Engineering Problems in Milk Sanitation*

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Introduction.—Until fairly recently sanitary engineers have not considered that milk sanitation was a problem with which they should much concern themselves. Conclusive evidence of this may be seen in the past curricula of sanitary engineering courses. Practically none of the graduate sanitary engineers in the field today included a study of milk sanitation in their undergraduate courses.

Indeed, milk sanitation has in the past been considered to be a problem for veterinarians, bacteriologists, and epidemiologists rather than for engineers. Milk is an animal product and its sanitation is related to the health of animals. Therefore milk sanitation is a problem for veterinarians. It is advisable to make bacteriological analyses of milk. Therefore milk sanitation is a problem for bacteriologists. Epidemics occur as a result of unsafe milk supplies. Therefore milk sanitation is a problem for epidemiologists. Thus has run the philosophy of milk control here-tofore and such was the status of milk sanitation until twenty years ago and even later. At that time only one or two state sanitary engineering divisions were interesting themselves in milk control. In fact, the states in general were doing little, if any, real milk sanitation work. Actual enforcement of milk regulations was then, and still is, primarily a function of city health departments, but not a single city at that time employed a sanitary engineer in connection with milk sanitation work.

As time has gone on, however, it has become increasingly apparent that milk sanitation is not exclusively a problem for veterinarians, bacteriologists, and epidemiologists. The conviction has steadily grown that the pasteurization of all market milk supplies, an essentially engineering problem, is a vital necessity. This is because we have learned that no other measure and, in fact, no combination of other measures, gives adequate protection.

Tuberculin testing and other tests of the health of animals nearly, though not entirely, remove the bovine tuberculosis menace and reduce the danger from undulant fever, but these measures do not protect against streptococcal udder infections nor against other milk-borne disease organisms which may enter the milk after it has been drawn from the udder.

Health examinations of employees are valuable but fail to eliminate completely the typhoid fever carrier, and are relatively ineffective in preventing the contamination of milk with the organisms of septic sore throat, scarlet fever, and diphtheria. The cleaning and sterilization of containers and utensils offer valuable protection against disease organisms which may reach the milk from equipment, but cannot eliminate disease organisms which enter the milk before it comes in contact with the equipment, nor prevent subsequent contamination of the milk through spittle droplets, dust, or flies.

In short, pasteurization is the only public health measure which, if properly applied, will adequately protect against all infectious milk-borne disease organisms which may have entered the milk prior to pasteurization. Obviously the milk must be protected against recontamination.

This growing conviction of the all-importance of pasteurization has been reflected in an increase in the percentage of milk pasteurized. Thus, while at the beginning of the century the percentage of milk which was pasteurized in this country

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was negligible, by 1936 the percentage had risen to 83 percent for communities of 10,000 population and over, and to nearly 75 percent for communities of 1,000 population and over. Such acceptance by the people of this country of the milk sanitation advice of their public health authorities should be profoundly stimulating.

Now the use of the pasteurization process at once poses problems of the design and operation of pasteurization equipment, and it is at this point that the wisdom of adding sanitary engineers to the milk sanitation staff becomes sharply apparent. This has become particularly true since the advent of automatic pasteurization systems, as will be made clear later in this paper when we come to discuss the problems of thermostatic control, milk-flow stops, valve design, air and foam heater design, regenerator design, and others.

However, the function of the sanitary engineer is not limited to the immediate problem of pasteurization. His work really begins at the producing farm. In milk control and processing, the more important items to which the sanitary engineer should devote attention are as follows:

Dairy barn and milk house design. One of the first items with which he should concern himself is the design of the dairy barn and milk house, the drafting of plans which will insure that there is adequate space to prevent contamination due to overcrowding, adequate light to insure cleanliness morale, adequate ventilation to prevent the absorption of odors and flavors and the drip from condensation on the ceiling, proper construction of floors and walls to promote easy cleaning, and proper arrangement to facilitate the required sequence of operations.

