 33.—A flushometer valve at an infirmary with no vacuum breaker.

Fig. 34.—A side spud flushometer valve at a school with no vacuum breaker.

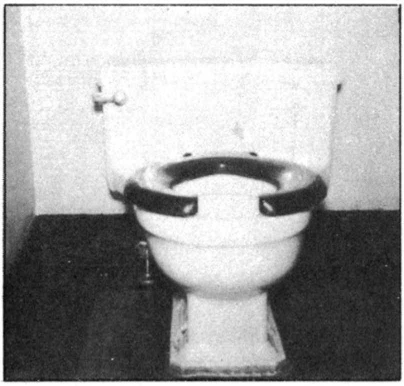


Fig. 35.—A water closet as an integral part of the school, submerged valve supply.

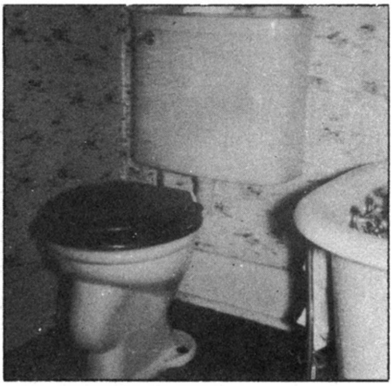
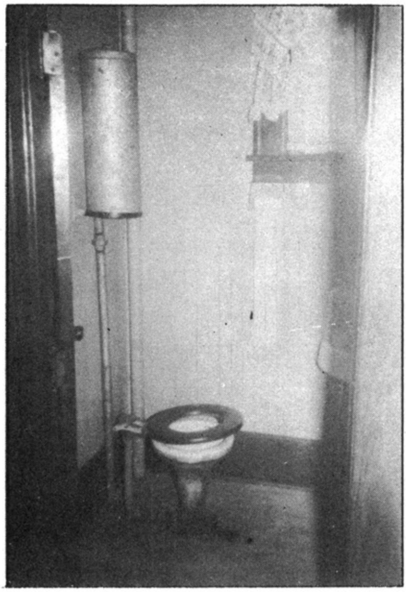
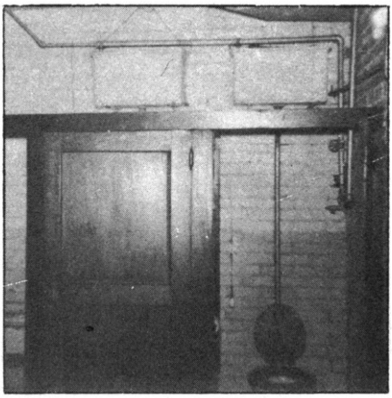


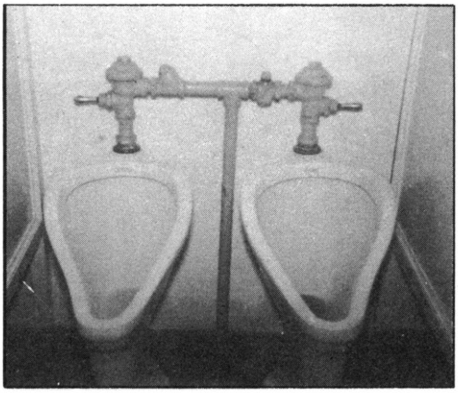
Fig. 36.—A water closet wall-supported, submerged valve supply. This is a common defect.

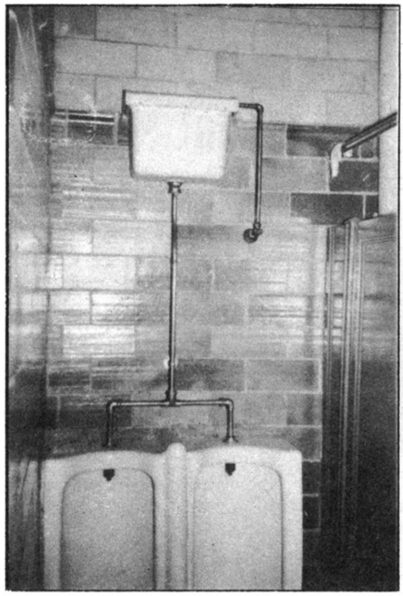




(Left) Fig. 37.—A seat operated flush stool.

(Above) Fig. 38.—A submerged inlets in open top pull-chain type stools located at a school.





(Above) Fig. 39.—Flushometer valves with no vacuum breakers. This is a siphonic jet type of urinal and under the conditions of a negative pressure and leaking or open valve, the trapped wastes in the bottom could be siphoned into the water supply line. These fixtures were found in a hospital.

(Right) Fig. 40.—A urinal at a high school. Submerged inlet in the elevated, covered, tank. The cover affords some protection against contamination. A negative pressure could only siphon water from the elevated tank.

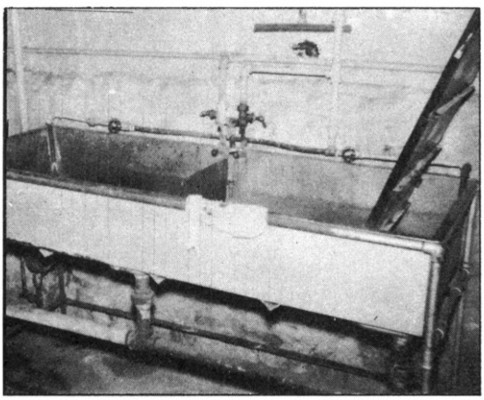


Fig. 41.—Photostat developing tanks. The two supplies enter the tank at opposite corners and discharge through a perforated line which is laid around the bottom edge of each tank. The perforated lines are constantly submerged during the developing process.

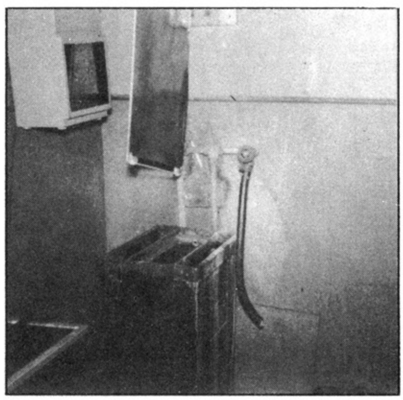


Fig. 42.—An X-Ray tank and hose on water supply which is submerged when washing negatives.

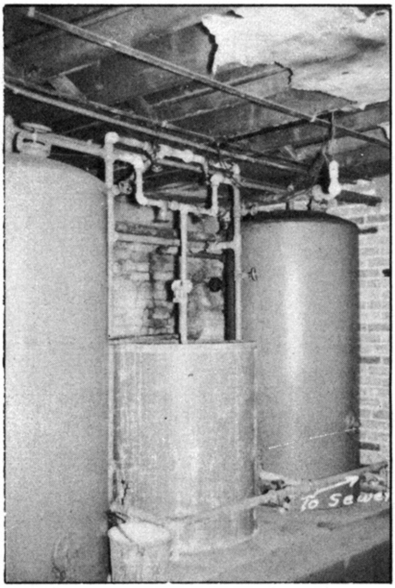


Fig. 43.—A water softener located at an infirmary. There is a submerged inlet in the brine tank and the backwash is connected to the sewer with no air gap.

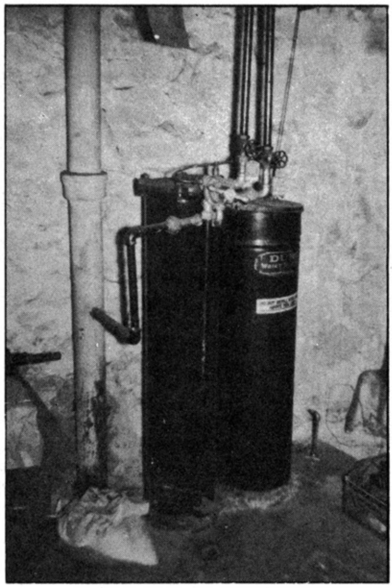


Fig. 44.—This plumbing hazard was found in a funeral home. The backwash line from this softener is an integral part of the sewer. The solid connection would permit sewage to enter the supply tank in case of a stoppage.

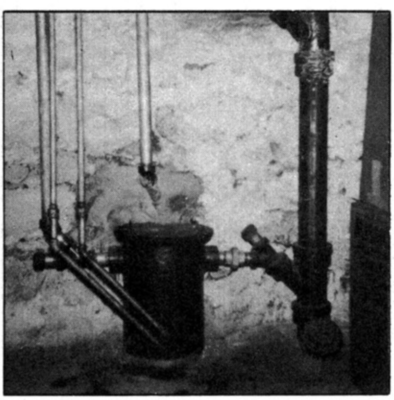
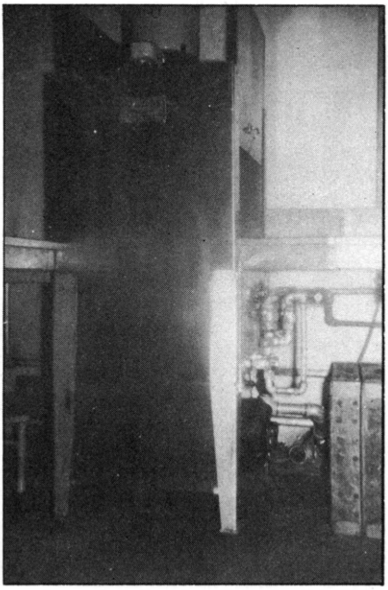


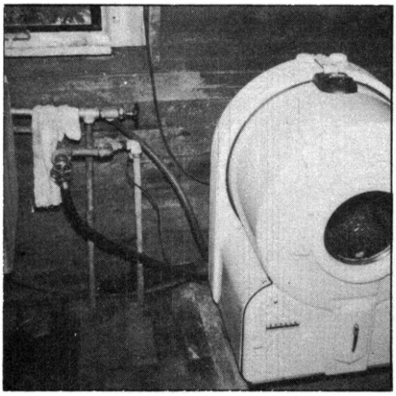
Fig. 45.—A grease trap with two submerged water lines, located at a college restaurant.

Fig. 46.—A sewer line over a food preparation table for a hospital.

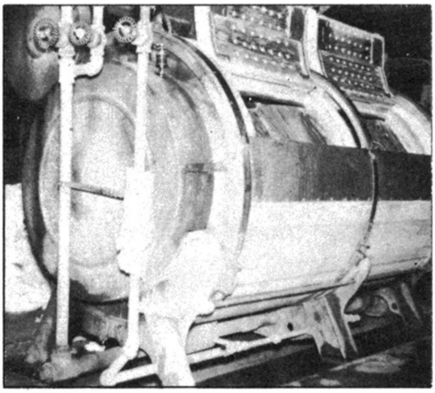


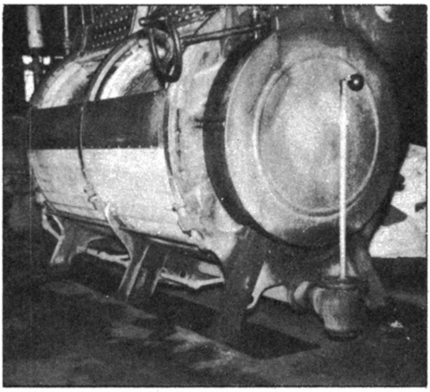
(Left) Fig. 47.—A dish washing machine with submerged inlets. Observe the supply entrance below the table shelf.

(Above) Fig. 48.—A submerged inlet on a cow watering trough. The cow presses a control lever in the basin with her nose to obtain water. These basins nearly always contain hay and mucus from the mouth of the cows.

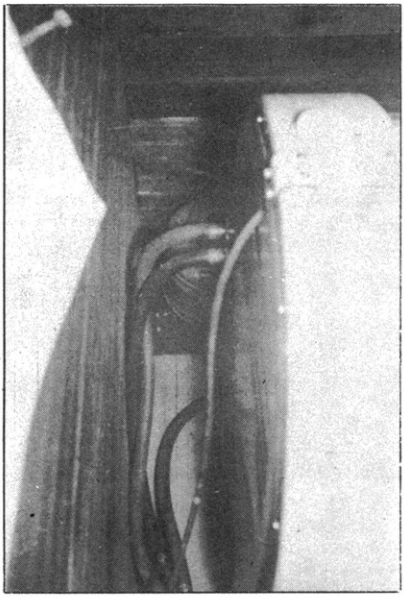


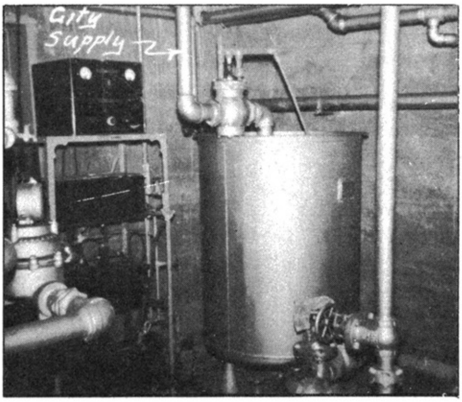
Figs. 49 and 50.—Two examples of Bendix washers with submerged water lines. Note the submerged hose supplies.





Figs. 51 and 52.—Large laundry machines with common supply and waste lines.





(Left) Fig. 53.—A view of the solid connections to a Bendix washer.

(Above) Fig. 54.—A swimming pool filtering plant.

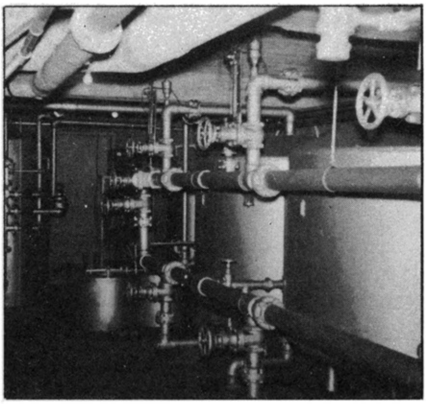


Fig. 55.—Submerged inlet for reservoir supply.

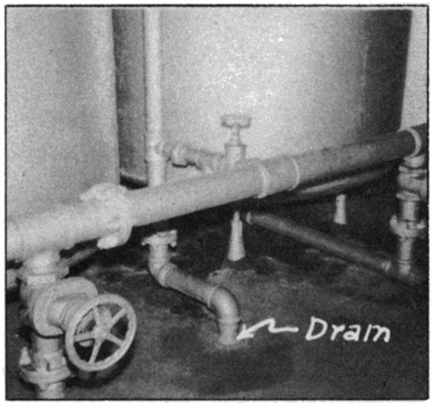


Fig. 56.—No air gap between filter drain and backwash to sump below.

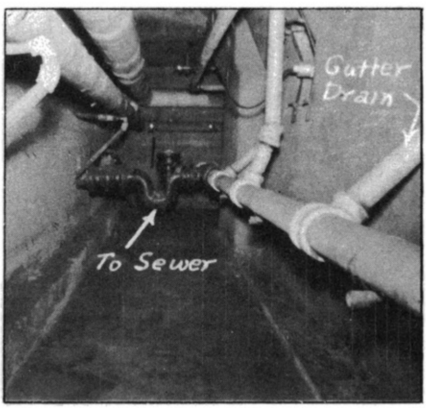


Fig. 56a.—A view of a scum gutter drain from a swimming pool through a closed system to the sewer. There is nothing to prevent sewage from entering the pool in case of a stoppage.

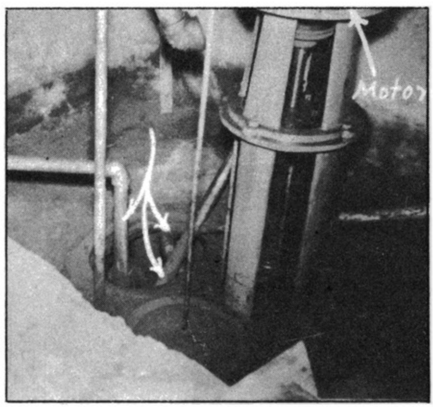


Fig. 57.—An electrically driven sump ejector for a filtering plant. Note the numerous submerged inlets in the sump.

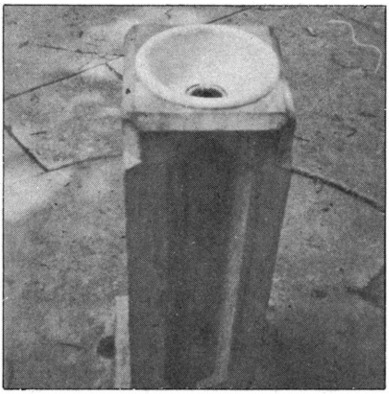


Fig. 58.—Outdoor fountain with inverted bubbler supply which emerges from the waste line and terminates below the overflow level of the fountain.

Fig. 59.—A fountain near an outdoor swimming pool. This supply also comes up through the waste line.

Fig. 60.—A public drinking fountain with water supply and waste pipes separated.

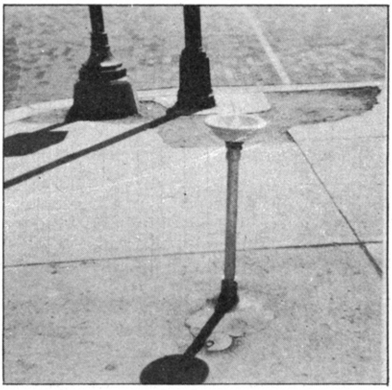


Fig. 61.—Drinking fountain with water supply pipe coming through waste pipe.

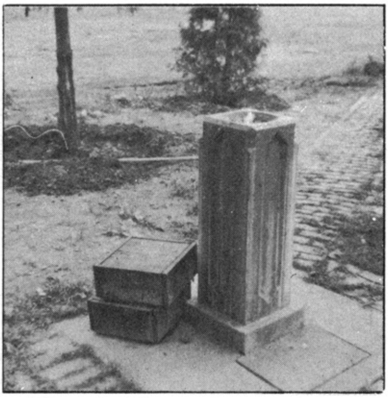


Fig. 62.—Fountain at a city park with supply line coming up through the waste line.

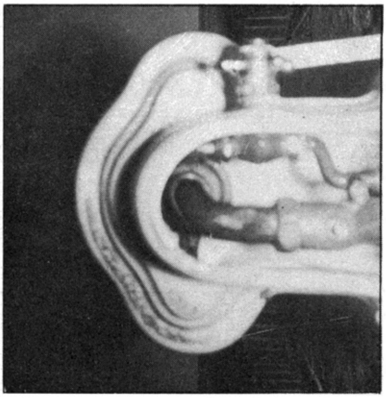


Fig. 63.—A view of the underneath supply and waste line at a high school. Although not clear in the picture, the supply line passes through the waste line. When the valve is opened a full supply of water comes from the line through the wall. Before emerging from the jet above, the flow is regulated so that a portion of the full supply goes to the jet while the remainder passes directly into the sewer.

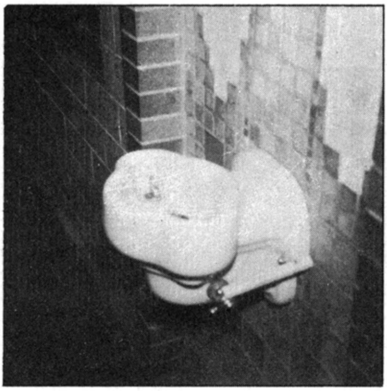
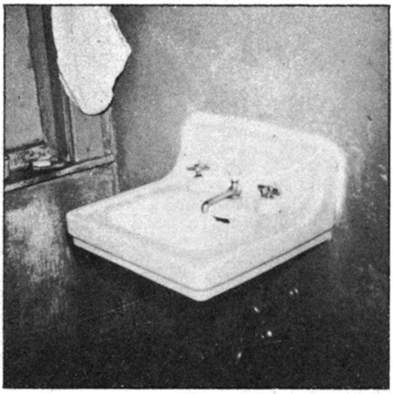
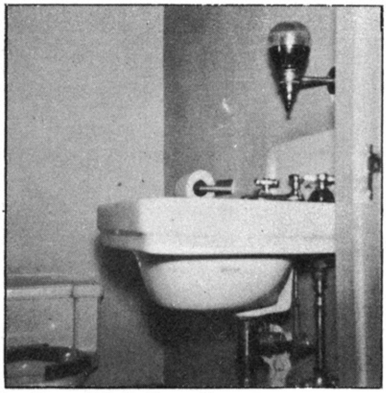


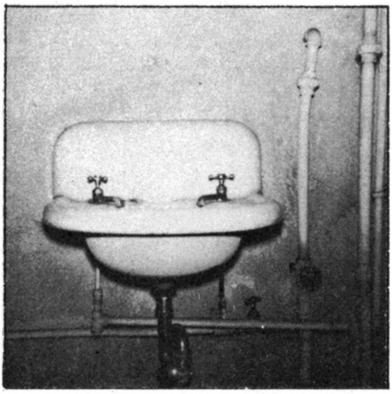
Fig. 64.—An angle jet below the overflow rim of the fountain shown in Fig. 63.

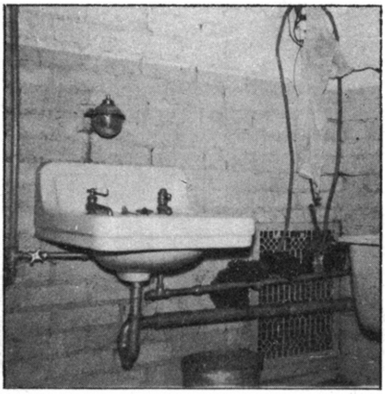
Fig. 65.—This is an inverted faucet at an athletic field which is used by the general public as a drinking fountain—the lip may easily be contaminated.





Figs. 66 and 67.—Two lavoratories with below the rim supplies and combination faucets. Observe the leaking faucet in Fig. 66. This is an illustration to show that lavatory valves aren't always tightly closed.





Figs. 68 and 69.—Views showing below rim supplies.

Fig. 70. — Approved lavatory with air gap between the inlets and lavatory overflow level.

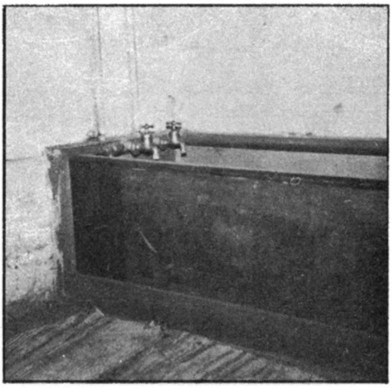


Fig. 71.—An old style metal lined bath tub with below rim supplies.

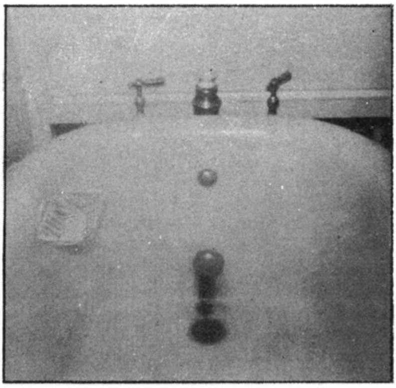


Fig. 72.—A combination outlet near the bottom of the tub. This is in a hospital where diseased individuals are most likely to be.

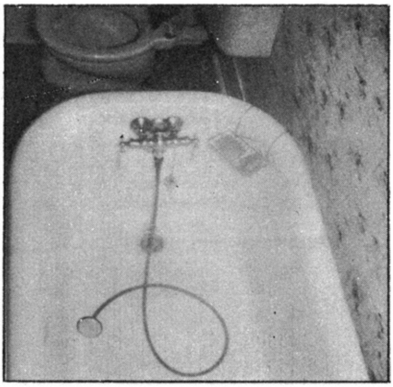


Fig. 73.—A typical tub with below rim supply and combination faucet. The hose is an auxiliary that usually is submerged in the contaminated water in the tub.

Fig. 74.—Dental chair with submerged inlet in saliva wash bowl. The ejector is operated by a water aspirator with no vacuum breaker. Occasionally the dentist uses a glass which is too tall and introduces another submerged inlet at the glass supply.

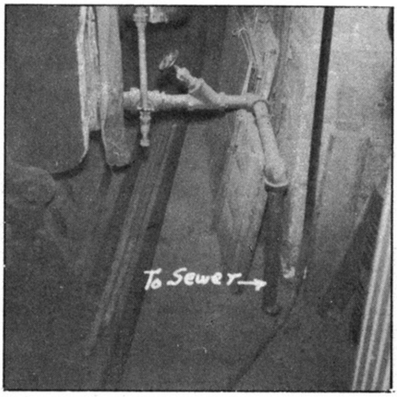


Fig. 75.—Here is a boiler draining directly into a sewer. Although the hazard here is not great, the installation constitutes a cross-connection.

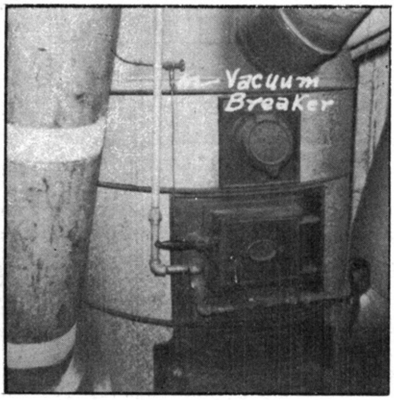


Fig. 76.—A home furnace with a drip line to the humidifier box below. The vacuum breaker prevents back siphonage.

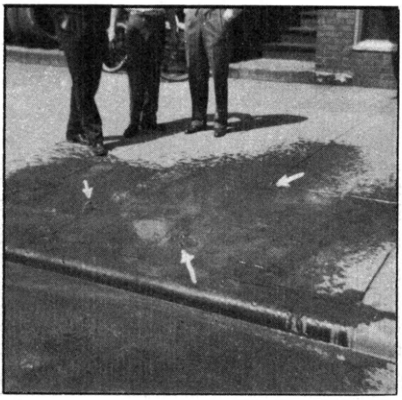


Fig. 77.—This is a view of a service line break. The water is gushing up through holes in the sidewalk. Shortly after this picture was taken the water was shut off. Inside the building were film developing tanks with submerged inlets and other plumbing defects from which waste water was probably siphoned into the water main.

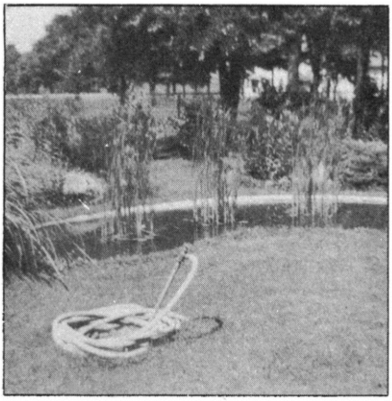
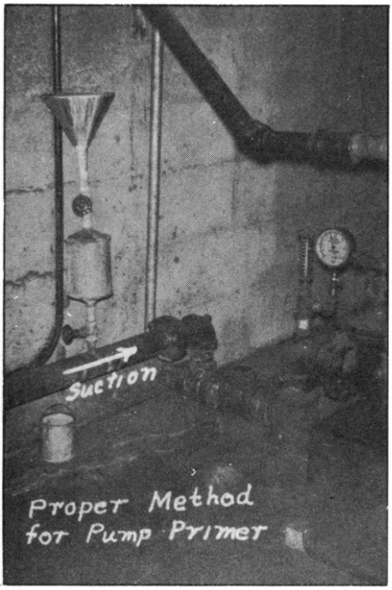
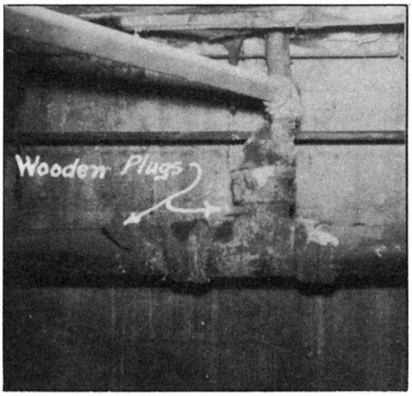


Fig. 78.—An outdoor fish pond in which the hose is submerged each time it is filled, thus creating a cross-connection.

