UNITED STATES DEPARTMENT OF AGRICULTURE

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EVAPORATION OF FRUITS

By

JOSEPH S. CALDWELL,

Plant Physiologist, Office of Horticultural and Pomological Investigations
Bureau of Plant Industry

CONTENTS

	Page
Extent and character of the fruit-drying industry	1
Principles involved in drying fruits	4
Community drying plants	7
Buildings and equipment for drying	8
The kiln evaporator	8
The individual kiln	9
The kiln-drying plant	15
The apple-drying workroom and its equipment	17
The prune tunnel evaporator	24
The operation of the tunnel evaporator	27
Small driers or evaporators	35
Treatment of the various fruits	35
Apples	35
Treatment of the various fruits—Continued	
Peaches	45
Apricots	49
Pears	49
Cherries	50
Prunes	50
Small fruits	54
Storing the dried products	57
Preparing evaporated fruits for market	58
Packing evaporated apples	58
Packing peaches, apricots, and pears	59
Packing prunes	61
Laws relating to evaporated and dried fruits	62

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CONTENTS.

	Page.
Extent and character of the fruit-drying industry	1
Principles involved in drying fruits	4
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The kiln evaporator	8
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Small driers or evaporators	35
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Apples	35
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Peaches	45
Apricots	49
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Cherries	50
Prunes	50
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EXTENT AND CHARACTER OF THE FRUIT-DRYING INDUSTRY.

THE TERMS "dried fruit" and "evaporated fruit" are popularly used to designate all fruits preserved by reduction of their moisture content to such a point that spoilage does not occur. In the trade the term "dried fruit" is applied to any product in which moisture reduction has been brought about by exposure of the fresh material to the heat of the sun, while products made by driving off the surplus moisture by the use of artificial heat are known as "evaporated" fruits, less frequently as dehydrated or desiccated fruits. While the processes of sun drying and drying with artificial heat in evaporating devices are widely different, the differences in the

[1] This bulletin is of interest to fruit growers who have such quantities of surplus fruit as to require the employment of large-scale factory methods for its utilization. It is intended to serve as a rather complete nontechnical handbook of information in regard to methods of evaporating fruits which are applicable to farm conditions.

This bulletin supersedes Farmers' Bulletin 903, "Commercial Evaporation and Drying of Fruits," by James H. Beattie and H. P. Gould. Much of the material in that publication is reproduced, with revision, in this bulletin. New sections dealing in considerable detail with the construction of the driers, the arrangement of the equipment, the practical details of handling the various fruits, and the choice of fruits to be used for evaporating purposes have been added.

25497°—23——1

quality of the products obtained are relatively slight, it is possible to apply both processes to any of the fruits ordinarily dried, and the extent to which one or the other method is employed in preserving any given fruit is determined by the climatic conditions prevailing during the period in which the drying must be done. By reason of the possession of an exceedingly favorable combination of dry atmosphere, continuous sunshine, and practical absence of rain or dew during the drying season, California has developed sun drying on a large scale and is the only State which has done so.

The fruits which are dried in commercial quantities in the United States are prunes, raisins, apricots, apples, peaches, pears, blackberries, Logan blackberries, and raspberries, with very small quantities of figs and cherries. Among these, prunes rank first in point of average annual production, which approximates 400,000,000 pounds. Of this total, sun-dried prunes, made only in California, make up almost or quite 50 per cent; the remainder are evaporated prunes produced by the States of Oregon, Washington, and Idaho, which rank in the order given in the quantities produced. Commercial drying of peaches, apricots, pears, and figs is practically wholly confined to Calfornia, and the method employed is exclusively sun drying, the average annual production approximating 62,000,000 pounds of peaches, 30,000,000 pounds of apricots, 19,000,000 pounds of figs, and 6,900,000 pounds of pears for the five-year period from 1915 to 1919, inclusive. Raisin making is likewise an industry peculiar to California, and the use of other methods than sun drying has been practically unknown up to a very recent period. The annual production of raisins in California has increased from 125,000,000 pounds in 1910 to 395,000,000 pounds in 1919, with an average production for the 10 years, 1910 to 1919, inclusive, of 225,400,000 pounds. Practically all the dry berries coming into the market are machine evaporated, raspberries being produced in New York and Oregon, while evaporated Logan blackberries were formerly produced in considerable quantities in Oregon. The increasing popularity of the Logan blackberry for canning and juice-making purposes has operated alike to extend commercial plantings and to reduce the quantities dried.

By reason of the late maturity of the varieties used for the purpose, the commercial production of dried apples is carried on exclusively in evaporators. Trustworthy figures as to annual production since the year 1909, in which the total was 44,568,000 pounds, are not available, but the average probably does not greatly exceed 50,000,000 pounds. This total is made up of contributions from a much wider area than is the case with any other fruit. Approximately 70 per cent of the total production comes from western New York. California has recently considerably increased her production, which has risen from an average of 6,800,000 pounds for the years 1910 to 1916 to a maximum of 25,000,000 pounds for 1919. By far the greater part of this total originates in the Pajaro district of Sonoma and Santa Cruz Counties. Oregon ranks next in point of production. Washington has only recently become a producer, but is at the present time very rapidly increasing her annual output, as is likewise the case in lesser degree with Idaho. Missouri, Arkansas, Pennsylvania, Illinois, North Carolina, Virginia, and West Virginia also produce variable quantities of evaporated apples, their average combined production being somewhat less than that of California. In so far as available figures enable a conclusion to be reached, it would appear that the evaporated-apple industry is growing in importance in the States of the Pacific Northwest, less rapidly in Arkansas and the Virginias, little if at all in New York, and is decreasing in quantity of output in the other producing States.

As a commercial practice sun drying no longer exists outside of California, but has there attained the rank of a primary industry, practically all the fruit used for the purpose being grown specifically for drying and without intention to offer it for sale in the fresh condition. As a consequence, varieties specially suited to drying purposes have been developed or selected and are planted to the exclusion of others. While a portion of the prune crop of the Pacific Northwest is sold fresh or evaporated according as market conditions may determine, by far the greater portion is grown specifically for drying, individual growers or groups of growers constructing such drying equipment as their acreage may require. With this exception evaporation is at the present time distinctly an industry developed by fruit growers as an adjunct to their chief business of producing fruit for market, and its relation to that business is that of a stabilizer or safety valve. In direct proportion as it has been developed in any given territory it serves to increase orchard returns by converting low-grade and unmarketable portions of the crop into salable products and to maintain fresh-fruit prices by absorbing a portion of the marketable grades in years of overproduction. As a consequence of this safety-valve relation to the fresh-fruit industry, the material coming into the evaporators has not been grown with reference to its special fitness for drying purposes, but varies widely from year to year in character and quality as well as in total volume. For these reasons the drying industry, unlike that of canning, in only a few exceptional cases has been engaged in by large commercial concerns making it their sole business and having definite acreages of material of specified varieties grown under contract for the purpose. The product of such plants constitutes only a very small percentage of the total output. The drying of fruits as practiced at the present time is therefore peculiarly a farm industry, carried on by fruit growers themselves as a part of the routine of harvesting and disposing of the crop. The plants in which the work is done are mainly small, their size being most frequently determined by the size of the owner's orchard, and there is great diversity in the drying apparatus, the accessory equipment, and the details of the drying methods employed, with a consequent absence of definite standardization of the product. This would be expected in view of the fact that 252,289 farms reported the production of dried fuits in the census of 1919.

