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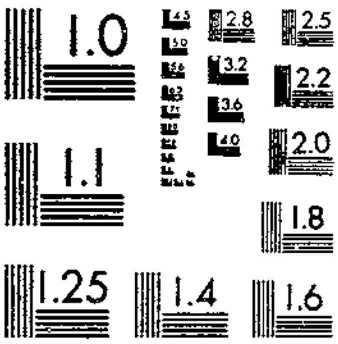

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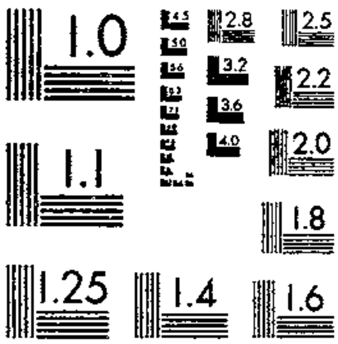

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NATIONAL BUREAU OF STANDARDS-1963-A

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EFFECT OF PLANT ARRANGEMENT, EQUIPMENT, AND METHODS OF OPERATION IN RELATION TO BREAKAGE OF BOTTLES IN MILK PLANTS

By C. E. CLEMENT, *Associate Market-Milk Specialist;* J. B. BAIN, *Associate Market-Milk Specialist;* and FRED M. GRANT, *Assistant Market-Milk Specialist, Division of Market-Milk Investigations, Bureau of Dairy Industry*

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INTRODUCTION

The breakage of bottles in milk plants is an item of great importance, and milk-plant operators have given considerable attention to it in recent years. Without doubt a large part of the breakage of bottles is indirectly due to imperfections in the glass and to variations in the quality and in the annealing of the glass, but it was not within the field of this study to go into these factors, it being assumed that they would not vary greatly between plants. In order to determine whether the plant layout and the equipment had any effect on the amount of breakage, studies were made by the Bureau of Dairy

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Industry in milk plants having various arrangements and using different types of equipment. The broken glass was collected as far as possible after each operation in the plant for a period of a few days. The glass collected at each point was weighed, and a careful study was made of the equipment and its arrangement in each plant. The broken glass was taken out at the following points: Checking-in platform, feed end of washer, discharge end of washer, the fillers, and the milk-storage room. The breakage of glass found at these points is expressed in pounds of glass per 1,000 bottles handled, unless otherwise indicated.

The observations made of the layout, equipment, and operation of each plant at the time the records were obtained have been supplemented by careful studies of the drawings of the plants. This bulletin presents information on the plants studied, compares plant layouts, and discusses the effects that the different arrangements of plants, types and arrangement of equipment, and methods of handling bottles had on breakage of bottles.

LOSSES FROM CHIPPED BOTTLES

The number of bottles that have to be thrown out because of chipped or cracked tops or lips is an important item. At 52 plants where the chipped bottles were kept separate from the other breakage, the average breakage due to chipped bottles was 25 per cent of the total breakage. The average total breakage, including chipped bottles, for these 52 plants was 15.5 pounds per 1,000 bottles filled. Of this 15.5 pounds, 3.9 pounds were bottles which could not be used again because of being badly chipped. The average of 3.9 pounds of bottles chipped per 1,000 bottles handled shows the importance of this item of loss in the average milk business.

There was a decided variation in the amount of chipped bottles at the 52 plants where the studies were made. (Table 1.) For example, 6 plants had a breakage from chipped bottles of less than 1 pound per 1,000 bottles handled, whereas chipped bottles at 7 plants amounted to over 7 pounds per 1,000 bottles handled.

TABLE 1.—*Pounds of glass in chipped bottles in 52 milk plants*

Item	Pounds of glass in chipped bottles, per 1,000 bottles handled											
	1 pound or less	1.1 to 2 pounds	2.1 to 3 pounds	3.1 to 4 pounds	4.1 to 5 pounds	5.1 to 6 pounds	6.1 to 7 pounds	7.1 to 8 pounds	8.1 to 9 pounds	9.1 to 10 pounds	10.1 to 11 pounds	Total
Average pounds of broken bottles	0.6	1.8	2.5	3.5	4.6	5.3	6.9	7.6	8.7	-----	10.6	3.9
Number of plants in group	6	8	12	6	6	4	3	2	3	-----	2	52

At one plant a study was made to determine the number of chipped bottles of different sizes, and whether they were returned from retail or family trade or from wholesale or store trade. As a special "store bottle" was used for wholesale trade at this particular plant, it was possible to determine separately the number of store bottles and family bottles chipped. The results of the study made at this plant for a period of eight days are shown in Table 2.

TABLE 2.—*Number of chipped bottles thrown out at one milk plant in eight days*

Day	Quarts			Pints			Jars [1]			All sizes		
	Store	Retail	Total	Store	Retail	Total	Store	Retail	Total	Total store	Total retail	Total
1	466	124	590	71	12	83	82	44	126	619	180	799
2	465	140	605	44	27	71	17	89	106	526	256	782
3	371	53	424	55	14	69	26	178	204	452	245	697
4	422	118	540	97	25	122	52	78	130	571	221	792
5	366	79	445	72	22	94	25	70	95	469	171	634
6	300	31	331	111	1	112	26	78	104	46[illegible]	171	634
7	195	23	218	72	33	105	29	51	80	[illegible]	110	547
8	117	21	138	41	24	65	25	30	55	296	107	403
Total chipped bottles	2,702	589	3,291	563	158	721	282	618	900	3,547	1,365	4,912
Bottles filled	301,733	285,251	586,984	63,307	95,091	158,398	32,559	327,816	360,375	397,599	708,158	1,105,757
Bottles chipped per 1,000 filled	8.9	2.1	5.6	8.9	1.7	4.6	8.7	1.9	2.5	8.9	1.9	4.4

[1] Includes all bottles smaller than pint size.

Table 2 shows that the number of bottles chipped per 1,000 filled was quite uniform for bottles of all sizes. It also shows that for bottles of all sizes a much greater proportion of store or wholesale bottles was chipped than of the retail bottles used for family trade. Although it was not possible to take out all the chipped bottles at the checking-in platform when they were checked in from the routes, many of them being taken out at other points in the plants, observations at this plant and at other plants indicated that by far the greater proportion of the chipping was done after the bottles were loaded out and before their return to the plant for refilling. The high ratio of wholesale bottles to retail bottles chipped (approximately 4.7 to 1) also seems to support the assumption that most of the chipping of the bottles occurs on the routes rather than in the plant. Bottles of milk and cream sold through stores are handled many times and often receive considerable rough handling, especially when they are returned to the cases in the stores.

As most of the chipping seemed to occur while the bottles were out on the routes and the amount chipped in the plants themselves was apparently a minor factor, in studying the effect of the various plant arrangements and types of equipment on breakage the chipped bottles were kept separate from the other breakage as far as possible and have been eliminated in making the comparisons, except where it was evident that the chipping occurred in the plant.

RELATION OF SIZE OF PLANT TO BREAKAGE

The breakage weighed in 121 plants handling between 10,000 and 100,000 or more bottles daily indicated that size of plant had no direct influence on the number of bottles broken. (Table 3.) The average breakage for the 121 plants was 12.3 pounds per 1,000 bottles handled. It will be noted that the average for any group of plants varied only slightly from this general average. There were considerable variations in the plants within each group, however, indicating that factors other than size were responsible for the differences.

TABLE 3.—*Breakage of bottles in plants of different sizes*

Size of plant (number of bottles handled daily)	Plants	Average weight of glass broken per 1,000 bottles handled	Size of plant (number of bottles handled daily)	Plants	Average weight of glass broken per 1,000 bottles handled
	Number	*Pounds*		*Number*	*Pounds*
10,001 to 20,000	24	10.4	60,001 to 80,000	9	11.5
20,001 to 30,000	19	11.5	80,001 to 100,000	6	13.9
30,001 to 40,000	16	13.1	100,001 or over	18	13.7
40,001 to 50,000	17	13.1			
50,001 to 60,000	12	12.5	Total or average	121	12.3

DISTANCE TRAVELED BY BOTTLES IN PLANTS NOT A FACTOR IN BREAKAGE

A study of the plant layouts and of the breakage at the various small plants showed quite clearly that the distance the bottles traveled in the plants was not a factor in itself. The coefficient of correlation between the breakage and the distance the bottles traveled was only 0.18, indicating that there was little relation between the breakage and the distance in itself and that the methods used to transfer the bottles from place to place was the cause of the variations at the various plants. Day[1] states:

> Coefficients above 0.70 give almost certain evidence of correlation, and any above 0.50 are ordinarily significant; coefficients under 0.30 give very little indication of any definite connection between the variables.