Dairy farm water supplies. The next item which should receive the attention of the sanitary engineer is the design and construction of dairy farm water supplies. Six and one-half pages of the Public Health Service Milk Code are now devoted to this item alone. The subject is important because of the intimate relationship between dairy farm water supplies and the process of milk production. Contaminated water supplies would mean that the slightest relaxation or accident in the bactericidal treatment of milk utensils and equipment which had been washed in the dairy farm water supplies might produce disaster. Local milk inspectors have paid insufficient attention to farm water supplies.

Dairy farm excreta disposal. In most cases, water carriage of excreta is not resorted to on dairy farms. Instead sanitary privies of the pit type are widely used, and while such privies are relatively simple their design and construction are within the province of the sanitary engineer. In some cases, too, farms desire to use a water carriage system of excreta disposal, and in these cases the sanitary engineer should be called upon to give advice.

Pasteurization plant design. In pasteurization plant design we have the problems of adequate light and ventilation, proper construction of floors, walls, and ceilings, proper drainage, proper layout to separate the milk receiving and utensil cleaning processes from the pasteurization and subsequent operations, so as to avoid cross-contamination, and the proper design and installation of milk receiving, filtration or clarification, pasteurization, cooling, and bottling equipment.

The engineering divisions of several state boards of health have devoted some attention to the drafting of plans for pasteurization plants. Figure 1 shows a plant developed by the sanitary engineering division of one of the southern states, namely, North Carolina. In that state, the division offers its services to milk distributors who are contemplating the construction or reconstruction of a plant.

This calls attention to another and even more recent development. In the 1939 edition of the Public Health Service Milk Code there will appear the requirement that plans for all dairies and milk plants which are hereafter constructed, recon-
Figure 1

Lay-out of Milk Pasteurization Plant
SECOND FLOOR PLAN

FIGURE 1

Lay-out of Milk Pasteurization Plant (continued)
Notes: 1 Floors shall be of concrete, tile or other impervious material and shall slope to trapped drains at the rate of about 1/4" per foot. Drains should be located at the ends of rounded gutters running along the base of the walls. Floors should slope from the center of a room toward these gutters. This method of floor drainage will insure a dry floor in the center of a room, which is the most travelled portion.

2 Walls and ceilings should be finished with tile or hard portland cement plaster.

(Valuable information on concrete and cement plaster may be obtained from the Portland Cement Association, 33 West Grand Ave., Chicago, Ill.)

3 All openings into the outer air shall be screened with 16-mesh wire screening to prevent the entrance of flies. Screen doors must open outward.

4 All doors must be self-closing.

5 Powerful fans should be installed at the outside entrances to the receiving room, wash room and loading vestibule. These fans should be operated so as to prevent the entrance of flies while these entrances are being used.

6 Separate equipment must be provided for the handling of your milk products.

7 All milk piping must be at least 1 1/2" in size.

8 Equipment must conform to the specifications of the United States Public Health Service Milk Ordinance and Code.

9 Refrigeration equipment should be selected before construction of cold storage and compressor rooms is begun.

10 Joints between floor and wall should be rounded to a radius of about one inch.

11 Floors should be reinforced with metal grid plates at points of hardest service, especially in the receiving and cold storage rooms and in the loading vestibule.

12 The milk pipe line from the receiving room must be brought through the floor of the pasteurizing room in such a way that floor drainage will not drip down through the opening and contaminate equipment in the receiving room below. A piece of 4" cast-iron pipe cast in the floor and projecting above 12" above the pasteurizing room floor is a good condit.

13 The clarifier must be connected to the pasteurizers by sanitary milk piping and connections.

14 The finding of cisterns and sewage or contaminated water supplies and sewage or contaminated water supplies, potable water inlets submerged so as to permit back siphonage during intervals of negative head, sewer lines located above pasteurizers or other milk processing equipment, instances of poten-

structured, or extensively altered shall be submitted to the health officer for approval, and the further requirement that in the case of milk plants signed approval shall be obtained from the state health department. This requirement will parallel the similar requirement long existing in many states that plans for water and sewage structures must be approved by the state health department. It is reasonable to believe that in the future it will be a routine matter for sanitary engineering divisions of state boards of health to be required to pass upon all plans for pasteurization plant construction or reconstruction.