It is the purpose of this bulletin to describe in detail the types of artificially heated evaporators found by the test of actual use to be best suited to specific purposes, to describe model installations of labor-saving machinery, and to give somewhat full discussion of improved methods of handling the various fruits in preparation for drying as well as during the drying process. The drying installations described are of the most modern character, but are of such moderate size and cost as to be suited to the means and needs of the largest possible number of fruit growers. They are purposely so planned as to be capable of enlargement or alteration to meet the needs of a particular case.

PRINCIPLES INVOLVED IN DRYING FRUITS.

The purpose in view in drying any food material is to reduce its moisture content to such a point that the growth of organisms therein will no longer be possible, and to do this with a minimum of alteration in the food value, appearance, and palatability of the product. The necessity for avoiding changes in physical appearance and chemical composition, other than actual loss of water, puts very definite limitations upon the means which may be employed to bring about drying and makes an understanding of certain principles a prerequisite to successful work.

It is obviously of advantage that drying be brought about as rapidly as possible, since rapid drying minimizes opportunity for the growth of organisms and for the spontaneous chemical changes which set in as soon as the interior of the fruit is exposed to the air and since a short drying period increases the working capacity of the drying apparatus. There are three possible ways in which drying may be accelerated, namely, by passing currents of air over the material, thus giving a large volume of air for absorbing and carrying away moisture, by raising the temperature and consequently the moisture-absorbing capacity of the air, and by employing air which has previously had all moisture removed from it by passing through an air-drying apparatus. A theoretically perfect method of drying would, of course, combine all three means of hastening the process, and while such methods are in use in certain industries, they are impracticable for drying fruit because of their high cost.

Consequently, practical drying methods rely upon the use of heated air, with some means of maintaining the air in circulation over and through the product.

The moisture-carrying capacity of the air is a function of its temperature, and is practically doubled by every increase of 27 degrees in temperature. Consequently, the application of a relatively moderate degree of heat brings about a very great increase in its capacity to absorb moisture. This is evident from a consideration of the fact that raising the temperature of a quantity of air 108 degrees, from 60° to 168° F., for example, results in a sixteenfold increase in its moisture-carrying capacity. The temperature employed is consequently the most significant factor in determining the drying rate, and it is advisable to employ the highest temperature which can be used without injury to the material. But the use of extreme temperatures in drying fruits is impossible for three reasons. The various fruits contain 65 to 88 per cent of water when prepared for drying. If such water-filled material were suddenly exposed to dry air having a temperature approaching that of boiling water, the rapid expansion of the fluids of the tissues would burst the cell membranes, thus permitting the loss of many of the soluble constituents of the fruit by dripping. Some decomposition of the sugars of the fruit would also occur at such temperatures, and the caramel formed would injure both the flavor and the appearance of the dry product. Furthermore, the very rapid drying of a thin layer at the surface of the material would occur, and this dry layer would retard the movement of water outward to the surface from the interior of the material, thus slowing down the drying process. The maximum temperature which can be employed without producing these injurious effects varies considerably with the different fruits, since it depends in every case upon the physical structure and chemical composition of the particular fruit, but it is in all cases very considerably below the boiling point of water.

There must also be a careful adjustment between the amount of heat applied and the volume of air passing through the apparatus. The heat required to convert the water evaporated from the liquid condition to vapor is very considerable; the evaporation of 1 pound of water absorbs a quantity of heat which would reduce the temperature of 65,000 cubic feet of air by 1° F., or 1,000 cubic feet by 65° F. It would seem at first glance that the greatest efficiency in a drying apparatus would be effected by allowing the heated air to expend most of its heat in vaporizing water and to permit it to become saturated before allowing it to escape from the drier. This is not the case, for several reasons. Air at any given temperature takes up water vapor quite rapidly until it has absorbed about half the quantity it is capable of carrying at that temperature, after which absorption goes on at a rapidly diminishing rate. At the same time the air is losing heat through the vaporization of water, every reduction of 27° F. resulting in the loss of half its moisture-carrying capacity, this loss also operating to reduce the rate of absorption of moisture. Consequently, it is not practicable to secure saturation of the air before allowing it to escape, as this would make the drying exceedingly slow. The best practice aims at permitting the air to vaporize and absorb such an amount of moisture as will reduce its temperature by not more than 25° to 35° F. during its passage through the apparatus, thus effecting rapid drying at the expense of the loss of about half of the theoretical drying efficiency of the heat used. As a matter of fact this heat is not wholly lost, since the expansion and resulting buoyancy of the warm air maintains a current through the apparatus, if provision for its escape at the highest part of the drier is made. Without such provision, the air can not escape and will quickly become saturated, with the result that the escape of water vapor from the material is stopped and the fruit is cooked in its own juices. In most evaporators in common use the construction is of such a type that the air is admitted at the lowest portion of the apparatus and is allowed to escape at the highest point, the arrangement of material in the interior being such as to offer a minimum of obstruction to its flow upward. In other types, the air movement is made independent of gravity by placing fans in the air inlets or outlets or in both. Some driers of this type have the defect that the air movement is so rapid that the air can take up only a portion of the moisture it is capable of carrying, thus giving a low return for the fuel employed. Other driers obtain greater efficiency from the heat used by the employment of devices for the recirculation of the air, which is forced to pass repeatedly over the material before being discharged from the apparatus. As contrasted with driers in which the circulation is wholly dependent upon the buoyancy of the warm air, driers of this type gain somewhat in capacity as a result of the shorter time required for drying a given quantity of material, but are more expensive to construct and operate, are dependent for successful operation upon a source of power for driving the fans, and require a higher class of labor because of their more complicated character. In practice their efficiency is often lowered by reason of the fact that the rate of air movement is excessive, causing rapid drying of the surface of the material and thus retarding the escape of moisture from the interior of the product.

Whatever the type of drier employed may be, it is essential to success that drying be continuous and that the temperature be maintained fairly uniform throughout the process. The flesh of the various fruits is an excellent medium for the growth of a great variety of microorganisms, including both bacteria and fungi. As soon as the material is opened up to the air it becomes subject to attack by these organisms, which are present in great numbers in the form of spores upon the skins of fruit and in the dust of the workroom, with the result that considerable numbers become scattered over the surfaces of the prepared fruits. As long as the temperature of the material is maintained fairly high and the escape of moisture from the surface goes on uninterruptedly, the conditions are unfavorable for the growth and multiplication of these organisms, but if the temperature is permitted to drop and moisture accumulates upon the surface of the material, the spores germinate, the organisms multiply rapidly, and fermentation or souring of the material begins. For this reason material should never be prepared and allowed to stand before being placed in the drier, and the drying should be completed without interruption.