BREAKAGE IN TRANSFERRING BOTTLES BETWEEN FLOORS

The amounts of breakage at 126 plants were compared, to determine the effect of transferring bottles from one floor to a higher or lower floor by conveyors, elevators, escalators, chutes, etc. (Table 4.) Direct delivery of bottles to a higher floor by the bottle washer itself was not considered a transfer. For example, it was considered as only one transfer where the bottles were sent from the street floor to the basement to be washed and the washer itself elevated them back to the street floor to be filled.

TABLE 4.—*Effect upon breakage of number of times bottles were transferred from one floor to another*

Number of transfers between floors	Plants	Bottles handled daily	Glass broken per 1,000 bottles handled: Before washing	At discharge end of washers plus breakage at fillers	Total
	Number	*Number*	*Pounds*	*Pounds*	*Pounds*
No transfers, all operations on one floor	79	37,345	4.6	6.8	11.4
One transfer	14	59,914	4.9	6.1	12.4
Two transfers	30	75,892	5.8	7.8	14.6
Three transfers	3	47,212	8.4	12.9	24.0

[1] Day, E. E. STATISTICAL ANALYSIS. p. 209. New York. 1925.

The breakage increased with the number of transfers. In the group of plants which carried on all the operations on one floor, the total plant breakage averaged only 11.4 pounds per 1,000 bottles filled, whereas it was 12.4, 14.6, and 24.0 pounds at the plants making 1, 2, and 3 transfers, respectively. At most of the 14 plants making only one transfer the bottles were washed in the basement (having been transferred to that point from the street floor by a conveyor or chute) and delivered to the street floor by the washer itself. The breakage at these plants was only slightly greater, on an average, than the breakage at the 79 plants carrying on all the operations on one floor.

At two of the plants making three transfers the bottles were washed in the basement and then elevated to the second floor; at one of these plants the bottles were filled and then transferred to the milk-storage room on the street floor, and at the other plant they were stored and allowed to cool on the second floor and later transferred to the street floor to be filled and stored. At the third plant the bottles were stacked in the basement, sent to the second floor for washing and filling, and then sent back to the milk-storage room on the first floor.

At those plants where the bottles were transferred twice, the average total plant breakage was 28 per cent greater than was found at those plants which carried on all their operations on one floor with no transfers, whereas the total plant breakage was 110 per cent larger in those plants which had three transfers. Of course, other factors may enter. For example, at two of the plants in the last group the bottles were washed by the old style "in-the-case" washer, which, as is shown on pages 16 to 18, tends to break more bottles than does the direct system of washing and filling, principally because of more handling and less accurate temperature control. Furthermore, these data do not necessarily prove that it is impossible to transfer bottles two or three times without an excessively high breakage resulting, provided the conveyors, etc., are of proper design and are kept in good repair. These data do indicate, however, that on an average the breakage is considerably greater at plants where the bottles are transferred two or three times than at plants where all the operations are performed on one floor, or at plants where the bottles are sent to the basement to be washed and the washer itself elevates them to the street floor with no further transfers.

EFFECT OF MOVING BOTTLES TO AN UPPER FLOOR TO BE WASHED, AS COMPARED WITH WASHING THEM ON THE GROUND FLOOR OR IN THE BASEMENT

Table 5 shows the effect of moving bottles to the second or upper floors upon breakage as compared with washing them on the street floor or sending them to the basement for washing where the washer delivered them to the street floor.

TABLE 5.—*Effect upon breakage of moving bottles to an upper floor to be washed as compared with washing them on the ground floor or in the basement*

Location of washer	Plants	Bottles filled daily	Glass broken per 1,000 bottles filled		
			Before washing	At discharge end of washers plus breakage at fillers	Total
	Number	*Number*	*Pounds*	*Pounds*	*Pounds*
On ground or street floor	64	41,126	3.7	5.6	10.2
In basement [1]	9	57,671	3.8	5.3	10.2
On floors above the street or ground floor	17	62,010	5.3	7.3	14.4

[1] Bottles are delivered to the ground floor by the washer itself.

At the plants with the washers on the ground or street floor, both the breakage before washing and the total plant breakage were lower than at the plants where the washers were on a floor above.

There was little difference in breakage between those plants where the washers were on the street or ground floor and those plants where the washers were in the basement and elevated the bottles to the street floor. Where the bottles were sent to an upper floor to be washed, the breakage before washing and the total plant breakage were considerably greater than at the plants in the other two groups. The total plant breakage in the group of plants with washers on the upper floors was 14.4 pounds, as compared with 10.2 pounds in each of the two groups of plants which had the washers either on the ground floor or in the basement—41 per cent greater than in the two latter groups.

COMPARISON OF TYPES OF CONVEYORS FOR MOVING BOTTLES TO BASEMENT

Power control of conveyors was found to be an effective means of moving cases carefully between floors and keeping the breakage of glass down. The relative amounts of breakage before washing in two groups of plants equipped with power-controlled and gravity conveyors, respectively, for moving the bottles to the basement to be stacked or washed are shown in Table 6.

TABLE 6.—*Comparison of the results with two types of conveyors for moving bottles to basement*

Type of conveyor	Plants	Glass broken before washing, per 1,000 bottles handled
	Number	*Pounds*
Power-controlled	9	3.6
Gravity	12	6.2

On an average more breakage before washing was found in plants which used gravity conveyors for moving the bottles to the basement than in plants with power conveyors which controlled the movement of cases and prevented them from banging against each other.

EFFECT OF TRANSFERRING FILLED BOTTLES TO MILK-STORAGE ROOM ON FLOOR BELOW

While at some plants cases of filled bottles were moved between floors with small breakage, in general more bottles were broken between the filling and storage rooms where filled bottles were sent to lower floors. At plants where the filling room was on the second floor and the milk-storage room on the first floor, or the filling room was on the first floor and milk-storage room in the basement (as was found in one or two instances), there was twice as much breakage in the milk-storage room as at plants which had the filling and milk-storage rooms on the same floor. (Table 7.)

TABLE 7.—*Comparison of bottle breakage in moving filled cases from filling room to milk-storage room, when these rooms are on the same floor and when on of filled bottles to the milk-storage room on a lower floor*

Location of milk-storage room	Plants	Broken glass taken out in milk-storage room per 1,000 bottles handled
	Number	*Pounds*
On same floor	121	0.9
On a lower floor	21	2.0

EFFECT OF DIFFERENT TYPES OF CONVEYORS FOR MOVING FILLED CASES BETWEEN FLOORS TO MILK-STORAGE ROOM

The types of conveyors used to move the filled bottles between floors had an effect on the average quantity of glass taken out in the milk-storage room. (Table 8.) The average breakage in the milk-storage room of those plants using straight or spiral gravity conveyors was 2.4 pounds per 1,000 bottles handled, as compared with 1.4 pounds where power-controlled conveyors kept the cases from banging together and the bottles from striking each other.

TABLE 8.—*Effect upon breakage of different types of conveyors for moving cases of filled bottles to the milk-storage room on a lower floor*

Method of moving cases	Plants	Broken glass taken out in milk-storage room per 1,000 bottles handled
	Number	*Pounds*
Straight and spiral gravity conveyors	13	2.4
Power-controlled conveyors	8	1.4

Spiral roller conveyors required more attention than straight conveyors, especially when wet cases were rolled over them. Also, it was usually difficult to reach all sections of the spiral conveyors to lubricate the bearings, with the result that bearings became worn and the conveyor was not kept in free-running, first-class condition. In order to overcome the retarding action as the rollers become worn, and the braking effect of the curves, such conveyors were frequently installed with pitches so steep that the cases raced down. Apparently, it is a very difficult matter to install spiral conveyors with the correct balance between diameter of the spiral and its pitch so cases will travel down freely and easily without either stopping or racing.

In one plant the breakage in the milk-storage room was 3.7 pounds per 1,000 filled bottles. The spiral conveyor had so steep a pitch to overcome the braking effect of its small circumference that the cases of filled bottles speeded down the spiral, bouncing over the rollers. In five cases of filled half-pint bottles which followed each other consecutively, 3, 7, 4, 2, and 3 bottles, respectively, were bounced out of place. Although the displaced bottles, being small and short, caught on the cross wires of the case and did not fall out, their bouncing out of place showed the severe jolting that bottles were receiving on this conveyor.

In another plant the presence of two concrete beams close together limited the diameter of the spiral conveyor to 5 feet. This small diameter, together with the fact that it was a smooth-slide conveyor rather than a roller-bearing conveyor, caused the cases to stick frequently. A hook on the end of a long pole was used to break up the jams and start the cases moving.