Pasteurization plant water supplies. It first thought it might be assumed that nearly all pasteurization plants use public water supplies exclusively and therefore do not require the special attention of sanitary engineer, since public water supplies are presumably already within his jurisdiction. However, a number of pasteurization plants are located beyond city limits and have their own independent water supplies. In addition, a large number of plants make dual use of both an independent and a public water supply, and frequently have them cross-connected. Therefore each such plant should be studied by the sanitary engineer to determine whether such independent water supplies as are used are safe, and whether there is any cross-connection with the public water supply.

Plumbing. Pasteurization plant plumbing constitutes another important sanitary engineering problem. In 1935 W. Scott Johnson read an excellent paper on plumbing hazards in pasteurization plants before the Engineering Section of the American Public Health Association. He described the results of a plumbing survey of six pasteurization plants located in the city of St. Louis. He reported the finding of 210 separate plumbing defects involving 28 different kinds of milk plant equipment and including direct pipe connections between potable water supplies and sewage or contaminated water supplies, potable water inlets submerged so as to permit back siphonage during intervals of negative head, sewer lines located above pasteurizers or other milk processing equipment, instances of poten-
tial aerial pollution, and faulty drinking fountains.

**Pasteurization plant excreta and waste disposal.** This problem does not often engage the attention of a sanitary engineer, as in the majority of instances pasteurization plants are connected with a public sewer. However, some plants are located outside the public sewer districts and in these instances special sewage treatment plants must be designed. This may require experience beyond the ordinary problems related to excreta disposal as special consideration must often be given to the treatment of dairy wastes other than excreta. In the past the solution of this problem has often been unsatisfactory both because of the composition of dairy wastes and because of their extreme variability in amount and kind during a single 24-hour period. For example, within a period of a few hours, the waste may vary from buttermilk vat drainage of low pH to the relatively caustic drainage from a bottle washing machine.

**Design and operation of regenerators.**

We have here a problem which involves an engineering study of relative pressures in various parts of a heat exchange system. A regenerator, as understood by the milk industry, is simply a heat exchanger which is designed to permit the incoming cold raw milk to recapture some of the heat from the outflowing hot pasteurized milk. The regenerator may be either of the "tube within a tube" type with the heat exchange taking place between the milk in the inside tube and the milk between the inside and the outside tubes, the latter flowing counter-current to the former; or the regenerator may be of the plate type, which consists of a series of adjacent plates separated by gaskets and with a flow system so designed that the cold raw milk and the hot pasteurized milk flow in alternate layers between the plates. Again either of these two constructions may be employed but so arranged that the pasteurized milk transfers its heat to a circulating water medium which in turn warms the raw milk.

In either case the problem arises that if leakage develops in the metal separating the raw from the pasteurized milk, or separating the milk from the heat transfer medium, and simultaneously the raw milk is under higher pressure than the pasteurized milk or the circulating medium, then the raw milk may contaminate the pasteurized milk. For example, such higher raw milk pressures are often encountered because of the practice of placing the milk pump upstream from the raw side of the regenerator.

The solution, obviously, is to develop design, installation, and operation specifications to insure that the pasteurized milk side of the regenerator is under higher pressure than the raw milk side whenever there is any raw milk in the regenerator, including not only the routine flow period but also at the beginning of the day's run and during interruption periods, when the pressure picture may be quite different. Such specifications have been worked out in detail and described in Public Health Reports (1).

The solution involves not only the proper placing in the flow line of milk pumps and heat transfer medium pumps so as to take proper advantage of the differential between suction and discharge pressures but also proper elevations for the free milk levels, upstream from and downstream from the regenerator so that proper relative pressures may obtain during shutdowns. In addition, in certain designs it is necessary that hot water, chlorine solution, or previously pasteurized milk must, at the beginning of the day's run, be introduced into the pasteurized milk side of the regenerator before raw milk is admitted to the raw milk side. Otherwise the raw milk side may at this time be above atmospheric pressure and the pasteurized milk side at atmospheric pressure. Figure 2 shows an illustrative flow chart designed to insure that the relative pressures in the regenerator will always be such as to prevent contamination of the pasteurized milk by the raw milk.
FIGURE 2

Example of Layout to Insure Proper Regenerator Pressures

Notes:

- Raw Milk
- Pasteurized Milk

Raw Milk Supply Tank overflow is lower than lowest raw milk point in regenerator, hence ensures negative raw milk pressures.