Fig. 79.—A yard hydrant that is filled with water around the leaking hose connection. The supply valve is entirely submerged in this contaminated water.





(Left) Fig. 80.—A proper method for priming a pump which operates on a recirculation system or unsafe supply.

(Above) Fig. 81.—An illustration of "handy-man" sewer repair work. Similar repair work was largely responsible for the 1933 Chicago Epidemic.

PRESSURE GAGE RECORDS

During the survey, a Bristol pressure-vacuum recording gage was installed in some 45 different locations. A total of 90 charts was obtained during the survey. The gage was installed for 48 hours in each location. This permitted a check of one day's chart against another for duplication of records.

Sixteen of these charts have been included in the report because of the unusual pressures recorded. Each chart is presented as an illustration of low pressure, negative pressure, or some other point of interest. Some of the stories revealed by these charts are unique and serve to illustrate the point in question much better than words.

On none of the other charts were negative pressures recorded, but on many of them some very low pressures were indicated. For example, there is one on a private industrial supply where the maximum pressure was 15 pounds per square inch, but the minimum was one pound per square inch. Several instances of similar low pressures were obtained on municipal supplies.

At times these low pressures existed only momentarily, but such reductions in pressure are extremely dangerous. If this action is only instantaneous, but creates a vacuum during this short interval, then the results may prove to be very serious. Each location presents an individual problem. All the facts must be borne in mind before analyzing the hazards produced. For example, the conditions are more dangerous if the water supply is connected to some flushometer stools on an upper floor than if attached to a lavatory in the same room. These and other factors will influence the extent of the hazards produced in any given situation.

When one chances the safety of his water supply under extremely low or negative pressures, he is exposing himself to dangers as great as those of driving a car through a stop light on a main thoroughfare. The following illustration best explains this point: A person may have been driving a car for years and sneaking through the same stop light every morning on the way to work for quite some time, but he jeopardizes his life each time he violates this traffic law. Perhaps some morning the result of this violation may prove disastrous or even fatal not only to himself, but to others. Perhaps then it will be too late for him to say that he is going to heed the rules of safety.

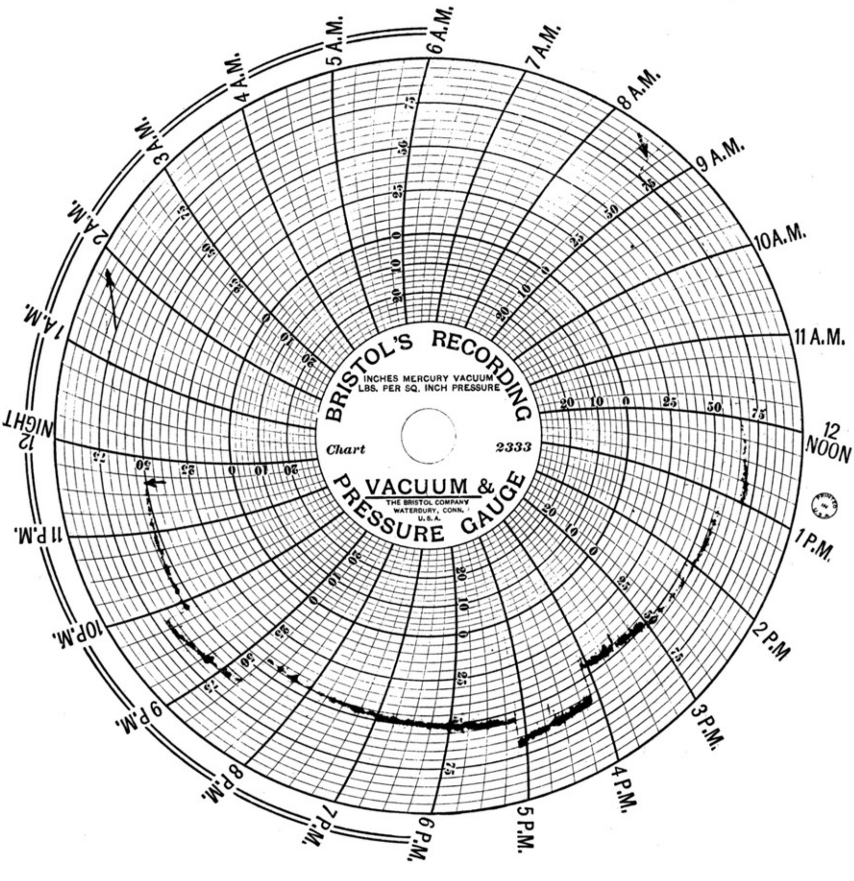


Fig. 82.

This is an unexplainable pressure recording on a dead-end line at an airport. Note that the pressure begins to increase at midnight and goes off the chart until about 8:30 A. M. Figure 83 is a recording of the following day. It shows the pressure increase beginning about 2:00 A. M. and returning about 10:30 A. M. The meter was installed at about 3:00 P. M.

There were some industries out on this main which were checked for cross-connections. None were found to be pumping water into the mains. A conference with the city water commissioner failed to reveal the cause of the phenomenon.

About a month later the pressure was checked at this same point and found to be normal. All further inspections and checking failed to reveal the cause of this exceptionally high pressure.

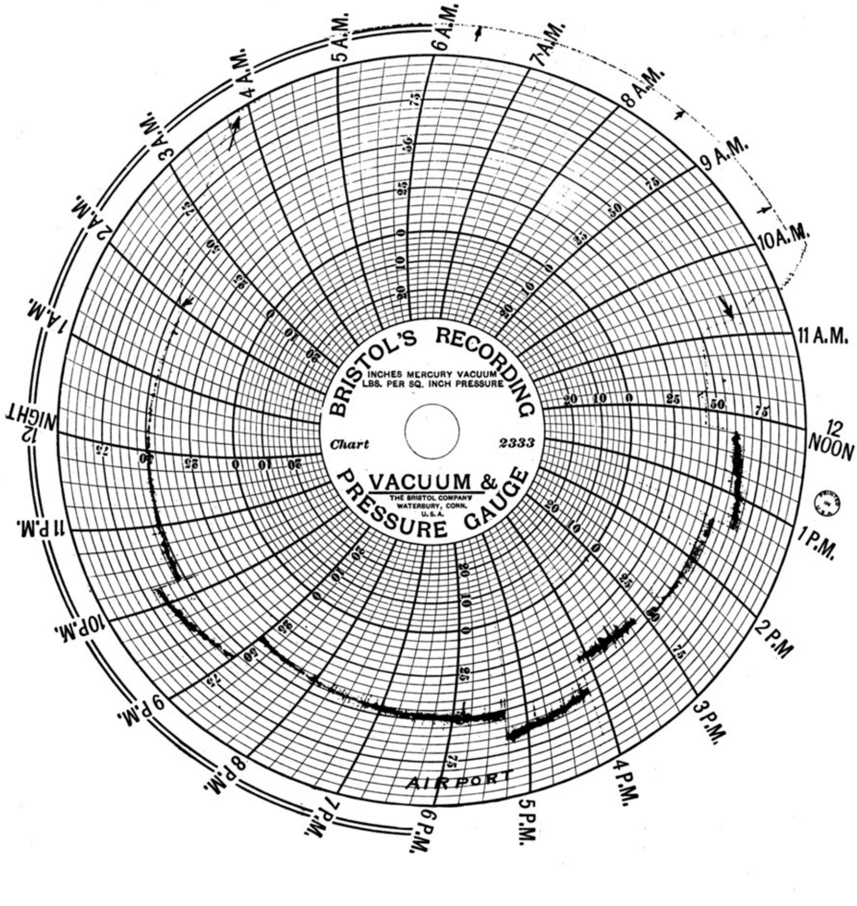

BRISTOL'S RECORDING
INCHES MERCURY VACUUM
LBS. PER SQ. INCH PRESSURE
Chart 2333
VACUUM & PRESSURE GAUGE
THE BRISTOL COMPANY
WATERBURY, CONN.
U.S.A.
AIRPORT
12 NOON
1 P.M.
2 P.M.
3 P.M.
4 P.M.
5 P.M.
6 P.M.
7 P.M.
8 P.M.
9 P.M.
10 P.M.
11 P.M.
12 NIGHT
1 A.M.
2 A.M.
3 A.M.
4 A.M.
5 A.M.
6 A.M.
7 A.M.
8 A.M.
9 A.M.
10 A.M.
11 A.M.

Fig. 83.

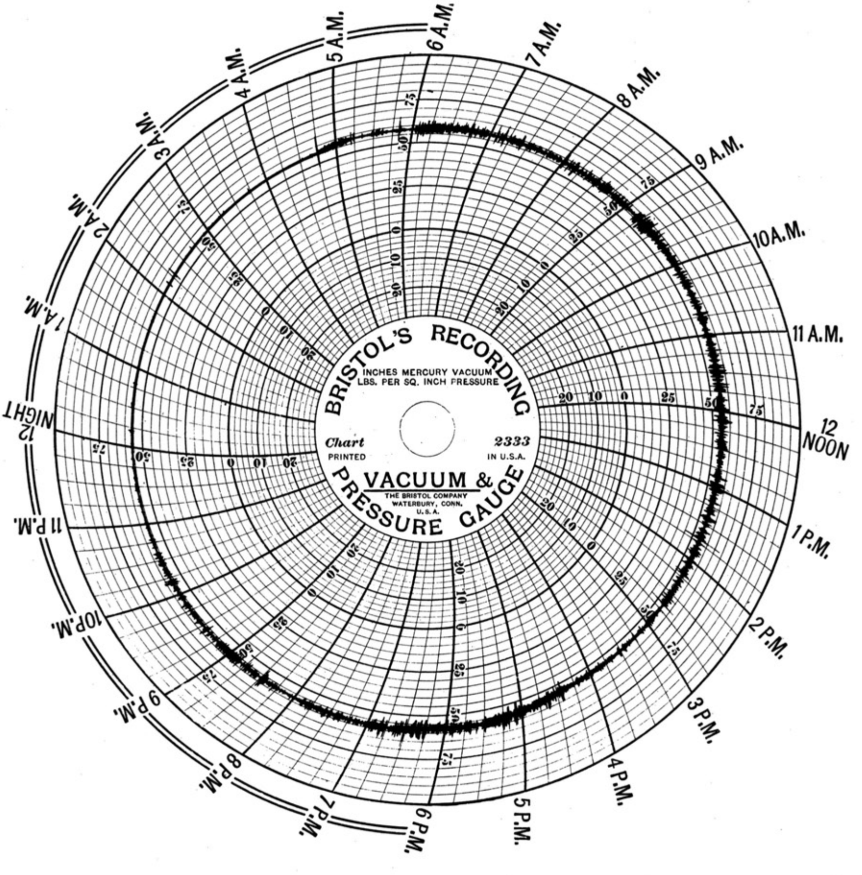


Fig. 84.

The above chart is an example of the more constant pressure maintained in a small village where an elevated tank is used instead of a standpipe supply.

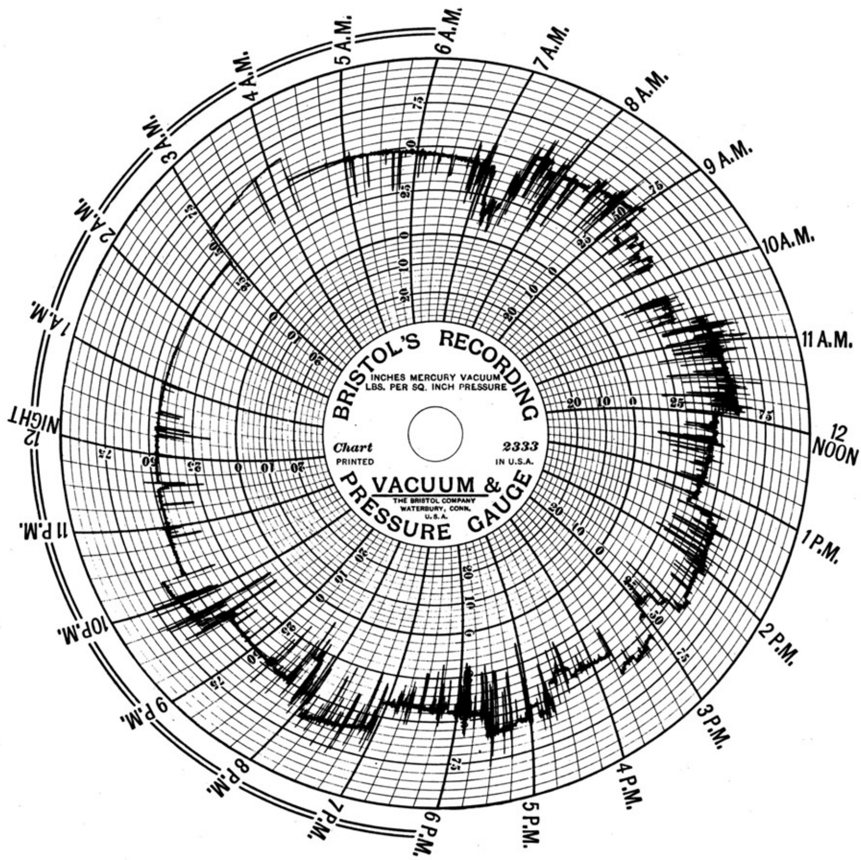


Fig. 85.

Illustrated in this recording are the low pressures obtained at a hotel building. On this particular chart there are no zero or negative pressures, but there are many instances where siphonage would occur if anything were to slightly disrupt the normal flow of water, thereby creating zero or negative pressures. The manager has instituted a program by which he plans to install vacuum-breaker valves on all water closets and eliminate all cross-connections as a protection to his water supply.

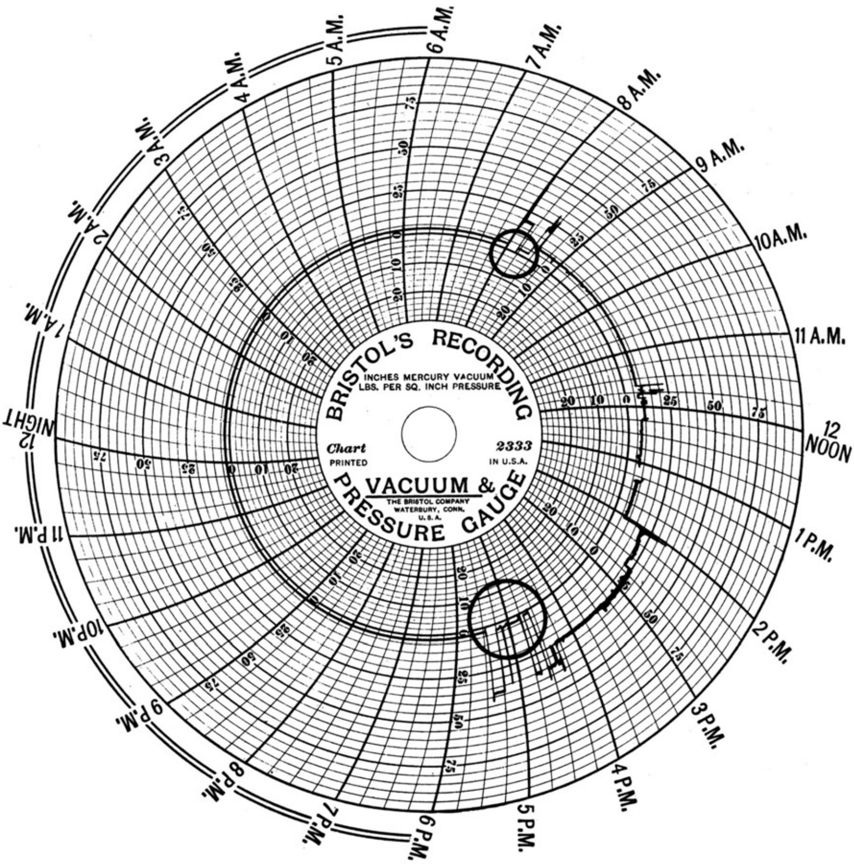


Fig. 86.

Due to the location of the gage for this recording, a small amount of water in the hose kept the pressure from returning to actual zero when the water was shut off during the night. Under these conditions two and one-half pounds of pressure is the actual zero of the chart. The gage was installed in a dairy at the cross-connection shown in figure 13 for a check on the city pressure. In the circles one can observe the fluctuations to zero or slightly below, which indicate negative pressures.

Figure 87 is a chart for the following day.

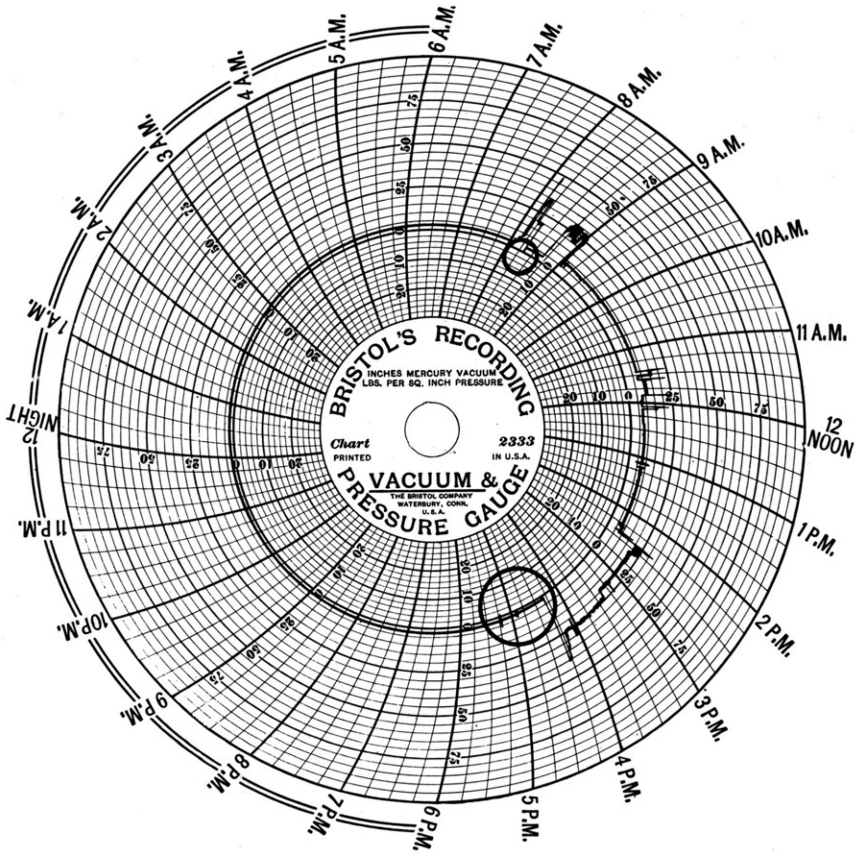


Fig. 87.

See note under figure 86 for information.

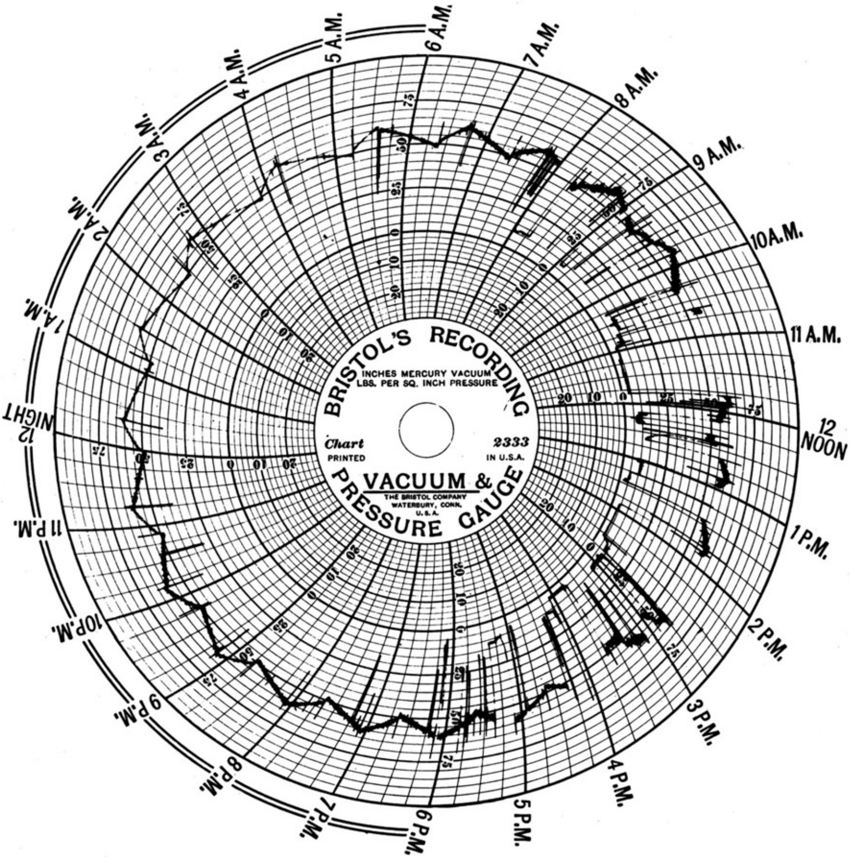


Fig. 88.

This is another recording in a dairy. Observe the consistently low pressures during the normal course of operation during the day. These pressures are too low to maintain an ever safe and sanitary water supply.

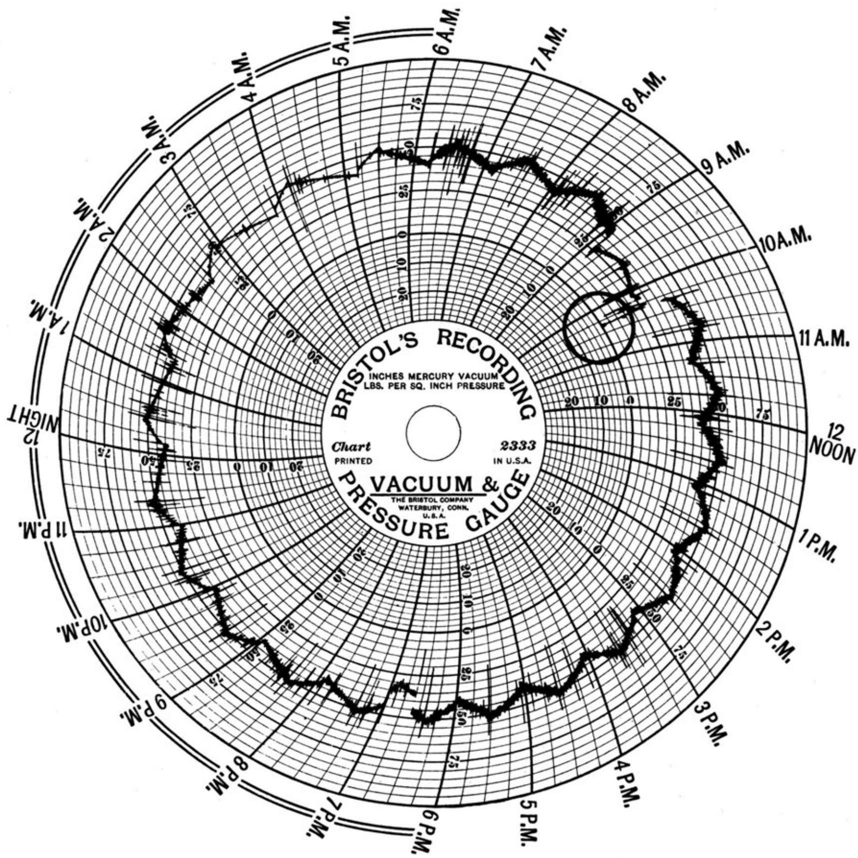


Fig. 89.

The zero pressure in the white circle was recorded at a public club house. The pressure gage was located on the third floor, and it was necessary to flush only four toilets consecutively to obtain this zero pressure.

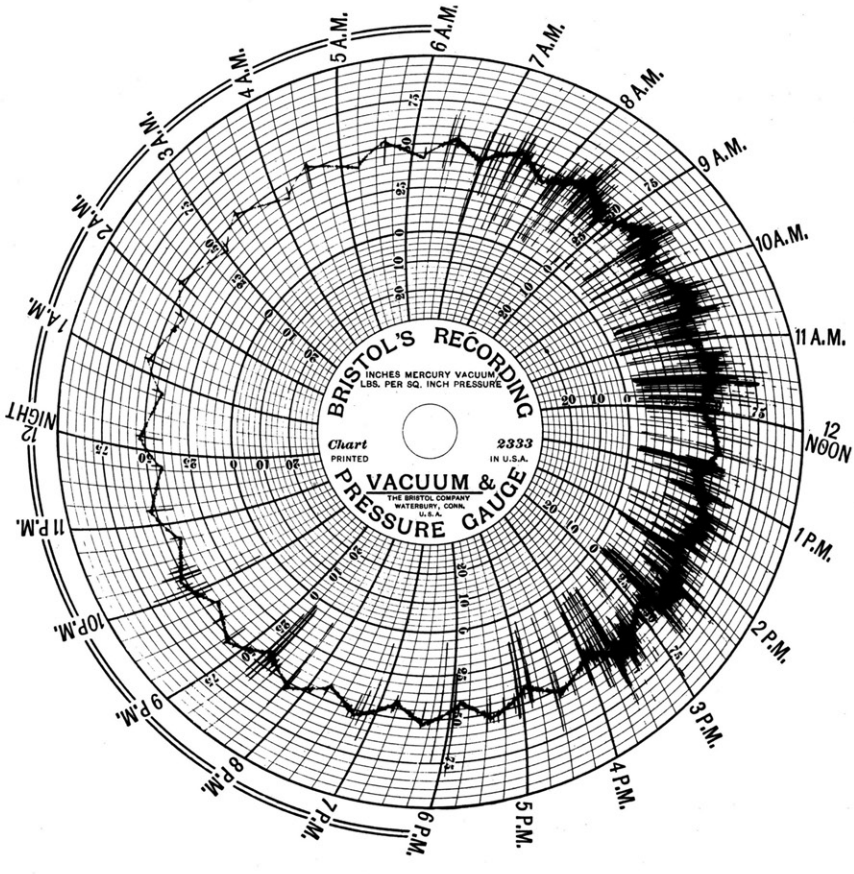


Fig. 90.

This record was made at a high school and grade school building. In the course of the day the pressure dropped to about one-half pound pressure and no mention need be made of the obvious low pressures recorded throughout the day. There were 96 cross-connections in this building. In the normal course of events the children would be safe, but ponder a moment over a power shut off or municipal pump breakdown!