Other conditions prerequisite to success in drying have to do with the selection and preparatory treatment of the material to be dried, and these determine the quality of the product to an even greater degree than does the type and manner of operation of the drier. Drying will not make an inferior article better, nor does it ever produce products indistinguishable from fresh. When conducted with the greatest care and the employment of the best methods known, dried products undergo perceptible modifications which do not affect their food value, but, nevertheless, make it easy to distinguish them. In order that these alterations, which affect texture and flavor in some degree, may be at a minimum, the materials used should be in prime condition, fully ripe, free from decay, and should be handled throughout their preparation with scrupulous regard for cleanliness. With most of the fruits usually dried, chemical changes which modify the color and appearance of the fruit set in as soon as the flesh is exposed by peeling and slicing. The application of such a degree of heat as can be used without injury to the material does not arrest these changes, but, on the contrary, it causes them to go on at a much more rapid rate than would be the case at ordinary air temperature until most of the water of the fruit has been driven off. This is particularly true of the oxidation of pigments and the changes in tannin occurring in such fruits as the apple, pear, apricot, and peach, which are responsible for the appearance of brownish discoloration of the flesh of these fruits when peeled. While such discoloration does not injuriously affect the palatability or the food value of the fruits in which it occurs, the purchasing public has learned to discriminate against such fruit, and the existing grades for commercial dried fruits consider color as being as important as any other single character in determining the market value. Consequently, the maker who desires to command for his product a ready market at top prices must employ suitable means for preserving the color of his fruit. These methods are considered in connection with the preparatory treatment recommended for the various fruits.

Success in drying, therefore, depends upon the employment of sound, ripe fruit of unimpaired table quality, the use of suitable means for preventing oxidation and other chemical changes in the material during the drying process, the employment of a drying temperature so regulated that the material may not be injured by excessive heating and so maintained that opportunity for fermentation and spoilage is avoided, and the provision of an adequate circulation of air to carry away the escaping moisture. Failure to give proper attention to any one of these factors will result in the production of an inferior grade of product or in the total loss of the material used.

COMMUNITY DRYING PLANTS.

In many communities in which the growing of fruit is not a primary industry, the aggregate quantity of unmarketable fruit may be such as to make advisable the construction of a community drying plant to which every grower in the vicinity may bring his surplus to be worked up. A number of considerations, which should be kept clearly in mind when the project of a community or cooperative evaporator is under discussion, may be briefly mentioned.

It must first be definitely ascertained whether the quantity of unused fruit is actually such as will justify the necessary expenditure. This information can only be obtained by a careful canvass of the district and a tabulation of the results. The making of such a canvass is a task calling for conservatism and the exercise of good judgment, for the reason that unintentional but gross overstatement of the unmarketed and unused portion of the fruit crop which could be used as evaporator stock is the rule rather than the exception. It must be borne in mind that in the case of apples, only mature, reasonably sound fruit of fair size will make a marketable dry product and that estimates which include premature drops, specked and decayed fruit, and small-sized cider apples are worse than useless because misleading. The canvass should take into account all fruits grown in the district, and should secure such detailed information as will give a clear idea not only of the total quantities of the various fruits grown, but also of the sequence in which they must be handled at the drier, the length of time over which the ripening of each will extend, the maximum quantity per day which the plant will be required to accommodate, and the extent of plantings not yet in bearing which will contribute to the stock of raw material when fruiting begins, if such plantings exist. The distribution of the material over the district should also be studied, in order that the drier may be located with reference to the sources of heaviest supply.

With this data in hand it is possible to determine the size and type of evaporator needed to care for the materials to be dried. As these will in most cases be rather varied, the evaporator must be of a general-purpose type; that is, its construction must be such that materials such as apples, peaches, plums and prunes, berries, sweet corn, and beans may be dried with equal satisfaction. Such a general-purpose evaporator must necessarily be one of the types employing trays. While a very considerable number of patented evaporators are to be found on the markets, the cash investment necessary to secure such machines is such as to be prohibitive in the case of many communities in which fruit growing is not a primary business. Consequently, there is very great need for simple, inexpensive drying equipment which can be constructed by an ordinary workman at the place where needed and will give satisfactory results when operated by intelligent amateurs. Of such driers as meet this requirement, the tunnel evaporator, described in a subsequent section, is in many respects the most satisfactory. For this reason, the construction of an evaporator of this type, and the nature and amount of equipment which will be required for handling the various fruits, are discussed with special fullness in the section on "The prune tunnel evaporator," page 24.

BUILDINGS AND EQUIPMENT FOR DRYING.

The evaporator buildings and accessory equipment described in the following pages are of two types. The kiln evaporator is designed specially for the handling of apples in large quantities, and is more widely used for that purpose than all others combined, but it is not well adapted to the drying of other fruits. For this reason, the building of a kiln evaporator in a district which is devoted to general fruit growing would be ill advised. The prune tunnel evaporator, on the other hand, is a general-purpose evaporator which may be employed for drying other materials as well as apples and is consequently better fitted to the needs of a farm or community which may have occasion to dry peaches, prunes, berries, or other fruits. For this and a number of other reasons, which will be pointed out in a subsequent section, a tunnel or modified tunnel drier should be built wherever a community drying plant is needed.

THE KILN EVAPORATOR.

The driers used in the farm apple-drying industry of the United States are at the present time almost exclusively of the kiln type. This type of drier first came into use for the drying of fruits in the eastern portion of the United States about 30 years ago, having been derived with some modification from a type of drier long in use in the British Empire and subsequently in the United States for the drying of hops. Its use was at first confined to the drying of raspberries, the drying of apples being at that time conducted in cabinet evaporators. This type was rather rapidly displaced by the kiln drier in that portion of western New York which produces the larger part of the commercial output, and from that territory its use has gradually extended until it is now almost exclusively employed in all districts in which evaporated apples are commercially produced, with the exception of the Pacific Coast States. In Washington, Oregon, and Idaho driers primarily intended for use with prunes are used to some extent in drying apples, although kilns are employed where apples are the chief fruit to be dried. In California, local conditions, such as an ample supply of Asiatic labor, have resulted in the retention of driers of the cabinet, or stack, type even when apples are the only fruit dried. The widespread and increasing use of the kiln drier has been brought about by the low first cost of the kilns, the relatively large capacity, the large extent to which labor-saving machinery may be made to replace handwork, and to a certain degree because their construction and operation are well understood by fruit growers and by the labor available in the apple-growing districts.

A kiln evaporator plant consists of a two-story building divided into two portions, one of which contains workrooms in which the fruit is received and prepared for drying, with storage rooms for fresh and dry fruit, the other containing the kilns or drying rooms. The individual kiln is the unit of structure, and plants of any desired capacity are obtained by constructing a series of such units.

THE INDIVIDUAL KILN.