Raw Milk Pump sucks raw milk through regenerator to heater and holders.

Pasteurized Milk Pump forces pasteurized milk through regenerator, cooler and check valve.

Point A in pasteurized milk line which is above highest raw milk point B by at least 3%, difference in elevation between B and lowest raw milk regenerator point C, this maintaining proper relative pressures during shutdowns.

Check Valve prevents reduction of pasteurized milk pressures during shutdowns.

Special problems relating to the requirement of the definition of pasteurization that every particle of milk shall be brought to the full pasteurization temperature and held thereat for the full holding time. This brings us to the aspect of milk sanitation which has introduced the most serious sanitary engineering problems. Only a few years ago this subject seemed to offer no problem at all. The pasteurization of milk was considered to be an extremely simple process, and few milk control officials thought it involved engineering problems. Milk was merely introduced into a simple vat, then brought to the required temperature by means of a revolving hot water coil, or otherwise, held for 30 minutes, and then discharged. Temperature was shown by a simple indicating thermometer.

Then health authorities began to ask for evidence as to what had been the temperature of the batches of milk which were pasteurized during the intervals between inspections. So recording thermometers were substituted for the indicating thermometers. Shortly it was discovered that the recording thermometer was not as reliable an instrument as the indicating thermometer, and that the actual milk temperature was frequently seriously below the recorded temperature. So we began to require the use of both indicating and recording thermometers, the more reliable indicating thermometer to serve as a check upon the recorder.

Simultaneous temperature differences in the holder, and close-coupled or flush-type valves. It was discovered that the temperature of the milk at the recording
and indicating thermometer bulbs might be and frequently was higher than the temperature of the milk in other parts of the holder, e.g., the zone between the face of the outlet valve and the main body of the milk. The milk in such outlet zones was frequently found to be 10° F. or more below the temperature of the main body of the milk.

As a result of this finding, the requirement was inserted in the milk code recommended by the Public Health Service that the design of the holder shall be such that simultaneous temperature differences between various points in the holder will be limited to a tolerance of not over 1° F. Furthermore all outlet valves are required to be of the flush or close-coupled type, that is, so designed as to bring the face of the outlet valve close enough to the main body of the milk in the vat to eliminate the "cold pocket" at the outlet.

Figure 3 illustrates a close-coupled valve of satisfactory design for holders in which properly designed agitators are employed, and sweep the milk currents into the outlet.

\[ \text{Vertical Section} \quad \text{Plan} \]

**Close-Coupled Side Outlet Valve Connected to Holder. Showing Design Requirements.**

\[ d = \text{diameter of outlet.} \]
\[ h = \text{depth of flare.} \]
\[ a = \text{greatest distance from valve seat to small end of flare (shall be not more than } 1\frac{1}{2}d). \]
\[ b = \text{smallest diameter at large end of flare (shall be not less than } b + d). \]

**Leak-protector valves.** It was also discovered that since practically all milk valves were of the metal seat type, and since practically all metal seat valves leak sooner or later, owing to such causes as scoring during cleaning, there was real danger that raw milk in the vat would leak out through the outlet valve into the pasteurized milk line before it had been completely pasteurized. It was also discovered that raw milk might leak through the inlet valve and recontaminate the milk in the vat while it was being pasteurized. So the Public Health Service inserted a requirement in its recommended Milk Code that all inlet and outlet valves must be of the leak-protector type, that is, so designed as to divert to the outside, by means of leak grooves or otherwise, any leakage which attempted to pass the valve face.

Satisfactory types of valves were developed both by the Public Health Service engineering staff and by the industry and are described on pages 88 to 97 of the Public Health Service Milk Code. Figure 4 illustrates one type of leak-protector valve.

