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CONDITIONS AFFECTING WEIGHT LOST BY CHEESE IN CURING.

L. L. VAN SLYKE

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CONDITIONS AFFECTING WEIGHT LOST BY CHEESE IN CURING.

L. L. VAN SLYKE.

SUMMARY.

I. The loss of weight by cheese in curing has not received systematic study in America under carefully controlled conditions.

II. Equipment for investigation. Six curing-rooms have been so built and equipped as to keep temperature and moisture under control. Each room is kept at a fixed temperature, and the different degrees represented in the work are the following: 55°, 60°, 65°, 70°, 75°, 80° F. The temperature varies only one or two degrees from the desired point, and then only for brief periods. The moisture is kept mostly between 70 and 80 per ct. of saturation. The method is given for determining proportion of moisture in air, with necessary tables.

III. Conditions affecting Loss of Weight in Cheese-Curing. The weight lost by cheese in curing is due almost entirely to evaporation of moisture from cheese, except at temperatures above 70° F., when there may be some added loss due to leakage of fat. The rapidity and extent of loss per 100 lbs. of cheese vary with the following conditions: (1) The percentage of moisture originally present in the cheese. The more moist the cheese, the greater and more rapid is the loss of weight. (2) The texture of cheese. The more open the texture, the greater the loss of moisture. (3) Temperature. Loss of weight increases with increase of temperature. (4) Size and shape of cheese. Loss of weight increases, when the size of cheese decreases. Increase of height or diameter of cheese decreases loss

of weight. (5) Proportion of water-vapor in air. The greater the moisture in the air of the curing-room, the smaller is the loss of weight of cheese.

IV. Some Practical Applications. (1) Value of water in cheese to dairymen. Water, put in cheese in right proportions and kept there, is money to the dairyman, increasing amount of cheese to be sold. (2) Moisture in cheese in relation to quality. Excessive loss of moisture in curing seriously injures commercial quality of cheese. (3) What percentage of moisture should cheese have? When consumed, cheese should have not less than 33 per ct. moisture. If cured at low temperatures, larger amounts can be held to advantage of quality. (4) Value of water in cheese to consumers. Cheese with fairly large amount of moisture, cured at proper temperature, is more palatable to most consumers. Less rind is thrown away. (5) Variation of loss of moisture with size of cheese. As small cheese loses moisture more rapidly than larger cheese, greater pains must be taken with small cheese to prevent excessive loss of moisture. (6) Loss of moisture and loss of fat. To avoid loss of fat by leakage and excessive loss of moisture, cheese should not be kept above 70° F. for any length of time.

V. Prevention of Loss of Moisture in Curing Cheese. Three systems have been proposed: (1) Immediate sale and removal of newly-made cheese. In this case the buyer assumes responsibility of curing in cold-storage and secures all the benefits. (2) Central curing-rooms, located so as to care for product of several factories and equipped with complete facilities for controlling temperature and moisture. This system has greater promise than any other. (3) Special curing-rooms in each factory are desirable when central curing-rooms cannot be had. Details are given, taken mainly from Bulletin No. 70 of the Wisconsin Agricultural Experiment Station, describing construction of curing-rooms and various kinds of sub-earth ducts.

I. INTRODUCTION.

It is well known among cheesemakers that cheese begins to lose weight immediately from the time it is taken from press and placed upon the shelves of the curing-room; this loss continues indefinitely. While there has been some study in Europe relating to the conditions and extent of loss of weight in cheese-curing, the results thus obtained are not generally applicable to the conditions prevailing in this country. Some study of this question has been made in America, but it has been rather desultory in character, lacking in systematic plan and thoroughness, and under circumstances not permitting careful control of conditions.

II. EQUIPMENT FOR INVESTIGATION.

CURING-ROOMS.

For the past three years, at this Station we have been making a systematic study of the various conditions that affect loss of weight in cheese during the progress of curing. The special equipment in the way of cheese-curing rooms has given us unusual opportunities to carry on such study under well-controlled conditions. We have a block of six distinct curing-rooms, separated from the outer walls of the building by a passage four feet wide. The rooms are farther insulated by double walls and air-spaces on every side of each room. These rooms are nine by ten feet and about eight feet high, and the wall space on three sides is provided with shelves 12 inches apart.

CONTROL OF TEMPERATURE.

The temperature and moisture in each room can be controlled independently of the other rooms. It is possible to obtain a range of temperature varying from 40 to 90 degrees Fahrenheit in every room. Each room is provided with a hot-air flue from below and a cold-air flue above, leading from the chamber in the attic which contains ammonia expansion-coils and brine-tanks. These two flues, one for cold and one for hot air, are closed by dampers, and these dampers are operated by means of compressed air tubes controlled by metallic thermostats. There is also a ventilating flue in the ceiling of each room. The thermostat is fixed so as to register some definite temperature in each room. For example, in one room the thermostat is set at 70 degrees Fahrenheit. When the temperature falls one degree below 70° F., the thermostat is affected in such a manner that a valve is turned and this causes compressed air to close the cold-air damper in the ceiling and to open the hot-air damper in the floor, thus restoring the temperature to 70°F. On the other hand, when the temperature rises to 71° F., the cold-air flue in the ceiling is opened and the hot-air flue is closed, when the temperature soon begins to drop. Thus, we have an alternate admission and exclusion of hot air and cold air, causing the temperature to rise a little above or fall slightly below the given point at which it is desired to hold the temperature of the room. So delicate is the operation of this system that merely breathing upon the thermostat will open the cold-air flue, while fanning the thermostat will open the hot-air damper. We are able, therefore, by this system to hold temperature within a very limited range. Under most favorable conditions, the limit of variation is only two degrees. Even with a much wider temporary variation, the temperature of the interior of a cheese would not be affected to the extent of more than a small fraction of a degree, as we have shown by placing a thermometer inside a cheese and keeping it there under observation for several weeks.

CONTROL OF MOISTURE.

It is more difficult to control moisture than temperature, so as to hold it within narrow limits. The most practicable and efficient method we have found adapted to our conditions, is to make use of yard-wide pieces of coarse felt, having a strong capillary power. One end of the felt dips in a trough of water situated near the top of the room and the lower end drops into a trough placed on the floor. The water is sucked in by the felt at the upper end and gradually distributes itself throughout the whole piece, the excess of water dripping into the lower trough. It is necessary occasionally to boil these pieces of felt cloth in water slightly acidulated with some acid, like acetic or hydrochloric, in order to remove mineral salts that accumulate and interfere with capillary action. The use of distilled or rain water would obviate this difficulty. Thus far we have kept the moisture as nearly as possible at 75 per ct. of saturation, though variations of five per ct. below and ten per ct. above may occur at times. The natural tendency is toward a higher percentage of relative moisture at lower temperatures.

METHOD OF DETERMINING MOISTURE IN AIR.