The individual kiln consists of a structure two stories in height, the first, or ground, floor being occupied by a furnace inclosed in a concrete or masonry room for distributing the heat, as shown in Figure 1, and the second floor, which is of slat construction, serving as the drying floor. The walls extend above the drying floor far enough to give sufficient headroom for working in the kiln and support the roof, which is fitted with ventilators for removing the moisture-laden air as it rises from the material being dried.

The ground plan and cross section of a typical kiln are illustrated in Figure 1. It will be noted that the kiln is 20 by 20 feet, the standard dimensions of a kiln of this type. The distance from the furnace floor to the drying floor is usually 16 feet and should never be less than 14 feet, as uniform distribution of heat to the drying floor can not be obtained with a height less than this. In order to give sufficient headroom for the storage room or workroom on the second floor along the side of the kiln, the roof on one side is not as steep as on the other side. The roof is so constructed that the ridge is in the middle of the kiln, with the ventilators along the ridge.

Foundation.—The foundation walls for the kiln may consist of any suitable material, their depth being determined by the nature of the subsoil and the character of the building material to be used for the superstructure. Concrete is the best foundation material, as, when once properly set, it is impossible for water to get under it and cause damage by freezing. Whatever the material used, the foundation walls should be of sufficient size to support the building without settling, as even slight settling throws the machinery out of alignment and causes leaks in the heating apparatus and in the hopper. If the walls of the kiln are to be of frame construction, the foundation is usually $2\frac{1}{2}$ feet above the surface of the ground, in order to make room for the air vents, to have the floors of the preparation room sufficiently high to prevent decay, and to give ample room for the circulation of air beneath it, as part of the air supply for the kiln must pass under this floor. When the walls of the kiln are of stone, brick, or masonry of any sort, the foundation is carried up only to the surface of the ground or far enough above to make it level, and the walls are started directly on this. The air ducts, described later, are placed in the walls below the level

25497°—23——2

of the workroom floor. If the ground upon which the building stands is firm and dry the earth itself may form the floor of the furnace room. If the location or soil is such that trouble from seepage is to be expected, the furnace room should be floored with a layer of concrete resting upon broken stone.

Walls.—The walls of most of the dry kilns are constructed of wood. Concrete, concrete blocks, hollow tile, brick, or stone makes a more durable structure, but the first cost is considerably higher. Wood kilns demand frequent repairs, are short lived, and take a higher rate of insurance than kilns made of other material. The most economical material to use must be determined by local condi-

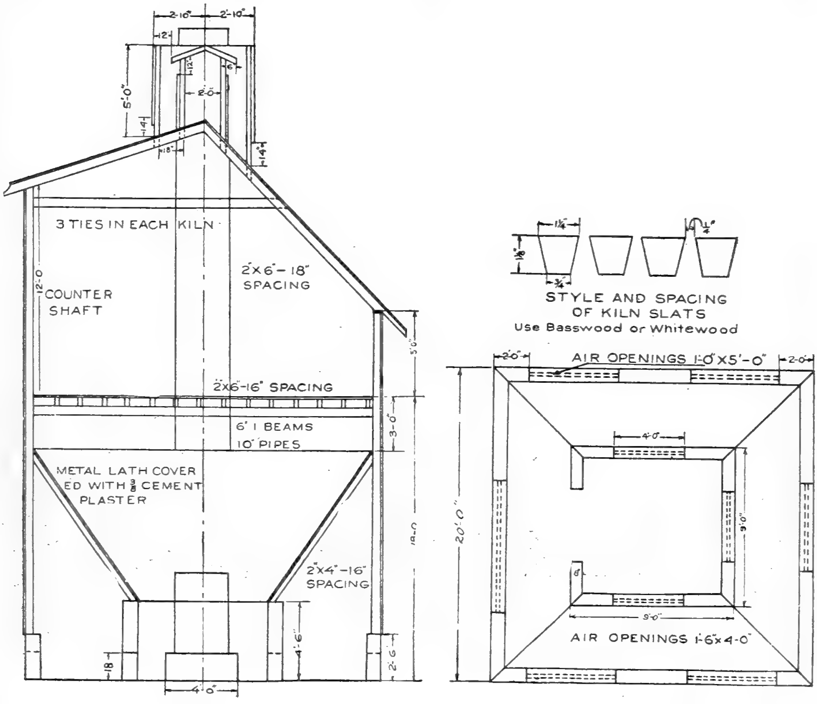

FIG. 1.—Cross section and ground plan of a kiln. When the kilns are built in rows the furnace rooms are not separated, but the furnaces have separate inclosures and hoppers for distributing the heat. The drying floors are separated by walls.

tions; if concrete is cheap in a particular locality, that may be the best material. The details of the construction of the kiln must be determined by the material used for the walls, but the interior dimensions remain the same irrespective of the kind of material selected. In the usual type of wood construction, the walls are made by setting 2 by 6 inch studding 16 inches apart, measured center to center. On the outside of the studding a layer of sheathing boards is placed diagonally. A layer of building paper is then applied, and the siding placed on the outside of this. When cement blocks are used, the wall, as a rule, is made 8 inches thick. The same dimension is used for hollow tile or brick. When stone is used, the walls must be 10 to 12 inches thick. Whatever the material used, the doors, windows, and other openings are the same size and the interior dimensions of the kiln are the same.

Roof and ventilators.—The roof is always of frame construction, consisting of 2 by 6 inch rafters spaced 24 inches apart and covered with sheathing and an asphaltum roofing paper. Metal roofing is not well adapted to kilns, as the sulphur fumes used in bleaching the apples soon corrode the metal. The method of constructing the roof is shown in Figure 1. The type of ventilator used on practically all modern kilns is shown in the same figure. The ventilators are always placed at the peak of the roof, so that the moisture-laden air will be quickly removed. This type of ventilator has been found to be wind and rain proof. No matter which way the wind blows the kiln is sure to draw. The wind passes through the opening between the roof and the outside wall of the ventilator and causes suction, which tends to create a draft from the interior of the kiln. Rain on the

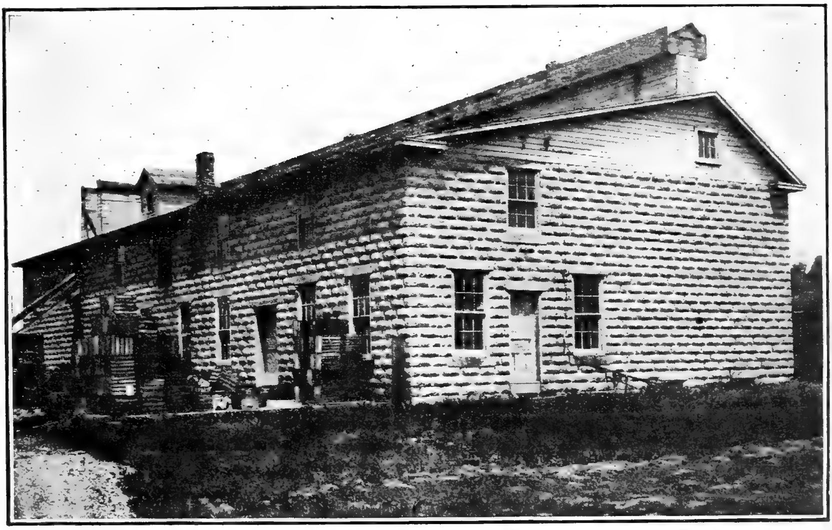

FIG. 2.—Drying plant at Victor, N. Y., equipped with modern ventilators.

roof of the ventilator falls between the outside and inside walls of the ventilator, strikes the main roof, and runs off. Figure 2 shows a drying plant equipped with ventilators of this type. Other styles of ventilators are used, but are not as efficient as the type just described.