**Milk foam.** Approximately simultaneously with the above development, it was also found that the foam which may be formed on the surface of the milk in a vat is likely, unless preventive measures are employed, to be colder than the main body of the milk, and this fact not be evident from the record of the temperature shown on the recording thermometer chart. Foam temperatures as much as 20° F. below the temperature of the milk proper have been encountered during studies made by the Public Health Service. Therefore it became necessary to develop means of heating or dissipating the milk foam. Our studies developed the fact that while radiant or convection heating of the air above the milk by means of electric or enclosed steam heaters was not very satisfactory because of the tendency of the dry hot air to rise away from the foam and thus not heat it, live steam admitted to the air space above the milk tended not only to heat the foam as it was formed but also to dissipate it. It was necessary, of course, to design the apparatus so as to prevent the discharge into the milk of either steam-line sediment or a significant amount of steam condensate. Furthermore, since the amount of steam required was very small, it was necessary to in-
FIGURE 4
Example of Leak Protector Valve (Outlet Type)
crease the sensitivity of the throat of the throttle valve to the maximum by placing a resistance in the line in such manner as to reduce the differential pressure on the two sides of the valve. This took the form of a small orifice placed downstream from the valve.

Figure 5 illustrates an air space heater as developed by the Public Health Service.

**Insurance of full holding time in manual vats.** Further studies showed that even when the recording thermometer charts indicate that the milk in the vat had been held at the required temperature for the full holding time it might nevertheless be true that the holding time is less than the required holding time. Suppose, for example, that the milk is discharged from the pasteurization vat at the pasteurization temperature. It may take 10 minutes or longer for the descending milk level to drop to the recording thermometer bulb. During this interval the recording thermometer will continue to show the pasteurization temperature. Later, when the milk control official inspects the charts, which are required to be preserved for his inspection, he may find charts which show 143°F. for the full required 30-minute period and yet some of the milk will have been discharged from the vat to the cooler after only 20 minutes holding. For this reason the Public Health Service Milk Code...
now requires that if cooling is begun in
the holder after the opening of the outlet
valve, or is done entirely outside of the
holder, the recording thermometer charts
shall show not merely 30 minutes, but
30 minutes plus the emptying time down
to the level of the recording thermometer
bulb.

Automatic pasteurization systems. Auto-
matic pasteurization is rapidly replacing
manual pasteurization, particularly in the
larger plants. This trend, as might be
expected, is introducing a whole series of
sanitary engineering problems. In the
case of the relatively simple manually op-
erated vats, if the design requirements
previously described have been satisfied,
and if the thermometers show that the
pasteurization temperature has been
applied for the full holding time, the
operator can open the outlet valve and dis-
charge the milk with the assurance that
it has been properly pasteurized. If the
recording thermometer does not show
both the required temperature and the
required holding time he can either in-
crease the temperature or the holding
time, or both, before opening the outlet
valve. The point is that the milk is not
discharged to the cooler and bottler until
the operator deliberately opens the outlet
valve. It is his duty and he always has
the opportunity to assure himself that the
process has been properly applied before
he opens the valve.

In the case of automatic pasteurization,
however, both admission to and discharge
from the holder are automatic and unless
otherwise prevented will take place even
if the milk has not been brought to the
proper temperature or held at that tem-
perature for the proper time. Further-
more, since the holding time is automatic-
ally controlled, any temperature failure
in the holder would require emergency
manipulation of the automatic time con-
tral, or diversion of the entire supply
back to the heater until the temperature
failure had been corrected. This, in the
case of batch type holders, would be ex-
tremely hazardous because of the quan-
tity of milk which would be required to
be repasteurized and the ever-present
temptation on the part of the operator to
shirk the responsibility in order to save
time. In these cases it has been con-
sidered fundamentally necessary, in the
formulation of the Public Health Service
Milk Code, to surround all automatic
pasteurizers with all necessary safeguards
to insure that the likelihood of either
temperature or holding time failure will
be reduced to the very minimum.