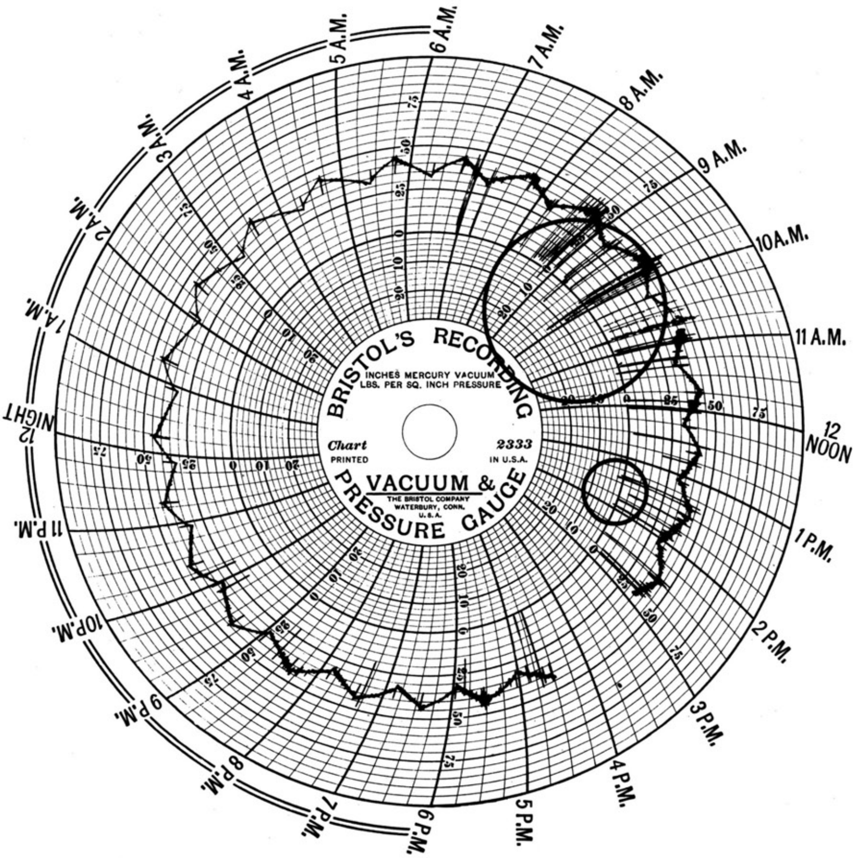


Fig. 91.

Figures 91 and 92 were recorded on consecutive days on the third floor of a college building. There were 19 cross-connections in this building, 10 of which were flushometer valves. With a negative pressure of 15 inches of mercury, need more be said? One sad note should be mentioned—the college administrative head does not believe that flushometer valves are hazardous enough to be replaced by vacuum breaker valves, even with this recording as evidence.

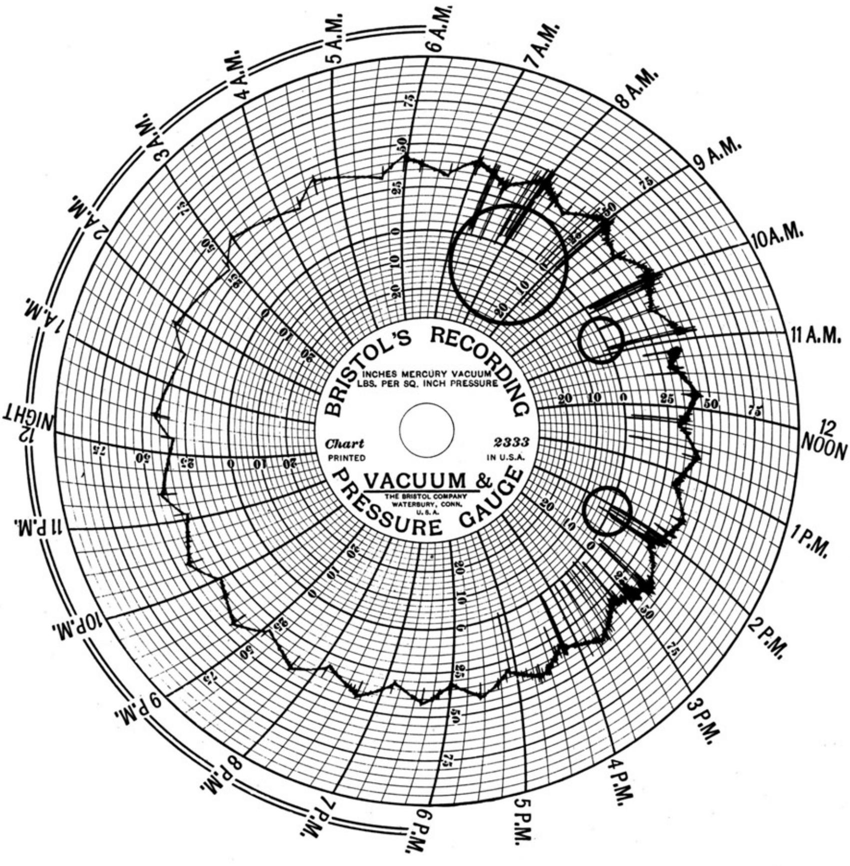


Fig. 92.

See previous chart for information.

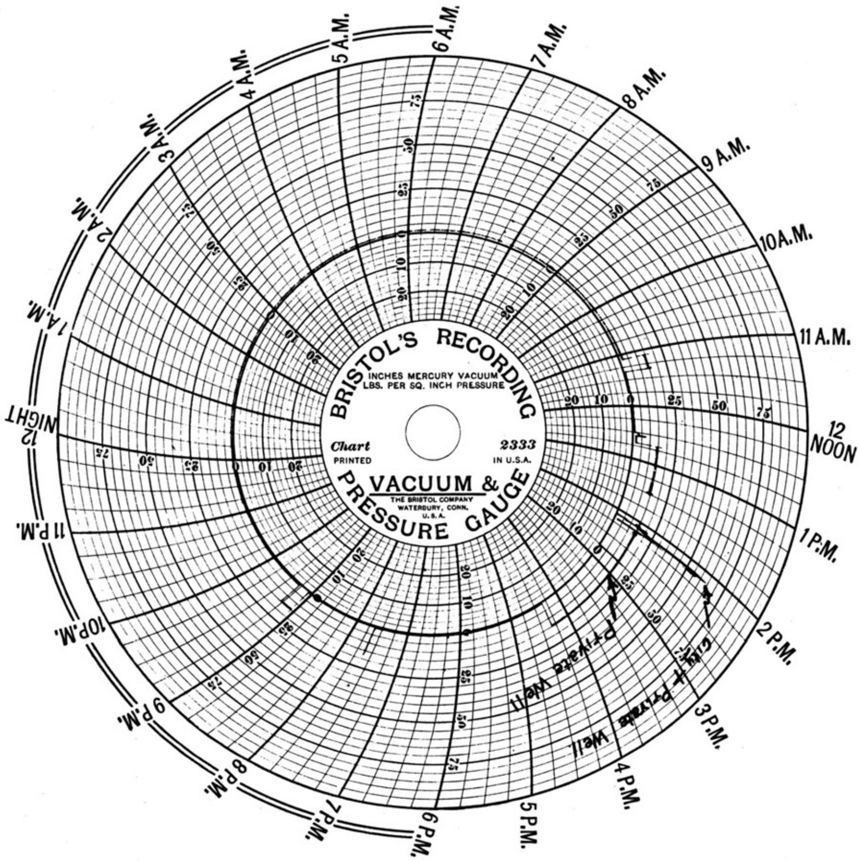


Fig. 93.

This installation in a theater at the cross-connection pictured in figure 15 was made specifically to see which of the two supplies maintained the higher differential of pressure. The city pressure was normally about 50#. The private well operated under a head pressure of 15#. This would indicate the municipal supply to be dominant except under unusual conditions when it fell below 15#, in which event water would be pumped into the city mains. This is all the more reason for the elimination of cross-connections with supporting evidence of pressures lower than 15# obtained on the city supply.

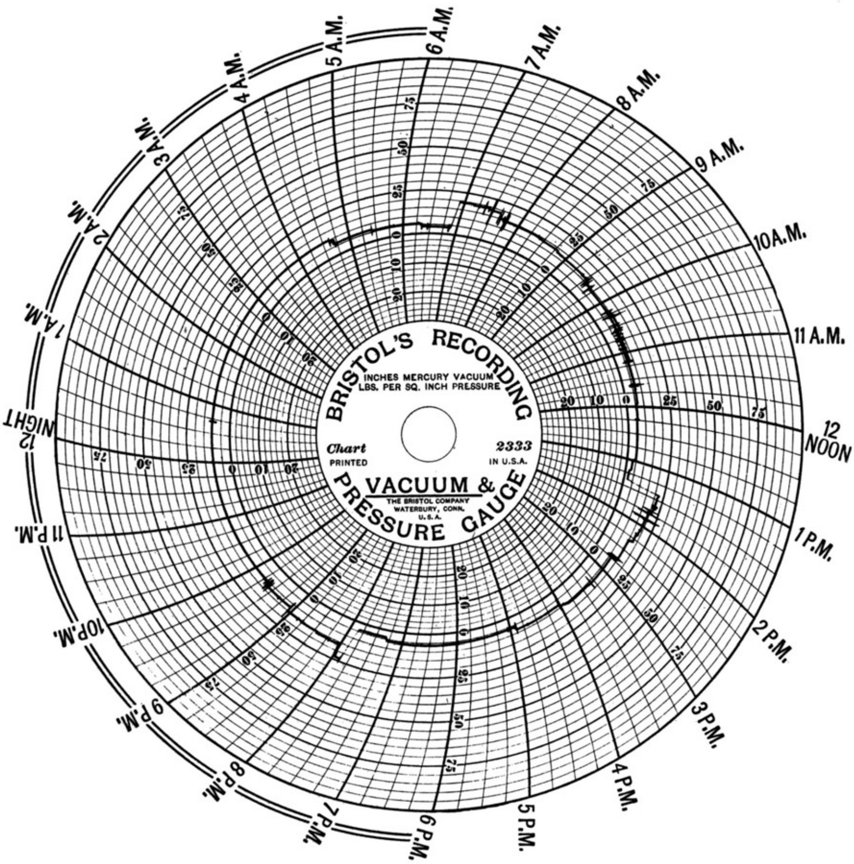


Fig. 94.

A recording at a large private home served by a two-inch service from the main. In comparison with other homes in the city this house is elevated rather high and it very closely approaches the elevation of the standpipe. In addition, it is situated on a dead end main. At this home was found the cistern water cross-connections pictured in figure 22. The cistern water is maintained under pressure, but no recording was made to determine the differential of pressure between the two supplies. However, from the recording shown it is evident that cistern water could easily be forced into the city supply.

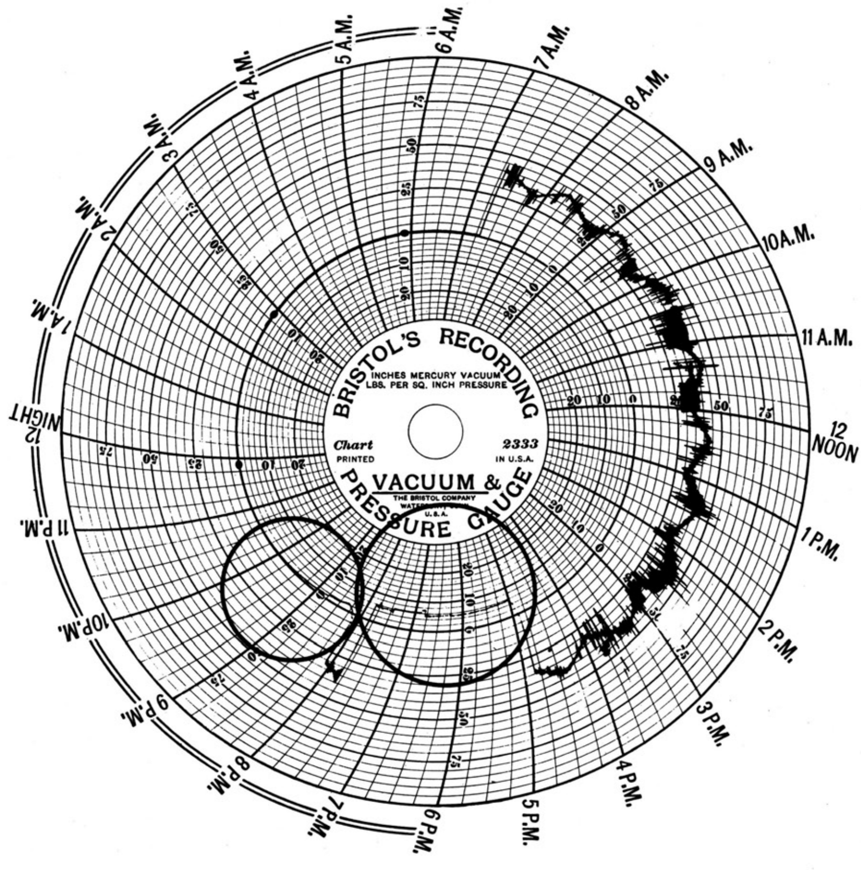


Fig. 95.

An interesting story was brought to light with this chart. The janitor had a habit of shutting off the supply at this large city school to conserve water, the reason being that the flushometer valves leaked on the second and third floors and wasted water over night. After he closed the main valve some children opened a drinking fountain on the second floor and got a drink. Where did the water come from? The supply was shut off!

From the chart it can be seen that an average negative pressure of about six inches of mercury was obtained for a period of nearly three hours. Following this the supply valve was opened for 20 minutes for a short play at the school about 8:00 P. M. After the supply was shut off again, a negative pressure was once more obtained, but over a period of two hours the vacuum was gradually relieved and finally returned to zero pressure.

When the janitor was questioned about this practice, he replied that he always arrived early in the morning and "flushed out the drinking fountains before the kiddies arrived."

Upon request the janitor discontinued this practice and left the supply on over night.

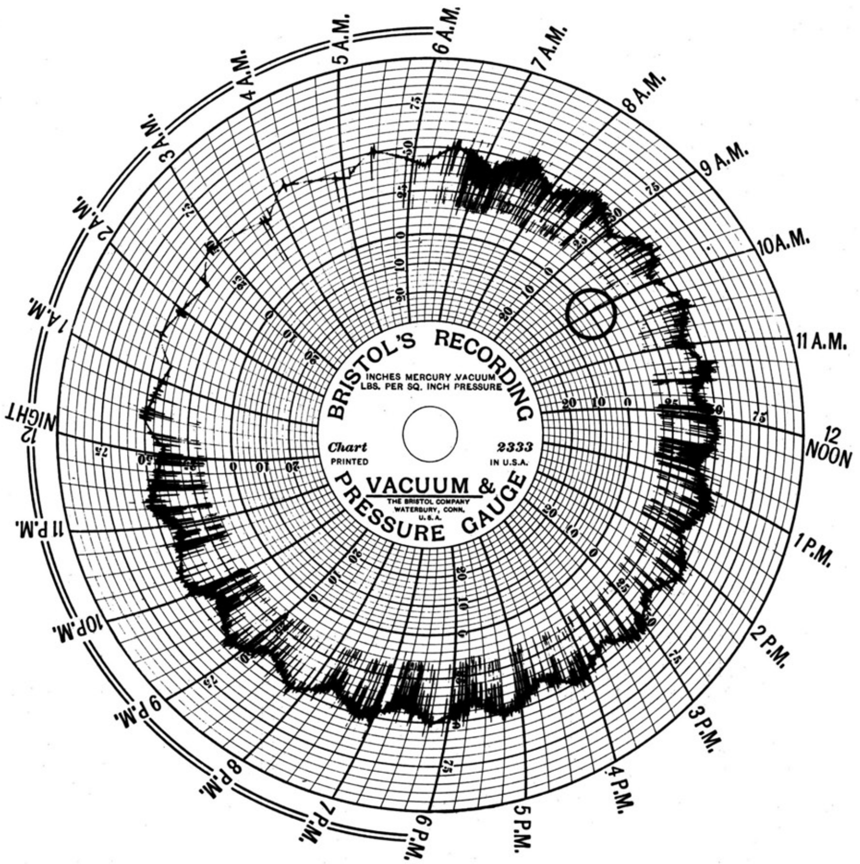


Fig. 96.

A negative pressure of two inches of mercury was recorded at this large dormitory for girls. There were 126 cross-connections in the building, 31 of which were flushometer valves with no vacuum breakers.

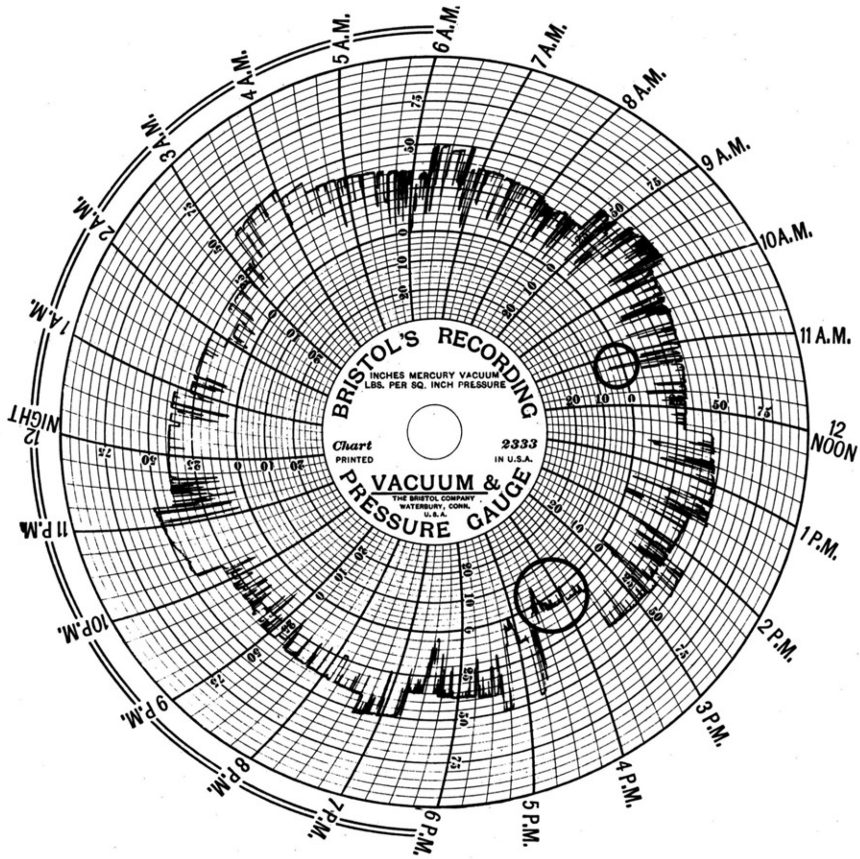


Fig. 97.

This chart was obtained at a hospital. The pressure gage was on the same level as the sterilization equipment shown in figure 26.

This was the building mentioned earlier with all the faulty plumbing and encrusted water lines.

Six inches of vacuum, as recorded here, should be a strong point of deliberation in connection with sterile operations.

CHAPTER V

PROCEDURE FOR CONDUCTING A CROSS-CONNECTION SURVEY

Before initiating a cross-connection survey, it is essential that the investigator receive some preliminary instruction and preparation. The nature of this study should include a working knowledge of hydraulics and an examination of several plumbing defects such as are shown in Appendix B of this report and their most likely locations. If the investigator has access to a large plumbing laboratory such as that at Chicago, Detroit, Cleveland, or any others, it would be very profitable to observe some of the plumbing defects on display by these laboratories. The various designs, connections, and functions of each piece of plumbing or equipment on display may be seen in operation. From these displays the observer can acquire an accurate and invaluable knowledge of cross-connections.

Access can be had to numerous articles and reports on investigations conducted at other localities. From these one should particularly note the types of defects found and the remedial procedures used for correction or elimination of the faulty plumbing.

Then, with a working knowledge of cross-connections, one can initiate the necessary steps preliminary to the actual survey.

One of the first decisions to be made is the object of the survey and and the manner of conducting it. The purpose of the survey must be known and what use is to be made of the results. The question must be answered as to whether the survey is to include a program for the elimination of defective plumbing, or whether the investigation is to include only a survey with future plans for remedying the errors which are sure to be found.

Another step is to decide on the method of gaining entrance to the buildings to be inspected. The author believes that the best results and cooperation will be obtained if the pattern of the program follows an educational procedure rather than one of exercising police powers.

To start with a news article should be released to the local papers giving an account of the survey and its importance. An example of such an article appears below and was used for this particularly survey.

In order to receive further cooperation, it has proved valuable to contact several key persons of the community. Such persons as the mayor, the city engineer, the superintendent of the water works, and other key people should be contacted. They should be acquainted with the nature and purpose of the program. Invaluable assistance and cooperation can be given by these people for conducting the survey.

Albion Water Supply Hazards Being Studied by Health Dept. As Epidemic Precaution Step

Cooperating with the state health department and the University of Missouri, the Calhoun County Health department in putting on an intensive study of water hazzards in this county. The field work will be carried out by Edward L. Stockton, graduate engineer from the University of Missouri. Mr. Stockton will have an office in the County Health department on Michigan Avenue in Marshall.

Specifically, Mr. Stockton will atempt to study and ferret out all cross connections in certain areas of the county. A cross connection is defined as any installation in the water supply system that brings pure water in contact with impure water, thus polluting the water supply that is to be used for human consumption.

The object of the survey is to locate such cross connections as now exist in the county and determine the extent to which these may become potential health hazards in sanitation and public health.

Reports of the findings will be turned over to the individual in charge of such buildings or property where they are found. Time will limit the survey to include probably only those areas within and around the city of Marshall and Albion. Plans are in progress to inspect plumbing in such places as dairies, hospitals, industries, public and semipublic buildings, a sampling of residences, schools and restaurants.

Dr. Robins stated that in his opinion this is a most timely survey and will prove very valuable to the people in these areas. Under the cooperative plan this service which ordinarily is expensive will be gratis to the citizens and strictly on a voluntary cooperative plan.

Albion Evening Recorder, March 20, 1941.

Local plumbers should also be visited and given the same information as the public officials. They are usually aware that cross-connections exist but, in general, are not sufficiently alert to realize the potentially dangerous hazards involved. Possible solutions to the anticipated hazards may be discussed with the plumbers, and in addition it should be pointed out that the plumber will benefit financially by breaking some of the cross-connections found and installing new valves or fixtures. Such information serves to interest them in the program and to show the merits of safe and sanitary plumbing. It should be pointed out that this is to be a service to the community and that the plumbers, the health department, if any, and everyone concerned can benefit from it. The plumbers then will very likely cooperate in a commendable manner and give reliable information to supplement the work throughout the project.

Depending upon the size of the area and the nature of the community, it may be necessary to familiarize other key people with such a program before it is launched. Public health would benefit if additional groups of interested parties such as physicians, the hospital association, the real estate board, the hotel men's association, the master plumbers, journeymen's representatives, the agricultural extension agents, and manufacturers of plumbing and sterilizing equipment in every city or community would get together, acquaint themselves with all angles of the problem and work out a cooperative plan for its solution which most nearly meets the approval of all.

Simultaneously a form letter should be set out to various places which are to be inspected requesting permission to make a survey at each particular place. An example of such a letter may be found in Appendix D. This letter should explain the nature of the program, its purpose and importance. Such letter is recommended for two specific reasons; first, that time is saved from verbose explanation of the reasons for the survey and, second, that even if it is not returned it affords an excellent means of introduction when the place is visited for inspection. In places where the letters aren't returned, such explanations as mislaying it, being "too busy to answer it", not understanding "what was wanted", et cetera, are usually received. Nevertheless, admission will be refused in only a very small percentage of the cases, if a diplomatic approach is used and some additional information about the survey is given.

In those places in which cross-connections present a public health hazard these defects should be specifically pointed out and their damages described. Verbal recommendations for corrective measures should be made followed by a letter of conformation as a followup of the survey. In practically all cases, the plumbing code can be used to supplement the inspector's recommendations for making the necessary corrections, but it is unlikely that this method will need to be used.

In industrial establishments, or relatively large places, letters should be sent recommending the correction or discontinuation of existing cross-connections. In cases where private and municipal supplies are physically united, a copy of the state laws or bulletins governing the condition in question may be sent with the letter. This method may produce desired results in obtaining corrections.

In places where less hazardous conditions are found, such as below-rim lavatory supplies, bath tub supplies, et cetera, the dangers may be pointed out and recommendations given to replace such valves or fixtures with approved materials either when these valves become leaky or when any new equipment is installed. This procedure may suffice in the inspection of all private residences.

During the course of the survey it will also be necessary to contact well drillers in the communities. They must be educated to the fact that no private water supply should be directly connected with a public supply without the consent of water or public health officials. All well drillers should be made conscious of the fact that the union of any two supplies constitutes a direct cross-connection. They should also be made aware of the potential hazards which might result from such a union of supplies.

As the survey progresses, individual problems will arise which cannot be discussed in a general procedure such as this. These problems may be dealt with when they present themselves. If most of the general procedure follows the outline above, the program should function rapidly and smoothly.

CHAPTER VI

SUMMARY

The area surveyed was in general Calhoun County, Michigan, including the cities of Marshall and Albion, the villages of Homer and Athens a portion of Battle Creek Township, and numerous other places throughout the County, both urban and rural.

From the 1940 census there are 15,795 families, which corresponds to a total population of 50,753, in Calhoun County exclusive of the city of Battle Creek. The combined number of homes in Marshall (1,540), Albion (2,560), Athens (205), and Homer (180) is 4,485. It is assumed that all of these homes have water under pressure, as do an estimated additional 815 homes in rural districts and other urban areas. Thus a total of 5,300 families, or approximately one-third of the total number of homes in the area, have water under pressure.

Work on this project was started on February 1, 1941, the first five weeks being spent in preliminary studies at the University of Missouri, at the Chicago Plumbing Laboratory, at the Calhoun County Health Department, at the Michigan State College library, and at the Michigan Health Department. The remainder of this initial period was spent in outlining survey procedures and in chosing a representative cross-section of the area to be surveyed. Approximately four and one-half months were devoted to collecting data and information in the field. The last seven weeks were spent in writing up the final report. The project in its entirety consumed a total of seven and one-half months time.

The following summary itemizes the more important findings of the survey:

1. During the course of the survey 205 different establishments were inspected and a total of 1,935 inter-connections and cross-connections were found. This is an average of about 9.4 cross-connections per building inspected.
2. An estimated 25,000 cross-connections exist in the area.
3. During the survey twenty-nine private homes were inspected in which an average of four cross-connections per building was found.
4. On the basis of the results obtained from the survey, one-third of the total number of defects found were considered potentially dangerous. From this a calculated 8,300 dangerous plumbing hazards are present in this area.
5. It is estimated that one cross-connection or plumbing defect exists to every two persons in Calhoun County.
6. Only a small percentage of rural homes have water under pressure. Consequently, relative few plumbing hazards exist in rural areas.
7. The larger percentage of rural homes are confronted with well water supplies improperly protected from surface contamination rather than the hazards presented by defective plumbing.

8. A multitude of improperly designed plumbing fixtures and equipment accounts for the largest percentage of the hazards.

9. Less than a dozen vacuum-breaker valves in water closets were observed over the entire area.

10. Manufacturers recently, have designed fixtures and appliances which are safe and sanitary, for almost any desired installation provided they are properly installed.

11. Plumbing hazards still exist even with the most up-to-date plumbing fixtures because of improper installation.

12. The first item that requires attention in the elimination of plumbing hazards is the education of plumbers in modern codes and specifications.

13. Master plumbers in these smaller towns or cities often follow older established practices of their own which usually conform to an outdated plumbing code.

14. Many plumbers do not understand and are hesitant to accept some of the modern practices of correct plumbing installation.

15. All plumbers should attend short courses regularly in order to keep abreast of modern accepted practices.

16. Properly trained inspectors must check on plumbing installations at the time of erection to see that sanitary installations are made.

17. A pressure recording gage installed at various locations disclosed negative pressures on water lines as great as 15 inches of mercury under normal operation of properly maintained municipal water supply systems.

18. Several pressure charts indicated dangerously low pressures at various intervals with no abnormalities in city pressure. (See Chapter V).

19. A group of drawings is presented in Appendix B which shows numerous observed types of defective plumbing installations and suggested methods of remedy.

20. The results of this and similar surveys should awaken public health officials to the fact that many hazardous plumbing installations exist in all areas and, at frequent intervals, become potentially dangerous. As a safeguard to public water supplies and public health, such defects should be eliminated.