Heating apparatus.—Cast-iron, hard-coal furnaces are universally used in apple kilns throughout the Eastern States. These furnaces have a grate of 5 to 8 square feet and are capable of supplying heat for a standard 20 by 20 foot kiln. Such furnaces are of very heavy construction, weighing 1,500 to 1,800 pounds, and consequently they maintain a fairly uniform temperature with only occasional attention from the fireman. The products of combustion pass through sheet-iron pipes arranged in rows under the floor and finally into the chimney. Three systems of piping are in use, all of which are illustrated in Figure 3. The difference in these systems consists in the extent

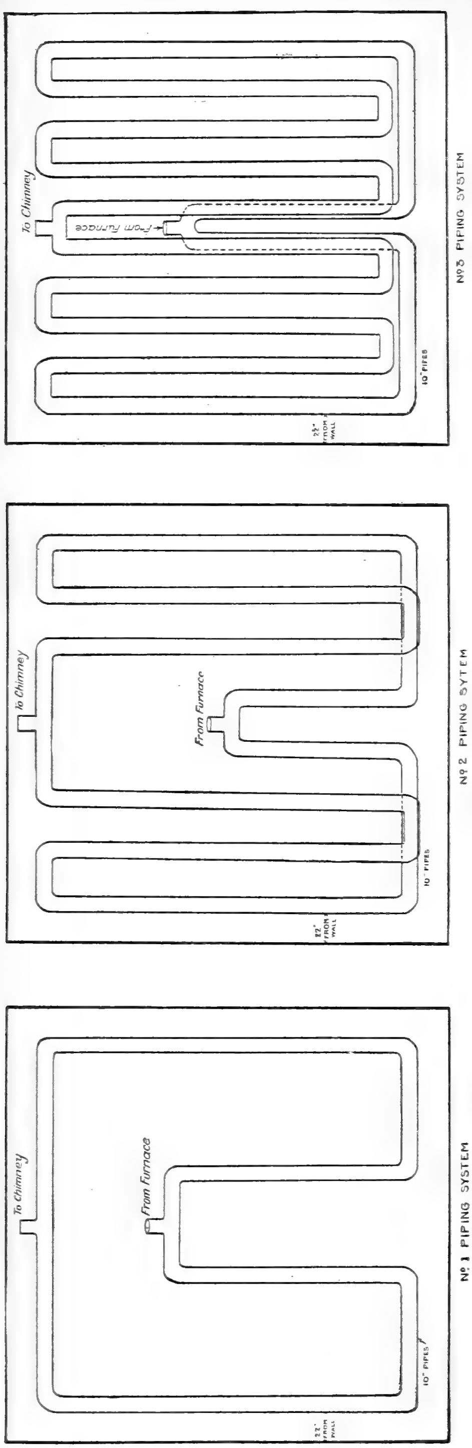

FIG. 3.—Diagrams showing three different methods of piping kiln driers. System No. 1 is in frequent use, but No. 2 is more efficient and the one most frequently used. While system No. 3 is the most efficient, it is rather expensive to install and to maintain. The products of combustion pass through the piping system and finally to the chimney.

and the distribution of the pipes under the drying floor. In all these systems a section of double-thickness Russia iron pipe, 10 inches in diameter and 4½ feet long, is placed on top of the furnace. This reaches a point about the same distance from the drying floor. The course of the hot gases in the different systems may be followed by referring to the illustration. The outside row of pipes is placed about 22 inches from the wall of the kiln. The whole piping system is given a gradual rise from the furnace to the flue and is held in place by wires or chains attached to the joists. Openings fitted with covers are provided at several points, in order that the piping may be cleaned out without taking it down. At the point where the pipe enters the flue the pipes are about 2 feet below the joists of the drying floor. Some furnaces are fitted with two openings for pipes, and with this type of furnace one opening is used for each side of the kiln and the pipes are joined with a tee just before entering the chimney. The second system illustrated is used to a greater extent than any of the others, for the reason that the third system, while giving greater radiating surface, is very difficult to keep free from soot. In the Pacific Coast States and in parts of the South the absence of supplies of hard coal makes the use of other fuel necessary. Wood is generally used. The furnaces employed are usually heavy stoves of the box type, fitted with special linings, although brick or stone furnaces lined with fire brick and covered with heavy sheet-iron tops are also successfully used. When wood is the fuel used, especial care must be taken to keep all joints of piping and furnace tight, as the volatile resins of the wood may otherwise impart a disagreeable flavor to the fruit. It is impracticable to use soft coal, on account of the soot and smoke.

Chimneys.—As it is the practice to build the kilns in rows, it is the usual custom to build a 2-flue chimney in the wall between two kilns to serve both furnaces. The chimneys have two 8 by 10 inch flues and must be carried above the highest part of the building, so there will be a good draft. Near-by trees which are higher than the building may cause much difficulty in securing a good draft, and this point should be borne in mind in determining the location of the plant.

Distributing hopper and air ducts.—Drying in these kilns depends on passing heated air through the material which is spread on the drying floor. It is necessary to have suitable openings, so that cold air can be admitted at the bottom of the kiln, be heated by being passed over the furnace and its piping, and, after passing through the material to be dried, discharged through the ventilators at the top of the building. The sizes and location of the ducts for the inlet of the air are shown in Figure 1. These ducts are $1\frac{1}{2}$ feet high by 5 feet long, and are four in number, two on each side of the kilns. When the kilns are built in rows, two air ducts are placed in each side wall and the partition walls between the furnace rooms of the individual kilns are omitted. This is brought out in Figure 4. To give more uniform results, the furnace is set in a square concrete or masonry inclosure. This is a comparatively recent improvement in kiln construction. It consists of a concrete inclosure 9 feet square and $4\frac{1}{2}$ feet high directly in the middle of the furnace room. This has three openings, each 18 inches by 4 feet, on three sides of the inclosure, and the fourth side has a portion 4 feet wide cut away to serve as a fire door. The upper portion of this opening is covered with a sheet-iron door. On top of this wall a hopperlike structure is built, the bottom corresponding to the top of the concrete inclosure and the top meeting the side walls of the kiln at a point 3 feet below the drying floor and 13 feet from the ground. The frame of this hopper is of 2 by 4 inch scantling, covered on the inside with metal laths and three-eighths of an inch of cement plaster. The sides of the hopper are made perfectly tight, so that no air can reach the drying floor without entering the bottom of the hopper through the air ducts. This prevents unequal drying on the sides of the kiln as a result of wind, and at the same time the hopper prevents loss of heat by radiation through the side walls. Many operators believe that properly constructed hoppers reduce the fuel consumption by at least 15 to 20 per cent. The details of construction are shown in Figure 1.