Thermostatic control. Accordingly the
first requirement which has been laid
down in the Public Health Service Milk
Code is that all automatic systems must
be provided with thermostatic control of
the temperature of the milk entering the
holder. This requirement has further
been expanded, for purposes of convien-
cence, and in order to avoid what might
be termed "hay-wire" pasteurization,
include any system in which the milk is
brought to the pasteurization temperature
before it enters the holder. Obviously
it would be possible to have an operator
continuously present at a temperature con-
tral valve as a substitute for thermostatic
control, but while this might give good
results most of the time, it is obvious
that the slightest lapse in attention would
result in the passing of unsafe milk.

Automatic milk-flow-stops. Since even
the best thermostatic control occasionally
fails, it was highly advisable to include
an additional safeguard which would
function at such times and serve as an
extra factor of safety. The best such
safeguard is a device which will auto-
matically halt the flow of milk beyond
the holder if the thermostat fails or if
any temperature drop occurs in the
holder. It was soon found that such a
"milk-flow-stop" could take either of two
forms:

(1) An automatic milk pump stop
which would automatically stop the milk
pump motors whenever the milk tempe-
range dropped below the pasteurization
temperature and automatically restart
the motors whenever the required milk tem-
perature was again reached, or
FIGURE 6

Flow-diversion valve
(2) An automatic milk-flow diversion device which would automatically divert the milk away from all downstream points whenever its temperature dropped below the required pasteurization temperature, and automatically reestablish forward flow when the milk again reached the required temperature.

Figure 6 illustrates an automatic flow stop of the diversion valve type.

The requirement that a milk-flow stop be installed immediately brought into focus two collateral problems, namely:

(1) What should be included in the specifications for “milk-flow stops”? and
(2) Where should they be required to be located?

After careful study a set of specifications for milk-flow stops was inserted in the Public Health Service Milk Code. These include (a) the sealing of the milk-flow stop setting so as to insure that any change in the setting will come to the attention of the health officer, (b) the prohibition of manual switches which would permit cutting out a milk-pump stop, (c) the prohibition of any by-pass, (d) required routine daily tests for cutout and cut-in temperatures, (e) the requirement that failure of the primary motivating power will automatically stop or divert the flow, (f) the requirement of leak-protector features on all flow-diversion valves, (g) the requirement that the actuating bulb of the flow-diversion device shall be located immediately upstream from the valve, and (h) a limitation of thermometric lag, and routine tests required to determine its magnitude.

With reference to the location of the milk-flow stop, it became apparent that if the holder system is so designed that the milk therein can neither increase nor significantly decrease in temperature between the time it leaves the heater and the end of the holding period, the milk-flow stop may safely be located either upstream or downstream from the holder.

If on the other hand the holder is provided with a supplementary heating device intended to insure that all zones will remain at or above the pasteurization temperature, it is necessary that a milk-flow stop be located upstream from the holder, as otherwise milk might enter the holder below the pasteurization temperature, be raised to or above the pasteurization temperature during the holding period by the supplementary heating device, and thus pass the milk-flow stop with impunity if it were located downstream from the holder.

Again, if the holder is so designed that some of the milk may drop significantly in temperature before the end of the holding period it is considered necessary that a flow stop be located downstream from the holder, as otherwise milk may enter the holder at the pasteurization temperature, drop below it during the holding period, and thus have passed the milk-flow stop with impunity if it were located at the inlet to the holder and not at the outlet.

Finally, if the holder is so designed that the milk in it may either rise in temperature or drop significantly in temperature before the end of the holding period, it is, of course, necessary to require a milk-flow stop both upstream from and downstream from the holder.

Figure 7 illustrates a flow diagram for an automatic 30-minute pasteurizer of the multiple holder type, with a flow diversion valve located upstream from the holder.

It at once becomes apparent that the above specifications are dependent for their effectiveness upon a proper definition of “significant temperature drop.” After careful consideration this term was defined in such manner as to allow a temperature drop of not more than 1° F. when only automatically controlled holder heaters are turned on during the holding period, and of not more than 2½° F. even if all automatically controlled holder heaters cease functioning at the beginning of the holding period. Automatically controlled holder heaters are defined as heaters which are connected with an upstream milk-flow stop in such manner as to stop the flow of milk into the holder
when the heating medium drops below the temperature required to keep the milk throughout the holder at the required temperature.