These facts show why plant managers should pay careful attention to the design and installation of spiral conveyors if they are to be used.

COMPARISON OF DIFFERENT METHODS OF GETTING BOTTLES TO WASHERS

The amount of glass broken in transferring bottles to the washers ranged from 32.0 to 44.7 per cent of the total breakage in 76 plants where four different systems were used for getting the bottles from the checking-in platform to the washers. (Table 9.) The four systems were as follows: (1) The washer was so near to the checking-in platform that a conveying system was not required; (2) conveyors were used with a minimum stacking of bottles; (3) trucks were used; and (4) conveyors were used with considerable stacking of cases. Only those plants where checking in, washing, and filling were all accomplished on one floor are included in this comparison.

TABLE 9.—*Comparison of bottle breakage when various systems were used in getting bottles to washer from checking-in platform*

System used for moving bottles	Plants	Bottles handled daily	Broken glass per 1,000 bottles handled		
			Breakage before washing	Total plant breakage	Breakage before washing, in percentage of total plant breakage
	Number	*Number*	*Pounds*	*Pounds*	*Per cent*
Direct transfer, with washer close to checking-in platform	15	10,140	2.4	7.5	32.
Conveyors used with some stacking of bottles	24	41,073	3.1	7.8	39.
Trucks used	12	28,948	4.9	11.5	42.
Conveyors used, with considerable stacking of bottles	25	50,794	5.9	13.2	44. 7

On an average, fewer bottles were broken before washing in those plants where the washer was located close to the checking-in platform. With this system very little handling of bottles is required, but of course its use is practicable only in the smaller plants.

The advantages of a good conveyor system are shown in the lower average breakage in the 24 plants which had well-arranged conveyors and required only a minimum amount of stacking of cases, as compared with that in the 25 plants where considerable stacking was necessary. In the latter plants the breakage before washing was not only greater but it represented 44.7 per cent of the total plant breakage, as compared with 39.7 per cent in plants in the former group.

The plants using well-arranged conveyor systems with a minimum amount of stacking also had a much lower breakage before washing and total breakage than the plants using trucks to transfer the bottles from the checking-in platform to the washers.

At the plants using trucks for this purpose, the handling of the cases of bottles in loading the trucks and the frequent rough handling of the truck loads of bottles resulted in greater breakage than at the plants using conveyors with a minimum of stacking. The breakage where trucks were used was, however, less than at the plants using conveyors with a large amount of stacking.

COMPARISON OF RESULTS WITH POWER-CONTROLLED CONVEYORS AND WITH GRAVITY CONVEYORS

In the foregoing comparison of methods of moving bottles to the washers, conveyor systems were classified on the basis of the amount of stacking or rehandling of cases required. In order to compare results with different types of conveyors, irrespective of the amount of rehandling of cases, 39 of the plants with conveyor systems were arranged in two groups. (Table 10.) The first group of 25 plants had long conveyors which depended solely upon gravity for moving the bottles to the washers. In the second group of 14 plants an electric switch at the washer enabled the operator to control the movement of cases over the conveyors, which included mechanical power boosters in addition to other lengths of gravity roller conveyors.

TABLE 10.—*Effect upon bottle breakage of type of conveyor used in moving bottles to washers*

Type of conveyor	Plants	Bottles handled daily	Glass broken per 1,000 bottles filled: Before washing	Glass broken per 1,000 bottles filled: Total plant breakage
	Number	*Number*	*Pounds*	*Pounds*
Gravity conveyor used	25	53,979	6.5	14.6
Power conveyor, or gravity and power conveyor, with movement of bottles controlled by operator, usually at feed end of washer	14	64,892	3.6	9.5

The average breakage before washing was 6.5 pounds, and the total plant breakage was 14.6 pounds in the group of plants which depended upon gravity without control, as compared with 3.6

pounds and 9.5 pounds at corresponding points in the other group of plants which had the movement of cases controlled by electric switches at the washer.

At plants where the men putting the cases of bottles on the conveyor could control the flow of bottles to the washer, as in the case of a short conveyor, automatic control would not, of course, be necessary, and such plants were not included in the comparison.

The effect of the use of gravity conveyors as compared with power-controlled conveyors was also noticeable at the checking-in platform. In some plants where gravity roller conveyors extended at right angles to the side of the checking-in platform, some drivers would throw or slide the cases along the conveyor as far as possible to speed them up and to hasten unloading. This practice caused cases to bang against each other, and, furthermore, frequently a case would slide along the side rail and topple off on the floor. If a power-controlled conveyor were used, the cases would not be likely to bang and topple off.

COMPARISON OF RESULTS WITH VARIOUS TYPES OF CONVEYORS FOR MOVING BOTTLES LONG DISTANCES

On account of the more elaborate conveyor systems required in large plants, 16 of the larger plants where the bottles were transferred long distances were classified into three groups, according to the type of conveyor used. (Table 11.) Plants where the bottles were sent to the floors above the street floor are not included. In the first group gravity conveyors were used throughout, with booster sections where necessary to keep the bottles moving. In the second group gravity conveyors were also used, but at all points where the cases of bottles might come too fast or jam, switches were installed which were operated by electricity. When the conveyor became full of cases of bottles the switch would operate automatically and shut off the booster which brought the bottles up on the conveyor. When the bottles had passed on, this automatic stop would be released and permit more cases to come along the conveyor. This arrangement tended to prevent any jamming of the cases of bottles on the conveyor. In the third group of plants power conveyors were used.

TABLE 11.—*Comparison of bottle breakage when different types of conveyors were used for moving bottles long distances*

Type of conveyor	Plants	Glass broken per 1,000 bottles handled	
		Before washing	Total
	Number	*Pounds*	*Pounds*
Gravity	5	6.2	12.5
Gravity, equipped with automatic stops	4	2.6	7.4
Power	7	2.9	7.3

The breakage was the greatest when gravity conveyors without automatic control were used. There was very little difference in the results whether gravity conveyors equipped with automatic stops or power-controlled conveyors were used. The data in Table 11 illustrate the importance of having gravity conveyors properly under control.

EFFECT OF SHARP CURVES AND TOO STEEP INCLINES

The paths that the bottles traveled from the checking-in platform to the milk-storage room differed widely in different plants. Some plants had been so laid out that the conveyors had many sharp curves and steep grades, so the course of the bottles was similar to that found on roller coasters or derby racers in amusement parks. Some other plants were so arranged that the bottles traveled through the plant more nearly as they would on a slow-moving miniature railroad. Sharp curves and steep grades were frequently the indirect as well as the direct cause of severe jolting and bumping of cases and breakage of bottles.

One cause of the high breakage in some plants was that there was a sharp curve at the top of a booster, as shown at *b* in Figure 1, A. Such curves exerted a braking effect on the cases when they arrived at the top of the booster *a*. This frequently caused cases to buckle up and bottles to fall out. When there was a few feet of straight conveyor (*d* to *e*, fig. 1, B) with a slight downward grade between the top of the incline and the curve, the cases gained enough momentum to offset the braking effect of the curve and carry them around the curve. This also increased the speed of the cases, moving them away from the top of the incline and preventing them from hampering the movement of other cases arriving at the top of the booster.

As an example of the relatively large amount of breakage due to having a sharp curve too close to the booster, in one plant the breakage of glass before washing amounted to 7 pounds per 1,000 bottles handled. The conveyor arrangement in this plant is illustrated in Figure 1, A. In this plant the cases of dirty bottles from the checking-in platform were elevated by a power conveyor to the second floor for stacking, washing, and filling. The power conveyor came through the second floor, as shown, and continued to elevate the cases of dirty bottles to point *a*, to provide for gravity acceleration to move the cases over the gravity roller conveyor toward the washers. The sharpness of the curve at *b* had such a braking effect on the cases as to slow them up, and frequently a case would stop at point *b*. Another case coming up the booster would not have enough momentum to move itself around the curve and start the first case. The result was that both cases would stop. The third case would also stop, causing the fourth case to buckle up, drop bottles out, and break them. The breakage here was caused by two factors: (1) The curve was too close to the booster; (2) the booster was so steep that it was easier for a case to buckle up than it was for it to push the line of cases around the curve.