TABLE I
LIST OF PLUMBING DEFECTS AND THEIR LOCATIONS

Type of Cross-Connection / Type of Establishment	Airport	Bakeries	Newspaper	Clothing Store	Dairies	Dormitories	Food Establishment or Drug Store	Funeral Home	Hospital	Industries	Laundries	Libraries	Physician & Dentist	Picture Studio	Public Buildings	Residences	Schools	Sewage Treatment Plant	Slaughter House	Total Cross-Conn.
Total No. Visited	1	2	1	3	7	5	60	7	5	14	2	3	10	1	31	29	20	1	1	205
Air Conditioning Unit	* -	-	-	2	-	-	1	1	-	-	-	-	1	-	-	-	-	-	-	5
Aspirator	* -	-	-	-	-	-	-	5	1	-	-	-	-	-	-	2	1	-	-	9
Bath Tub	# -	-	-	-	-	20	4	3	23	-	-	-	1	-	-	-	-	-	-	77
Bed Pan Washer	* -	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2
Bendix Washer	* -	-	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-	-	3
Boiler Drain	# -	-	-	-	1	-	2	-	2	4	-	-	-	-	1	1	6	-	-	17
Cow Watering Troughs	* -	-	-	-	44	-	-	-	20	-	-	-	-	-	-	-	-	-	-	64
Compressor and Condenser Units	* -	-	-	1	2	1	12	-	1	2	-	-	1	-	4	1	-	-	-	25
Dental Chair	* -	-	-	-	-	-	-	-	3	-	-	-	12	-	-	-	-	-	-	15
Digester circulation system	# -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Dish Washing Machine	* -	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	5
Dish Washing Tanks	# -	-	-	-	-	1	8	-	-	-	-	-	-	-	1	2	-	-	-	12
Drinking Fountains and Drains	* -	-	2	-	-	-	-	-	7	66	1	2	2	-	10	-	46	-	-	136
Film Developing Tanks	* -	-	-	-	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-	4
Fire Sprinkler Drain	* -	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2
Flushometer Valves	* -	-	-	-	-	31	6	1	130	55	-	4	-	-	30	5	170	-	-	363
Flush Valve in Catch Basin	# -	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3
Furnace Humidifier	# -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	4
Glass Washer	# -	-	-	-	-	-	9	-	-	-	-	-	-	-	1	-	-	-	-	10
Grease Trap	* -	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Hot Water Heater	# -	-	-	-	-	-	-	1	2	-	-	-	-	-	1	-	1	-	-	5
Industrial Vats	* -	-	-	-	9	-	-	-	-	16	1	-	-	-	-	-	2	-	5	33

*Indicates direct cross-connection
#Indicates cross-connection condition

TABLE I (cont'd)
LIST OF PLUMBING DEFECTS AND THEIR LOCATIONS

Type of Cross-Connection / Type of Establishment	Airport	Bakeries	Newspaper	Clothing Store	Dairies	Dormitories	Food Establishment or Drug Store	Funeral Home	Hospital	Industries	Laundries	Libraries	Physician & Dentist	Picture Studio	Public Buildings	Residences	Schools	Sewage Treatment Plant	Slaughter House	Total Cross-Conn.
Instrument Sterilizing Tank	* -	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4
Laundry Tub	# -	-	-	-	-	8	-	-	5	-	11	-	-	-	1	7	2	-	-	34
Lavatory Supply	# 1	-	-	2	1	69	41	3	65	34	-	6	11	1	57	20	86	-	-	397
Loose Hoses	# -	-	1	-	8	-	7	1	1	14	-	-	-	-	1	1	11	-	1	46
Photostat Machine	* -	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	2
Potato Peeler	# -	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2
Private Well and City Water	* -	-	-	-	2	-	-	1	-	10	-	-	-	-	2	-	-	-	-	15
Pump by-pass to sump	# -	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	2
Pump primed by City Water	* -	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	3
Refrigerator Drain	# -	2	-	-	-	-	10	-	-	-	-	-	-	-	3	-	-	-	-	15
Scum Drain from Swimming pool	* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
Sewer line over Preparation Table	# -	-	-	-	-	1	6	-	2	-	-	-	-	-	1	1	2	-	-	13
Sinks	# -	-	-	-	-	-	8	-	3	1	-	-	3	-	1	1	2	-	-	19
Steam Lines	# -	-	-	-	8	-	-	-	1	-	-	-	-	-	-	-	-	-	3	12
Steam Table	# -	-	-	-	-	-	3	-	1	-	-	-	-	-	-	-	1	-	-	5
Steam Vacuum Pump	# -	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	2
Steam Welder Cooling Water to Sewer	* -	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5
Unsealed Well Casing	# -	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	2
Sump ejector operated by City Water	* -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Urinals	* -	-	-	-	-	-	2	-	7	9	-	1	-	-	10	1	21	-	-	56
Water Closet Valves	* 1	3	2	4	4	15	80	12	4	110	2	5	11	1	99	44	36	-	-	430
Water Softener Backwash	* -	-	-	-	-	4	2	-	2	-	2	-	-	-	-	2	3	-	-	15
Water Sterilizing Tank	* -	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
X-Ray Tank	* -	-	-	-	-	-	-	-	3	-	-	-	3	-	-	-	1	-	-	7
Yard Sprinkler Hydrants	# -	-	-	-	-	-	-	1	-	-	-	-	-	-	48	-	-	-	-	49
																		Total		1935

TABLE II
SUMMARY OF DEFECTS FOUND IN DIFFERENT LOCALITIES AND IN VARIOUS TYPES OF BUILDINGS

Locality		Building						
		Public	School	Hospital	Food	Business	Industrial	Residence & Others
Marshall	No. Buildings Inspected	14	6	3	12	6	7	15
	Cross-Connections							
	Indirect	44	42	27	22	5	21	25
	Direct	85	62	48	41	17	55	38
	Total	129	104	75	63	22	76	63
	Hazardous	32	43	33	8	5	7	6
Albion	No. Buildings Inspected	10	5	1	34	12	6	15
	Cross-Connections							
	Indirect	153	110	30	38	24	90	30
	Direct	86	176	22	127	43	167	36
	Total	239	286	52	165	67	257	66
	Hazardous	94	127	19	62	17	91	5
Battle Creek Township	No. Buildings Inspected			1	17			5
	Cross-Connections							
	Indirect			56	15			6
	Direct			29	33			12
	Total			85	48			18
	Hazardous			28	7			7
Homer	No. Buildings Inspected	8	1		8	4		4
	Cross-Connections							
	Indirect	12	0		6	0		7
	Direct	12	14		14	8		4
	Total	24	14		20	8		11
	Hazardous	0	15		5	2		1
Athens	No. Buildings Inspected	1				1		1
	Cross-Connections							
	Indirect	1				2		3
	Direct	1				1		3
	Total	2				3		6
	Hazardous	0				1		2

TABLE III
SUMMARY OF THE DEFECTS FOUND WITH THE NUMBER OF PLACES INSPECTED IN EACH AREA

Places Inspected (number)	% of Total	Location	Indirect Cross-Connection	Direct Cross-Connection	Hazardous	Total	% of Total	Ave./Bldg.
63	31	Marshall	186	346	134	532	27.5	8.5
91	44	Albion	475	688	448	1163	60.1	12.8
23	11	Battle Cr.	77	74	42	151	8.8	6.6
25	12	Homer	26	52	22	78	4.0	3.1
3	2	Athens	6	5	1	11	0.6	4.0
205	100%		770	1165	647	1935	100.0%	Ave. 9.4

APPENDIX A

ILLUSTRATIONS OF WATER-BORNE OUTBREAKS

The following illustrative water-borne outbreaks are given because they are instructive and because they are also classic in the historical annals of sanitation.

The Case of the Broad Street Pump.[1]

One of the earliest, one of the most famous, and one of the most instructive cases of the conveyance of disease by polluted water is that commonly known as the epidemic of Asiatic cholera connected with a Broad Street (London) well, which occurred in 1854. For its conspicuously circumscribed character, its violence and fatality, and especially for the remarkable skill, thoroughness and success with which it was investigated, it will long remain one of the classical instances of the terrible efficiency of polluted water as a vehicle of disease.

. . . The Inquiry Committee estimated that in this year 'the fatal attacks in St. James's Parish were probably not less than 700', an from this estimate computed a cholera death rate, during 17 weeks under consideration, of 220 per 10,000 living in the parish, which was far above the highest in any other district. In the adjoining Charing Cross district of St. Martin's-in-the-Fields (including a hospital) it was 33. In 1848-1849 the cholera mortalty in St. Jame's Parish had been only 15 per 10,000 inhabitants.

The result of the inquiry consequently was that there had been no particular outbreak or increase of cholera in this part of London, except among the persons who were in the habit of drinking the water of the above-mentioned pump well.

I[2] had an interview with the Board of Guardians of St. James's Parish on the evening of Thursday, 7th of September, and represented the above circumstances to them. In consequence of what I said the handle of the pump was removed on the following day . . . .

An Epidemic of Asiatic Cholera[3]

The great epidemic of Asiatic cholera which occurred in Hamburg, Germany, in 1892 was traced to an infection of the public water supply, and was probably due to the excrement of certain Russian emigrants detained for a while in crowded barracks on the banks of the Elbe River while enroute to America. Among these emigrants, many of whom came from areas in Russia where cholera had been raging, were doubtless some mild and missed cases of cholera, as well as others who were still convalescent carriers. The dejecta of these people were disposed of in the Elbe River as was the sewage of the city of Hamburg. The water supply of Hamburg at that time was derived directly from the Elbe, and pumped, without purification of any kind, into the water mains for the immediate use of the citizens. A neighboring suburb (Wandsbeck) and the city of Altona which forms virtually a part of Hamburg, remained almost entirely free from the disease. The former, population 20,---, had an excellent water supply not drawn from the river; the latter, population 143,000, drew its water supply from the river at a point below the outfall sewer of the city of Hamburg, and this water supply, therefore, contained more sewage than did the Hamburg water, but with this difference:—the Altona water supply was purified by slow sand filtration before it was delivered to the consumers. The Hamburg water supply was untreated. After the epidemic, Hamburg also introduced excellent filters with most satisfactory results.

[1]Sedgwick's Principles of Sanitary Science and Public Health, Prescott & Horwood, 1935, 128, 29, 32.
[2]Dr. John Snow.
[3]Ibid., pp. 160.

This epidemic is one of the most interesting in the history of sanitary science. It demonstrated that disease follows the lines of travel, for several cases of cholera among emigrants embarking at Hamburg arrived on board ship in New York and caused great consternation in America. A few cases actually did find their way into this country. The price of safety against the importation of disease from abroad is eternal vigilance.

North Boston, Erie County, N. Y.[1]

Briefly, the facts of the epidemic as determined on investigation were these. North Boston in 1843 was a very small community, about "an hundred rods in diameter," composed of 43 persons distributed among nine families. The community was "about 18 miles from Buffalo and 12 miles from the lake shore, at a considerable elevation above the level of the lake." Up to the time of the epidemic the health of the community had been excellent, and typhoid fever was an unknown disease.

"On the 21st of September a young man from Warwick, Massachusetts, being on a journey westward, took lodgings at the tavern, kept by a man named Fuller. He had been ill for several days, and had kept on his journey until he felt unable to proceed farther. He remained at the tavern and died on the 19th of October." There was no question that he was suffering from typhoid fever, and the clinical and autopsy evidence obtained on some of the subsequent cases that developed confirms the identity of this disease. The first local resident attacked was the son of Fuller, the innkeeper, aged 16 years. He was attacked on the 14th of October, twenty-three days after the arrival of the stranger. Between then and December 7, "twenty-eight of the forty-three persons comprising the little community at North Boston, all of them under 30, were attacked with fever, and in ten instances the disease proved fatal." It was evidently one of the most devastating epidemics of typhoid fever on record.

Recent Water-borne Epidemics[2]

While the great epidemics of water-borne typhoid fever are now part of sanitary history, small epidemics are still occurring with comparative frequency. Wolman and Gorman[3] record 242 epidemics of typhoid fever and dysentery which occurred in the United States from 1920-1929, and which were responsible for 9,367 cases of typhoid fever, 84,345 cases of dysentery, and 630 deaths from typhoid fever. During the same decade there were 40 epidemics of water-borne typhoid fever in Canada, resulting in 2,836 cases and 145 deaths. In the United States, 64.9 per cent of the epidemics occurred in cities having a population less than 5,000. In Canada 77.5 per cent of the epidemic recorded occurred in cities of the same population group. In other words, epidemics of the water-borne intestinal diseases have been largely eliminated in the more populous cities and towns with the adoption of modern methods of water purification. In the smaller towns, where adequate funds for water purification purposes may not be so readily available, the problem of water-borne disease must still be considered of primary importance.

Those cities and town recorded by Walman and Gorman which experienced epidemics of water-borne typhoid fever during the decade, 1920-1929, and where 100 or more cases were reported are as follows: Winona Lake, Ind.; Salem, Ohio; Santa Ana, Calif.; Akron, N. Y.; Olean, N. J.; Brigham City, Utah; Helena, Mont.; Bloomington, Ill.; Chicago, Ill. Pittsburgh, Calif.; Salt Lake City, Utah; Fort Wayne, Ind.; Crafton, W. Va.; Alpena, Mich.; Albany, N. Y.; Franklin Boro, N. J.; and Covington and Newport,

[1] Ibid., pp. 138-139.
[2] Ibid., pp. 163-166.
[3] American Journal of Public Health, Feb. 1931, 115-129.

Ky. In addition the widespread epidemic of water-borne dysentery which occurred in Detroit, Mich., in February, 1926, and which resulted in at least 45,00 cases, should be included in this list. This epidemic, the most extensive outbreak of dysentery of record, the best, modern rapid sand filter plants, and was apparently due to laxity in control.

A tabulation of Wolman and Gorman's latest report indicates the seriousness with which cross-connections must be considered in the light of disease outbreaks.

TABLE IV

MAJOR CAUSES OF OUTBREAKS AND ILLNESSES IN ORDER OF MAGNITUDE[1]

United States

Classification	Number
Outbreaks	
Surface pollution of shallow wells	52
Cross-connection with polluted water supply	40
Contamination of spring or infiltration gallery by pollution of watershed	31
Contamination of brook or stream by pollution on watershed	27
Use of polluted water from a river or irrigation ditch, untreated	25
Inadequate chlorination - only treatment	23
Cause of outbreak undetermined	20
Typhoid Fever Cases	
Cross-connection with polluted water supply	2122
Seepage of surface water or sewage into gravity conduit	1814
Inadequate chlorination - only treatment	1418
Surface pollution of shallow wells	1161
Inadequate control of filtration and allied treatment	649
Underground pollution of well or spring in creviced limestone or rock	633
Contamination of spring or infiltration gallery by pollution of watershed	630
Interruption of chlorination - only treatment	594
Diarrhea and Dysentery Cases	
Inadequate control of filtration and allied treatment	48,761
Overflow of sewer or flood water into top of well casing	10,870
Seepage of surface water or sewage into gravity conduit	9,540
Cross-connection with polluted water supply	8,514
Miscellaneous	6,500

1 Wolman-Gorman, Water-Borne Outbreaks, Their Significance, Page 81.

APPENDIX B

ILLUSTRATIONS OF PLUMBING DEFECTS

A few diagrams of faulty plumbing have been prepared to illustrate conditions which were found during surveys of buildings in various parts of the county. The illustrations titled "sanitary" show a solution which may be used in correcting these defects. It is impracticable to illustrate all of the defects which may create public health hazards, but when the fundamental principles are understood defects can be found by those responsible for their correction.

Portions of the narrative have been copied, and a few of the diagrams have been reproduced, with borrowed ideas, from the Minnesota State Board of Health Plumbing Bulletin of 1939. The information is applicable in this vicinity and to this report. Many of the ideas originated in the field while conducting the survey.

CHICAGO PLUMBING LABORATORY

The writer visited the Chicago Plumbing Laboratory as a part of the preliminary training prior to beginning the survey. The knowledge and experience gained here proved invaluable in knowing what to observe when inspecting various places. The following is quoted from their literature.

> This laboratory was installed to show and correct the danger of cross-connections, submerged supplies and improper installations, which causes pollution and contamination of water, in the water supply system.
>
> The accompanying photograph is of the exhibit. The testing rack on the right together with the tanks, pumps and other equipment of this laboratory is for the purpose of testing all types of plumbing fixtures, appliances and appurtenances under various vacuum and pressures.
>
> The first fixture on the testing rack to the left is a side spud siphon jet floor type closet bowl, equipped with a piston type flush valve.
>
> The second fixture is a back inlet spud siphon washdown closet bowl with jet floor type, equipped with a diaphragm type flush valve and vacuum breaker.
>
> The third fixture is a back inlet spud siphon jet closet bowl floor type equipped with piston type flush valve.
>
> The fourth fixture is a top spud Duojet closet bowl equipped with a diaphragm type flush valve.
>
> Here there are two pipes, one of which is a one inch pipe, and the other a two inch pipe. They are used to test the necessary air gap between the end of the pipe and the water.
>
> The fifth fixture is a wall hung siphon jet urinal equipped with piston type flush valve.
>
> The units to the left of the center column are permanent installations, for demonstration of back siphonage and cross-connections and other violations.
>
> A harmless dye is used to color the water to more easily follow the flow of contaminated water from the fixtures through the glass and transparent tubbing into the water supply system and to other fixtures.
>
> The fixtures in this group are demonstrated for back siphonage with a 24-inch natural vacuum created in the riser shown in the center of the column. This vacuum is created when the control valve is shut off and a faucet in the supply line is opened in the basement.
>
> All the fixtures on the upper level are filled to overflowing showing a

stoppage in the fixture, or waste line.

The first fixture on the upper level to the right is a top spud wall hung siphon jet closet bowl equipped with a diaphragm type flush valve.

The second fixture is a side spud siphon jet floor type closet bowl, equipped with a piston type flush valve.

The third fixture is a Work Sink or Slop Sink equipped for convenience with a hose attachment.

The fourth fixture is an instrument sterilizer, note the supply for this fixture is in the bottom, completely submerged.

The fifth fixture is a top spud siphon jet floor type closet bowl equipped with a piston type flush valve.

The sixth fixture is a Porcelain Lavatory on a pedestal and eqipped with a submerged supply.

The seventh fixture is a bath tub and is equipped with a submerged supply.

The first fixture on the lower level to the left is a bath tub, and is equipped with an over the rim supply.

The second fixture is a wall hung lavatory with legs attached. It is equipped with an over the rim supply.

The third fixture is a closet combination equipped with a ball cock, having an approved vacuum breaker attached.

The fourth is a dual installation of aspirators; the one to the left is equipped with a vacuum breaker; the one to the right is not equipped with a vacuum breaker, or port holes.

The fifth unit is a compressor and condensor coil, as used for air condition and refrigeration.

The sixth fixture is a drinking fountain equipped with one of the latest improved type bubblers.

The seventh fixture is a dental lavatory, and it is equipped with a vacuum breaker.

The eighth fixture is a Glass Washer which has an overflow feature that prevents any back-siphonage.

The next fixtures are glass front tanks where the possibility of back siphonage is demonstrated. In the upper tank there are several basin-cocks. A valve is used for top inlet supply to urinal tanks. On the left side of the tank are water supplies used for tanks, vats, or vessels commonly used in factories and industrial plants, where acids, caustic-soda and other chemicals are used. In the lower tank we have two ball cocks and a No. 4½ bath faucet. The ball cock to the right is equipped with a vacuum breaker.

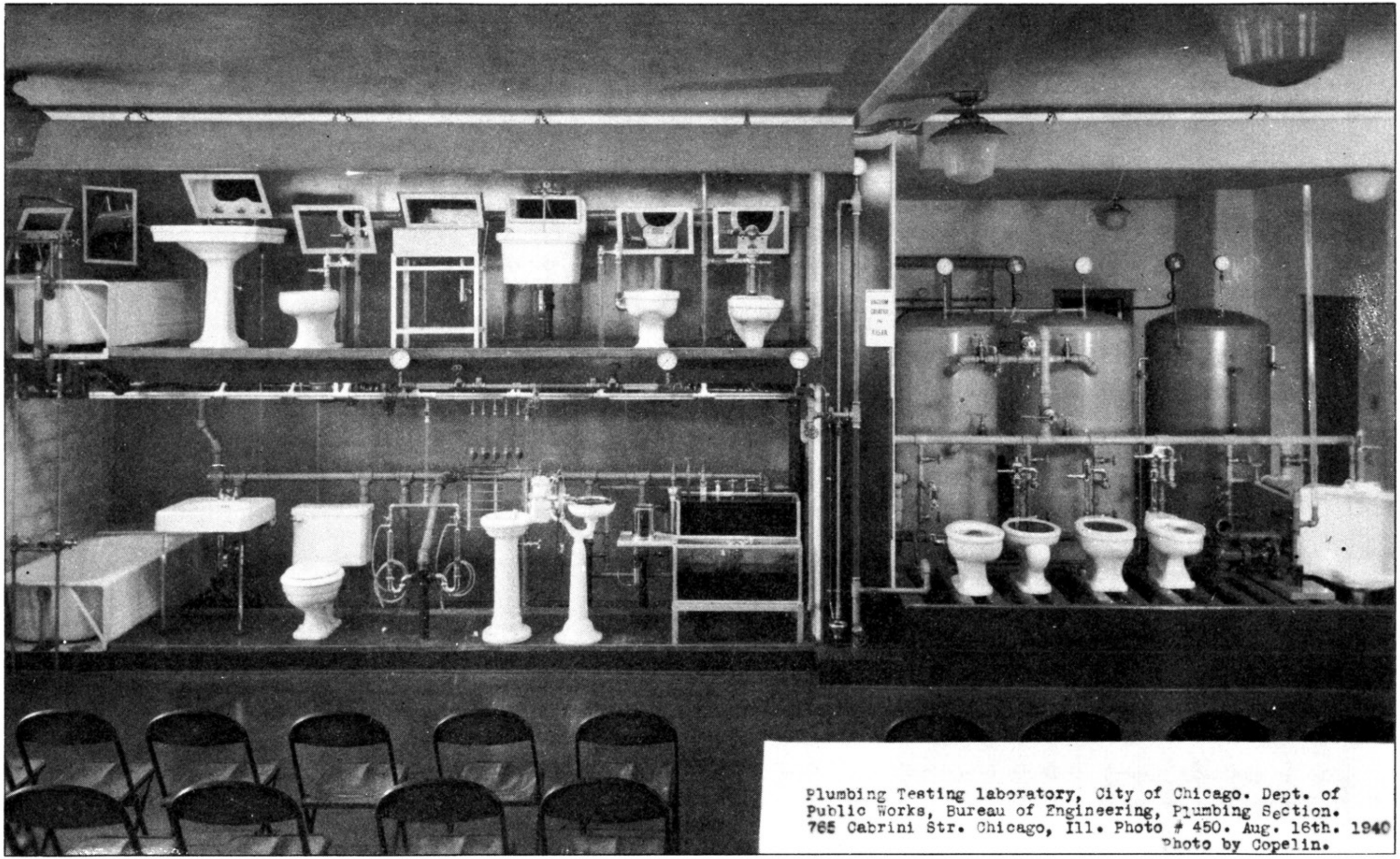
In the center, above the drinking fountain, and at the upper level, we have another type of dangerous cross-connection between the secondary water supply and the city water supply.

A secondary water supply is water from a river, well, reservoir or, in many instances, water that is used for cooling systems, and in many manufacturing plants, in all of which a sure supply is necessary at all times.

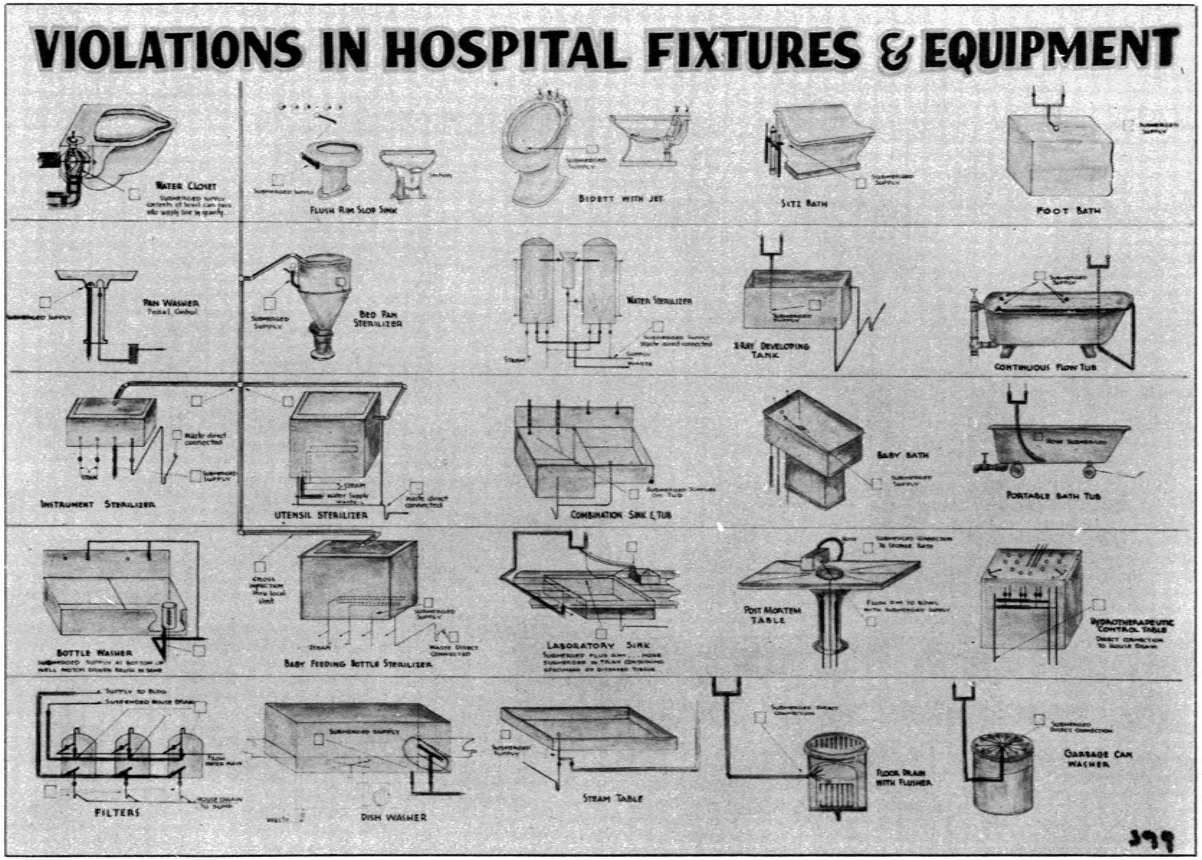
On the city water side to the left, both check valve and gate valve have a 1/32″ hole bored in them to represent defective valves.

Ordinarily a secondary water supply pressure would be considerably greater than is necessary for the City pressure to be maintained, and you can readily see that with a greater pressure on the foreign water supply through those two defective valves, the foreign water would force its way into the city water supply and into the water supply system.

Valves of this type nearly always develop leaks within a short time after being used, and we might also state that check valves are not allowed by the City of Chicago to be used with a connection of this kind because of the danger involved of contaminating the City water supply if the valve were defective.



Plumbing Testing laboratory, City of Chicago. Dept. of Public Works, Bureau of Engineering, Plumbing Section. 765 Cabrini Str. Chicago, Ill. Photo # 450. Aug. 16th. 1940 Photo by Copelin.