Further study showed the necessity for a number of special requirements for systems in which the milk-flow stop is located upstream from the holder, and other special requirements for systems in which the milk-flow stop is located downstream from the holder. To give the details of these special requirements would undesirably expand this paper.

There are obviously also special requirements with reference to time control for automatic systems. These include requirements relative to the use of constant-speed motors or limited maximum-speed motors on milk pumps and timing devices, the prevention of inter-pocket flow, the prevention of air or gas accumulation in tubular or equivalent stream-flow holders, and the checking of the holding time by means of dye tests, or otherwise, immediately after installation or after any replacement or alteration in design.

**Conclusion.** Many details have necessarily been omitted in the above discussion, but enough has been said to demonstrate two important facts:

1. *Milk sanitation is a problem which now requires and will in the future increasingly require the serious attention of sanitary engineers.*

   It is rapidly becoming apparent to state boards of health that their sanitary engineering divisions should be related to the problem of milk sanitation. Information collected by the Public Health Service shows that in at least 25 states milk sanitation work is now being done by the divisions or bureaus of sanitary engineering, whereas two decades ago only one or two state sanitary engineering bureaus interested themselves in the problem. A similar tendency is beginning to appear in some of our local health departments. The total number of sanitary engineers engaged in milk control in this country is now:

   (a) By the state boards of health—17 full time and 75 part time, and
   (b) By local boards of health—14 full time and 36 part time.

This paper should not be understood to imply that only public health engineers...
should be employed in milk sanitation. That would be as unwise as to insist that only veterinarians, or only bacteriologists, or only epidemiologists, or only dairying graduates should be employed in this field. Nor should this paper be understood to imply that all milk sanitation work must necessarily be under the administrative direction of a sanitary engineer. The capacity for administration does not reside solely in any one profession. If a state board of health employs more than one individual in milk control, the one who shows the best administrative capacity should be placed in administrative charge, irrespective of whether he is engineer, veterinarian, bacteriologist, epidemiologist, or dairy expert.

Nevertheless it seems inescapable, from the facts presented in this paper, that every state health department without exception, should employ at least one sanitary engineer full-time on milk sanitation work and, where possible, the milk control work should be a function of the state sanitary engineering division. Except in the case of large cities which employ their own sanitary engineers, no pasteurization plant should be constructed or reconstructed and no pasteurization equipment should be installed or modified without the approval of the milk sanitation engineer. His services should be available to all city health departments in connection with the interpretation of any item of sanitation which is of an engineering character, and he should be prepared to give the city health departments advisory assistance in connection with the testing of holding time, thermometric lag, the approval of indicating and recording thermometers, milk-flow stops, regenerators, etc. In addition, the services of the sanitary engineer should be available on all other items previously referred to in this paper, such as the sanitation of water supplies, excreta disposal, dairy wastes disposal, etc.

(2) Sanitary engineers should be adequately trained to discharge their milk sanitation functions.

It has been emphasized in this paper that the sanitary engineers of this country face a grave responsibility in connection with milk sanitation. As evidence of the magnitude of this responsibility a survey conducted by the Public Health Service for the year 1936 developed the fact that in communities of more than 1,000 population, over 5,000,000 gallons of milk per day, or over 1,800,000,000 gallons of milk per year are pasteurized. To insure that no part of this ocean of milk may transmit disease is a problem of such magnitude that it is not too much to ask that the future graduate sanitary engineers who will engage in this work be properly trained for it. It is still true that most of the sanitary engineers who graduate today are without the necessary specialized training and it is believed that every institution which prepares men for the sanitary engineering field should ponder the desirability of including milk sanitation as one of the subjects of instruction.

Those sanitary engineers who have already graduated and who are now engaged in or may in the future wish to undertake milk sanitation work, should either attend post-graduate courses in milk sanitation or one or more of the milk sanitation short courses or seminars which are being conducted by various state boards of health and the Public Health Service.

1. Contamination of Pasteurized Milk by Improper Relative Pressures in Regenerators. Reprint 1921 from the Public Health Reports, April 1, 1938.