The relative amount of moisture in air can be determined by means of an instrument known as a *hygrometer*, of which there are several forms. One form indicates the percentage of moisture directly by means of a needle or hand; this is the most convenient kind of hygrometer and is probably sufficiently accurate for ordinary purposes. A more accurate instrument consists of two sensitive, standard thermometers. The bulb of one is exposed to the air directly, like any thermometer, and is known as the dry-bulb or dry thermometer, while the other has its bulb wrapped in a piece of muslin to hold water, and is known as the wet-bulb or wet thermometer. The wet thermometer should be fixed in a frame that enables one to whirl it easily. The form of hygrometer used by us is made by Julian P. Friez, Baltimore, Md. The dry thermometer indicates the temperature of the air in the room. The wet thermometer, properly used, indicates a lower temperature than does the dry thermometer, because the water in the muslin bound about the bulb evaporates and the evaporation is accompanied by a lowering of the temperature immediately around the bulb. The less moisture there is in the air, the more rapidly does evaporation take place and the lower is the temperature indicated by the wet thermometer. The greater the moisture in the air, the less rapid is the evaporation and the smaller the difference between the temperature indicated by the dry and wet thermometers. When the two thermometers indicate the same temperature, then there is no evaporation taking place from the bulb of the wet thermometer, because the air is saturated with moisture, that is, holds as water-vapor all it can at that temperature. If the moisture is increased beyond this point or if the temperature is lowered, some of the water-vapor will be condensed into visible drops of water.

In order to use a hygrometer for the purpose of ascertaining the proportion of moisture in air, we note first the temperature indicated by the dry thermometer. Then we dip in water the bulb (wrapped in muslin) of the wet thermometer, whirl it vigorously for one or two minutes and then quickly read the temperature. The whirling is for the purpose of quickly causing evaporation. It is well to repeat the whirling two or three times, noting the temperature of the wet thermometer after each whirling. The different temperature readings should agree, if the whirling operation is equally thorough each time. Pains must be taken to keep the muslin about the bulb moist during the different whirlings. After getting the temperatures of the two thermometers, we subtract the number indicating the temperature of the wet thermometer from the number showing the temperature of the dry thermometer. Then we turn to prepared tables of figures and find the column of figures, at the top of which is the difference obtained by the foregoing subtraction. If the exact figure is not there we take the one nearest it. We then follow down this column until the figure is found opposite the number in the left-hand column which is the same as the temperature indicated by the dry thermometer. The number thus found indicates the relative amount of moisture in the air, or percentage of saturation; that is, how much moisture the air actually holds, compared with what it could hold at that temperature if saturated.

The preceding statements can be better understood by use of a specific illustration. Suppose we find by actual trial that the readings of the two thermometers of our hygrometer are as follows:

Dry thermometer	70°F.
Wet thermometer	65°F.
Difference	5°F.

We turn to the tables given at the end of this bulletin (taken from Weather Bulletin No. 127, U. S. Dept. of Agr.) and look in the upper horizontal row for the number 5. Having found this, we follow down the column until we come opposite the number indicated by the dry thermometer (70) in the vertical column at the extreme left. This brings us to the figure 77, which indicates the relative amount of moisture in the air ; in other words, the air contains 77 per ct. as much moisture as it can hold at 70°F.

III. CONDITIONS AFFECTING LOSS OF WEIGHT IN CHEESE-CURING.

The loss of weight in cheese during the process of curing under proper conditions may be regarded for practical purposes as being due entirely to the evaporation of water from the cheese. Of course, the mechanical loss of fat by exudation from cheese kept at high temperatures must be considered, but with proper control of temperature such loss will not take place. The small amount of loss due to the formation and escape of carbon dioxide and other gases from cheese can be neglected for the purpose we now have in view.

The rapidity and extent of loss of moisture in cheese during the process of curing vary with several conditions, chief of which are the following :

(1) The percentage of moisture originally present in the cheese.

(2) The texture of the cheese.

(3) The temperature of the curing-room.

(4) The size and shape of the cheese.

(5) The proportion of water-vapor present in the air of the curing-room.

LOSS OF MOISTURE AS INFLUENCED BY THE PERCENTAGE OF WATER PRESENT IN GREEN CHEESE.

In presenting the results of our study under this division of our subject, we will first make use of some extreme cases, in which the percentage of water in the cheese varied from 55 to 35. In the following table we give the percentage of water originally present in the cheese fresh from press and the amount of water lost per 100 pounds of cheese for each of four weeks, the conditions of temperature and moisture of air being the same for the different cheeses.

TABLE I.—LOSS OF MOISTURE IN CHEESES CONTAINING DIFFERENT PERCENTAGES OF WATER.

Water in 100 lbs. green cheese.	Water lost by 100 lbs. of green cheese.			
	In 1 week.	In 2 weeks.	In 3 weeks.	In 4 weeks.
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
55	9.0	11.2	12.3	16.8
50	5.5	9.2	11.0	12.9
45	4.5	6.3	8.0	9.5
35	3.3	4.2	4.9	5.7

An examination of these figures suggests the following statements:

(1) There is a marked general tendency for very moist cheese to lose water more rapidly than cheese having less moisture, other conditions being uniform. Thus, the cheese containing 55 per ct. of moisture lost nearly three times as much moisture by evaporation each week as did the cheese containing 35 per ct. of water, and nearly twice as much as the cheese containing 45 per ct. of moisture.

(2) At the end of four weeks, the cheese containing 55 per ct. of moisture had lost about one-third of its water; the one with 50 per ct. had lost one-fourth; the one containing 45 per ct., one-fifth; and the one with 35 per ct., one-sixth. It is thus seen that the more moist the cheese, the greater is the proportion of its water lost by evaporation; and, hence, the moisture in the different cheeses tends to become more nearly alike. However, they would not all reach the same condition of moisture-content, except under very unusual conditions.

The results presented in such extreme cases are full of interest but do not have practical application to conditions commonly present in cheese-making. There is, however, a practical question in this connection to be considered later.

We will consider one more illustration, in which the variations of moisture in the green cheeses are within narrow limits and essentially similar to cases occurring in factory work. The data in the following figures represent averages obtained with four different lots of cheese. The cheeses weighed about 30 lbs. each.

Water in 100 lbs. green cheese, lbs.	41.7	38.7	37.6	35.4
Water lost by 100 lbs. cheese in 6 weeks, lbs.	5.3	4.6	4.5	4.2

These data show that the loss of moisture increases as the amount of water in the green cheese increases, even though the amount of moisture in the green cheese varies within comparatively narrow limits. Variation in other conditions may, of course, interfere with this general tendency.

LOSS OF MOISTURE AS INFLUENCED BY TEXTURE OF CHEESE.

Cheese filled with holes will occupy more volume than the same weight of cheese free from holes. Hence, cheese with such faulty texture has a larger surface exposed for evaporation relative to its weight and will lose more moisture. Then, in addition, the presence of numerous holes in cheese greatly facilitates the escape of moisture from the interior of the cheese to the surface. This is a partial explanation of the fact that cheese high in moisture loses water more rapidly than cheese containing less moisture. It is well known that cheese containing high percentages of water usually develops holes abundantly, especially when cured at or above ordinary temperatures.

LOSS OF MOISTURE AS INFLUENCED BY TEMPERATURE.

In our study of the influence of temperature upon loss of moisture we used six different temperatures, viz: 55°, 60°, 65°, 70°, 75°, 80° F. In one case a temperature of about 32° F. was employed. The degree of moisture was kept as nearly uniform as possible in the different curing-rooms.

In this connection we will present the results secured with cheeses 15 inches in diameter, and weighing, fresh from press, about 65 lbs., the usual standard size of the most common type of American Cheddar cheese. Work with the cheeses at 75° and 80° F. was discontinued after 16 weeks. The number of cheeses of this size available for our work has not been sufficient to cover the ground as fully as is desirable.

TABLE II.—LOSS OF MOISTURE AT DIFFERENT TEMPERATURES.