VIOLATIONS IN HOSPITAL FIXTURES & EQUIPMENT
WATER CLOSET
FLUSH RIM SLOP SINK
BIDETT WITH JET
SITZ BATH
FOOT BATH
PAN WASHER
BED PAN STERILIZER
WATER STERILIZER
X-RAY DEVELOPING TANK
CONTINUOUS FLOW TUB
INSTRUMENT STERILIZER
UTENSIL STERILIZER
COMBINATION SINK & TUB
BABY BATH
PORTABLE BATH TUB
BOTTLE WASHER
BABY FEEDING BOTTLE STERILIZER
LABORATORY SINK
POST MORTEM TABLE
HYDROTHERAPEUTIC CONTROL TABLE
FILTERS
DISH WASHER
STEAM TABLE
FLOOR DRAIN WITH FLUSHER
GARBAGE CAN WASHER
399

NEWS ITEMS CONCERNING CROSS-CONNECTIONS

The following news items are reproduced to show that the press is awake to the dangers of cross-connections.

Suppose It Had Been Arsenic?

CROSS-CONNECTION HAZARDS in water distribution were dramatically demonstrated at Cleveland a few days ago (*ENR*, Sept. 28, 1939, p. 389) when a city water main was found to be clogged with paraffin! Investigation revealed that someone at an oil refinery had made a "mistake" and turned liquid paraffin into the water main instead of a refinery line. The pipes clogged included 600 feet of 8-in. main and a great length of 6-in. pipe. In other words the paraffin travelled a long way and affected the supply of a great many people before it was discovered. Suppose arsenical wastes or some other toxic substance from an industrial plant had been turned into the water main "by mistake"? Instead of clogged mains Cleveland would have had clogged mortuaries. Where would the responsibility for such a tragedy lie—on the conscience of the man who made a "mistake" or on the municipality that failed to discover cross connections which permitted such mistakes to occur?

Time Magazine
1940

MEDICINE

Manteno Madness

On a flat plain 48 miles south of Chicago lie 60 squat red-brick buildings. They house the 5,500 insane patients and 760 employes of Manteno State Hospital. Finished in 1937, this dreary-neat plant boasts many a modern improvement, including special wells, tapping a limestone water-table 17 feet underground, which supply the hospital with water. Life at Manteno rolled along with the quiet, machinelike monotony common to State institutions until one day last August, when a half-dozen patients complained of diarrhea.

Hospital doctors examined them, reported them to the Board of Health as dysentery cases. Next day the number had tripled, and State Welfare Director Archibald Leonard Bowen, knowing that many modern doctors do not recognize a case of typhoid when they see one, at once chlorinated the hospital's water supply, sent a truckload of typhoid vaccine to the hospital. But it was too late.

The disease spread to a dozen, a score, a hundred. Patients lay moaning in bed. Others, whipped by mad fear, beat against the screened windows, grappled with attendants. Some of the attendants fell ill. All were panicky. Every night kitchen boys and orderlies disappeared. Over 45 ran away in all.

Last week Manteno's Director Ralph Thompson Hinton announced that the epidemic was finally cleaned up and that peace had returned to Manteno. The toll: 384 stricken, 47 dead. Engineers, examining the miles of Manteno sewers, suspected a small leak in the tiles, believed that contaminated water had seeped into the wells. Prospect was that Manteno would either build a filtration plant on the grounds or start piping water from Kankakee's safe water supply ten miles away.

Time Magazine
1940

CROSS CONNECTION POLLUTES ROCHESTER WATER SUPPLY . . .

Panic Grips Upstate City's 324,000 Residents as Open Valve Mixes Unfiltered River Water With Potable Drinking Water — Typhoid Epidemic Narrowly Averted

THE hazards of contamination of potable drinking water were never more forcibly impressed upon the public than during the past month, when the health of an entire city and even the lives of many of its men, women and children were jeopardized by the simple opening of a gate valve.

It happened right here in New York State—in Rochester, one of our most important industrial centers—and it came too close to the point of being a major catastrophe to be laughed off, even by the most extreme scoffers at the importance of proper plumbing as a health measure.

According to State Zone Delegate George J. Long's report to THE LADLE, Rochester has a high-pressure water system in the downtown district designed for fire-fighting purposes. The water for this system is pumped out of the Genesee River. An emergency cross connection had been made between the system and the city's potable drinking water supply mains.

"On Wednesday, December 11," reports Mr. Long, "a crew foreman, after repairing a leak in the gate valve in this cross connection, inadvertently opened the valve and let the river water mix with our drinking water. This condition existed for 17 hours before it was discovered and the valve turned off.

"A general alarm to boil all water before using it was sent out. Many cases of slight sickness occurred, but nothing serious happened and on December 18 everything was cleared up. The cross connection was removed and now (December 19) Rochester is back to normal again."

When Mr. Long speaks of his city as now being "back to normal" he does so advisedly, for the near-calamity literally turned Rochester into a bedlam of confusion and fear for the better part of a week.

Dr. Paul A. Lembcke, district health officer, reported to the State Health Department at Albany that during the 17 hours the valve was open "six million gallons of (unfiltered) river water were believed to have entered the mains."

Dr. Arthur Johnson, city health officer, urged all Rochester residents to undergo vaccination against typhoid fever, typhoid vaccine was rushed to Rochester by the State Health Department, and public clinics were established throughout Rochester and its suburbs to provide free treatment for the city's 324,000 residents.

Dr. Johnson said tests taken by chemists showed that much of the water supply was highly contaminated. "We will continue," he said on December 13, "to introduce chlorine into the city drinking water under heavy pressure until repeated checks demonstrate that the contamination has been eliminated. This may take a week."

While all this was going on, the city fathers held an investigation, following which the local water bureau superintendent was discharged and the foreman of the repair crews suspended. Public Works Commissioner William H. Roberts took personal charge of the bureau and promised "a thorough survey of the entire water distribution system to make absolutely certain that such an occurrence never will happen again."

Although the bureau's records indicated, he said, that all valves connecting the drinking water mains and the high-pressure fire-fighting system had been removed or sealed in 1928 (including the unit which caused all the trouble and which was shown as sealed), Commissioner Roberts promised to "dig wherever any such connections ever were shown to have been on the city maps and records. This time we will make absolutely sure that all are removed. The work will begin immediately."

The Ladle
Jan., 1940

BOWEN GUILTY OF NEGLECTING MANTENO DUTY

Faces Possible Fine and Removal from Office.

A. L. Bowen, state director of public welfare, was found guilty yesterday by Judge James V. Bartley in the Kankakee county Circuit court at Kankakee of gross omission of duty in connection with the typhoid epidemic last year at the Manteno state hospital. Manteno is one of 28 state institutions under Bowen's charge. The maximum penalty possible under the verdict would be a $10,000 fine and removal from office.

It was the second time Bowen faced the court on the charge. He was tried by a jury last February but Judge Bartley dismissed the jurors when they were unable to reach a verdict after deliberating 96 hours. Attorneys for both sides then agreed to let Judge Bartley decide the case on the basis of testimony given at the trial.

Water Supply Blamed.

In his ruling yesterday Judge Bartley upheld the contention of State's Attorney Samuel Shapiro of Kankakee county that the epidemic, as a result of which 60 persons died, was caused by the water supply from four polluted wells on the grounds at Manteno and that Bowen had ignored public health department warnings that the wells were contaminated.

"The evidence in this case shows beyond all reasonable doubt that the defendant [Bowen] paid no attention whatever to the reports of the department of health," Judge Bartley said. "On the contrary the evidence shows that on one occasion when the water situation was being discussed while he was engaged in his duties at Manteno and the report of the department of health was being presented to him, he said the water would have to wait as there were more important things to take care of.

Discredits Theory of Defense.

"Why Mr. Bowen refused to heed the warnings of the public health department I cannot understand. The defense adopted the theory that the epidemic was caused by a patient in the institution. I do not believe this patient had anything whatever to do with the epidemic."

Attorney John Mayhew, counsel for Bowen, said he would ask for a new trial. Judge Bartley set July 11 for hearing any motions offered by the defense. Bowen said he had nothing to say on the guilty finding.

State's Attorney Shapiro, who conducted the investigation of the typhoid epidemic, said charges against Dr. Ralph T. Hinton, suspended managing officer of the institution, and Mrs. Lillian Williams, hospital dietician, would be dismissed by the state. Previously Bowen said that Hinton has been suspended permanently and Mrs. Williams removed from her duties. Both Dr. Hinton and Mrs. Williams were indicted with Bowen.

Chicago Tribune
June 28, 1940

Soda Pop and Beer Gush From Faucets In Joliet Residences

JOLIET, Ill., Jan. 15 (U.P.)—All was confusion Saturday when housewives opened kitchen faucets to draw water for their breakfast coffee and tasted beer—or was it soda pop?

Water Commissioner Joseph F. Whalen said that he didn't know what was wrong, but he was going to find out. He was certain that it was something more than overworked imagination because more than one housewife had tasted it. One woman said it tasted like beer. A man said definitely it was beer and he wanted it stouter, with a collar on it. Another woman said it was strawberry soda. Others said it tasted like vanilla.

Whalen thought that perhaps the trouble was pressure. He said two breweries and two soft drink bottling plants were located in the neighborhood from which the compliants came. The companies supply their own water from wells, he said, but their private water lines have cross connections with city mains.

He believed the pressure in the private pipes had risen above the city's pressure and had forced the multi-flavored water into the city's supply.

Columbia Missourian
Jan. 15, 1940

Beer Piped Through Town's Water Mains

By Associated Press.

JOLIET, ILL., January 12.—East Joliet residents turned on their water faucets today and beer flowed.

Some called City Commissioner Joseph F. Whalen to complain. Others said it was great. One man asked if it couldn't be made a little stronger.

Whalen said that a brewery vat apparently had overflowed into the city water system and made the water taste strongly of beer.

A crew of men sought the offending vat. Meanwhile, beer, hot and cold, ran from hundreds of taps.

St. Louis Globe Democrat
Sept. 10, 1939

Lays Deaths of 52 to Sewer Leak

By Associated Press.

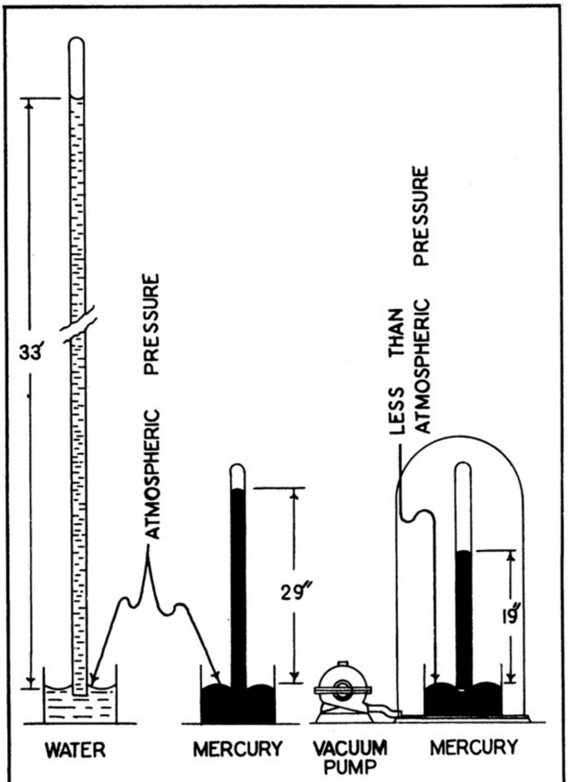
MANTENO, ILL., October 19.—Testimony that he believed sewerage seepage into the water supply was responsible for a typhoid epidemic that resulted in the deaths of 52 persons at the Manteno State Hospital, was given a Coroner's jury today by Dr. Ralph T. Hinton, the hospital's managing officer.

The inquest was into the death of Emily Dalton of Chicago, No. 51, who died October 15. The jury returned a verdict of death from typhoid fever and made no recommendations.

Dr. Hinton said the first case of illness was discovered July 15.

St. Louis Globe Democrat
Jan. 12, 1940

DIAGRAM OF CROSS-CONNECTION CONDITIONS



Courtesy of Minn. Health Dept.

Fig. 98.—Explanation of a partial vacuum.

When a partial vacuum is formed in a water-supply line, the danger of contamination of the water from certain kinds of plumbing defects is greatly increased. To understand how a partial vacuum may be created in the water supply piping, it is necessary to be familiar with some of the elementary principles of hydraulics that are involved in the problem. Most pressure gauges are calibrated to read zero at atmospheric pressure. Thus the pressure indicated is the pressure above atmospheric and not the absolute pressure. Pressure less than atmospheric are considered as negative pressures, partial vacuums, or for convenience just 'vacuums.' They are measured from the atmospheric datum and are usually expressed in inches of mercury, feet of water or pounds per square inch.

If a tube, say 40 inches long, closed at one end and filled with mercury, is inverted in a container of mercury, the level of the mercury in the tube will drop until it is, in this locality, approximately 29 inches above the level of the mercury in the container. This means that the pressure of the atmosphere is capable of sustaining the weight of a column of mercury 29 inches in height. The space above the mercury in the tube will be devoid of pressure and will be, essentially, a perfect vacuum. If the same experiment were carried out at sea level the height of mercury would be about

30 inches. Because atmospheric pressure is greater at sea level than in this vicinity, a longer column of mercury can be sustained. If the whole apparatus could be enclosed in a vessel from which the air could be exhausted, it would be possible to reduce the height of the column by reducing the pressure on the surface of the mercury in the open container. If the height of the column of mercury were lowered from 29 inches to, say, 19 inches, by this means, a negative pressure of 29 minus 10 or 10 inches would be indicated. This would be recorded as 10 inches of vacuum.

If a long tube containing water were used in this experiment instead of the tube of mercury, the height of the water column would be about 33 feet instead of 29 inches, because the specific gravity of mercury is 15.6 times that of water. Vacuum gauges attached at intervals along this vertical column would indicate various intensities of vacuum ranging from zero at the bottom to 29 inches in the space at the top.

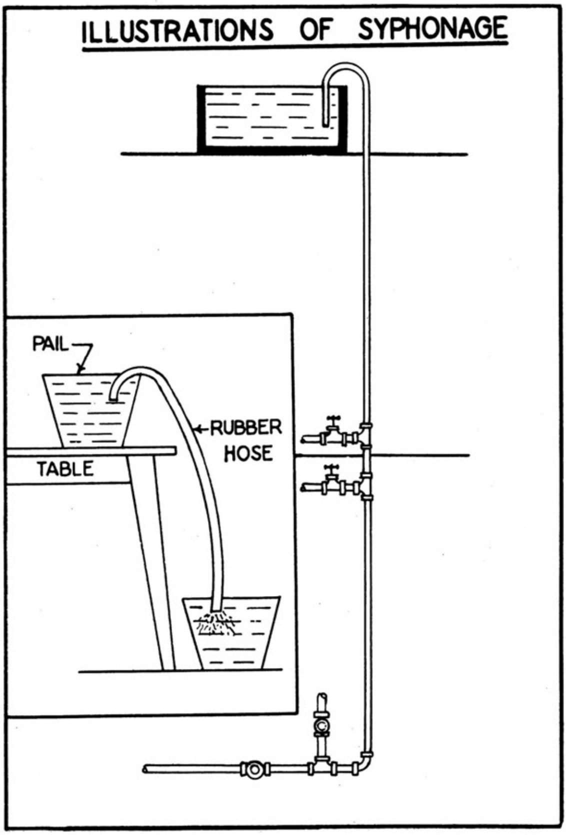


Fig. 99.—In any siphon there are two legs, a long one and a short one. The short leg dips down into the liquid to be moved (pail on table, and the long leg carries the liquid to the lower level to which it is to be transferred. When the fluid starts to flow through the rubber tube, it will continued until the upper pail is drained or until air enters the hose and breaks the siphon.

In the other sketch, the short leg dips down into the tank, and the long log is formed by the pipe leading down to the street main. Siphonic action is set up in siphon when the liquid in the long leg starts to flow out. Passage of the liquid creates a vacuum at the top of the siphon. Instantly a vacuum starts to form, atmospheric pressure on the surface of the liquid in the tank forces liquid over into the long or outlet leg of the siphon, and this action continues until the liquid in tank is lowered to the bottom of the short leg, or until siphonic action is interrupted in some cther way. The question arises as to what might cause siphonage to start in the case of the pipe arrangement. This could be done by closing the main valve "X," thus stopping admission of water to the tank, and then opening any one of the two valves "Y" or "Z," which would allow water to siphon out of the tank.

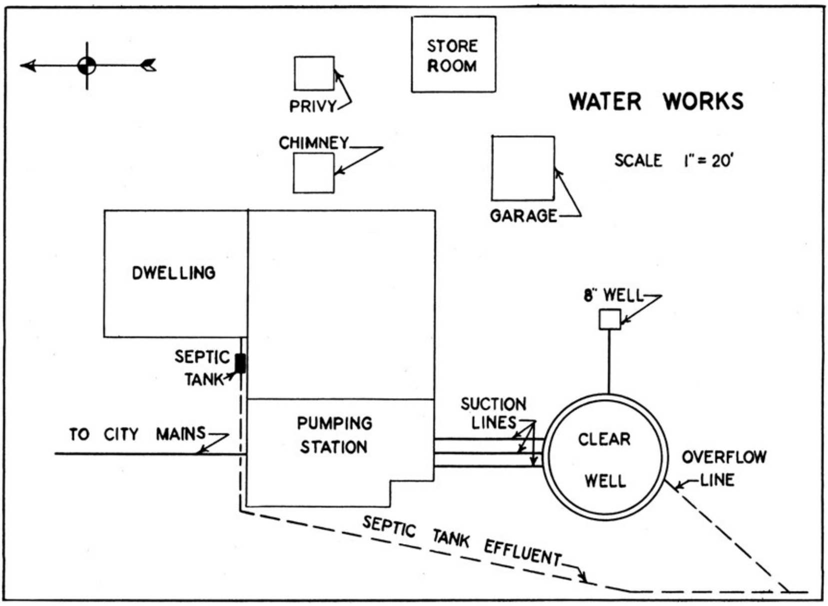


Fig. 100.—This is a plan view of the pumping station of a city water works showing the location of the septic effluent with respect to the clear well.

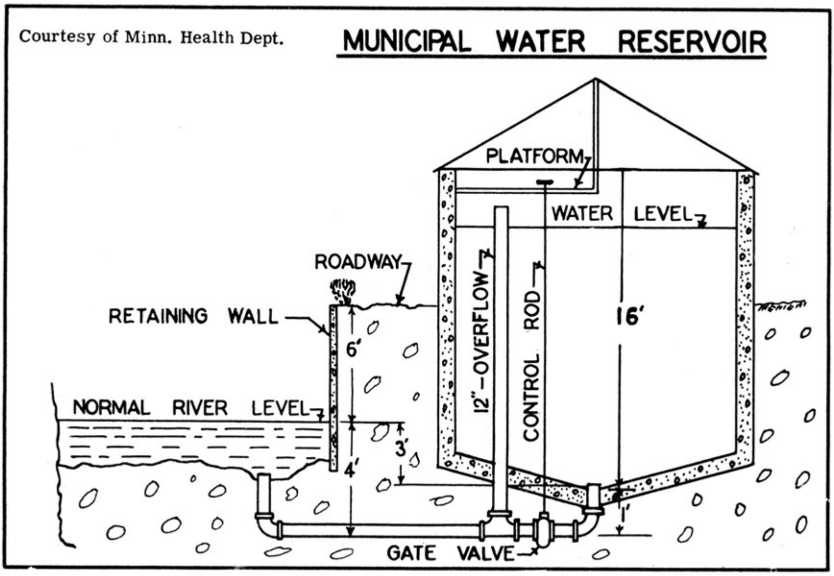


Fig. 101.—A sketch showing the connection between a municipal water reservoir and a stream. The normal river level is 3 feet above the bottom of the reservoir. The tank is drained and cleaned once a year.

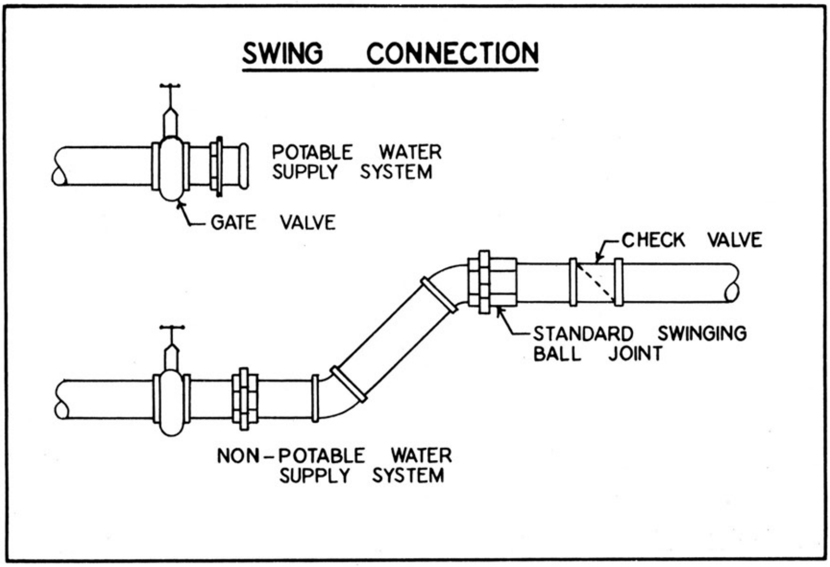


Fig. 102.—A suggested plumbing arrangement where dual supplies must be maintained for immediate use. The connection can be made to either supply, but never to both simultaneously.

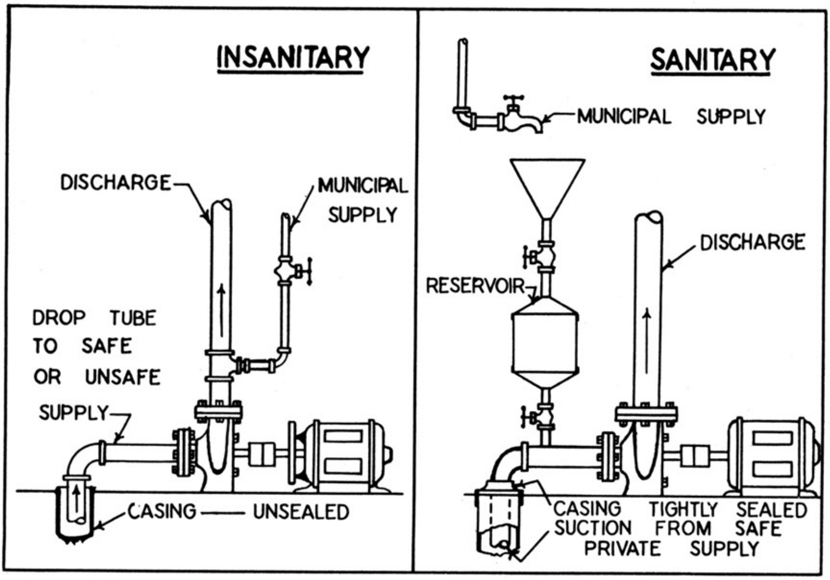


Fig. 103.—Priming device for lift pumps in which the water supply is protected from contamination.

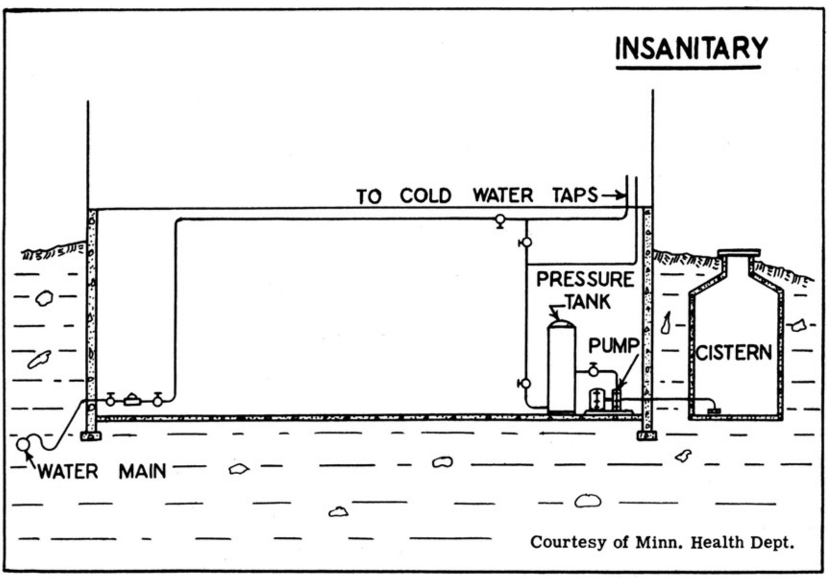


Fig. 104.—A typical cross-connection between an unsatisfactory cistern water supply and a city water supply.

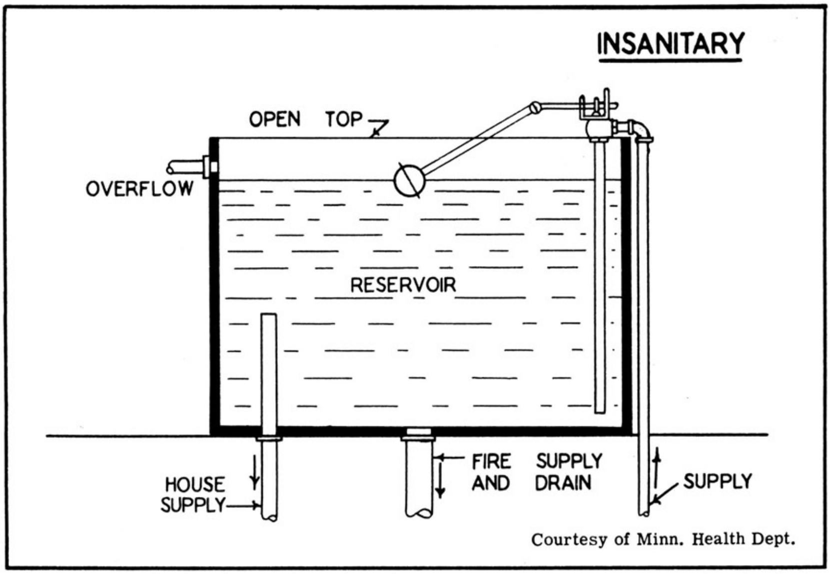


Fig. 105.

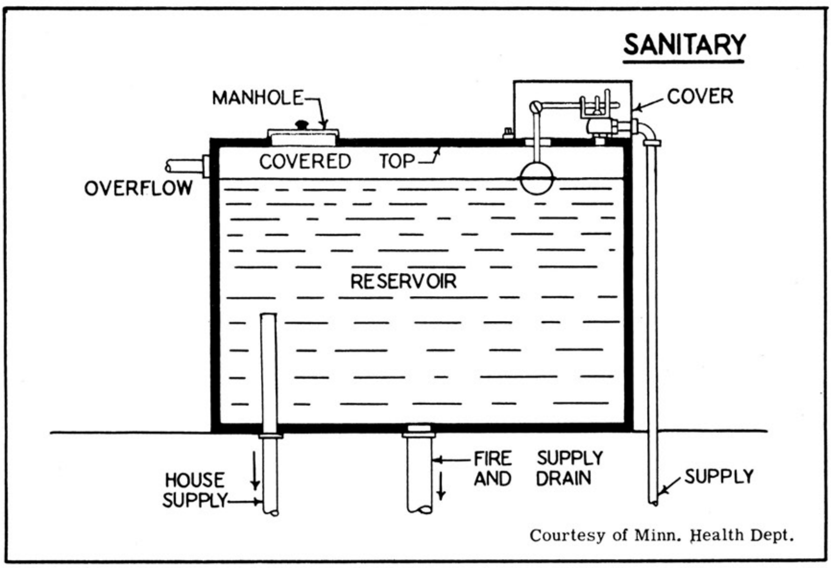


Fig. 106.