The drying floor.—The drying floor carries considerable weight and must be strong. The usual type of construction is to have two wood or steel beams set into the side walls of the kiln and spaced evenly. The joists are placed at right angles to these girders and are set back

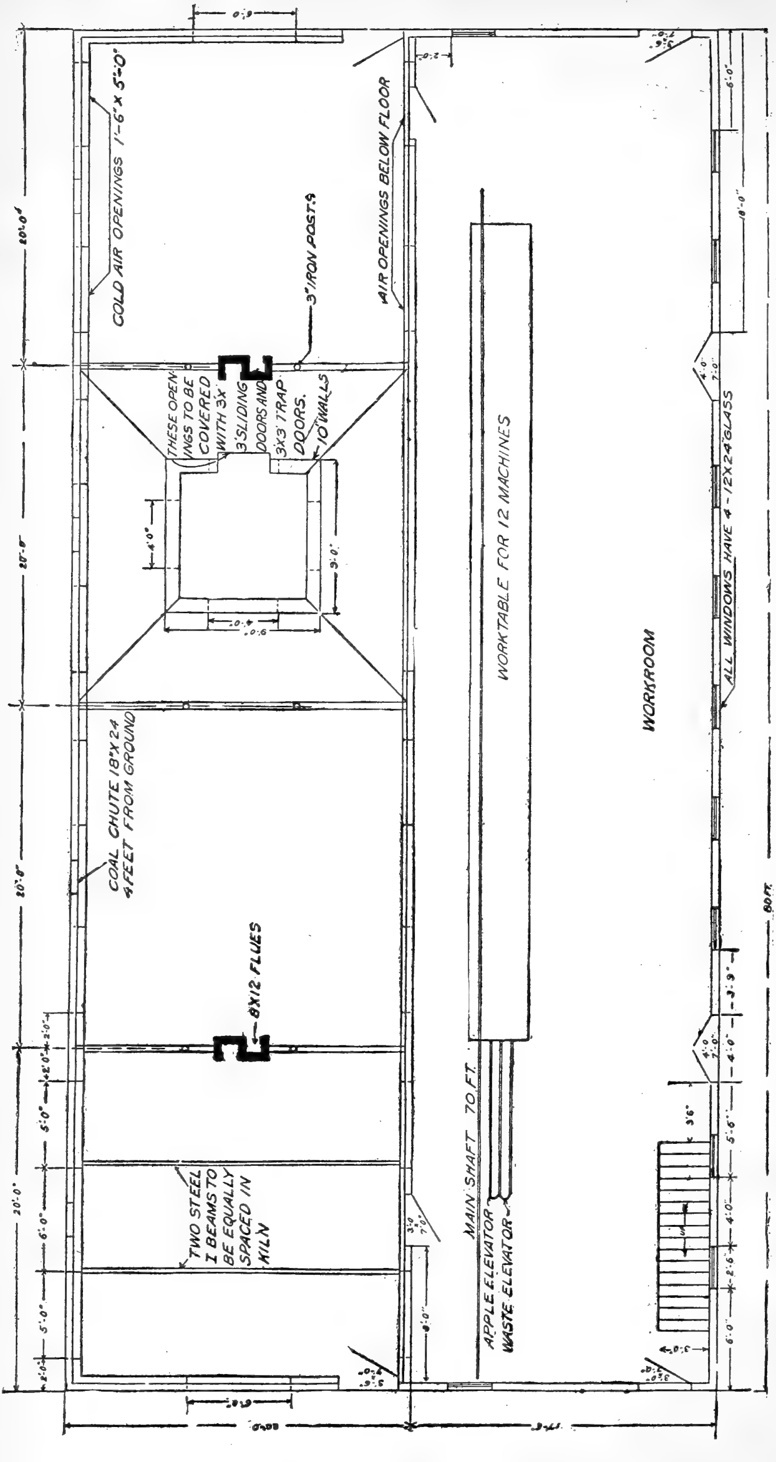

FIG. 4.—Ground-floor plan of a 4-kiln evaporating plant. The workroom provides ample space for an office and for lockers for the use of employees, as well as room for storing sufficient fruit for a day's run.

into the wall at either end. The salts that make the drying floor proper are of whitewood or basswood, $1\frac{1}{8}$ inches thick, $1\frac{1}{4}$ inches wide on the upper side, and three-fourths of an inch on the side next the joist. In cross section they are keystone shaped. They are placed one-fourth of an inch apart with the narrow side down, in order that the openings between them may not be clogged with material lodging in them. The floor strips should run at right angles to the side of the kiln containing the door, so that it will be easy to handle the product with shovels. Basswood or whitewood is used for making kiln slats, for the reason that these woods do not warp or split under heat and are free from resins or other constituents which could give foreign odors or tastes to the product. After the floor is in place it is oiled three times at intervals of a week with lard oil, paraffin oil, or a mixture of equal parts tallow and boiled linseed oil, applied very hot, in order thoroughly to impregnate the slats. This prevents sticking of the fruit. After the kiln is in use, a few oilings each season will keep it in good condition, but it should be thoroughly scrubbed with strong hot soapsuds twice a week during the season.

THE KILN-DRYING PLANT.

Several individual kilns constitute a drying plant. As it is necessary to have enough drying capacity to keep the machinery and help employed, the number of kilns in a plant varies, but economic considerations would generally forbid the construction of a plant having less than four kilns, since installations of power-driven equipment in a smaller plant would be almost as expensive as in a four-kiln plant. A plant of this size is large enough to keep the operators busy, and plants larger than this increase the fire risk without adding much to the economy. A plan sometimes followed when a larger capacity than is offered by the four-kiln plant is desired is to erect two sets, separated by a space of 75 to 100 feet, with an overhead bridge connecting them. One set of machinery and one workroom serve for both, yet the fire risk is considerably reduced.

Location of the plant.—The drying plant is, of course, located near extensive orchards. Each 20 by 20 foot kiln will evaporate from 100 to 150 bushels of apples every 24 hours, a four-kiln plant operated continuously for a working season of 60 days evaporating 20,000 or 25,000 bushels of apples if peels and cores are also dried, or a somewhat larger quantity if these are disposed of in other ways. If the venture is to be profitable, sufficient fruit must be available to keep the plant busy for the maximum period.

Arrangement of the plant.—When a four-kiln unit is used the kilns are usually arranged in a row with the work and storage rooms along one side. The first-floor plan of such a plant is shown in Figure 4. The structure is 80 feet long and the kiln portion 20 feet wide. The workroom portion is $17\frac{1}{2}$ feet wide and 80 feet long. The furnace floor is dirt at the ground level, while the workroom floor is on top of the foundation. Air inlets in the outer wall permit the air to pass freely beneath the workroom floor to the air inlets of the furnace rooms. Steps lead down from the workroom to the furnace room. Usually one end of the workroom is partitioned off and used as an office, for supplies, or sometimes as bins. Frequently the bins are built outside the kiln in a row along the main building, as shown in Figure 5. In other cases the bins are covered, as shown in Figure 6.