Temp. of curing-room.	Water lost by 100 lbs. of green cheese in									
	1 week.	2 weeks.	3 weeks.	4 weeks.	8 weeks.	12 weeks.	16 weeks.	20 weeks.	24 weeks.	28 weeks.
Deg. F.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
55	1.6	2.6	3.2	3.7	5.2	6.1	6.8	7.5	8.1	8.6
60	1.7	2.8	3.4	3.9	5.5	6.5	7.5	8.5	9.3	9.9
65	1.9	3.0	3.6	4.1	5.8	7.0	8.2	9.2	10.1	10.5
70	2.0	3.1	3.7	4.3	6.0	7.8	9.0	10.1	11.1	12.0
75	2.2	3.3	4.0	4.7	7.2	9.7	11.4	—	—	—
80	2.4	3.7	4.5	5.2	8.3	11.6	15.5	—	—	—

Attention is called to the following points:

(1) At 55° F. the total loss of moisture is less than it is at the higher temperatures. This is true at the end of the first week and continues so through all the weeks following.

(2) The loss of weight increases in a marked degree with increase of temperature. During the first four weeks the loss of weight increased about three ounces for each increase of five degrees of temperature between the limits of 55° and 70° F. From 70° to 75° F., the increase was six and one-half ounces, and from 75° to 80° F., the increase was eight ounces for each 5° F. additional. As between 55° and 80° F. the loss increased on an average one ounce per 100 lbs. of cheese for each additional degree Fahr. At the end of two months, comparing 55° and 80° F. the loss increased two ounces per 100 lbs. of cheese for each degree; and at the end of three months, three and one-half ounces.

(3) The average weekly loss of weight or rate of loss increases with increase of temperature. This statement can be more clearly understood by means of the subjoined table, which has been prepared from the data given in Table II.

TABLE III.—AVERAGE WEEKLY LOSS AT DIFFERENT TEMPERATURES.

Temp. of curing-room.	Average loss per week. Water lost by 100 lbs. of green cheese.									Lbs. total loss for six months
	1st week.	2d week.	3d week.	4th week.	2d month.	3d month.	4th month.	5th month.	6th month.	
Deg. F.	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Lbs.*
55	25.6	16.0	9.6	8.0	6.0	3.6	2.8	2.8	2.4	8.1
60	27.2	17.6	9.6	8.0	6.4	4.0	4.0	4.0	3.2	9.3
65	30.4	17.6	9.6	8.0	6.8	4.8	4.8	4.0	3.6	10.1
70	32.0	17.6	9.6	9.6	6.8	4.8	4.8	4.4	4.0	11.1
75	35.2	17.6	10.2	10.2	10.0	10.0	6.8	—	—	—
80	38.4	20.8	12.8	10.2	12.4	13.2	15.6	—	—	—

An examination of this table shows the smallest weekly loss at 55° F. in every case and a clear tendency for the loss to increase with increase of temperature.

(4) It is noticeable that the loss is greater the first week than during any other week. At 55° and 60° F. the loss the first week is equal to the combined losses of the second and third weeks. At the higher temperatures the loss during the first week is nearly equal to the combined losses of the second, third and fourth weeks.

(5) The weekly loss decreases continuously as the cheese grows older. This is true at all temperatures.

(6) The comparatively rapid loss of moisture during the early stage of curing is entirely consistent with the fact previously shown, that loss of moisture increases with the moisture content of the cheese. The cheese contains its maximum of moisture when new. In addition, the bandage holds considerable water which quickly evaporates. Then, again, the outer surface of the cheese, in drying, begins to harden, the pores of the cheese-cloth filling to some extent with dried matter, and this condition tends constantly more and more to diminish evaporation, provided cracking is prevented.

(7) An examination of Table III shows that the cheese at 80°F. after the fourth week, had an increased weekly loss of weight, while at the lower temperatures the weekly loss fell gradually. This extra loss was due to leakage of fat from the cheese, which was very noticeable on the surface of the cheese and on the

shelf. The cheese at 75°F. also lost some fat by leakage, as the figures in the table indicate for the second and third months.

(8) To illustrate the influence of temperature below 55° F. upon loss of moisture in cheese curing, we give some results secured with cheeses weighing 30 lbs., 13 inches in diameter. The last weighing was taken when the cheeses were five weeks old.

Temperature. degrees F.	32	55	60	70
Weight, lost by 100 lbs. of cheese in five weeks, lbs.,	3.0	4.6	4.6	4.9

The reduction in temperature below 55°F. is seen to be attended with decreased loss of moisture in a marked degree.

LOSS OF MOISTURE AS INFLUENCED BY SIZE AND SHAPE OF CHEESE.

We will first present data secured with cheeses having the same diameter but varying in height. These cheeses were 7 inches in diameter, being of the type commonly known as "Young Americas." They were made from one vat of milk and subjected to uniform conditions. They were all kept at a uniform temperature of 65° F.

TABLE IV.—WEIGHT LOST BY CHEESE OF VARYING HEIGHT AND UNIFORM DIAMETER.

Height of cheese.	Weight of green cheese.	Water lost by 100 lbs. of green cheese in								
		1 week.	2 weeks.	3 weeks.	4 weeks.	8 weeks.	12 weeks.	16 weeks.	20 weeks.	24 weeks.
Inches.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
3	4.6	3.4	5.3	6.4	7.0	10.7	12.9	13.9	15.9	17.0
4	6.1	3.3	5.1	6.1	6.7	9.7	11.5	13.0	14.0	15.6
5	7.9	2.8	4.2	5.5	6.3	8.3	9.8	11.2	12.6	13.4
6	9.3	2.5	3.9	5.2	6.0	7.8	9.4	10.6	11.6	12.8
7	11.0	2.3	3.4	4.7	5.6	7.4	8.9	10.5	11.2	12.4

The data in this table suggest the following statements:

(1) The loss of weight was greatest in the cheese whose height was least. The loss decreased with increase in height. Taking the total loss for the first four weeks, it is seen that an increase of

one inch in height reduced the loss of moisture about 5½ ounces per 100 lbs. of cheese.

(2) The general tendency in all the cheeses was a decrease in the weekly rate of loss of weight as the cheese grew older. The weekly rate of loss was greater in the smaller cheeses for the first two months, after which the rate was fairly uniform in all the cheeses.

We will now consider data furnished by cheeses having approximately the same height but varying in diameter. The results represent, in case of the smaller cheeses, averages covering from ten to twenty-five separate lots of cheese.

TABLE V.—WEIGHT LOST BY CHEESE OF VARYING DIAMETER AND UNIFORM HEIGHT.