The good effect of proper location of the curve at the head of the booster is illustrated in a plant which also elevated the dirty bottles to the second floor over a booster and then moved them at right angles, but with one important difference. This difference was that there was a few feet of straight conveyor between the top end of the booster and the curve (*d* to *e* in Fig. 1, B). The conveyor being straight where it joined the booster, the cases on reaching the straight section moved down freely by gravity alone and kept the head of the booster free from stalled cases. The pitch of the gravity conveyor was enough to slightly increase the momentum and

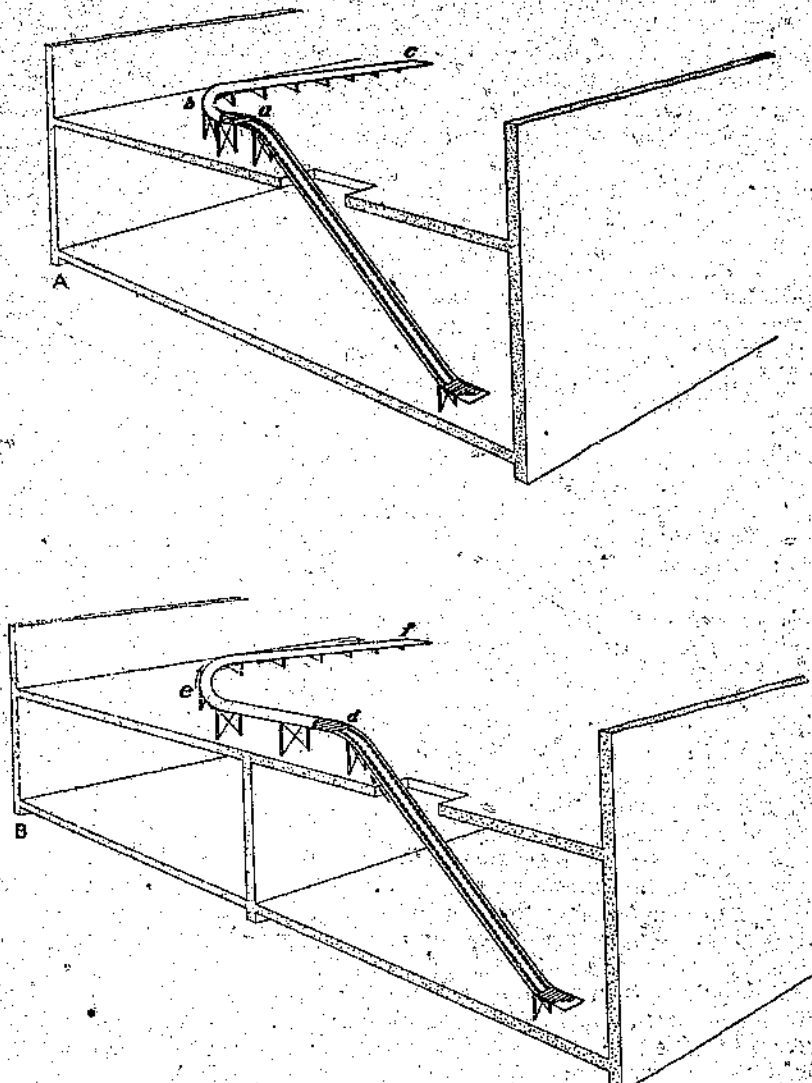

FIGURE 1.—Combination of a steep booster and gravity conveyor having a sharp curve: A shows an installation which frequently causes trouble, because the curve is too close to the top of the booster; B shows the better location of the curve

speed of the cases. This increase in momentum also helped to keep the head of the booster free and to carry the cases around the curve. Moreover, the curve was of large radius, which was another factor in allowing the cases to move slowly over the conveyors. This difference in the arrangement of the conveyors in the two plants was reflected in the fact that only 2.9 pounds of glass per 1,000 bottles handled was broken before washing in the latter plant, as compared with 7.0 pounds in the former plant.

COMPARISON OF POWER AND GRAVITY CONVEYORS FOR MOVING FILLED CASES LONG DISTANCES TO MILK-STORAGE ROOM

The breakage from moving filled cases into the milk-storage room was observed in two groups of plants using principally power and gravity conveyors, respectively. (Table 12.) The plants in the first group used either long continuous power conveyors or long power conveyors with only short lengths of gravity conveyors for moving the filled cases from the fillers to the stacking space in the milk-storage room.

TABLE 12.—*Average breakage when long power and gravity conveyors were used in moving cases of filled bottles*

Kind of conveyor used	Plants	Bottles handled daily	Broken glass taken out in milk-storage room per 1,000 bottles handled
	Number	*Number*	*Pounds*
Continuous power	9	43,993	1.2
Gravity roller	4	51,129	2.5

Many plants used gravity roller conveyors for moving the cases from the fillers to the stacking space in the milk-storage room, but only those plants were included in the second group which moved the bottles exceptionally long distances over gravity conveyors, either with or without power boosters. At all the plants included in this comparison, the filling room and the milk-storage room were on the same floor level.

The average breakage of filled bottles taken out of the milk-storage room was 1.2 pounds per 1,000 bottles handled in the group which used nearly continuous power-conveyor systems for moving filled bottles long distances, as compared to 2.5 pounds in the group which mainly used gravity roller conveyors. This breakage includes all breakage resulting from transferring the filled bottles from the filling room to the point where the filled bottles were stacked in the milk-storage room, as well as breakage which resulted from handling the cases in stacking them and in taking them down from the stacks.

The power conveyors moved the filled cases slowly and without severe bumping of cases.

EFFECT OF CONVENIENCE OF CONVEYORS ON BREAKAGE

The manner in which conveyors were installed in relation to convenience of operation was an important factor in the rapidity of handling the cases and in the amount of breakage. The effect of convenience of conveyors on breakage was shown particularly at the checking-in platform and in the stacking room.

Table 13 compares the breakage before and after washing in two groups of plants with respect to convenience at the checking-in platform. The first group was made up of plants where the conveyors were conveniently arranged for the men loading and unloading cases. The plants in Group 2 had conveyors which were not convenient and handy for loading and unloading.

TABLE 13.—*Average breakage in two groups of plants with convenient and inconvenient arrangements of conveyors at checking-in platform*

Arrangement of conveyors	Plants	Bottles handled daily	Glass broken per 1,000 bottles handled	
			Before washing	Total plant breakage
	Number	*Number*	*Pounds*	*Pounds*
Group 1: Conveyors convenient and handy for loading and unloading	23	47,232	3.0	8.4
Group 2: Conveyors not convenient or handy	12	40,494	7.6	15.6

The average breakage before washing in the plants in Group 1 having conveniently arranged conveyors was 3.0 pounds, as compared with 7.6 pounds in the plants in Group 2. In many of the plants in Group 1 the conveyors extended close enough to the wagons or trucks and were of such height that the drivers, when standing in or beside their wagons, could set the cases on the conveyors with little movement and only slight clicking of the bottles in the cases. Two of the plants had movable roller conveyors which could be extended into the larger trucks. These conveyors were easy to move and enabled the driver to place the cases directly on the conveyor as he worked toward the forward end of the truck in unloading.

In one of the plants in Group 2 the conveyor was located so far from the edge of the checking-in platform that an extra man was required to transfer cases to the conveyor. In the rush of unloading he did not have time to take the step or two necessary to place the cases on the conveyor, so he tossed them on, some cases striking very hard and breaking bottles. If the conveyor had been closer to the edge of the platform this banging of cases and breakage would have been less. This same condition was found in another plant where the usual practice was to throw or toss the cases onto the conveyor. Frequently a case would topple over and the bottles would fall out. In some plants the conveyors were so high that the drivers had to throw the cases up to the conveyors or have an extra man to help unload.

The effect of convenience on breakage of bottles was shown also in the arrangement of conveyors in the stacking room, or wherever the men had to load cases on or take them off the conveyors. In some of the plants in Group 2 the conveyors were so close to the floor that the men had to bend their backs to set the cases on. The natural and more common practice was to drop the cases onto the conveyor with a bang. This jolted and jarred many bottles, the bottles sometimes striking against each other, especially in worn cases having loose cross or bottom wires.

The arrangement of conveyors with reference to the size and shape of stacking space was also a factor in the breakage of bottles. In one plant the stacking room for bottles was nearly square, with the main conveyor near one side. When the room was full of stacked cases, a man tossed the cases upon the conveyor, gradually working farther away from the conveyor until the distance was so great that an extra man was required to pass the cases along.

Plant 326 in this study was a well-arranged and well-equipped milk plant. The ground-floor plan of this plant is shown in Figure 4 (p. 26). In this plant the stacking spaces and conveyors were well arranged for moving and stacking dirty bottles before washing. Each stacking space was rectangular in shape rather than square, and the conveyors were convenient to all sections of the stacks, so that in no place were the cases carried long distances by hand.

EFFECT OF CONDITION OF CONVEYORS IN MILK-STORAGE ROOM ON BREAKAGE

The condition of the conveyors in the milk-storage room was a factor in the breakage at that point. This is shown in Table 14.