Insanitary and sanitary receiving water reservoirs.

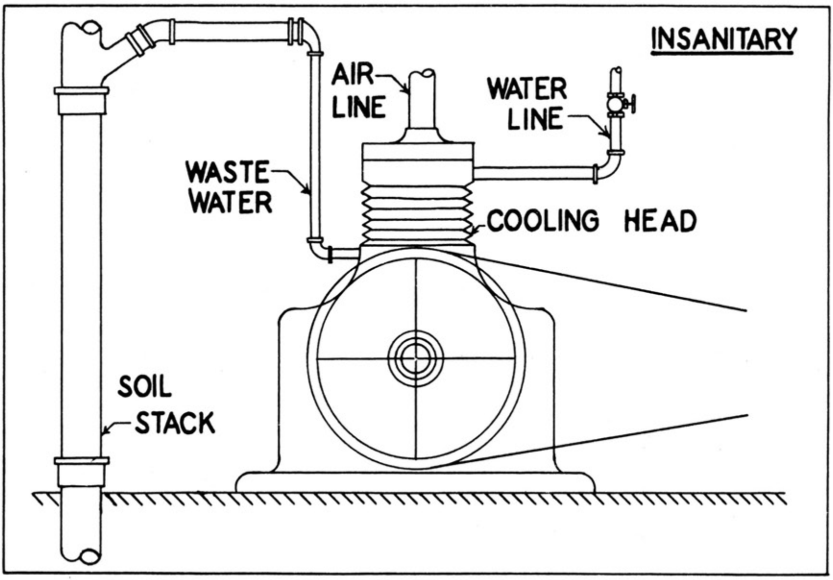


Fig. 107.

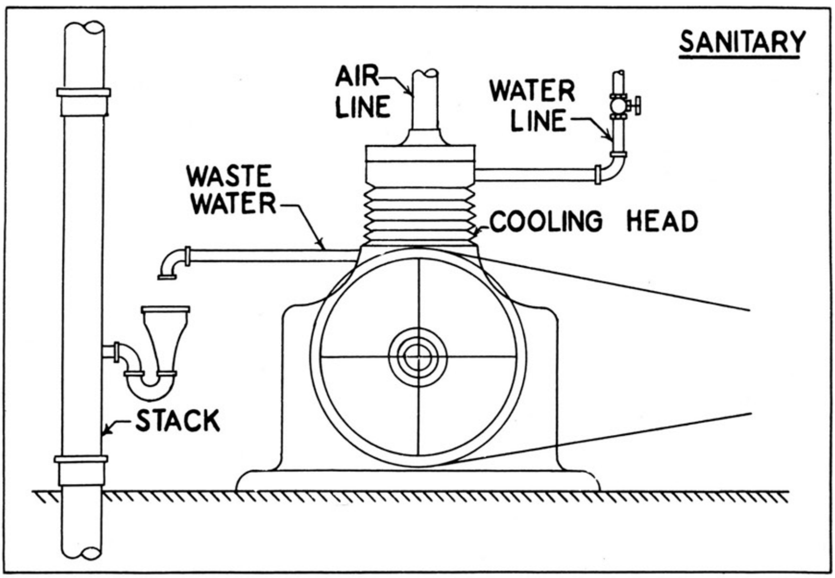


Fig. 108.

Typical air compressor unit showing both insanitary, Fig. 107, and sanitary methods, Fig. 108, of installation.

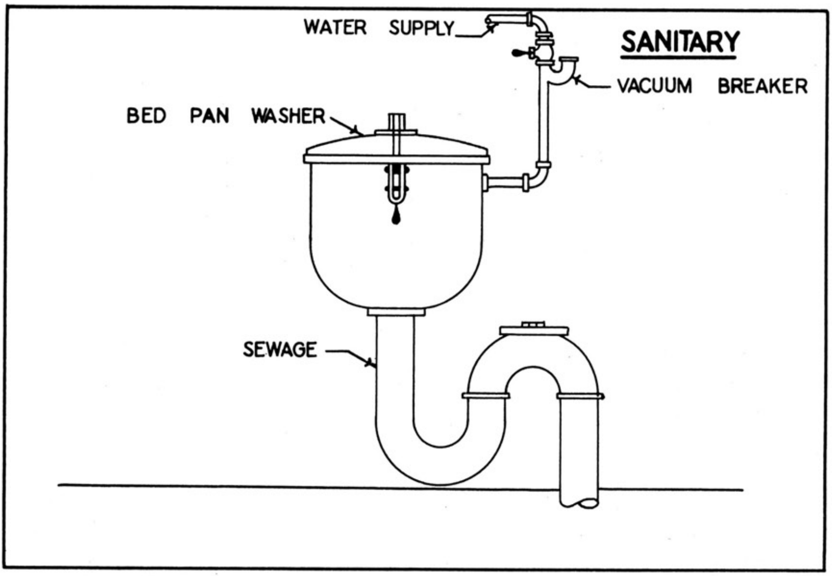


Fig. 109.—A sanitary hospital bed pan washer. The vacuum breaker should be at least 6 inches above the tank and periodically checked for proper functioning.

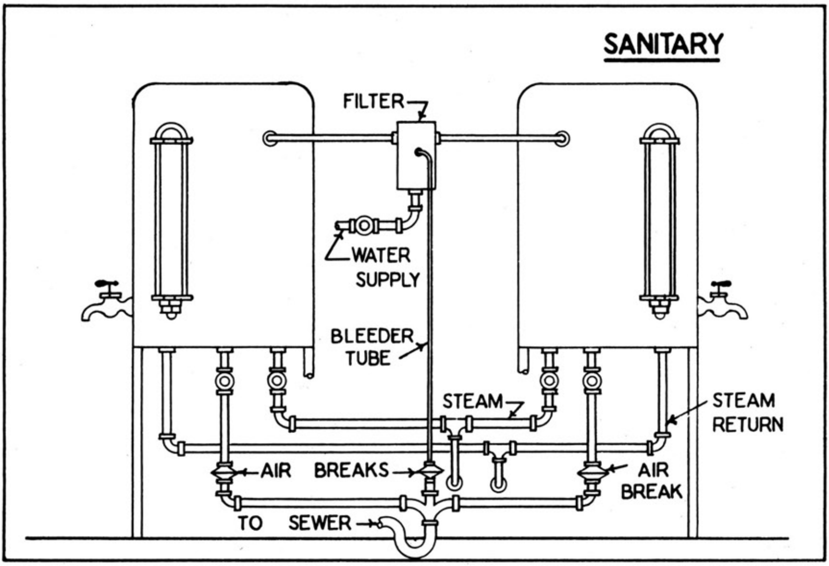


Fig. 110.—A hospital water sterilizing unit properly installed.

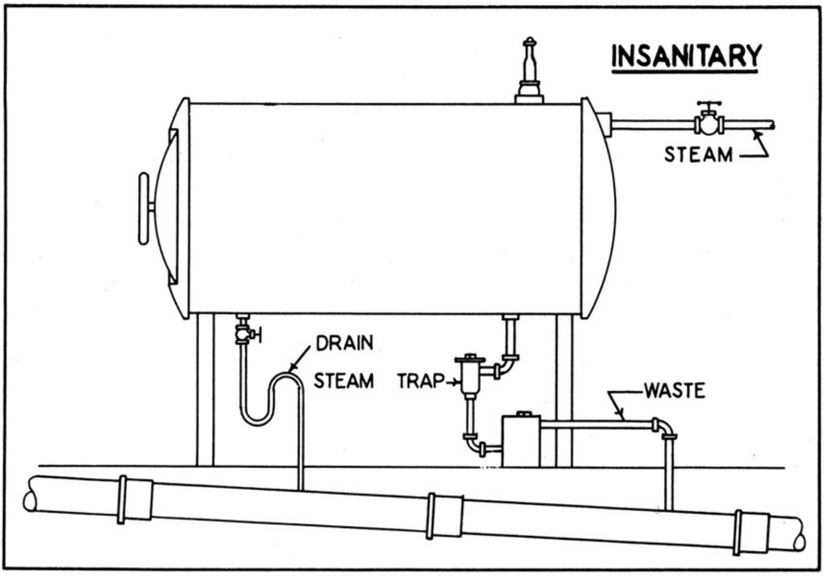


Fig. 111.

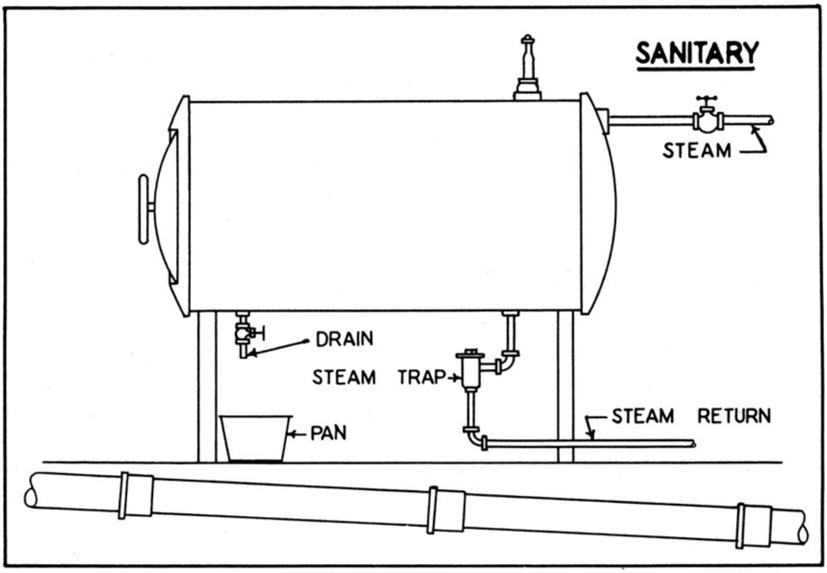
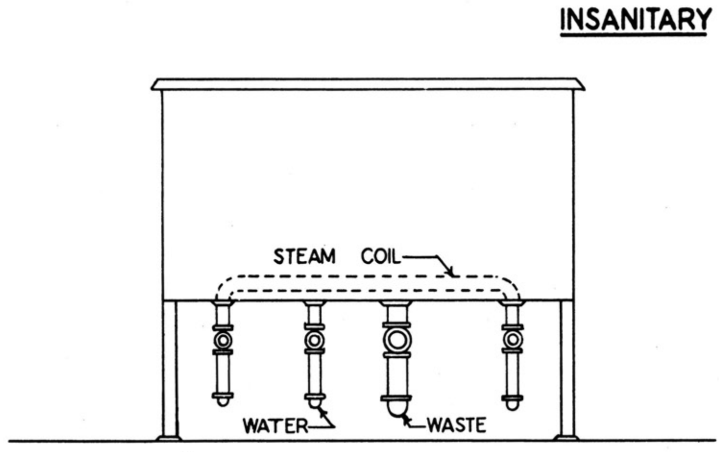


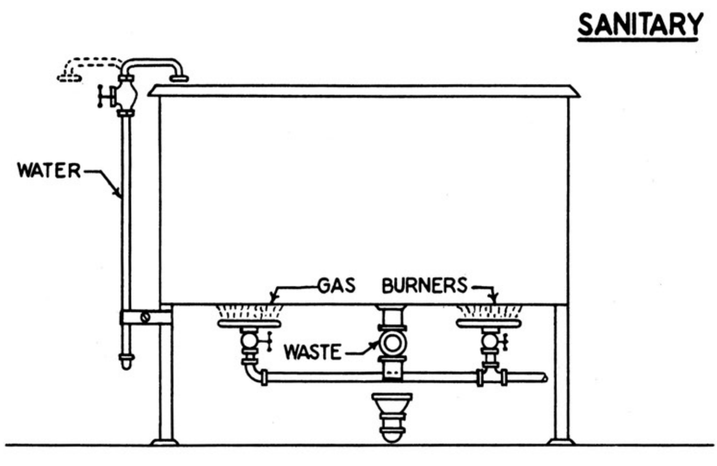
Fig. 112.

Autoclave sterilizing equipment.



Courtesy of Minn. Health Dept.

Fig. 113.



Courtesy of Minn. Health Dept.

Fig. 114.

A typical hospital instrument sterilizer in which the piping on the insanitary installation, fig. 113, has been changed to a sanitary installation, fig. 114.

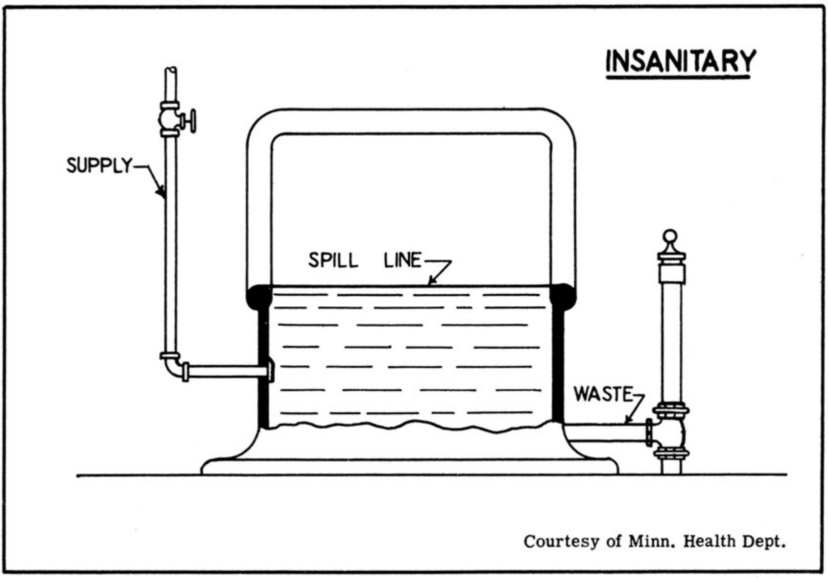


Fig. 115.

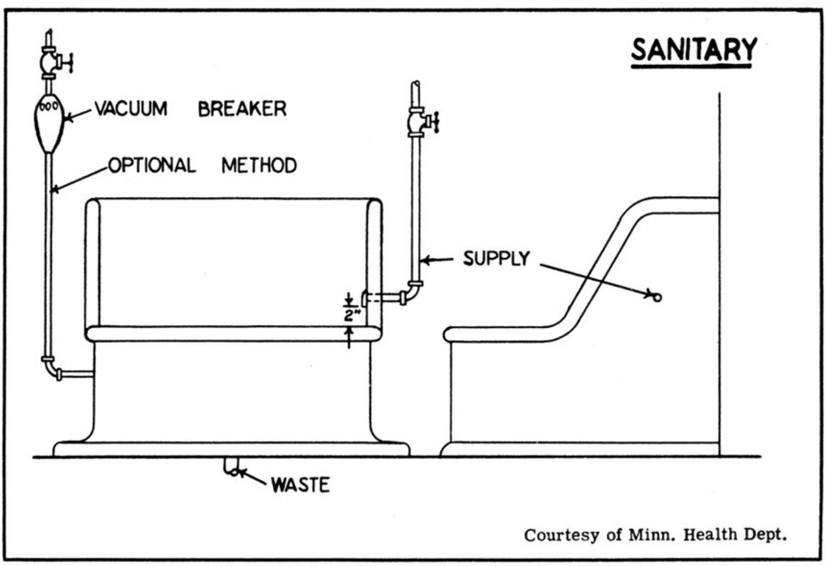


Fig. 116.

Sitz bath with submerged inlet, fig. 115, and alternate methods of correction, fig. 116.

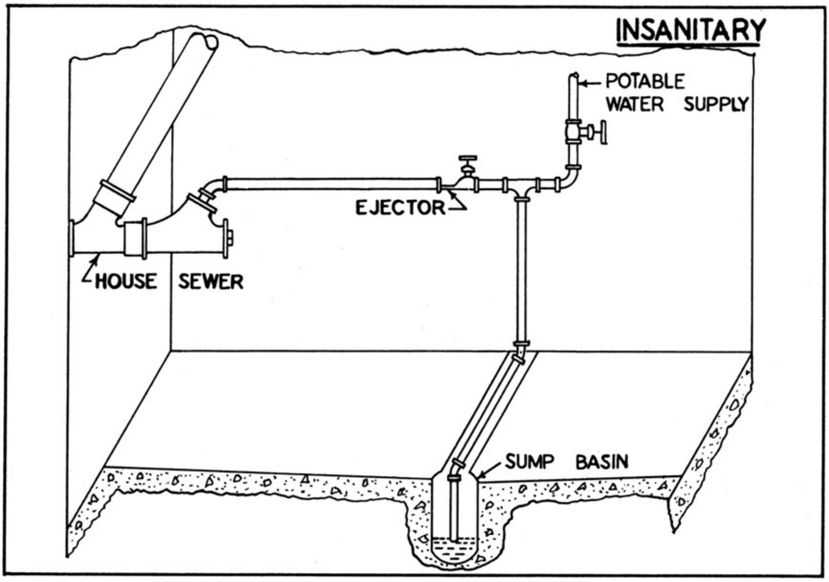


Fig. 117.

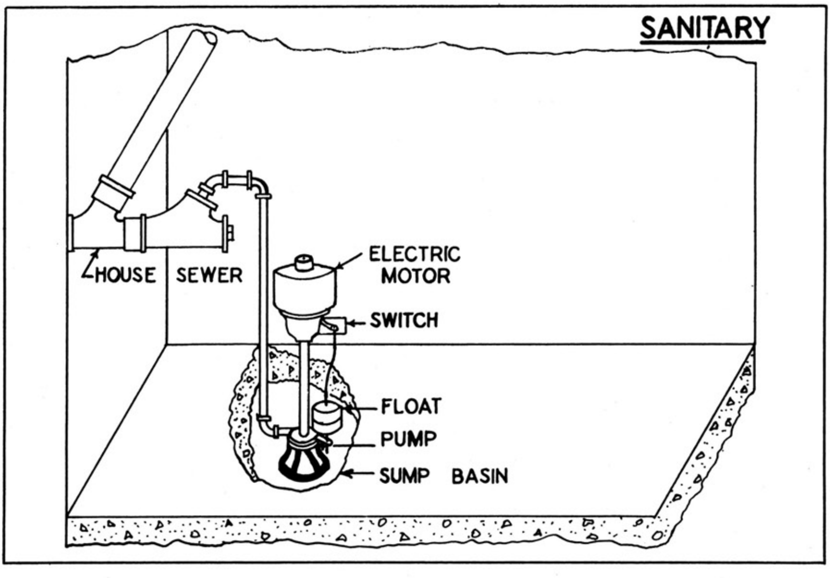


Fig. 118.
Insanitary and sanitary cellar drain installations.

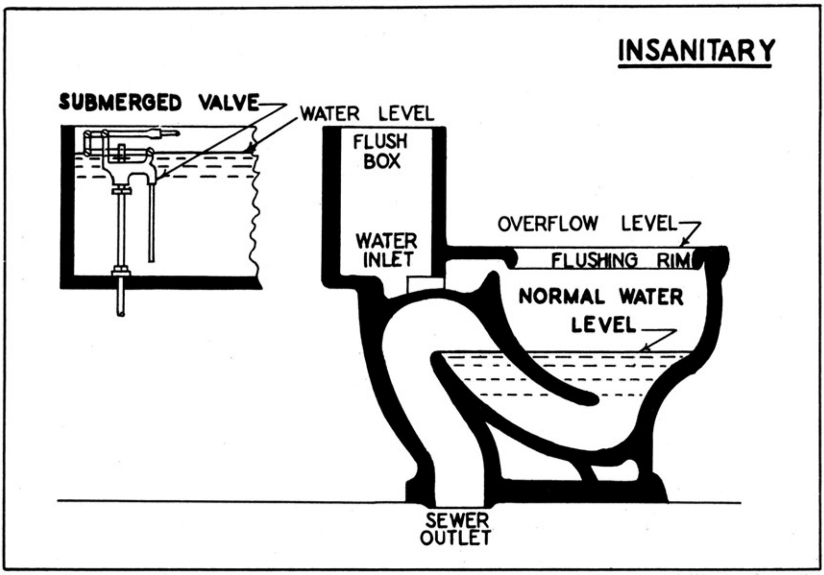


Fig. 119.—Submerged supply in water closet box. The box is an integral part of the stool and would be contaminated with sewage in case of a stoppage. Wall boxes have similar submerged valves through which contaminated water could be siphoned. In the wall boxes the contents of the stool would not be siphoned, but the water is contaminated by spiders, crickets, cockroaches and people throwing contaminated articles into the box.

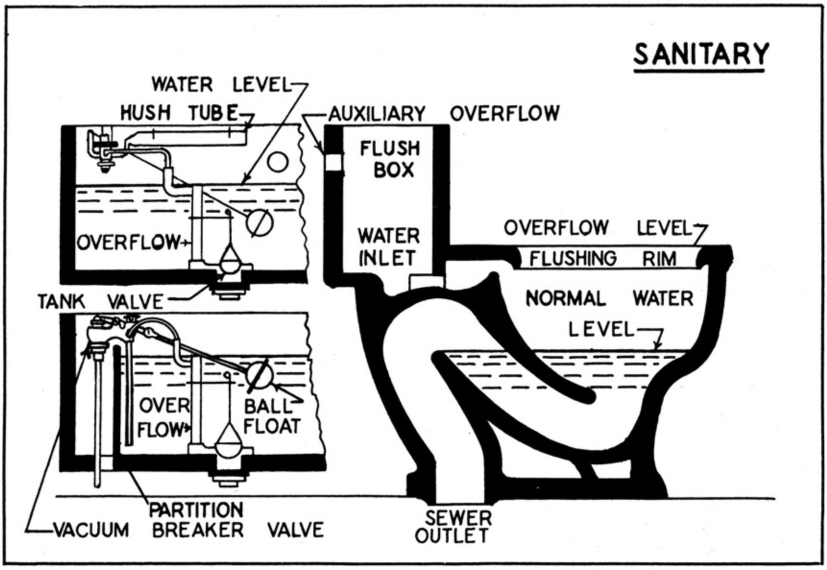


Fig. 120.—An alternate method for prevention of back siphonage from water closet bowl shown in fig. 119.

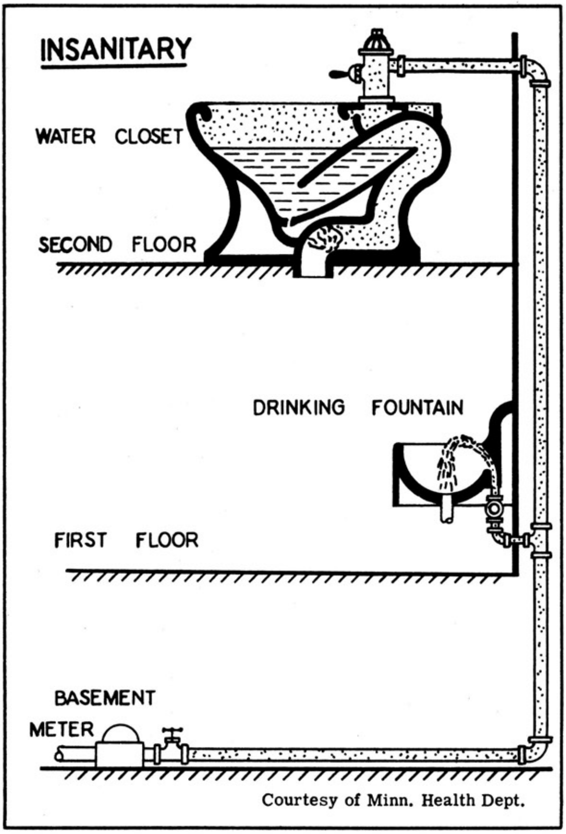


Fig. 121.—A typical plumbing cross-connection through a water closet, equipped with a flushometer valve, and drinking fountain.

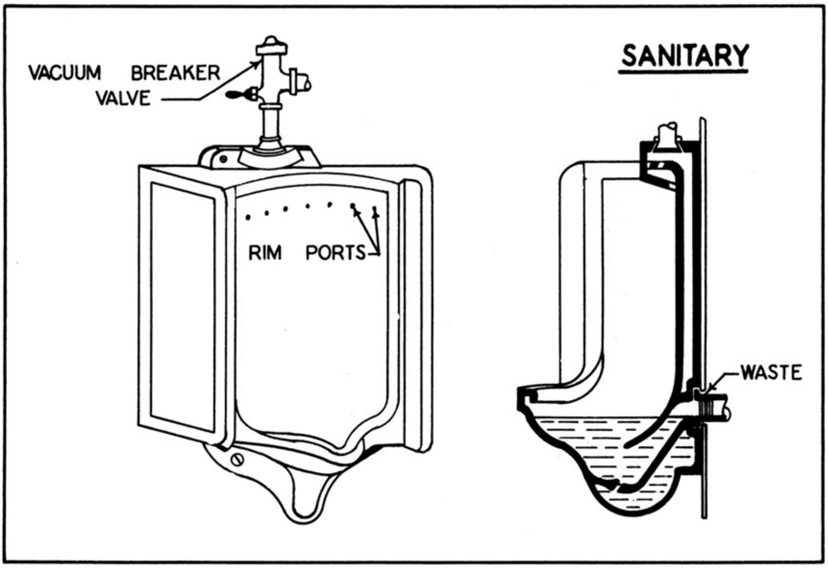


Fig. 122.—Urinal with vacuum valve. The vacuum breaker valve is necessary to prevent siphonage of the trap contents, because the flow of air through the rim ports is insufficient to break the vacuum which may be produced.