Diameter of cheese.	Weight of green cheese.	Temperature of curing-rooms.	Water lost by 100 lbs. of cheese.							
			1 week.	2 weeks.	4 weeks.	8 weeks.	12 weeks.	16 weeks	20 weeks.	24 weeks.
Inches.	*Lbs.*	*Deg. F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
15	65	80	2.4	3.7	5.2	8.3	11.6	15.5	——	——
7	9	80	3.6	5.2	7.3	10.9	12.7	14.5	16.3	17.1
15	65	75	2.2	3.3	4.7	7.2	9.7	11.4	——	——
7	9	75	3.1	4.8	6.6	9.2	11.1	12.7	14.1	15.1
15	65	70	2.0	3.1	4.3	6.0	7.8	9.0	10.1	11.1
11	23	70	3.0	4.2	6.1	7.7	9.2	10.6	11.6	12.4
7	9	70	2.9	4.5	6.2	8.9	10.9	12.2	13.9	14.6
15	65	65	1.9	3.0	4.1	5.8	7.0	8.2	9.2	10.1
13	31	65	2.0	3.4	5.1	6.2	7.7	8.7	9.3	10.2
11	22	65	2.6	3.7	5.3	6.9	8.1	9.5	10.4	11.3
7	9	65	2.5	3.9	5.6	7.9	9.5	10.9	12.1	13.1
15	65	60	1.7	2.8	3.9	5.5	6.5	7.5	8.5	9.3
13	31	60	1.7	2.7	4.3	6.1	7.3	8.4	9.5	——
11	22	60	1.9	3.6	4.5	6.3	7.5	8.7	9.6	10.5
7	9	60	2.4	3.7	5.5	7.7	9.3	10.6	11.9	12.8
15	65	55	1.6	2.6	3.7	5.2	6.1	6.8	7.5	8.1
13	29	55	1.5	2.7	4.2	5.7	7.2	7.9	8.9	9.4
11	20	55	2.1	3.6	4.6	6.4	7.4	8.8	9.4	10.1
7	9	55	2.2	3.6	5.1	7.2	8.8	9.8	11.0	12.0

A study of the preceding table brings out the following points:

(1) In general, at all temperatures, the loss of weight in cheese

increases when the diameter of the cheese decreases. Taking the cheeses having diameters of 15 and 7 inches respectively, at the age of four weeks, we see that at a temperature of 80° F. the smaller cheese has lost 2.1 lbs. more per hundred pounds of cheese than has the larger cheese.

(2) The difference in loss of weight between cheeses of different diameters is greatest at 80° F. and gradually decreases with decrease of temperature. Illustrating this point with the 15 and 7 inch cheeses at the age of four weeks, we have the small cheese losing more than the large cheese by the following amounts per hundred pounds of cheese: at 80° F., 2.1 lbs.; at 75° F. 1.9.; at 70° F., 1.9 lbs.; at 65° F., 1.5 lbs.; at 60° F., 1.6 lbs.; at 55° F., 1.4 lbs.

(3) At 65° F. we find that an increase of two inches in diameter reduces the loss of weight about one-half pound per hundred pounds of cheese, when the cheeses are four weeks old. When the cheeses are 16 weeks old, the decrease in loss of weight is one pound for an increase of two inches in diameter.

We have two additional illustrations to present, in which cheeses were made from the same milk and cured under the same conditions. We present these data in the following table:

TABLE VI.—WEIGHT LOST BY CHEESES OF DIFFERENT DIAMETERS.

Diameter of cheeses.	Weight of green cheese.	Temperature of curing-room.	Water lost by 100 lbs. of cheese in							
			2 weeks.	3 weeks.	5 weeks.	7 weeks.	8 weeks.	12 weeks.	16 weeks.	20 weeks.
Inches.	*Lbs.*	*Deg. F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
13	36	55	2.9	3.6	4.5	4.9	5.4	6.4	7.2	8.1
7	10	55	3.9	4.9	6.3	6.9	7.2	8.7	9.9	11.5
13	29	60	2.8	3.7	4.7	5.7	6.0	7.3	8.2	9.3
7	9	60	3.8	4.8	6.7	7.9	8.2	9.7	11.2	12.5

LOSS OF MOISTURE AS INFLUENCED BY PROPORTION OF WATER-VAPOR PRESENT IN AIR OF CURING-ROOM.

The relative amount of moisture in air, or, more properly, the degree of saturation, exercises a marked influence upon loss of water in cheese-ripening. While we have not carried systematic investigation far in this line, we can present data that will clearly illustrate the influence of this factor. Cheeses, which were made from the same milk, were placed in the curing-room at 60°F. One cheese was kept on the shelf in the ordinary manner, the air of the room containing from 75 to 80 per ct. of all the moisture it could hold at 60° F. The other cheese was placed under a bell-jar and kept in an atmosphere completely saturated with moisture. The results secured by this treatment are presented in the table following. The amount of moisture in the fresh cheese was not determined and we start, therefore, with the moisture in the cheese at two weeks.

TABLE VII.—LOSS OF MOISTURE IN CHEESE KEPT IN AIR COMPLETELY AND PARTIALLY SATURATED WITH MOISTURE.

Age of cheese.	In air partially saturated.		In air completely saturated with moisture.	
	Moisture in cheese.	Water lost by 100 lbs. of cheese.	Moisture in cheese.	Water GAINED by 100 lbs. of cheese.
	Per ct.	*Lbs.*	*Per ct.*	*Lbs.*
2 weeks	35.99	——	35.93	——
1 month	35.23	0.76	35.87	——
2 months	34.86	1.13	36.01	0.08
6 "	31.87	4.12	37.04	0.11
12 "	26.30	9 69	37.63	1.70
15 "	24.85	11.14	37.85	1.92

Attention is called to the following points in connection with this table:

(1) In case of the cheese kept in air partially saturated with moisture, there is a loss of moisture from the first, which at the end of 15 months has reached the total of 11.14 lbs. per hundred pounds of cheese.

(2) In the cheese kept in a moisture-saturated atmosphere, there was practically no loss of moisture in the cheese, but at the end of 2 months the moisture in the cheese had actually increased and continued to increase steadily, until, at the end of 15 months, there had been an actual gain of 1.92 lbs. of moisture per 100 lbs. of cheese.

(3) The two cheeses, containing the same amount of moisture at the beginning, were found to differ, at the end of 15 months, 13 per ct. in moisture, as the result of being kept in air containing different degrees of moisture.

IV. SOME PRACTICAL APPLICATIONS.

We have been considering those conditions that are most prominent in influencing the loss of moisture in cheese and have called attention to the results secured by us. We come now to consider these results in their practical application to the interests of the factory owner, his patrons and the consumers of cheese. In this connection we will discuss the following topics:

(1) Value of water in cheese to dairymen.
(2) Moisture in cheese in relation to commercial quality.
(3) What percentage of moisture should cheese have?
(4) Value of water in cheese to consumer.
(5) Variation of loss of moisture with different kinds of cheese.
(6) Loss of moisture and loss of fat.

VALUE OF WATER IN CHEESE TO DAIRYMEN.

To the cheese-maker and producer of milk, water in cheese is money when put there in the right way and in proper proportions. It is essential, in the process of manufacture, to incorporate water in cheese in quantities best suited to the requirement of the market for which the cheese is intended, and then it is equally essential that the water be kept there with the least possible loss. From the dairyman's standpoint, it is desirable to sell as much water in cheese as will suit the consumer. In preventing excessive loss of moisture, there is more water to sell at cheese prices.

From inquiries made among cheese-makers, we find quite a variation in respect to the loss of moisture experienced by them in curing cheese. One of the most complete records, covering an entire season, furnished by a cheese-maker and factory owner who has better than average conditions for curing-rooms, makes the average loss of weight during thirty days amount to about five pounds per hundred pounds of cheese. Others report an average loss for the first thirty days as high as ten pounds per hundred pounds of cheese. The average loss lies somewhere between these two extremes and would probably not be far from seven pounds per hundred pounds of cheese.

An examination of Table II shows that the loss of moisture can be reduced to four pounds per hundred pounds of cheese. Using this figure as a basis for calculation, we find that, for every hundred pounds of cheese, from one to six pounds, with an average of three pounds, of water could be saved to sell at cheese prices. This would mean an increase of 8 to 48 cents, with an average of 30 cents, received for every hundred pounds of cheese. This would mean an average saving of three hundred dollars a season for a factory with a total season's output of one hundred thousand pounds of cheese. One cheese-maker reports that he calculated one season's loss from shrinkage and found it over six hundred dollars. While such losses may not be regarded as large in comparison with the total receipts, they constitute a noticeable percentage when viewed as a decrease of profits, and are well worth saving.