TABLE 14.—*Effect of condition of conveyors on amount of broken glass taken out in milk-storage room*

Condition of conveyors	Plants	Bottles handled daily	Broken glass taken out of milk-storage room per 1,000 bottles handled
	Number	*Number*	*Pounds*
Group 1: In good repair and well lubricated, with live, free-running rollers	6	21,024	0.7
Group 2: Had worn bearings and depressed and sluggish rollers	5	42,254	2.6

There was less bumping and jolting of cases, and consequently less breakage of bottles, on gravity conveyors which were kept well lubricated and in good repair than on conveyors which had worn and depressed bearings and those which had sluggish rollers. Poor condition of the rollers oftentimes was due to lack of frequent and regular lubrication and failure to keep the conveyors in first-class repair.

In one plant in Group 1 in Table 14, when a length of conveyor began to show signs of needing repair, even if it was not expected to break down immediately, it was taken out at once and another conveyor which had been previously repaired and held in reserve was put in its place.

EFFECT OF HANDLING UPON BREAKAGE

A study was made to determine how much more breakage there was in plants which required much handling of bottles than in plants so arranged and equipped that handling of bottles by employees was reduced to a minimum. At the 22 plants comprising Group 1 in

Table 15 a large amount of handling was required to move the bottles in the plant from the checking-in platform through to the milk-storage room and out again. At the 18 plants in Group 2 in Table 15 a small amount of handling was involved.

TABLE 15.—*Effect upon breakage of number of times bottles are handled*

Amount of handling	Plants	Bottles handled	Glass broken per 1,000 bottles handled	
			Total before washing	Total plant breakage
	Number	*Number*	*Pounds*	*Pounds*
Group 1: Plants which had considerable handling of bottles	22	46,155	7.0	16.7
Group 2: Plants which had very little handling of bottles	18	36,176	3.4	1

It will be noted that the total plant breakage in Group 1 was 7.6 ($16.7-9.1=7.6$) pounds (or 83 per cent) greater than that in Group 2. The largest percentage increase between the two groups at any one point occurred before washing, where the amount of handling was greatest. At this point the breakage in Group 1 was 3.6 pounds or 106 per cent greater than that in Group 2.

One way in which bottles are broken in handling is shown in Figure 2, A. In stacking cases some men rest the case on its front edge *a*, on top of the stack, with the rear side raised at a wide angle. The man then lets go of the case, letting it flop into place. This flopping through a wide arc, *b*, and the subsequent jolt often cause the bottles to strike sideways forcibly enough to crack and break. As cases of filled bottles come down with a hard jolt—and bottles filled with milk will strike more forcibly than empty bottles—even greater care should be exercised when stacking filled cases. A quart bottle of milk weighs 3.7 pounds, and a filled case between 60 and 65 pounds, so even a short drop may break the glass.

The tendency for empty bottles to break when cases are allowed to flop over in stacking (as in figure 2, A) is also greater when the bottles are inverted in the cases, as at plants where in-the-case washers are used and the washed bottles are stacked for cooling before being filled. Some bottle cases do not prevent bottles from striking together when they are inverted in the cases, and frequently bottles are cracked if the cases are not handled carefully when stacked.

Figure 2, B, shows a man stacking cases carefully. He is holding the case of bottles in a nearly level position as he sets its front edge down on top of the stack, *c*. If he then lets go of the case while it is in this position its rear side will drop only an inch or two at most, and in a nearly vertical direction, without flopping and with only slight jarring of the bottles.

COMPARISON OF BREAKAGE WHEN DIFFERENT SYSTEMS OF WASHING AND FILLING BOTTLES WERE USED

A study was made to compare the effect which the direct, indirect, and semidirect systems of washing and filling bottles had on breakage. The direct system refers to the use of the soaker type of washers which cool the bottles in the machine and from which they go directly to the fillers. With the indirect system the bottles are washed in the cases in a pressure washer and then stacked for cooling, and later they are taken down from the stacks and transferred to the fillers. The semidirect system is similar to the indirect, with the exception that the bottles are cooled by sprays of cold water in

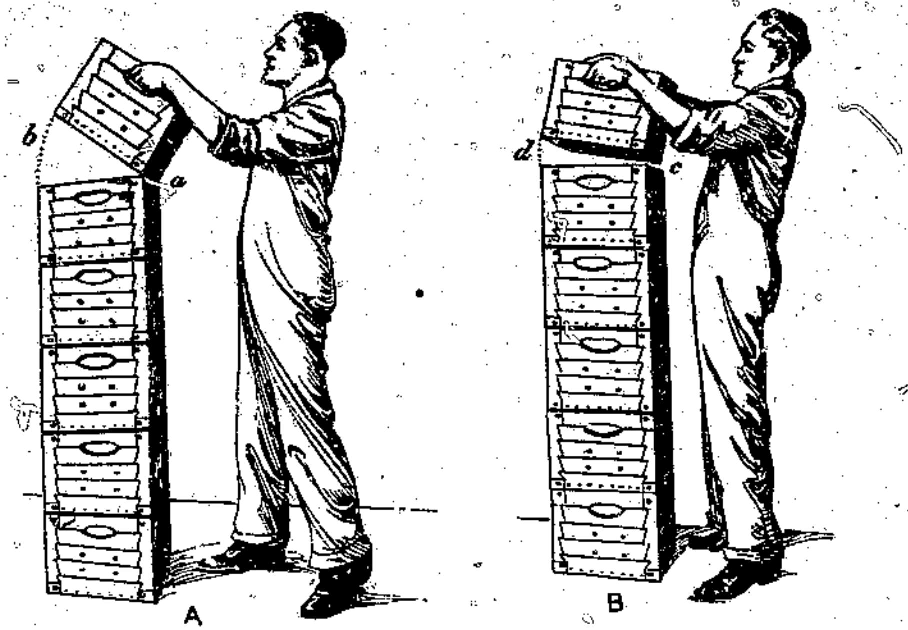

FIGURE 2.—Two ways of stacking cases of bottles. In A the rear side of the case will flop through a wide arc and bottles may get cracked or broken; in B the bottles even with rough handling are less likely to get cracked or broken

passing through the machine and move directly to the fillers from the bottle washers. A comparison of the breakage in these three systems is shown in Table 16.

TABLE 16.—*Breakage of bottles in milk plants using the direct system as compared with the indirect and semidirect systems*

System used	Plants	Bottles handled daily	Broken glass taken out per 1,000 bottles handled			Breakage at discharge end of washers plus breakage at fillers, in percentage of total plant breakage
			Before washing	At discharge end of washers and at fillers	Total plant breakage	
	Number	*Number*	*Pounds*	*Pounds*	*Pounds*	*Per cent*
Direct	95	54,448	4.8	5.8	11.8	49.2
Indirect	21	41,667	4.5	7.8	12.6	57.4
Semidirect	4	45,383	4.6	9.4	15.2	61.8

The average amount of broken glass taken out at the discharge end of the washer and at the fillers was 5.8 pounds per 1,000 bottles handled where the direct system was used, as compared with 7.8 pounds in those plants using the indirect system. This latter breakage is 34.6 per cent greater than that at the plants using the former system. The breakage at the discharge end of the washer plus breakage in the fillers was 57.4 per cent of the total plant breakage in the plants using the indirect system, whereas the breakage at these points was only 49.2 per cent in the plants using the direct system.

The high average breakage at the discharge end of the washers plus breakage at the fillers in plants using the indirect system was doubtless due to the greater amount of handling of bottles required for stacking and taking down from the stacks and the lack of proper temperature control. The bottles washed by the semidirect system, being cooled in the machine, were frequently subjected to wide and rapid changes in temperature, which caused temperature cracks. Furthermore, the bottles were often subjected to bangs and jars as the cases passed through the washer, traveling on the conveyor to the filler, and in removal from the cases for filling.

Many of the washers in plants using the indirect and semidirect systems had been in service many years, and on many of the machines the thermometers were either broken or inaccurate.

In plants using the indirect system the bottles were not cooled in the machines, as in plants using the semidirect system, but they had to be stacked for cooling, and this extra handling, especially while the bottles were hot, tended to cause breakage.

At one plant using the indirect system the hot bottles were stacked for cooling in a room with a low ceiling. Exhaust fans were installed to draw out the hot air and hasten the cooling of the bottles. The cold air passing over and close to the bottles caused bottles to crack. At another plant with a low ceiling in the stacking room, a spray of cold water was used to finish cooling the bottles just before they went to the filler. A considerable proportion of the broken bottles taken out before going to the fillers had been cracked seemingly by temperature changes.