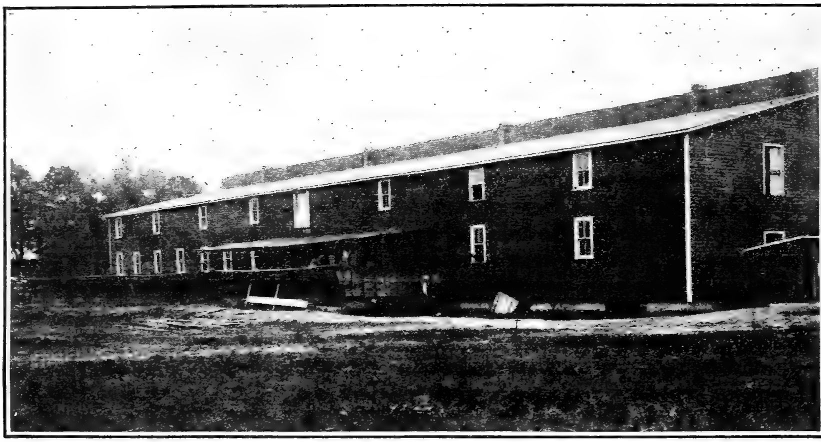

FIG. 5.—A large drying plant with the storage bins located along the side of the workroom.

Both these illustrations show typical drying plants. Figure 5 is one of all-wood construction, and Figure 6 is one with stone walls up to the drying floor and the remainder of wood.

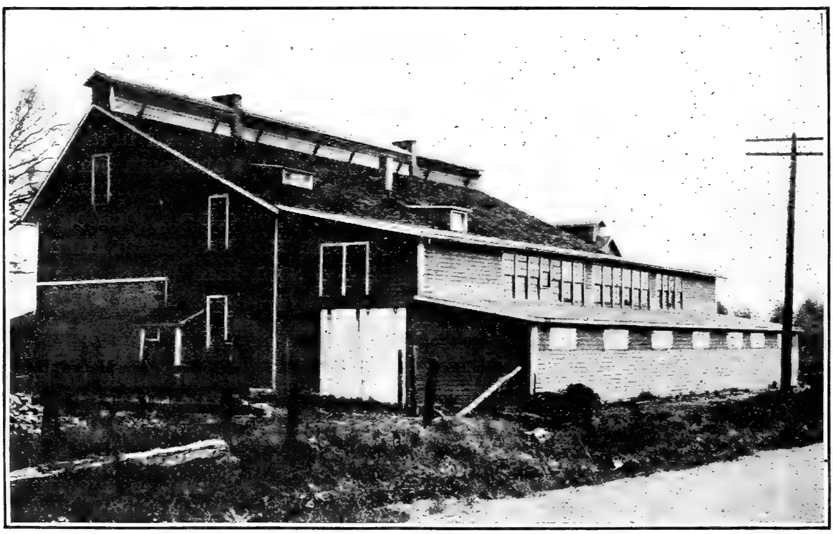

FIG. 6.—A drying plant with the storage bins under cover. The building is of frame construction with the exception of the walls of the kiln up to the drying floor, which are of stone. This plant has a capacity of 400 to 600 bushels of fresh fruit during each 24 hours.

The workroom on the second floor is taken up with the bleacher, the slicer, and a space for conditioning the evaporated material. It may also have bins where fruit is stored and delivered by gravity to the worktable below. The bleacher is swung from the rafters $6\frac{1}{2}$ feet above the floor, so that there is headroom to enter the kilns. It discharges fruit directly into the hopper of the slicer which stands immediately beneath the end of the bleacher. The plan of the second floor and the location and size of the bleacher are shown in Figure 7. The floor of the conditioning room is level with the drying floors of the kilns, in order to facilitate handling the material. The floors of the workrooms should be made of a good quality of dressed, matched flooring, carefully laid to facilitate cleaning. As they are required to bear considerable weight, they may well be double. A stairway is provided between the first and second floors. The location of the windows and doors and the size of the various openings are shown in Figures 4 and 7.

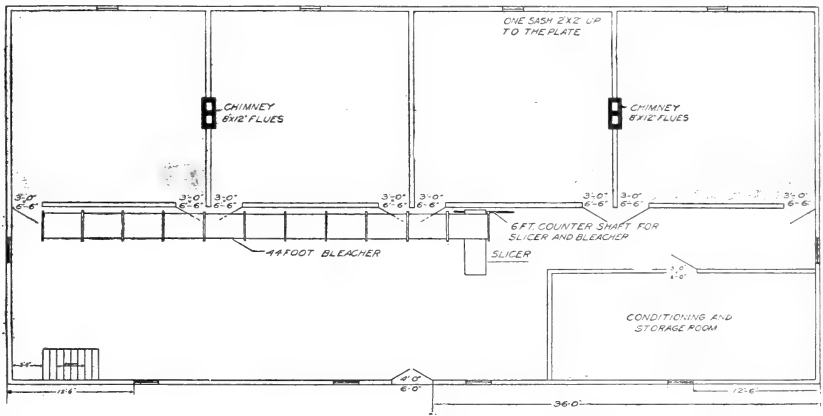

FIG. 7.—Second-floor plan of a 4-kiln drying plant. The drying floor and workroom are on the same level. The bleacher is hung from the rafters with sufficient headroom for passing into the kiln.

THE APPLE-DRYING WORKROOM AND ITS EQUIPMENT.

Equipment necessary in the workroom.—The essential equipment of the workroom of an apple-drying plant includes a washing tank with an adequate supply of fresh water, a grader, a worktable equipped with belt conveyors for carrying pared apples and waste, peeling machines, elevators for carrying pared apples and waste to the second floor, elevated bins with gravity chutes for supplying unpared apples to the worktable, the bleacher (a closed box with a slat-and-chain conveyor and a stove for burning sulphur), the slicer, a chopper for working up apples too small or soft to be profitably made into pared stock, shafting, belting, pulleys, and an electric motor or a gasoline engine to operate the machinery, low, broad-wheeled hand trucks for moving prepared fruit from the slicer to the kilns and from kilns to the conditioning room, a conditioning room screened to exclude insects and provided with partitions or bins for keeping the various grades of stock separate, baskets, trimming knives, wooden shovels, tools for adjusting and repairing machines, and a supply of spare parts of such equipment as is subject to wear or breakage (pulleys, link chain, paring-machine gears, knives, and coring spoons), a supply of reliable thermometers reading to 212° F., a box press for use in packing the dried fruit, a box-nailing machine, a supply of box shook, mops, pails, and brooms, and means for heating water for cleaning.