MOISTURE IN CHEESE IN RELATION TO COMMERCIAL QUALITY.

We have just called attention to increased receipts coming from cheese, as a result of preventing excessive loss of moisture. Such saving of moisture not only increases the amount of cheese to be sold but also increases the value of the cheese from the standpoint of commercial quality.

In Bulletin No. 184, of this Station, Mr. Geo. A. Smith, Dairy Expert, has presented the results of work showing the influence of temperature upon the commercial quality of cheese. No attempt is there made to analyze the results and point out the immediate causes affecting quality, and attention is, therefore, called to the subject here.

The relations existing between moisture and flavor are known only in a very general way. But we know something of the general relation between moisture and texture. Excessive moist ure produces undesirable softness, from a commercial standpoint, and at ordinary temperatures favors the formation of holes, a serious fault in the texture of Cheddar cheese. On the other hand, deficient moisture favors the production of a crumbly, dry, mealy texture, which is an undesirable condition. High temperatures cause excessive loss of moisture and result in the production of crumbly texture. This condition injures the commercial quality of cheese and results in lower prices for such cheese. The following figures represent averages taken from data given on page 202, Bulletin 184, showing the general relation between texture and loss of moisture.

TABLE VIII.—EFFECT OF TEMPERATURE OF CURING ON TEXTURE AND MOISTURE OF CHEESE.

Temperature of curing-room.	Texture of cheese. (Perfect texture is 25).	Moisture lost by 100 lbs. of cheese.
		Lbs.
55 degrees F.	24.6	8.5
60 "	24.4	9.0
65 "	23.6	9.2
70 "	22.0	10 2
75 "	21.4	10.7
80 "	20.6	13.1

WHAT PERCENTAGE OF MOISTURE SHOULD CHEESE HAVE?

Much of the cheese made in New York State contains, in the fresh state, from 36 to 37.5 per ct. of water. The home-trade cheese, much of which is made in the fall, contains 38 to 40 per ct. of water. For the average consumer, it is safe to say, the amount of moisture in cheese should be not less than between 33 and 35 per ct. at the time of consumption. Taking everything into consideration, it is reasonable to expect better results in reference to quality by holding a moderate amount of moisture in the green cheese and so curing as to lose only a small amount of water, than by holding an excessive amount of moisture in the green cheese and so curing as to lose a larger amount of moisture. Some cheese-makers expect that they must lose ten pounds of weight per hundred pounds of cheese in curing, and they attempt to meet this loss by retaining 40 per ct. or more of moisture in the cheese. Such a practice can not lead to good results from any point of view.

A fact that should not be lost sight of in this connection is this: Cheese cured at such low temperatures as are favorable to diminishing the loss of moisture can carry larger amounts of moisture from the start without impairing the quality.

VALUE OF WATER IN CHEESE TO CONSUMERS.

In the first place, cheese that has not lost too much of its moisture is more pleasing to the taste of the average consumer. In the next place, the more completely a cheese dries out, the harder and thicker is the rind and the greater the loss to the consumer. Most people have become accustomed to such a waste, but much of it is unnecessary. In a carefully cured cheese, the rind is comparatively moist and only a very thin portion need be lost, and even this can be used in cooking.

VARIATION OF LOSS OF MOISTURE WITH DIFFERENT KINDS OF CHEESE.

It has been pointed out that cheeses of small size lose more moisture per hundred pounds than do cheeses of larger size. In making small cheeses like "Young Americas" the proportion of loss is much greater, and hence the demand is still more imperative that these shall be cured under conditions where the loss of moisture shall be greatly reduced. This applies also to such sizes as "Flats" and "Twins." It is not surprising that the manufacture of small cheeses of the Cheddar type has been discouraged. Even at the higher prices that they bring, the extra loss of moisture and additional cost of manufacture are not satisfactorily covered. In the manufacture of small fancy kinds of soft cheese, these statements do not apply, because an essential part of the equipment consists of curing-cellars of fairly low temperature and high moisture content.

LOSS OF MOISTURE AND LOSS OF FAT.

High temperatures, which favor increased loss of moisture, also favor loss of fat by exudation from the surface of the cheese.

When cheese is kept at a constant temperature even of 70° F., there is evidence of some, though small, loss. At 75° F. the loss becomes considerable and increasingly large with increase of temperature above 75°F.

V. PREVENTION OF LOSS OF MOISTURE IN CURING CHEESE.

From the data previously presented, it has been seen that loss of weight in cheese curing is due to lack of control of temperature and moisture in the curing-room. Three methods or systems have been proposed for the purpose of controlling these conditions or obviating the need of controlling them:

(1) Immediate sale and removal of green cheese.
(2) Central curing-rooms for the use of several factories.
(3) Special curing-room in each factory.

IMMEDIATE SALE AND REMOVAL OF GREEN CHEESE.

It was formerly a common custom to keep cheese at the factory for thirty days or more before selling it. For some time there has been a tendency to dispose of cheese at more frequent intervals, sales and shipments being made, in some cases, of cheese a week old. There appears to be an increasing desire to place cheese in the hands of buyers just as soon as they are willing to take it. Many buyers who have cold-storage facilities prefer to remove the cheese from the factory before it has had a chance to deteriorate under the adverse conditions of curing commonly present in factory curing-rooms. The system of removing cheese by buyers from the factory when less than a week old has the advantage for the cheese-maker of relieving him from all responsibility in relation to the curing process. There is, however, under such a plan the disadvantage of turning over to the buyer all the advantage that comes from increase of value as a result of good curing. With proper curing facilities, the cheese could be retained by the factory and held until it had increased very materially in value as a result of curing under good conditions. When cheese is sold green, or nearly so, the opportunity for increased profits, due to proper curing, is wholly lost.

CENTRAL CURING-ROOMS.

Four or five years ago Drs. Babcock and Russell made the suggestion that buildings, centrally located with reference to several cheese factories, be erected especially for curing purposes and designed to take care of the product of the several factories. Such a system has several advantages: (1) Enough money could be easily secured to build and equip a central curing-house that would be complete in its details and thoroughly efficient for controlling temperature and moisture. In fact, ideal conditions could be assured. No single factory could afford to provide itself an equally effective curing-room, or would be likely to do so. The cost for one central cheese-curing building, distributed among several factories, would be no more than would the cost of providing an inefficient curing-room in each individual factory. (2) Cheese stored in a central curing-house could receive more skillful and efficient attention than it could in curing-rooms located in each factory. (3) The cheese could be examined more economically by buyers, being collected in large quantities in a central curing-house. The buyer would be saved the necessity of visiting each factory separately. (4) The maximum saving could be effected in decreasing loss of moisture and in improving quality of cheese. Moreover, the cheese from any one factory or any number of factories would be more uniform in character when cured, than under present conditions or even with curing-rooms in individual factories. (5) Cheese, kept under ideal conditions during the curing process, can be held subject to market conditions, without risk of injury in respect to quality. Under the conditions commonly prevailing, cheese has to be sold to avoid the injury in quality that might result from longer holding at the factory. This is especially applicable in hot weather, a time when prices are likely to be lowest. Cheese kept in proper curing-rooms can be held for higher prices and will constantly improve in quality for quite a long period of time.

SPECIAL CURING-ROOM IN EACH FACTORY.