The breakage due to stacking hot bottles was partly due to the bottles being inverted in the cases. Cases are designed with crosspieces spaced primarily to keep bottles from striking against each other when upright in the case. In plants using the in-the-case washers, the bottles were placed in the case upside down, and often the cases would not prevent the bottoms of the inverted bottles in them from striking together and cracking when the bottles were stacked for cooling.

The chances for hot inverted bottles to strike together with sufficient force to break them is greater in plants where the cases are stacked higher than the men can reach easily.

EFFECT OF TEMPERATURE ON BREAKAGE

With the direct system of washing and filling bottles, at some plants high temperatures are used to kill bacteria, while at other plants chemicals are used and the temperature of the rinsing water is lower. Usually fewer bottles are broken when the temperatures are not so high or the temperature changes so great.

At nine plants the treatment to kill bacteria was changed from heat treatment to chlorine treatment. Records were obtained on the breakage at these plants before the change was made and after it was made. Table 17 shows that seven of the nine plants had less breakage after changing over to the chlorine treatment. The total decrease for all of the seven plants was 1,921 pounds per day, which is equivalent to a total yearly decrease of 701,165 pounds, or approximately 539,196 bottles. This number represents an average annual saving per plant of 77,028 bottles.

TABLE 17.—*Breakage of bottles in nine milk plants when using heat treatment and when using chlorine treatment to kill bacteria*

Plant No.	Bottles handled daily	Broken glass at discharge end of washer and at filler, per 1,000 bottles handled		Plant breakage per 1,000 bottles handled		Difference in plant breakage [1]	
		Heat treatment	Chlorine treatment	Heat treatment	Chlorine treatment	Per 1,000 bottles handled	Per day
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1	29,344	8.2	6.8	19.0	9.9	−9.1	−264
2	46,300	6.4	10.6	25.6	18.6	−7.0	−324
3	38,889	4.5	4.2	13.6	11.9	−1.7	−66
4	46,727	6.8	3.4	19.0	14.5	−4.5	−210
5	100,843	8.0	2.4	16.6	14.6	−2.2	−221
6	132,916	5.3	8.5	12.3	12.8	+0.5	+66
7	82,137	7.8	5.1	22.9	21.4	−1.5	−123
8	59,152	7.4	10.6	18.5	24.0	+5.5	+325
9	75,068	9.5	4.6	25.6	16.1	−9.5	−713
Total for plants showing decrease							−1921
Total for plants showing increase							+391

[1] It is not assumed that this difference was entirely due to the change from heat treatment to chlorine treatment, with lower temperatures, but this change was one of the important factors.

Although these nine plants effected savings in different ways at different points in the plant, the use of treatment with chlorine solutions in place of treatment with hot water apparently reduced the breakage due to sudden changes in temperature in most of the plants. When these plants were using the heat treatment, they treated their bottles with hot water at 180° F., or higher, and then cooled them down quickly to 45° or below before filling. Cooling the bottles so rapidly over such a wide range of temperature put them under a severe strain. When there was a change in the pressure of the steam used to heat the water, or in other conditions which caused sudden changes in the temperature of the washing, treating, or cooling water, many bottles were cracked before the proper temperatures could be reestablished.

EFFECT OF CONDITION AND TYPE OF CASES ON BREAKAGE

The function of a case is not only to hold up the weight of the bottles and contents but also to cushion the bottles from jolts and jars. Worn cases oftentimes failed to protect bottles against breakage. In stacking cases, sagging bottoms cause breakage by permitting bottles to strike the tops of bottles in the case beneath. Sagging bottoms are especially hard on filled bottles, both in stacking cases and when the cases travel over conveyors not in good condition. A worn case with a sagging bottom might have enough resilience left to carry empty bottles over an uneven conveyor without their striking on the rollers; whereas filled bottles, especially the larger sizes, would receive blows hard enough to crack them.

Various types of cases used also differed somewhat in the protection they afforded bottles against striking each other sideways. The crosspieces should protect bottles from cracking or breaking by absorbing shocks instead of transmitting them. In some kinds of cases, this cushioning effect on bottles was effected by the position and number of cross wires or pieces between the bottles; in others, by metal crosspieces shaped to cushion the bottles against blows; and in still other cases, by wooden crosspieces with grooves for the bottles. However, as a rule the condition of the case seemed to have more effect than the design of the case in protecting the bottles from breakage.

Protection of bottles from breaking is as important a function of a case as is that of holding bottles for ease in handling. But through wear or rough handling, cases frequently failed to protect bottles adequately, long before their condition made it impossible for them to hold bottles. In many plants breakage of bottles in the cases was due in large part to the common practice of not repairing or discarding a case until the handles broke out or until protruding or bent wires obstructed the movement of cases on conveyors.

Sharp curves on conveyors wore the cases on the corners. Also, moving filled cases around sharp curves, and the practice common in some plants of throwing and dropping cases so they landed on an edge or corner tended to force some of the cases out of shape. Although many of the cases were well designed and constructed, they could not be expected to properly protect the bottles and contents under this kind of rough treatment.

BREAKAGE IN MILK-STORAGE ROOM

The breakage of filled bottles being transferred from the fillers to the milk-storage room and being handled in the milk-storage room, has been mentioned previously. (See Tables 7, 8, 12, and 14.) The amount of glass broken in these operations, as taken out in the milk-storage room, is reported here separately because of its importance. Breakage of bottles at the fillers and in transferring to and handling in the milk-storage room resulted in the loss of at least a part if not all of the contents in addition to the bottle itself. Even when the contents were not entirely lost, additional expense and labor were required to handle the milk. The breakage due to these causes in 116 plants are shown in Table 18.

TABLE 18.—*Range in breakage of bottles in milk-storage room in 116 plants, in pounds of broken glass per 1,000 bottles handled, showing the low breakage in some plants as compared with others*

Range (pounds)	Plants	Range (pounds)	Plants
	Number		*Number*
0.5 or less	27	3.1 to 3.5	5
0.6 to 1.0	37	3.6 to 4.0	1
1.1 to 1.5	24	4.1 to 5.0	(1)
1.6 to 2.0	9	5.1 to 5.5	1
2.1 to 2.5	7	5.6 to 7.5	(1)
2.6 to 3.0	4	7.6 to 8.0	1

[1] There were no plants falling within the ranges of 4.1 to 5.0 pounds, and 5.6 to 7.5 pounds.

At 64, or more than half, of the 116 plants the breakage did not exceed 1 pound per 1,000 bottles handled; at 33 it ranged between 1 and 2 pounds; at 11 it was 2 to 3 pounds; and at 8 it was 3 to 8 pounds. Of the 64 plants with low breakage, 37 were in the group where it was 0.6 to 1.0 pound, and 27 plants were in the group where the breakage was 0.5 pound or less; moreover, in the latter group there were 3 plants which had only 0.1 pound of breakage, 5 which had 0.2 pound, and 8 which had 0.3 pound. These facts show that with the exercise of reasonable care it is entirely practical to have a low breakage in the milk-storage room.

In one plant the low breakage in the milk-storage room was attributed to the plant's having plenty of floor space, so that it was necessary to stack the cases only six cases high. Stacking six cases high for quarts and seven cases high for pints made it easier to stack the cases and to take them down, and low breakage resulted. In some plants, during the rush of loading out in the morning, the men had to work fast and where cases were stacked higher than a man could reach conveniently, accidents caused considerable breakage.

COMPARISON OF NUMBER OF BOTTLES BROKEN, BY SIZES

At 69 plants the breakage of bottles of the various sizes was kept separate. The order of the breakage by sizes of bottles, expressed in number of bottles broken per 1,000 bottles handled, is shown in Table 19.

TABLE 19.—*Order of breakage of bottles by sizes at 69 plants*

Order of breakage [1]	Plants	Percentage of total plants
	Number	*Per cent*
Quarts, jars, pints	19	27.5
Jars, quarts, pints	17	24.6
Quarts, pints, jars	14	20.3
Pints, quarts, jars	11	16.0
Jars, pints, quarts	6	8.7
Pints, jars, quarts	2	2.9
Total	69	100.0

[1] By order is meant the highest, second highest, and third highest number of bottles broken per 1,000 handled; for example, "Quarts, jars, pints" means that the breakage of quart bottles was the highest and the breakage of pint bottles was the lowest.

It will be noted that the most common order was (1) quarts, (2) jars (bottles less than 1 pint in size), (3) pints; and the second most common order was (1) jars, (2) quarts, (3) pints. The order (1) pints, (2) jars, (3) quarts was the least common, there being only two plants in this group.