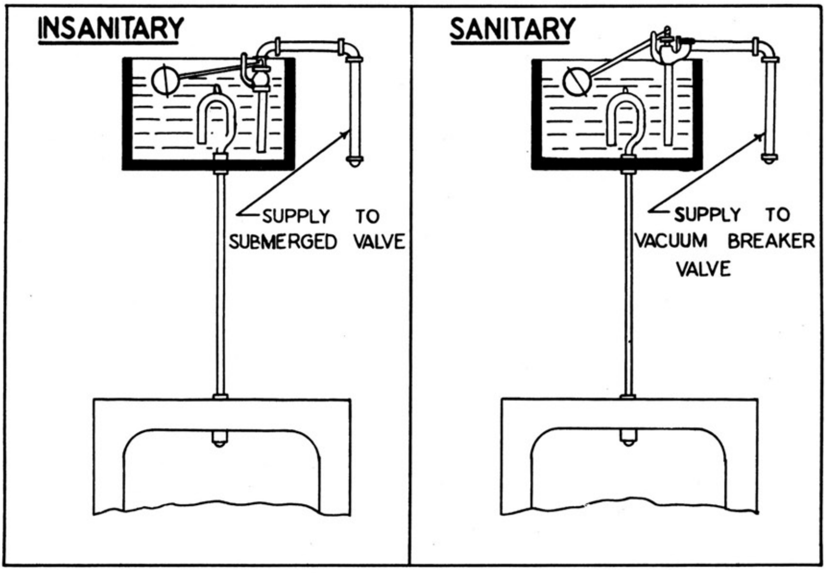
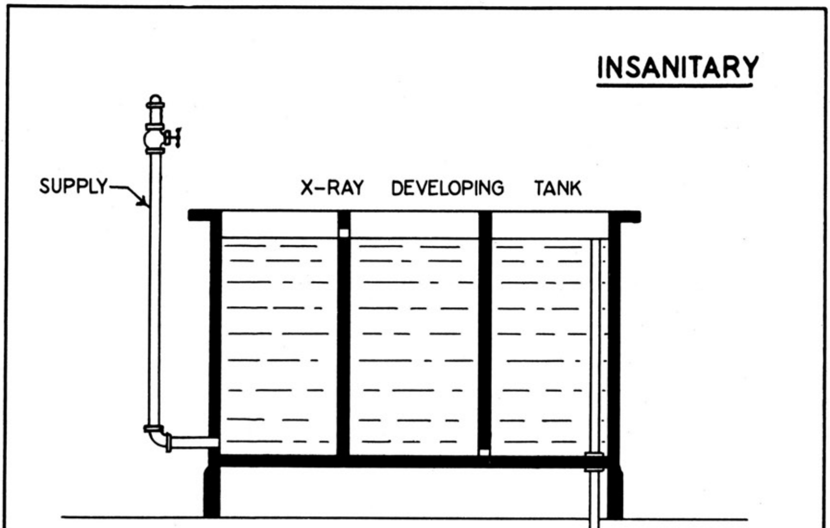
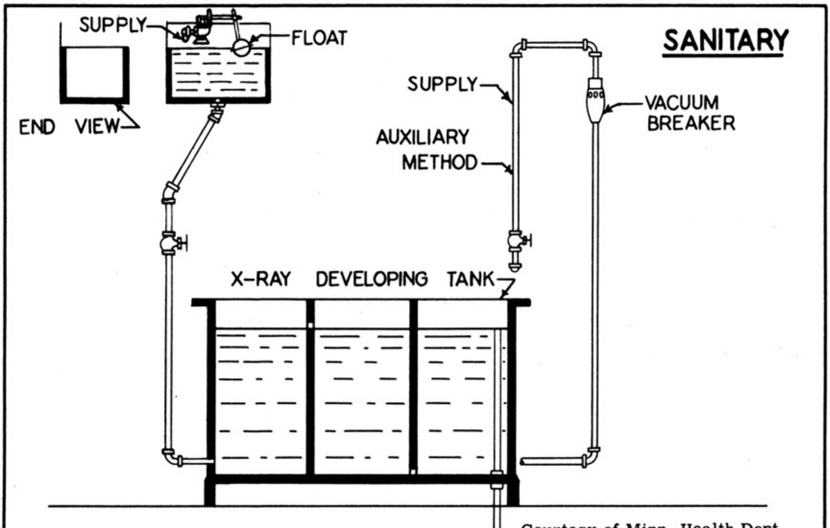


Fig. 123.—Wall urinal supply tanks.



Courtesy of Minn. Health Dept.

Fig. 124.



Courtesy of Minn. Health Dept.

Fig. 125.

X-Ray tank installation with alternate methods for correction. Cross-connections in photostat machines can be eliminated in a similar fashion.

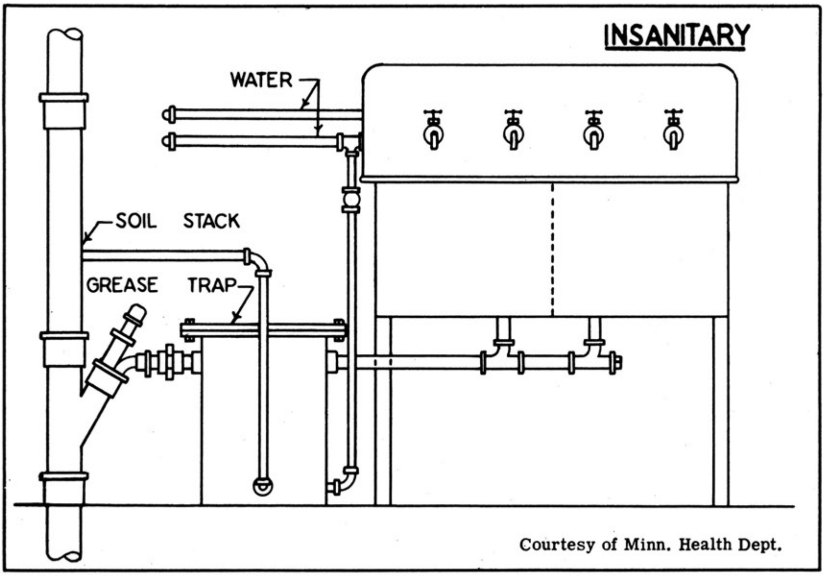


Fig. 126.

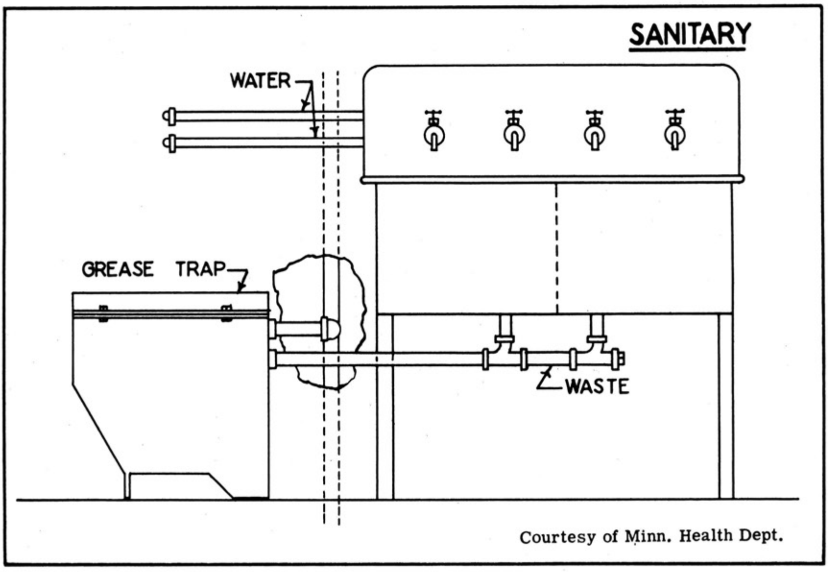


Fig. 127.

A water-cooled grease trap installation.

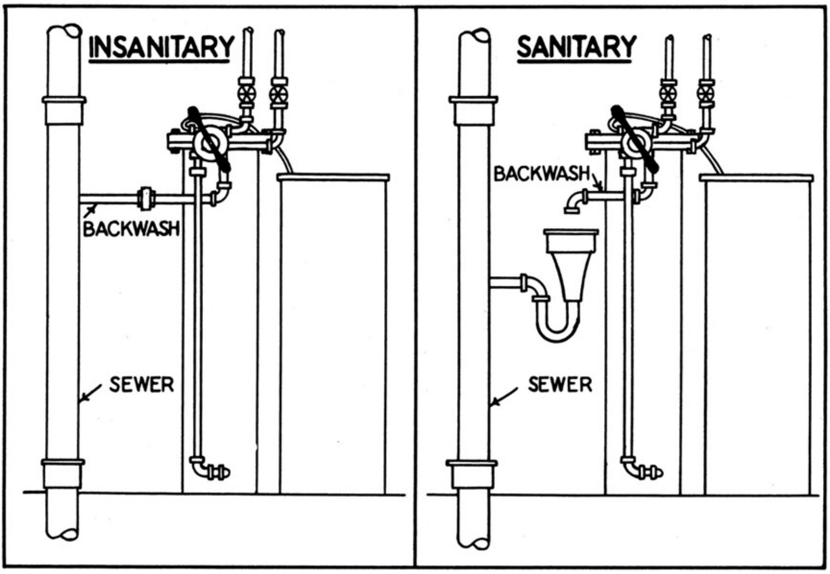


Fig. 128.—Water softener plumbing installations.

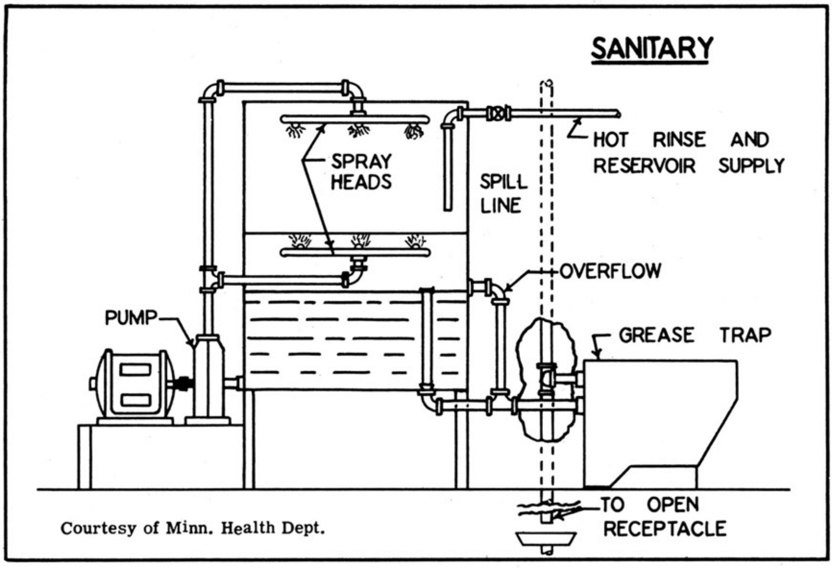


Fig. 129.—Dish washing machine with grease trap.

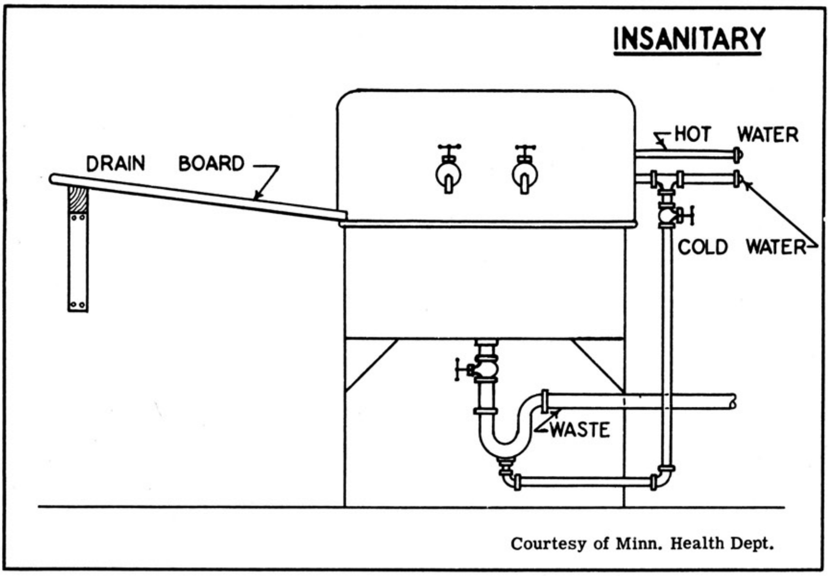


Fig. 130.—A kitchen sink with water supply connected to trap in order to flush drain in case of stoppage. Such practice should not be permitted.

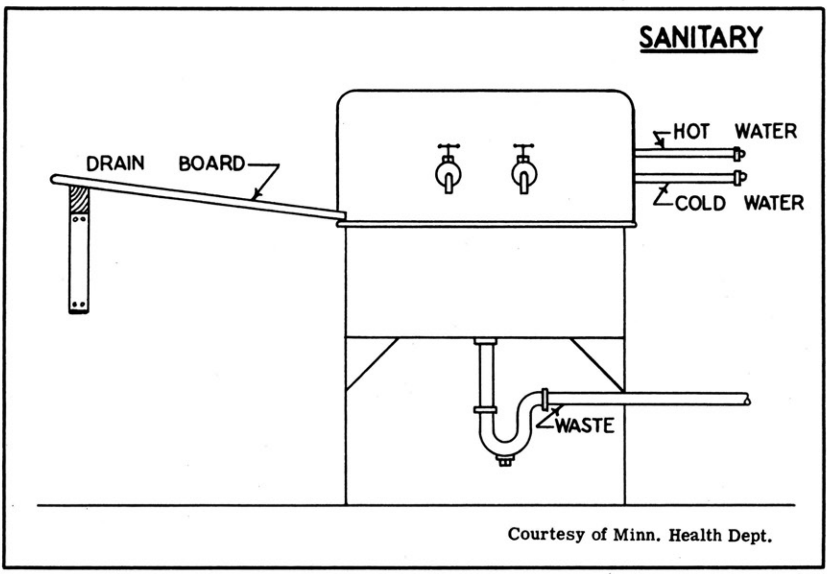


Fig. 131.

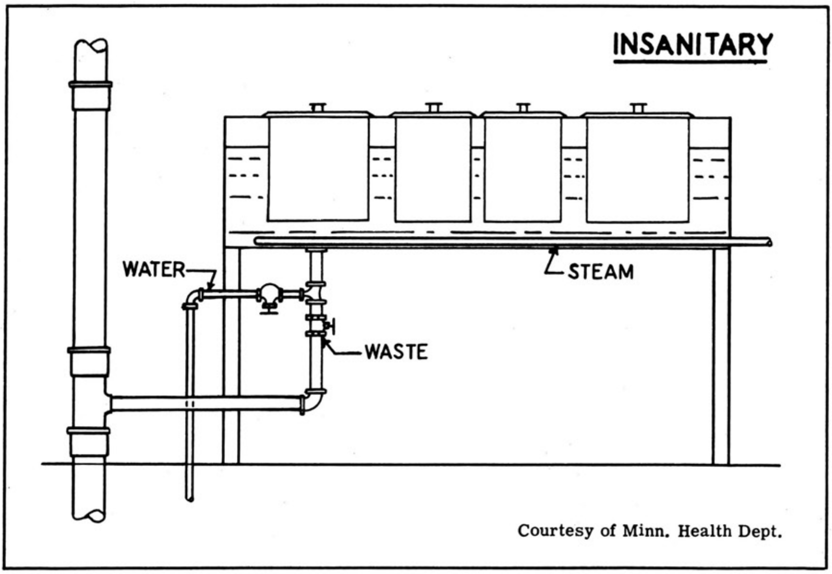


Fig. 132.

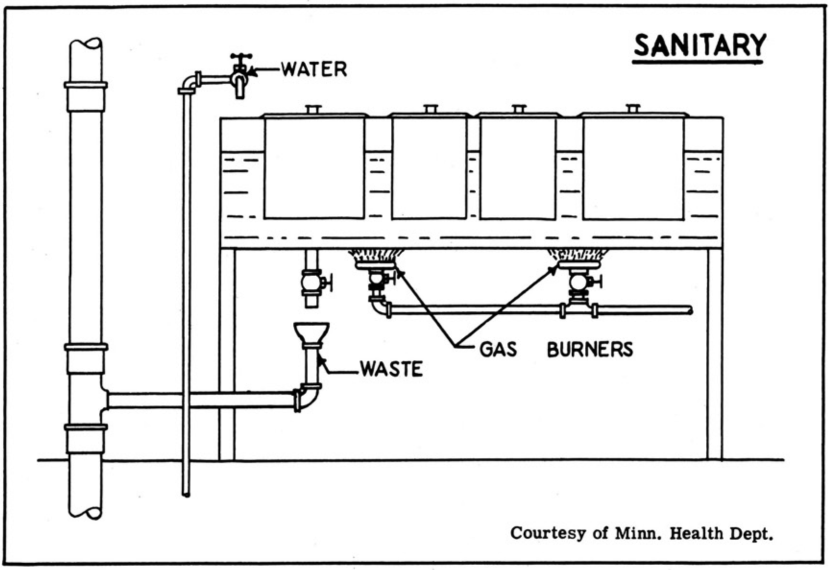


Fig. 133[1]

Insanitary and sanitary steam table plumbing arrangements.

[1] Ibid.

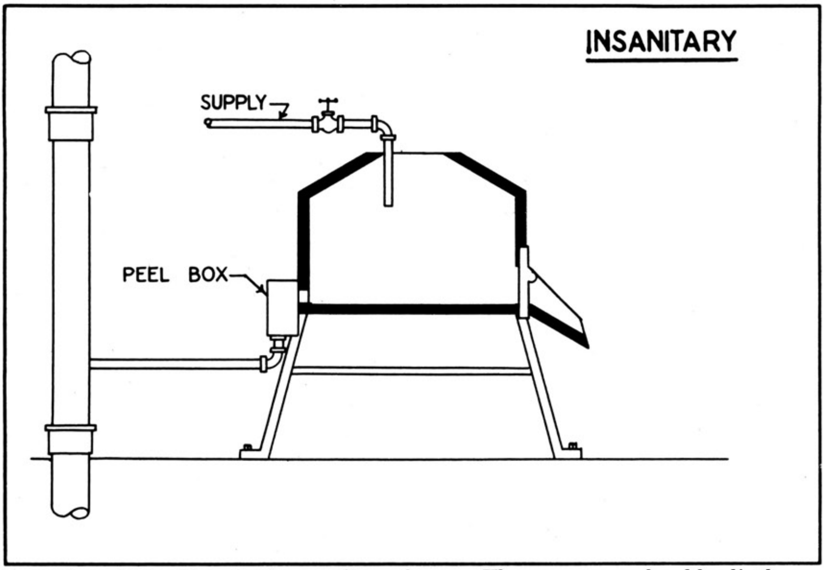


Fig. 134.—Vegetable peeling box. The wastes should discharge into an open trap with an air gap. With the above installation sewer gases can return to the box and the peelings can be carried directly into the sewer to cause a probable stoppage.

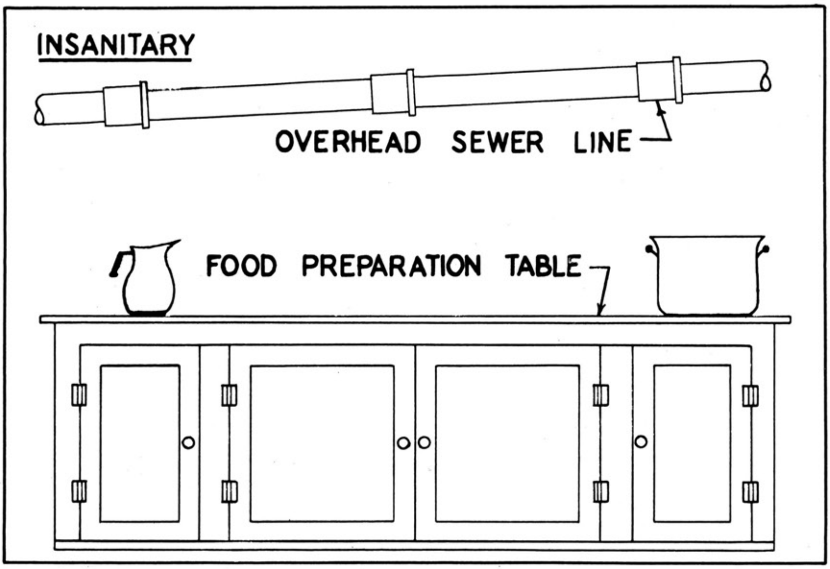


Fig. 135.—All pipes leak at some time. In this case such results could be disastrous.

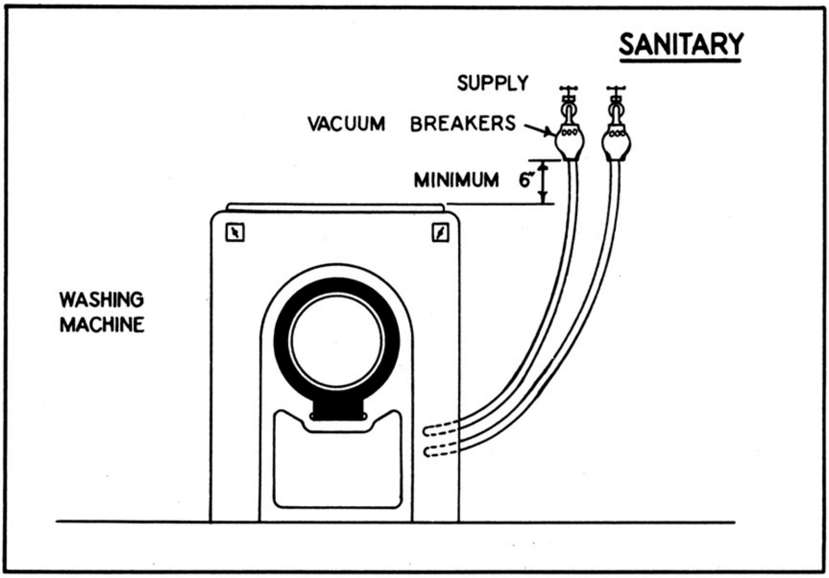


Fig. 136.—Bendix washing machine (or similar make).

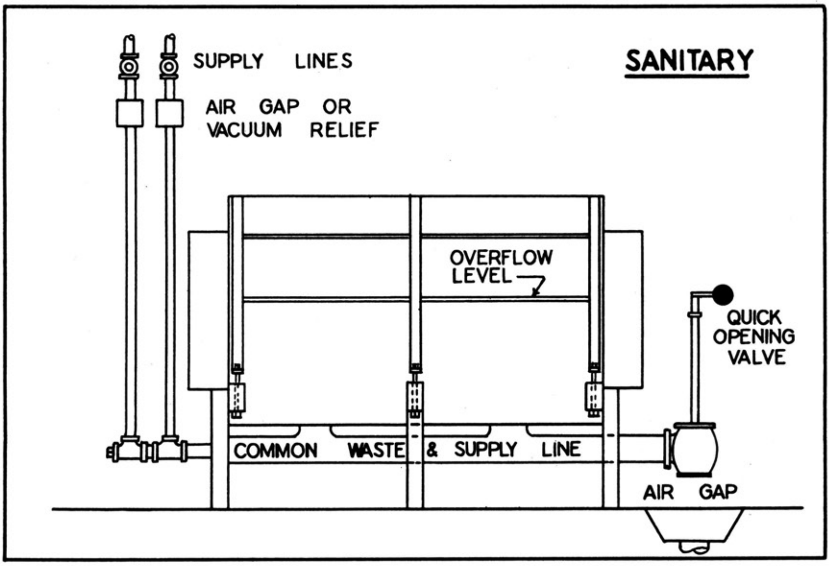
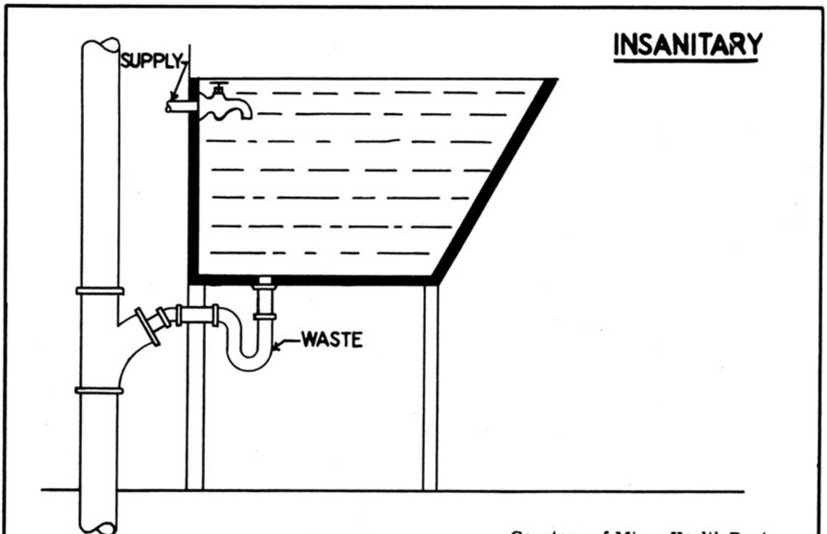
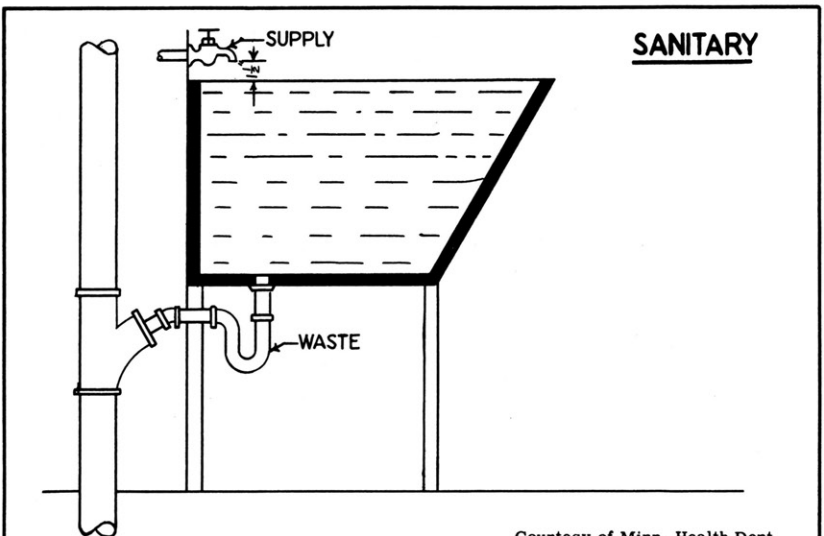


Fig. 137.—Large laundry tub with common waste and supply line.



Courtesy of Minn. Health Dept.

Fig. 138.



Courtesy of Minn. Health Dept.

Fig. 139.

Safe and unsafe laundry tub installations.

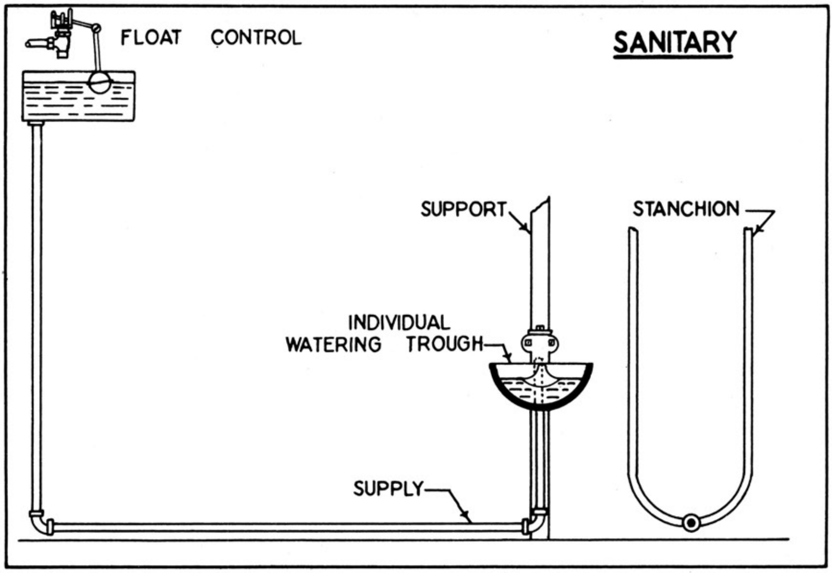


Fig. 140.—A cow watering basin hookup. This arrangement prevents excessive pressure at the basin to scare the cow when drinking.

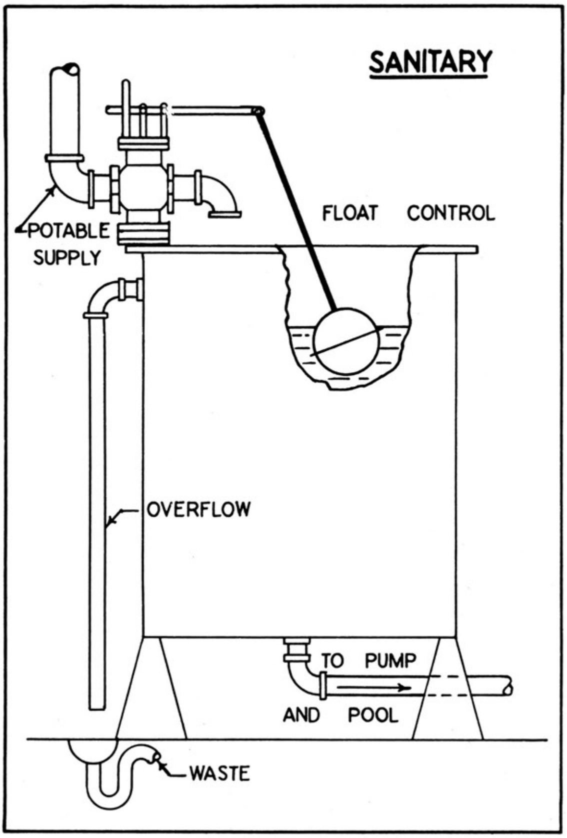


Fig. 141.—Swimming pool water makeup tank properly installed.