When it is impossible to coöperate with other factories in the construction and use of a central cheese-curing building, then it is desirable that one shall make a cheese-curing-room in the factory, even though the results secured may not be perfect. Some attempt to control temperature and moisture in curing cheese will give better results than are possible in the absence of any system, a condition too general at present in the cheese factories of New York.

The subject of a special curing-room in each cheese factory has been very fully discussed in Bulletin No. 70 of the Wisconsin Agricultural Experiment Station and several factories in that state have made such curing-rooms. The system has also been studied and applied in Canada by Prof. James Robertson, Commissioner of Agriculture and Dairying for the Dominion.

The following statements are, for the most part, condensed from Prof. F. H. King's Wisconsin Bulletin No. 70. The cuts are from the same source.

Curing-rooms may be constructed above ground or under ground and may be of wood or masonry, or a combination. Considering moderate cost, convenience, and efficiency, a curing-room built of wood entirely above ground is the most practicable for the average factory.

(1) *Location.*—A curing-room above ground should be placed on the north side of a building in order to be protected as much as possible from the direct rays of the sun. It is advantageous also if the room can be shut off on the other three sides by hallways, stairways, other rooms or building screens.

(2) *Windows* in a curing-room should be as few and as small as consistent with the amount of light necessary. They should be made double, as nearly air-tight as possible, and preferably in one section, fitted closely and permanently in place. If necessary to exclude direct sunshine, blinds or awnings should be placed outside.

(3) *The door* of a curing-room should be built to resemble that of a refrigerator.

(4) *Walls* should be built like those of cold-storage and ice-houses. The studding outside should be covered with matched sheathing and drop siding, with a layer of three-ply acid and water-proof paper between. The paper recommended by Prof. King is manufactured by the Standard Paint Co., New York and

Chicago. On the inside a layer of matched sheathing is nailed to the studding, then strips of inch furring two inches wide, to which are nailed two thicknesses of matched sheathing, with paper between. The outer air space between the studding is

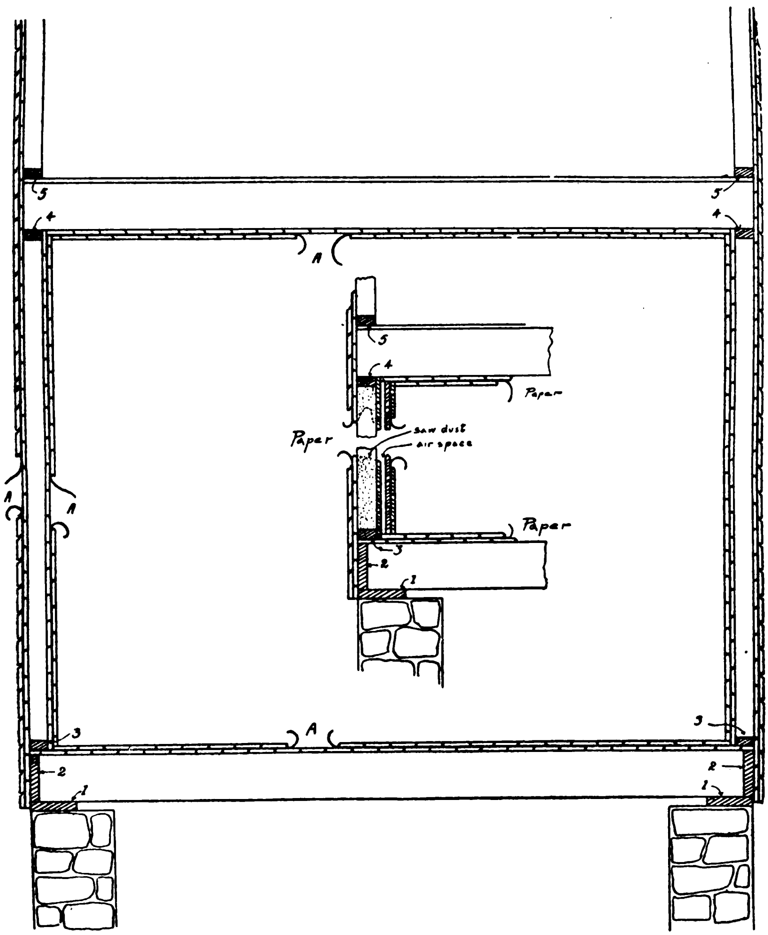

FIG. 1.—Showing the construction of wood curing-room. 1, 1, 1, sill; 2, 2, 2, a two-by-ten spiked to ends of joist; 3, 3, 3, a two-by-four spiked down, after first layer offloor is laid, to toe-nail studs to; 4, 4, 4, a two-by-four spiked to upper ends of studding of first story. A, A, A, A, three-ply acid and waterproof paper. The drawing in the center shows space between studding filled with saw dust and another dead-air space to be used when the best ducts cannot be provided.

(From Wis. Agr. Exp. Sta. Bul. 70.)

filled with sawdust or similar material and the spaces left by the furring are closed air-tight at the ceiling and floor. (See Fig. 1.)

(5) *Ceiling and floor* should also consist of two thicknesses of

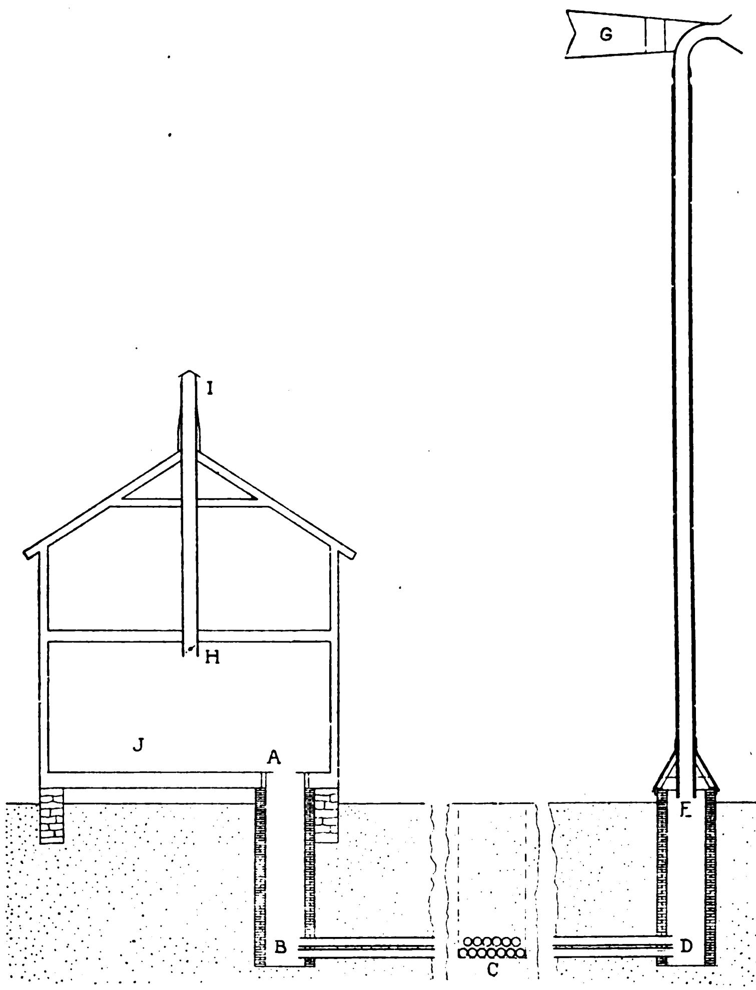

FIG. 2.—Section of cheese-curing room and horizontal multiple sub-earth duct. A, inlet to curing room; B, end of sub-earth duct in bricked entrance to factory; C, cross-section of the multiple ducts; D, E, bricked entrance under funnel at outer end of sub-earth duct; F, funnel with mouth 36 inches across; G, vane to hold funnel to the wind; H, ventilating flue with damper.