For all 69 plants the average breakage of bottles by sizes was highest for quarts and lowest for pints. The average breakage of quarts was 9.6 bottles per 1,000 quart bottles handled; that of pints was 7.2 bottles per 1,000 pints handled; and that of jars, 8.1 per 1,000 jars handled.

As before stated, this study was made in selected plants with different layouts and systems in order to show the effect of plant arrangement on breakage of bottles; therefore, the average breakage for these plants can not be said to represent the average breakage for all plants. However, the data presented in Table 19 roughly indicate the relative breakage of the various sizes of bottles at the average plant. The data indicate that as a rule the breakage of quart bottles usually is the highest, and that more jars will be broken in proportion to the number handled than pints. Usually a quart bottle will break easier than a smaller bottle when subjected to the same blow. Furthermore, in the bottles that were examined, more temperature cracks were found in quart bottles than in the smaller bottles. Likewise, pint bottles probably will break more easily than half-pint bottles when subjected to the same blow. The small-sized bottles (one-half pint, one-third quart, and one-fourth pint) are, however, subjected to more blows and strains in the average milk plant than the larger bottles (pints and quarts). When cases are traveling on gravity conveyors or on escalators, the smaller bottles are bounced out of the cases more readily than are the larger bottles. While in the washing machines, the smaller bottles tend to receive more jolts and blows than the larger bottles, as these machines are designed primarily for bottles of quart and pint size. At the fillers a large proportion of the small-sized bottles are filled with cream, and in bottling cream small bottles sometimes stick to the valves of the filler after the valves are released and get knocked off the bottle carrier. Also, the smaller bottles, on account of their small diameter, show a greater tendency to topple over and slide off the bottle carriers of the filler. This tendency is aided by leaking valves, which permit cream to escape on to the carrier or platform of the filler, thereby causing jars to slide off the carrier or platform as it is raised to bring the bottles into contact with the valves for filling.

BREAKAGE IN SMALL PLANTS

Conditions found in small plants were frequently different from those observed in medium-size and large plants. The breakage in the 23 plants handling fewer than 10,000 bottles daily is shown separately from the breakage in the 121 plants of medium to large size in Table 20.

TABLE 20.—*Comparison of the breakage of glass at different points in large versus small plants*

[Breakage is shown in number of pounds of broken glass per 1,000 bottles handled]

Breakage	Plants handling from 10,000 to 100,000 bottles daily (average for 121 plants)	Plants handling less than 10,000 bottles daily (average for 23 plants)	Difference
Breakage before washing:			
At receiving platform, including breakage of bottles resulting from unloading the wagons and dumping returned milk	*Pounds* 1.7	*Pounds* 1.0	*Pounds* 0.7
At feed end of washer	3.0	1.5	1.5
Total	4.7	2.5	2.2
Breakage in washing and filling:			
At discharge end of washers	2.6	1.8	0.8
At fillers	3.9	2.2	1.7
Total in washing and filling	6.5	4.0	2.5
Breakage in milk-storage room, including breakage in transferring filled bottles to storage, stacking, and loading out at checking-out platform	1.2	0.6	0.6
Total plant breakage	12.4	7.1	5.3

The average breakage in the 23 small plants was 7.1 pounds per 1,000 bottles handled, or nearly 43 per cent less than the average breakage for the medium-size and large plants. The figures for the breakage in different parts of the plants show that small plants broke fewer bottles at all points than the medium and large plants.

Low breakage depended more upon the arrangement of the plant and the kind and condition of the equipment than upon the size of the plant. However, plants handling a small number of bottles were more inclined to have plant conditions favorable to low breakage than was always possible in plants of medium or large size. For example, many of the small plants, because they were small, had the feed end of the washer located only two or three steps from where the wagons were unloaded. The bottles were stacked close to the washer and neither conveyors nor other equipment was required to move them to the washer. In small plants, as a rule, bottles did not travel as far as in larger plants, and the number of feet of conveyors or other equipment to keep in condition was less. In small plants, the manager or superintendent, in addition to supervising the operations, frequently worked with the other employees, and all employees would naturally exercise more care. Small plants handled fewer bottles and consequently when a bottle was broken it was more noticeable and not regarded as a passing incident as breakage was sometimes considered in some larger plants.

WHEN IS BREAKAGE HIGH OR LOW?

Various factors may affect the amounts of breakage. Some of the more important factors which have a direct effect on the quantity of glass broken, as previously brought out, as are follows: General arrangement of plants; arrangement of equipment in plants;

types of equipment; care and condition of equipment; changes in temperature to which bottles are subjected, care in handling bottles; and the quality of the glass of which the bottles are made.

The total plant breakage showed the combined effect of all these factors. (Table 21.)

TABLE 21.—*Classification of 121 milk plants according to number of plants falling within the various ranges of total plant breakage*

	Number of plants having a breakage per 1,000 bottles handled of—							
	5 pounds or less	5.1 to 7 pounds	7.1 to 10 pounds	10.1 to 13 pounds	13.1 to 16 pounds	16.1 to 19 pounds	19.1 to 22 pounds	22.1 pounds or higher
Number of plants	4	11	26	34	20	16	6	4
Average pounds broken	4.2	6.1	8.5	11.6	14.5	17.4	20.1	26.6

In 41, or 34 per cent, of the 121 larger plants studied the average breakage did not exceed 10 pounds. Thirty-four other large plants, or 28 per cent, averaged between 10.1 and 13 pounds. Therefore, in 75 plants, or 62 per cent of the 121 plants, the plant breakage did not exceed 13 pounds per 1,000 bottles handled.

At these 121 plants, on an average, 39 per cent of the total breakage in the plant occurred before washing. Fifty-two per cent of the broken glass was collected at the discharge end of the washer and at the fillers, and the remaining 9 per cent of the breakage was taken out in the milk-storage room. Breakage from chipped bottles, as a rule, was not included in the above figures for plant breakage, because most of the chipping occurred while the bottles were away from the plant. As stated on page 2, the breakage from chipped bottles amounted to about 25 per cent of the total breakage, and the breakage in the plant represented the remaining 75 per cent.

COMPARISON OF TWO MILK PLANTS

A medium-sized plant, called plant 321 in this study, was an old, poorly arranged plant which had been enlarged one or more times. Another plant, 326, was a new, well-arranged and well-equipped plant. The floor plans of these two plants are shown in Figures 3 and 4.

In plant 321 many of the conditions prevailed which had been found to cause high breakage of bottles. Plant 326 had most of the features which were found to contribute to keeping the rate of breakage low.

Plant 321 handled 42,227 bottles daily. The plant breakage averaged 27 pounds per 1,000 bottles handled. The poor arrangement of this plant was due in part to enlargements which had been made in order to increase capacity.

The high breakage was due to a number of conditions, some of which are apparent from the plan shown in Figure 3. The bottles had to travel longer distances in all parts of the plant than would have been necessary if the plant had been well arranged. Traveling long distances does not necessarily cause bottles to break if they are moved carefully and with a minimum of handling.

AN OLD, POORLY ARRANGED PLANT

In this plant there were long lengths of gravity conveyors without control. This permitted cases to bang against each other. For example, after being unloaded from the wagons, the cases of dirty bottles traveled down a fairly steep gravity conveyor, frequently striking the cases at the lower end of the conveyor. Also, every case had to be taken off the conveyor and stacked before washing. The broken glass taken out before washing amounted to 9.3 pounds per 1,000 bottles handled.

In this plant the bottle-washing room was separated from the bottle-filling room by a can-washing room and a covered yard. Instead of being moved over continuous power conveyors controlled by switches, as in some plants where bottles are moved long distances, the cases of clean bottles were moved over gravity roller conveyors without control. Two separate boosters were required to move the cases of clean bottles through to the filling room. The conveyors were old and not in good repair. Also, turns in the conveyors

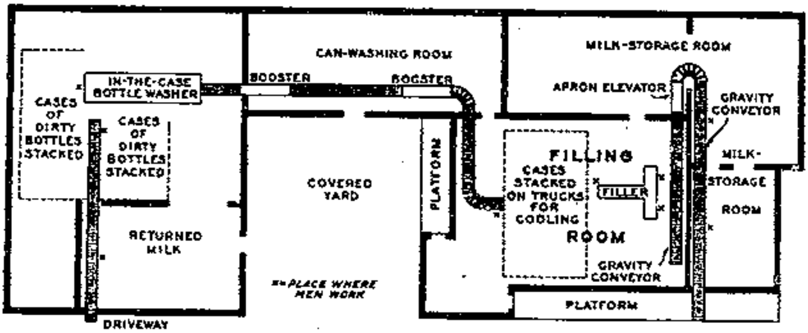

FIGURE 3.—Floor plan of an old, poorly arranged milk plant which had been enlarged one or more times

hindered the continuous and smooth movement of the cases of hot bottles.