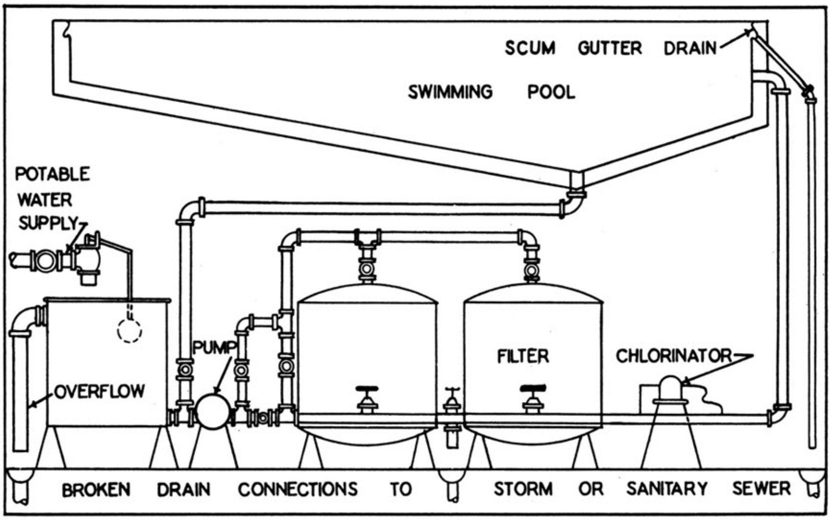


Fig. 142.—A proper installation of a piping system for a swimming pool.

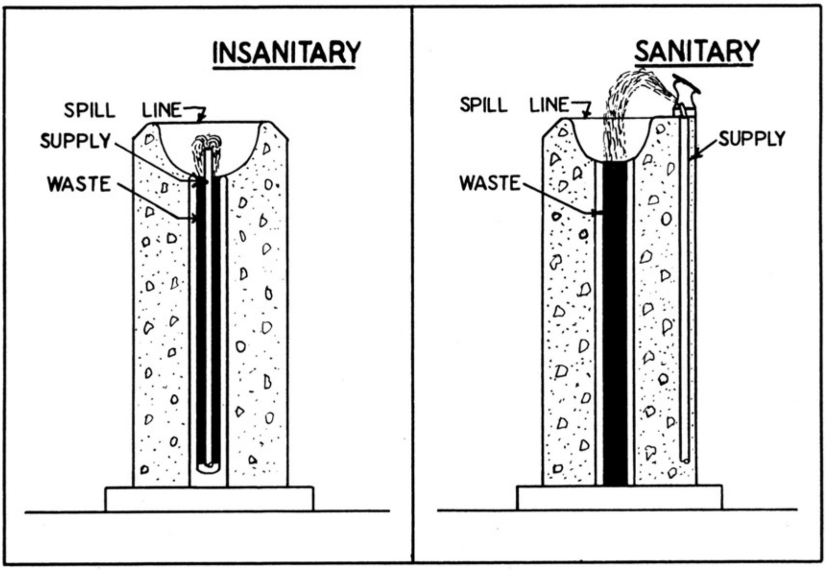


Fig. 143.—The good and the bad in outdoor drinking fountains.

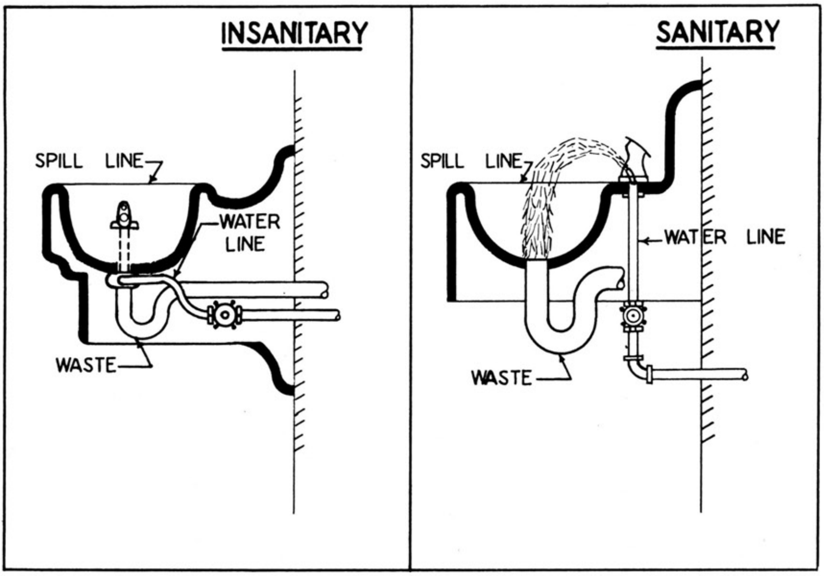


Fig. 144.—Drinking fountain with supply passing through waste line, and a proper installation.

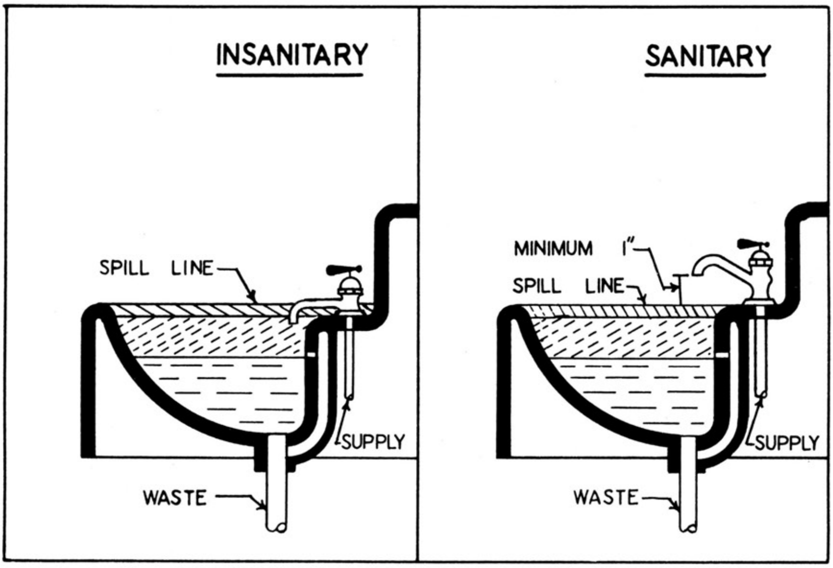


Fig. 145.—Lavatory installations.

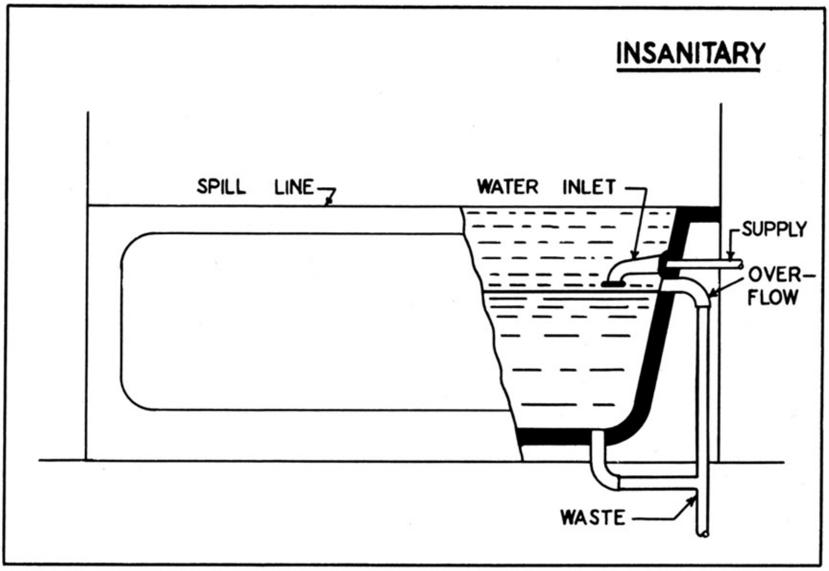


Fig. 146.

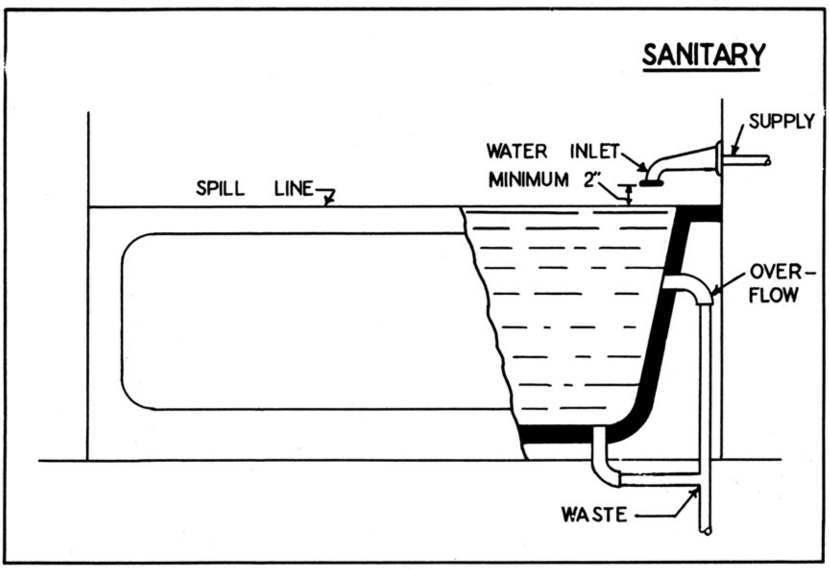


Fig. 147.

Bath tub installations.

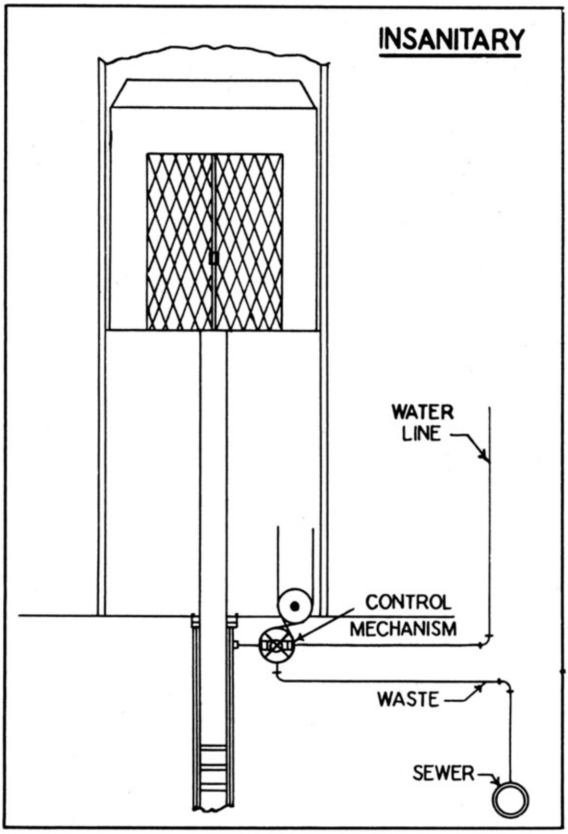


Fig. 148.—Hydraulic elevator using a water supply direct to the piston with waste water connecting directly to sewer.

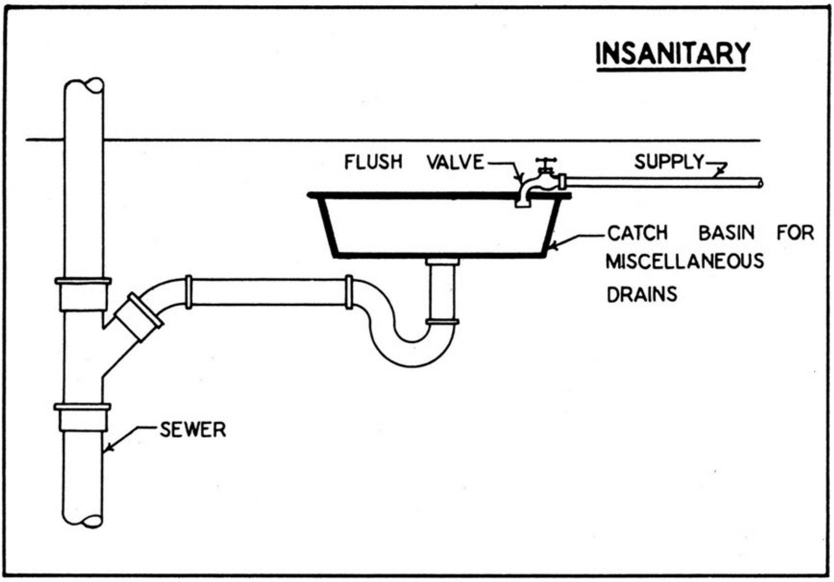


Fig. 149.—Catch basin flushing installation.

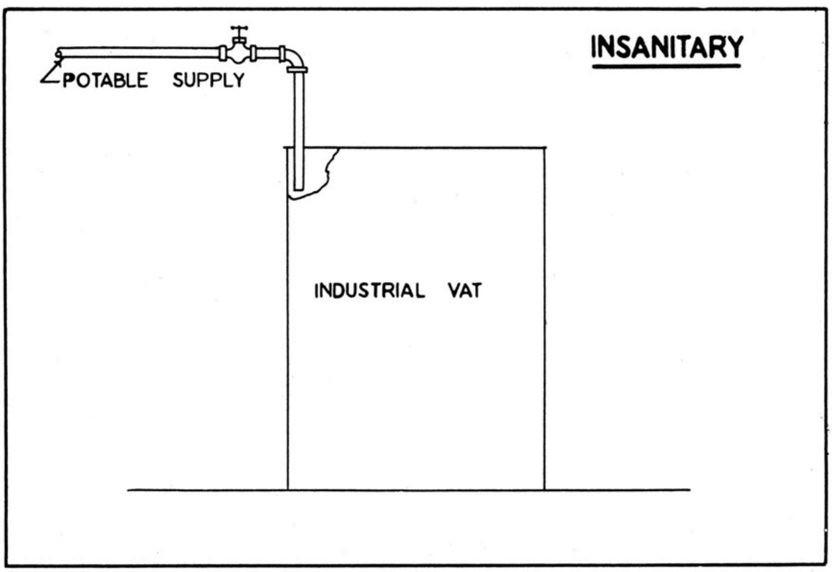


Fig. 150.—An insanitary industrial vat, the supply should terminate above overflow rim.

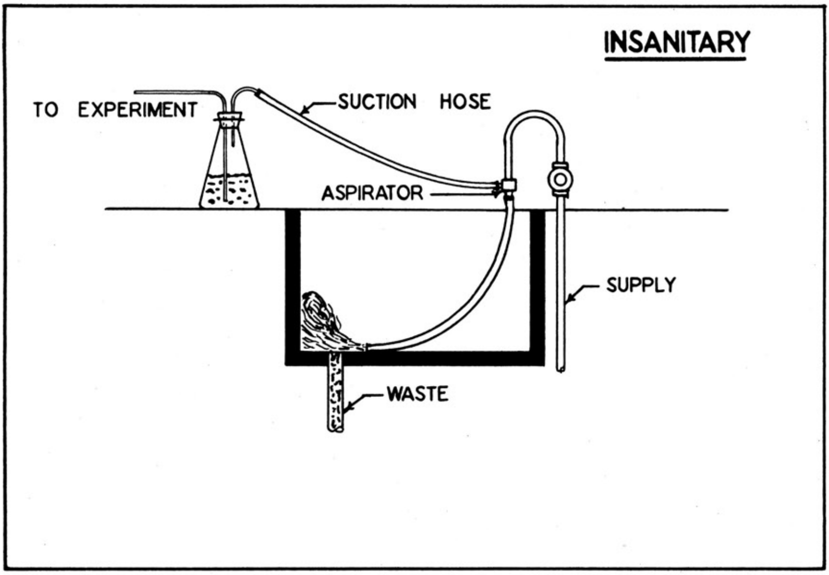


Fig. 151.—Common laboratory installation.

APPENDIX C

CROSS-CONNECTION INSPECTION FORMS

The following inspection form was used for each individual inspection. Each item was described and enumerated on the second page. Any unusual plumbing defects were drawn on the third sheet and pictures of the faulty plumbing were attached thereto.

The summary sheet on the front is included to determine at a glance, the total number of defects and the general type. If further description of the item was requested, it could be described on page 2 or even illustrated or photographed on page 3.

The form of the sheet was very satisfactory except for two items on the summary sheet. Urinals should be included under "submerged Supplies", and refrigerator drains should be classified under "Cross-connections."

CALHOUN COUNTY HEALTH DEPARTMENT

A UNIT OF THE MICHIGAN COMMUNITY HEALTH PROJECT
OF THE W. K. KELLOGG FOUNDATION

MARSHALL, MICHIGAN

HUGH B. ROBINS, M. D.
County Director

(Copy of form letter sent out requesting inspection)

Dear Sir:

We are sponsoring an important water hazard survey in our county, cooperating with the State Health Department and the University of Missouri. This work will be carried out by Mr. Edward Stockton, Sanitary Engineer from the University of Missouri, who will have an office in the County Health Department.

In this survey we are attempting to locate as many of the potentially dangerous cross connections in our water supply as possible. All information must be given voluntarily and will be considered confidential.

The survey will include all public buildings, most semi-public buildings, certain business establishments such as dairies, and a limited number of homes.

I think this is a very timely service to our community. If you would like us to include your establishment in the survey, please write your name and address below and return this memorandum to me.

Respectfully yours,

Hugh B. Robins, M. D.,
Director.

Name ____

Address ____

HBR:CRO

(Copy of inspection blank used for individual inspections)

CO-OPERATIVE SPECIAL INVESTIGATION ON CROSS CONNECTIONS

UNDER THE JOINT DIRECTION OF THE W. K. KELLOGG FOUNDATION

OF BATTLE CREEK, MICHIGAN AND THE CIVIL ENGINEERING DEPARTMENT

OF THE UNIVERSITY OF MISSOURI

SURVEY OF DEFECTIVE PLUMBING WITHIN BUILDINGS

CALHOUN COUNTY

NAME OF BUILDING .... DATE ....
ADDRESS ....
SURVEYED BY Edward L. Stockton, Fellow in Public Health Engineering ....

S U M M A R Y

SUBMERGED SUPPLIES

LAUNDRY TUBS ....
STEAM TABLES ....
SOAP KETTLES ....
DISH WASHERS ....
STERILIZERS ....
MAKE UP WATER TANKS ....
INDUSTRIAL VATS ....
WATER CLOSET VALVES ....
MISCELLANEOUS ....
....

BELOW RIM FIXTURES

LAVATORIES ....
BATH TUBS ....
SINKS ....
LABORATORY SINKS ....

DRINKING FOUNTAINS
DISAPPROVED
....
....

CROSS CONNECTIONS

OLD WELLS ....
FLUSHOMETER VALVES ....
PUMP PRIMING ....
SWIMMING POOLS ....
PUMPS ....
COOLING WATER ....
STERILIZERS ....
WASHERS ....
MISCELLANEOUS ....
....

TANKS

ROOF SUPPLY ....
SURGE ....
OPEN ....
WOOD COVER ....
MISCELLANEOUS ....
....

DEFECTIVE PLUMBING

....
....
....

PRESSURE

....
....

-2-

WATER SUPPLY

Source ....
Outside water sources ....
Pressure ....
Temperature ....
No. of persons directly or indirectly associated with place of inspection ....
....
Size of service from main ....
Fire Sprinkler system branch from service? .... Size ....
Condition of piping ....
Condition of valves ....
Boiler blow off and (or) drain to where? ....
Coolers and condensers drain to where? ....
Make up water tanks: ....
  Inlet submerged? ....
  Discharge to suction side of pump? ....
  Drain to? ....
Drinking fountains ....
Lavatories, description & No. ....
Bath tubs, description & No. ....
Urinals, description & No. ....
Toilets, description & No. ....
Sinks, description & No. ....
Industrial vat description (Industry, dairies etc.) ....
....
Steam tables ....
Dish washers ....
Laundry tubs ....
Sterilizers ....
What pumps have primer lines? ....
Dead end lines? ....
Are any house drains over or near food handling? ....
Over ice boxes, refrigerators or drinking water tanks? ....
Miscellaneous ....
....
....

MISCELLANEOUS DRAINS

Drains from floors	Discharge to? ....
" " ice box	" " ....
" " water cooled bearings	" " ....
" " hot water heater	" " ....
" " flesible hose	" " ....
" " hydraulic elevators	" " ....

Others: ....
....
....

MISCELLANEOUS INFORMATION

....
....

APPENDIX D

LIST OF MANUFACTURERS OF APPROVED PLUMBING AND ANTICROSS-CONNECTION EQUIPMENT

The following plumbing fixtures and specialties have been approved for use in the City of Detroit, and must be used for all new construction and replacements. To the best of our knowledge no other city in Michigan has any such requirements.[1]

Accepted equipment in the City of Detroit.

A. **Grease Traps.**
   1. Boosey.
   2. Romulus.
   3. Josen-Size A-1-B and A-2 if trapped and vented.

B. **Oil Interceptors.**
   1. Boosey #1612.

C. **Vacuum Breakers for Flushometer Valve Toilets.**
   1. Crane—Vigilant.
   2. Sloan V-60. A.
   3. Speakman—Si-flo.

D. **Toilet Bowls with Integral Vacuum Breakers.**
   Douglas Siphon Proof Toilet Bowls.
   Type A. Siphon jet.
   Type B. Wash down.
   Type C. Blow out.
   Type D. Reverse Trap.

E. **Small Vacuum Breakers.**
   1. Crane—Size ¾″-½″-⅜″ on discharge side of valve in position of an elbow 7″ above rim of fixture.
   2. Sloco (Sloan)—¾″-½″-⅜″ installed in down feed leg 7″ above rim of fixture.

F. **Vacuum Breakers For Lawn Sprinkler Lines.**
   1. John A. Brooks.

G. **Large Condenser, Refrigerator, Air Conditioning or Cooling Water Wastes.**
   1. Led into an anti-splash funnel set into an increaser on the top of the waste with a series of overflow openings bored or cut in the top of the increaser so as to provide an overflow if the sewer plugs or backs up.

H. **Accepted Ball Cocks.**
   1. Kohler—K-9250.
   2. Morency Van Buren—MVB-#21.
   3. Morency Van Buren—MVB-#14.
   4. Northern Indiania Brass—Nibco. .08.
   5. Northern Indiana Brass—Nibco Ace.
   6. Sherwood Brass Co.—Sherwood #86.
   7. Coldwater Brass Co.—(No number).
   8. John Douglas Co.—Douglas Siphon Proof.
   9. W. A. Case & Son Mfg. Co.—T/N.
   10. W. A. Case & Son Mfg. Co.—Water Saver.
   11. Standard Sanitary—B-1957.
   12. Crane Co.—(No number).

[1] Wm. H. Cary, Jr., *Manual of Plumbing Connections and Fixtures for Hotels and Resorts,* Mich. Dept. of Health, 22, 23.

13. Indiana Brass Co.—#88.
14. Peerless Selling—VB-500.
15. Wolverine Brass Co.—#1876 S. P. L.
16. James M. Teshen—Simpl Valv.

At the present time there are no state-wide regulations or laws covering all of the recommendations in this report or requiring the installation of approved fixtures and specialties. However, as more attention is given to sanitary activities throughout the state, no doubt such laws or regulations will be put into effect.

PLUMBING AND HEATING BUSINESS
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THE NATIONAL PLUMBING LABORATORY

List of Acceptances

"A"—Acceptances.

"PA"—Provisional Acceptances.

- A-1—To Scanlan-Morris Co., Madison, Wis., for "Water Fill and Vent-O-Stat Housing."
- A-2—To Doran Co., Seattle, Wash., for "Doran Water Saver Primer Valve."
- A-3—To the Imperial Brass Mfg. Co., Chicago, for "The Imperial Trap Primer."
- A-4—To Ritter Dental Mfg. Co., Rochester, N. Y., For "Ritter Dental Lavatory and Cuspidor."
- A-5—To S. S. White Manufacturing Co., Philadelphia, Pa., for "Master Unit" dental lavatory types A to O inclusive.
- A-6—To S. S. White Mfg. Co., Philadelphia, Pa., for "Dental Cuspidor No. 7."
- PA-1—To Sloan Valve Company, Chicago for "Sloan Vacuum Breaker."
- PA-2—To W. A. Case & Son Manufacturing Co., Buffalo, N. Y., for "T/N One Piece Water Closet."
- PA-3—To Scovill Manufacturing Company, Sturgis, Michigan, for "Morency-Van Buren Ball Cock."
- PA-4—To Beaton & Cadwell Mfg. Co., New Britain, Conn., for "No. 115 Agitator and Siphon Breaker."
- PA-5—To The Imperial Brass Mfg. Co., Chicago, for "Imperial (M-1111) Vacuum Breaker."
- PA-6—To Sherwood Brass Works, Detroit, for "Sherwood No. 86-a Ball Cock."
- PA-7—To Sloan Valve Company, Chicago, for "Sloan V-100-a Vacuum Breaker."
- PA-8—To Sloan Valve Company, Chicago, for the "Sloan V-100-B Vacuum Breaker."
- PA-9—To Weber Dental Mfg. Co., Canton, O., for "Model E Dental Unit."

PA-10—To Norman Boosey Mfg. Co., Detroit, for "No. 1 Boosey Vacuum Breaker."

PA-11—To Sloan Valve Co., Chicago, for "Lo-Flo Water Closet Combination."

PA-12—To W. A. Case & Son Mfg. Co., for its redesigned "T/H Tank Closet and Valve Combination."

PA-13—To Maid-O-Mist, Inc., Chicago, for water-feed arrangement for a humidifier.

PA-14—To Maid-O-Mist, Inc., for the "No. 59-F Water Boy Feed Valve."

PA-15—To Northern Indiana Brass Co., Elkhart, Ind., for "Model King 09A" siphon breaker ball-cock."

PA-16—To Associated Laboratories, Minneapolis, Minn., for "Gordon Detoxifier (or Berwin Irrigator.)"

PA-17—To Beaton & Cadwell Mfg. Co., New Britain, Conn., for "Cadwell No. 125 Vacuum Breaker."

PA-18—To American Sterilizer Co., Erie, Pa., for the "Aeroflush bed-pan & Urinal Washer & Sterilizer."

PA-19—To Weber Dental Mfg. Co., Canton, O., for "Model F Dental Unit."

PA-20—To the Chicago Faucet Co., Chicago, Ill., for the "Phillips Automatic Trap Seal Valve."

PA-21—To The Dierker Company, Los Angeles, Cal., for the "Dierker Therapeutic Apparatus."

PA-22—To The Bridgeport Brass Co., Bridgeport, Conn., for a vacuum breaker.

Approved by Department of Public Works, Bureau of Engineering, City of Chicago.

Aspirators with vacuum breaker, Miller Supply Company, 3100 South Sawyer Avenue, Chicago, Illinois.