(From Wis. Ag. Exp. Sta. Bul. 70.)

matched lumber with paper between, and joints made at corners should be very tight.

In constructing curing-rooms two things should be kept in mind ; first, that the walls should be as nearly air-tight as possible in order to keep out the warmer air outside and, second, that the walls should be poor conductors of heat. It is advantageous to cover the inside walls with two coats of shellac.

(6) *Ventilating-flue in ceiling.*—It is desirable to provide a tight ventilating-flue in the ceiling of the curing-room, extending above the roof. Its diameter may be six to eight inches. It should be provided with a damper. (See Fig. 2, H, I.)

(7) *Methods of controlling temperature and moisture in cheese-curing rooms placed above ground.*—After constructing a proper curing-room, it is essential to provide arrangements for controlling temperature and moisture. The construction of a curing-room is only a partial means toward this end. The following methods have been found effective in keeping the temperature during summer between 58° and 70° F. and at the same time modifying the moisture content of the air favorably: (a) Ventilation by air forced through horizontal sub-earth ducts or deep vertical sub-earth ducts and wells. (b) Ventilating over ice. (c) Evaporation of water.

Fig. 2 illustrates the construction of a horizontal sub-earth duct, which should be 12 feet or more below the surface of the ground and 100 feet or more in length. It is recommended that the sub-earth duct consist of three rows of 10-inch drain tile laid side by side at the bottom of the trench, or the trench may be dug narrower and one or two feet deeper and the tile placed one above the other. The shaft for carrying the funnel must be made tight ; it may be 12 inches square, if made of plank, or 12 inches in diameter, if made of galvanized iron. The height should be sufficient to enable the funnel to catch the wind readily. The construction and mounting of the funnel are illustrated in Fig. 3. The extreme diameter of the funnel should be about 36 inches.

The inlet from the sub-earth duct into the curing-room must be provided with some arrangement ot valves that will permit the air to be shut off wholly or partly. Too rapid entrance of air in warm weather will not permit enough cooling during passage through the duct. In case of dry winds, too rapid entrance would reduce the moisture too much.

In Fig. 4 there is illustrated a deep vertical sub-earth duct. Such a duct has the advantage of requiring less piping and also less wind will suffice to produce a current of air. The vertical

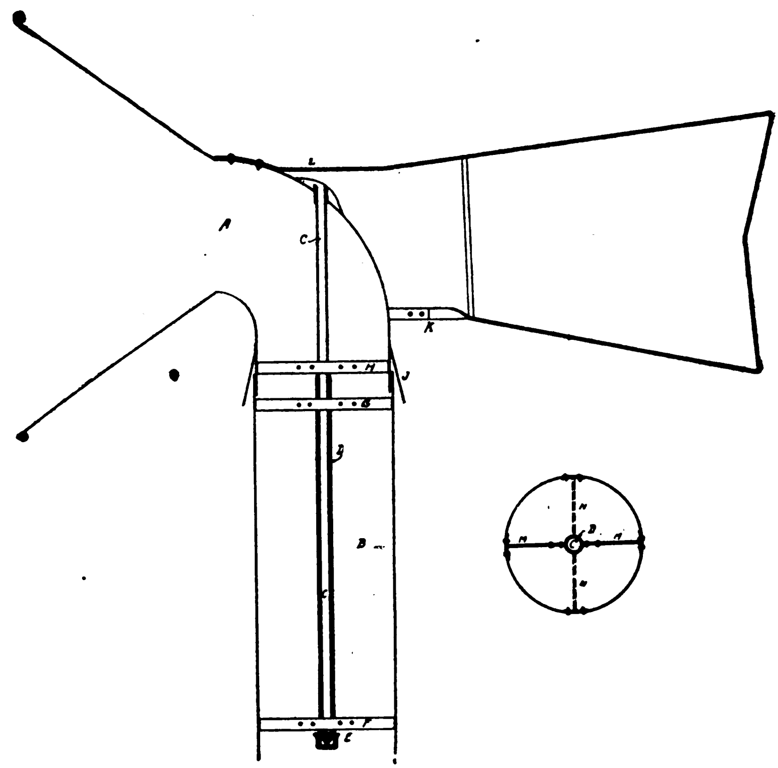

FIG. 3.—Showing how funnel and vane may be mounted. A, funnel; B, shaft of funnel; C, C, C, 1-inch gas pipe; D, D, 1¼-inch gas pipe; E, cap for support of 1-inch gas pipe; F, G, H, and M M and N N are stays of band iron bolted together and to the sides of the shaft to support the axis of the funnel; J, weather collar to turn rain out of shaft. K, L, band-iron to stiffen vane and attach it to funnel.

(From Wis. Ag. Exp. Sta. Bul. 70.)

duct should have a depth of not less than twenty-five or thirty feet, provided water is far enough from the surface. Thirteen lines of 6-inch drain or 5-inch galvanized iron conductor pipe may be used and placed as in the cut. The duct should be located near the north end of the curing-room or directly beneath it. A

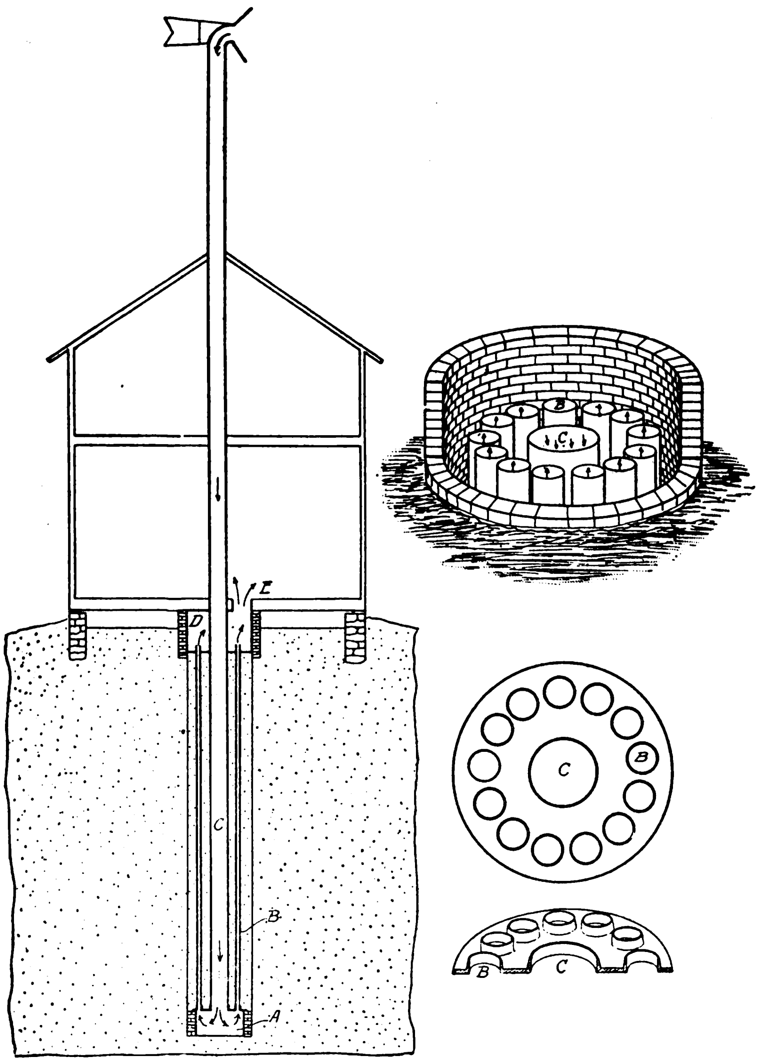

FIG. 4.—Showing vertical sub-earth duct. A, brick chamber 25 to 30 feet below surface and 40 inches inside diameter; B, tile or conductor pipe of galvanized iron; C, main shaft of funnel; D, brick chamber at upper end of duct. The circle and section represent a cast-iron plate to cover brick chamber A, and can be had of King & Walker, Madison, Wis.