An in-the-case washer was used, and the hot bottles had to travel by conveyor from the washer room the full length of the can-washing room and into the filling room. Here the cases were stacked on trucks and allowed to cool before being filled.

The 12.4 pounds of breakage at the discharge end of the washer and at the fillers was due to the extra handling required by the indirect system of washing and to the long distance the bottles were conveyed over gravity conveyors in poor condition, which was responsible for much bumping and banging of cases. Temperature cracks caused in washing represented part of the large breakage at this point.

The milk-storage room was irregular in shape and so located with reference to the filling room that the filled cases had another long distance to travel. The breakage of 5.3 pounds of glass in the milk-storage room shows the effect of the long, poorly arranged gravity conveyors, and extra handling. These conveyors were not kept in good repair. The filled bottles traveled into the milk-storage room in one direction and then completely reversed the direction by making a U turn and went out of the milk-storage room over a path parallel to the path of entrance.

Furthermore, at some places in the milk-storage room the conveyor was not located conveniently, and at these places the men had to carry the cases of bottles by hand some distance to stack them and back to the conveyors again when loading out.

The amount of handling of bottles in this plant was much greater than in well-arranged and well-equipped plants. Every case of empty dirty bottles had to be stacked or handled before it went to the washer. After being washed the cases of clean bottles were handled three times in the filling room, once in being stacked on trucks[2] for cooling, again in being removed from the trucks, and a third

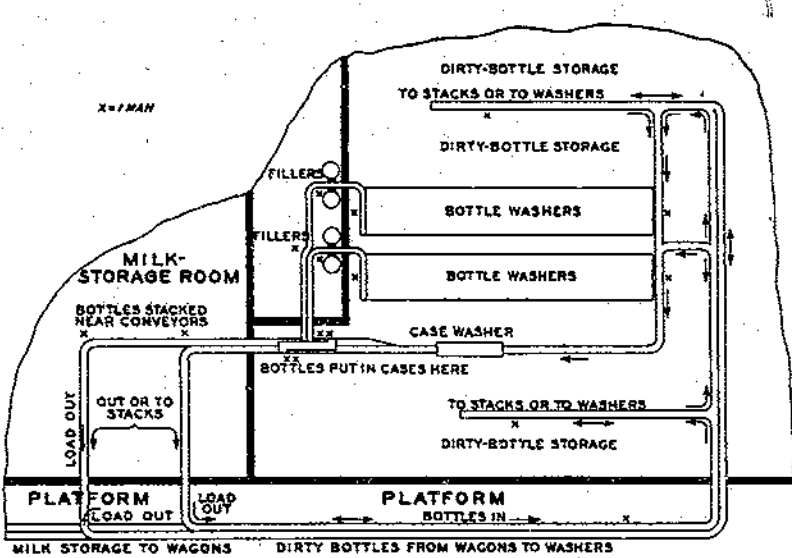

FIGURE 4.—Floor plan of a well-arranged and well-equipped milk plant

time in being inverted on the filler table preparatory to being filled. Also, considerable handling of cases was necessary in the milk-storage room.

A NEW, WELL-ARRANGED PLANT

Plant 326 handled 44,208 bottles daily. The total plant breakage was only 9.7 pounds per 1,000 bottles handled. The floor plan of this plant is shown in Figure 4. This plant and plant 321 were similar in one respect—both plants checked in the dirty bottles and loaded out the filled bottles on the same side of the building. But the two plants were different in many other respects. This plant occupied but little more floor space than the other plant, but it was so arranged and equipped that it could handle more than twice as many bottles, whereas plant 321 was already operating above its normal capacity. These two plans show the importance of plant arrangement in getting the largest output from the space and equipment provided, as well as in keeping the bottle breakage at a low point.

In plant 326 the cases of empty dirty bottles were unloaded directly onto a constantly moving conveyor which moved them slowly but continuously. The bottles were moved carefully and were not jolted

[2] The bottles were stacked in an inverted position in the cases.

nor banged together in the cases, as they frequently are when cases race down a conveyor and strike the line of cases near the lower end of the conveyor. Electric switches were located at convenient points so that the conveyors could be stopped at any time. Most of the dirty bottles went directly from the wagons to and through the washers, the only bottles stacked being those received before the washers were started, and the surplus bottles.

The bottles were washed in soaker-type washers and traveled directly to the fillers over mechanical conveyors. The filled bottles were then placed in cases and conveyed over power conveyors directly to the milk-storage room.

The average breakage at the discharge end of the washers, plus breakage at the fillers, was 4.0 pounds per 1,000 bottles washed, as compared with 12.4 pounds in plant 321, where the bottles were washed in an in-the-case washer and the hot bottles were moved over uncontrolled gravity conveyors in poor condition, to the filling room and there transferred to trucks, where they remained stacked for cooling before being filled.

SUMMARY

The bottle breakage in the plants studied depended to a large degree on the plant arrangement and on the equipment used.

Chipping of bottles caused many bottles to be discarded. A large proportion of this chipping occurred on the routes and especially on those routes having wholesale deliveries.

The size of the plant, in itself, was not a factor in the amount of breakage.

There was little relation between the distance the bottles traveled in the plant and the breakage.

There was a close relation between the number of transfers from floor to floor and the amount of breakage. Where the bottles were sent to an upper floor to be washed, both the breakage before washing and the total breakage were greater than where the bottles were washed on the ground floor or in the basement, if in the latter case the bottles were delivered to the ground floor by the washer itself. As a rule, at plants where bottles were moved to the basement to be washed the breakage was greater where gravity conveyors were used than where the transfer was made by power-controlled conveyors. Where the filled bottles were transferred to the milk-storage room on a floor below, the breakage in the milk-storage room was greater than where both the filling room and the milk-storage room were on the street floor and there was no transfer between floors. At the plants which had the milk-storage room on a floor below the filling room the breakage was greater where the transfer was made over straight or spiral gravity conveyors than where the transfer was made over power-controlled conveyors.

Both the breakage before washing and the total breakage were greater where trucks were used to transfer the bottles from the checking-in platform to the washer than where conveyors were used to make the transfer and there was a minimum of stacking of the bottles. Where the bottle washer was located close to the checking-in platform the breakage was less than where conveyors were used. At plants so arranged that there was a large amount of stacking of the bottles from the conveyors, the breakage was greater than at the plants at which the bottles were transferred by trucks.

When cases of bottles were transferred for considerable distances on conveyors, the breakage was greater at the plants using gravity conveyors than at those where power conveyors were used. However, where gravity conveyors were used, if these conveyors were equipped with automatic stops at points where jamming of cases was most likely to occur, the breakage was as low as where power conveyors were used. Steep inclines and sharp curves on gravity conveyors tended to result in higher breakage. The breakage was greater at the plants where gravity conveyors were used to move the filled bottles considerable distances to the milk-storage room than where power conveyors were used.

Where the conveyors were installed so that they were convenient for the men the breakage was less than where they were not convenient. The effect of convenience of conveyors on breakage was particularly marked at the checking-in platform and in the stacking room for empty bottles.

Keeping the conveyors in the milk-storage room in good repair and well lubricated was an important factor in holding down the breakage at that point.

Plants so arranged or so equipped that much handling of bottles was necessary had larger breakage than did those plants so arranged that only a minimum amount of handling was necessary.

At plants using the direct system of washing and filling bottles, both the total breakage and the breakage at the discharge end of the washers and at the fillers were less than at the plants using the indirect or semidirect systems. The breakage with the semidirect system was greater than with the indirect system.

Wide and rapid changes in temperature were important factors in breakage.

Worn cases with slack cross wires and sagging bottoms caused some breakage, especially in plants where the handling of cases, either by equipment or by men, was rough.

There was considerable variation in the amount of breakage in the milk-storage room. Many plants, however, had comparatively low breakage at this point, indicating that it is possible for a plant to be so arranged and equipped that breakage at this point can be kept down.

The relative amount of breakage of bottles by sizes was in the order of quarts, jars, and pints.

In the small plants studied the breakage was, as a rule, lower than in the large plants. This is attributed to the fact that plants handling fewer than 10,000 bottles daily do not require an elaborate system for transferring bottles from place to place, and conditions which tend to cause high breakage are not so likely to be present in them.

Although the human element is an important factor in any plant operation, and this is especially true in regard to care in handling bottles, it has been found that plant arrangements and types of equipment have an important influence on breakage of bottles, and the above factors were found to be the most important.

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