(From Wis. Agr. Exp. Sta. Bul. 70.)

deep; the intake pipe is 10 inches in diameter, rising just barely above the roof of the factory, entering the well, as shown at A, two feet below the surface of the ground and then descending inside the well a distance of 8 feet. Another 10-inch galvanized iron pipe starts 40 feet below the surface of the ground and rises to within 5 feet of it, when it turns and passes horizontally until it comes under the curing-room which it enters directly, as shown at B B B C. The top of the well is tightly closed.

In Fig. 6 the cut illustrates the cooling of air in a curing-room by forcing the air through cold water. When the ground water is within 12 or 15 feet of the surface, then a cistern 5 or 6 feet in diameter, shaped like a well, may be built, plastering with cement as in the case of ordinary cisterns. In this cistern can be placed an air duct made of galvanized iron as given in Fig. 6. The duct should be water tight. By connecting the cistern with the well, fresh water may be added from time to time as may be found necessary to keep water sufficiently cool to be effective.

In Canada, considerable work has been done in using ice in curing rooms to control temperature. Where ice can be obtained conveniently and cheaply, this method may be advantageously utilized. One or more ice boxes are placed in the curing-room, so built that air can circulate about the ice and into the curing-room. Also compartments, filled with ice, may be made adjoining the curing-room on the side or above, provided with openings into the curing-room which will allow a flow of air over the ice and into the curing-room.

Where special means are needed to secure moisture, this can be effectively done by means of yard-wide strips of any cloth material that has good capillary power. The pieces of cloth are hung about the room and kept more or less saturated with water. Experience will tell how much evaporating surface is needed to provide the degree of moisture needed.

TABLE SHOWING PERCENTAGE OF SATURATION OF MOISTURE IN AIR AT VARIOUS TEMPERATURES ACCORDING TO HYGROMETER.

Dry thermometer. Degrees Fahr.	Difference between the dry and wet thermometers in degrees Fahrenheit.																							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0
	Percentages of moisture in air.																							
40	96	92	88	84	80	76	72	68	64	60	56	53	49	45	41	38	34	30	26	22	19	16	12	8
41	96	92	88	84	80	76	72	69	65	61	57	54	50	46	43	39	36	32	29	24	21	18	14	10
42	96	92	88	84	81	77	73	69	65	62	58	55	51	48	44	40	37	34	30	27	23	20	16	13
43	96	92	88	85	81	77	74	70	66	63	59	56	52	49	46	42	38	35	32	29	25	22	19	15
44	96	92	88	85	81	78	74	70	67	63	60	57	53	50	47	43	40	37	33	30	27	24	21	17
45	96	92	89	85	82	78	75	71	67	64	61	58	54	51	48	44	41	38	35	32	29	25	22	19
46	96	93	89	85	82	79	75	72	68	65	61	58	55	52	49	46	42	39	36	33	30	27	25	21
47	96	93	89	86	83	79	76	72	69	66	62	59	56	53	50	47	44	40	38	34	31	28	23	22
48	96	93	89	86	83	79	76	73	69	66	63	60	56	53	51	48	45	42	39	36	33	30	27	24
49	97	93	90	86	83	80	76	73	70	67	63	60	57	54	52	49	46	43	40	37	34	31	29	26
50	97	93	90	87	83	80	77	74	70	67	64	61	58	55	52	50	47	44	41	38	36	33	30	27
51	97	93	90	87	84	81	77	74	71	68	65	62	59	56	53	50	48	45	42	39	37	34	31	28
52	97	94	90	87	84	81	78	75	72	69	66	63	60	57	54	51	48	46	43	40	38	35	33	30
53	97	94	91	87	84	81	78	75	72	69	66	63	61	58	55	52	49	47	44	42	39	36	34	31
54	97	94	91	88	85	82	79	76	73	70	67	64	61	59	56	53	50	48	45	43	40	38	35	32
55	97	94	91	88	85	82	79	76	73	70	68	65	62	59	57	54	51	49	46	43	41	39	36	34
56	97	94	91	88	85	82	80	77	74	71	68	65	63	60	57	55	52	50	47	44	42	40	37	35
57	97	94	91	88	86	83	80	77	74	71	69	66	64	61	58	55	53	50	48	45	43	40	38	36
58	97	94	91	89	86	83	80	78	75	72	69	67	64	61	59	56	53	51	49	46	44	42	39	37
59	97	94	92	89	86	83	81	78	75	72	70	67	65	62	60	57	54	52	49	47	45	43	40	38
60	97	94	92	89	86	84	81	78	75	73	70	68	65	63	60	58	55	53	50	48	46	44	41	39
61	97	94	92	89	87	84	81	78	76	73	71	68	66	63	61	58	56	54	51	49	47	44	42	40
62	97	95	92	89	87	84	82	79	76	74	71	69	66	64	61	59	57	54	52	50	47	45	43	41
63	97	95	92	89	87	84	82	79	77	74	72	69	67	64	62	60	57	55	53	51	48	46	44	42
64	97	95	92	90	87	85	82	79	77	74	72	70	67	65	62	60	58	56	53	51	49	47	45	43
65	97	95	92	90	87	85	82	80	77	75	72	70	68	65	63	61	59	56	54	52	50	48	46	44
66	97	95	92	90	87	85	82	80	78	75	73	71	68	66	63	61	59	57	55	53	51	49	47	45
67	98	95	93	90	88	85	83	80	78	76	73	71	69	66	64	62	60	58	55	53	51	49	47	45
68	98	95	93	90	88	85	83	81	78	76	74	71	69	67	65	63	60	58	56	54	52	50	48	46
69	98	95	93	90	88	86	83	81	78	76	74	72	70	67	65	63	61	59	57	55	53	51	49	47
70	98	95	93	90	88	86	83	81	79	77	74	72	70	68	66	64	62	60	57	55	53	52	50	48
71	98	95	93	91	88	86	84	81	79	77	75	72	70	68	66	64	62	60	58	56	54	52	50	48
72	98	95	93	91	88	86	84	82	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49
73	98	95	93	91	88	86	84	82	80	78	75	73	71	69	67	65	63	61	59	57	55	53	52	50
74	98	95	93	91	88	86	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56	54	52	50
75	98	95	93	91	89	87	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56	55	53	51
76	98	95	93	91	89	87	85	82	80	78	76	74	72	70	68	66	64	63	61	59	57	55	53	52
77	98	95	93	91	89	87	85	83	80	78	76	74	72	71	69	67	65	63	61	59	57	56	54	52
78	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	62	60	58	56	54	53
79	98	96	94	91	89	87	85	83	81	79	77	75	73	71	70	68	66	64	62	60	58	57	55	53
80	98	96	94	92	89	87	85	83	81	79	77	75	73	72	70	68	66	64	63	61	59	57	55	54