The arrangement of the equipment of the workroom is exceedingly important. The drying plant is a factory having a relatively short working season and handling bulky, highly perishable material upon which there is a relatively narrow margin of profit. Successful operation demands that the plant shall run at full capacity throughout the working season and that a high degree of efficiency of the labor employed be obtained by substituting automatic power-operated conveyors and elevators for hand labor in moving the bulky material from place to place in the plant and by assigning every employee a definite task which will keep him fully employed without wasted effort and without necessity for constant supervision. This can not be accomplished if the arrangement of the equipment is haphazard, as the unnecessary labor and the mutual interference of employees with one another which is unavoidable in badly planned workrooms results in a reduction of 10 to 30 per cent in the output of the plant or in a corresponding increase in the cost of production.

The arrangement of the workrooms and their equipment here described is the result of a study of a considerable number of evaporators, and it combines the best features and the most efficient labor-saving devices found in the course of that study with the results of experience in planning and equipping a number of plants. A number of evaporators equipped in this manner have been in successful operation for several seasons, and all the recommendations made have been subjected to the test of actual use. The primary purpose in view has been to make such an arrangement of the equipment as will carry the raw material through the plant along the shortest possible route and secure its rapid, uninterrupted passage through the various stages of preparation. Power-operated labor-saving devices have been employed wherever possible, for the reason that these are coming into practically universal use in the newer plants, and any drier which does not employ them will find that its higher costs of production constitute a very heavy handicap.

As the reasons for the arrangement of the various portions of the equipment will be most easily grasped by following the course of the fruit through the processes of preparation, they are described in that order.

Receiving, washing, and grading the fruit.—Whether fruit is stored in bins or received directly from wagons, a means of washing and grading the fruit is necessary. Washing is a prerequisite to the making of clean, high-grade stock, and the rapid wear of machines by sand and grit carried on unwashed stock is a consideration not to be forgotten by any operator to whom cleanliness does not make a sufficiently strong appeal. A grader which will separate fruit into several sizes is also essential, as paring machines, while capable of adjustment to peel apples of almost any size, must be adjusted to fruit of definite size if they are to do their best work. Some means of keeping the operators of paring machines supplied with fruit at all times is also a necessity.

The washing tank should be located outside and at one end of the building, at a distance of 10 to 12 feet. It should be so placed that fruit may be unloaded directly into it and should be sufficiently large to receive an ordinary wagonload at one time. A length of 6 feet, with a breadth and depth each of 4 feet, is a good size. The tank should be placed with the end, rather than the side, toward the building. It should be provided with a faucet for supplying water, and a large plug should be placed near the bottom to facilitate draining and cleaning.

From the washing tank the apples should be carried by a power-driven bucket-and-chain conveyor to the grader on the second floor of the building. This conveyor, like all others used in apple-drying plants, is made of a standard separable-link chain obtainable in a great variety of sizes and styles of links suited to various purposes. For making conveyors to carry materials in a horizontal plane, the type of link employed is one to which a hardwood slat is attached, the slats forming a flexible belt. For lifting materials vertically, or up an incline, the belt is made up of slats, as in the first case, but at intervals of 12 to 18 inches there are inserted special links to which "buckets" made of two wooden pieces of suitable width, nailed together to form an L-shaped trough, are attached. Link-belt chain of suitable sizes is carried by practically all the larger supply houses, and the wooden parts are readily made and attached by an ordinary workman. The conveyor runs in a flat trough 10 or 12 inches wide and 4 or 5 inches deep, supported by a trestle, and the belt returns beneath the trough. The upper end of the conveyor passes through the wall of the building at a point 8 to 10 feet above the second-floor level and delivers directly into the hopper of the grader. The lower end extends almost to the bottom of the tank, thus enabling the conveyor to remove practically all apples from the tank without attention, while at the same time acting as a stirrer to assist the washing. The inclination of the conveyor to the building prevents the dropping of fruit, while the open construction of the buckets allows the fruit to drain thoroughly before entering the building.

All that is necessary by way of grading is that the fruit be separated into sizes, each of which shall contain fruits varying not more than one-half inch in diameter, as paring machines are so constructed that they may be adjusted to handle fruit with this amount of variation in size. A good plan is to adjust the grader to separate into five sizes, the first of these consisting of fruits measuring $3\frac{1}{2}$ inches or more in diameter, the second of those measuring 3 to $3\frac{1}{2}$ inches, the third of $2\frac{1}{2}$ to 3 inches, the fourth of $2\frac{1}{4}$ to $2\frac{1}{2}$ inches, and the fifth including all fruits measuring less than $2\frac{1}{4}$ inches. These last are run into a separate bin to be pressed for juice or made into chops, as they are too small to be profitably worked up into white stock. The other sizes should be kept separate, so that each size may be delivered to machines adjusted for peeling that particular size. This may be accomplished by placing the storage bin in the corner of the second-floor workroom and placing the grader directly over it, so that the fruit of each size drops into a separate compartment, or by placing the grader at one side of the bin and arranging chutes through which fruit may roll into the various compartments. The bin should be large enough to contain stock for a day's run; dimensions of 20 by 8 feet with a height of 6 feet will permit this, yet give sufficient room for placing the grader above it.

A very simple device serves to deliver fruit automatically from the bin to the paring machines. Each compartment of the bin is provided with a false flooring inclined from all sides of the compartment to the center, thus forming a flattened hopper. From the center of each hopper a wooden chute 10 inches square passes through the floor, runs with a downward inclination of 1 or 2 inches per foot of length across the ceiling of the first-floor workroom to a point above the paring table, and descends vertically to end in a box placed beside the paring machine. A sliding door near the lower end of the chute enables the operator of the machine to fill the box as it becomes empty. If desired, the main chute may be divided, so as to

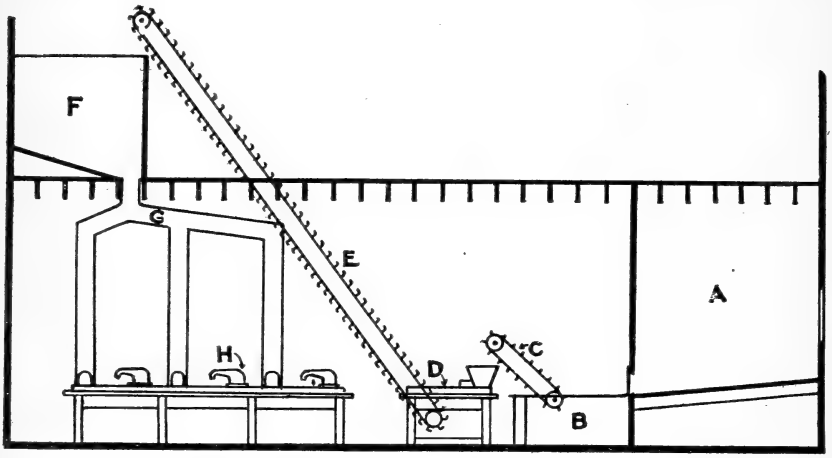

FIG. 8.—Sectional side view of an apple evaporator, showing a belt conveyor from the grader to the storage bin and chutes from the bin to the paring table. *A*, Apple bin with elevated floor and sliding door delivering into *B*, the washing tank; *C*, conveyor lifting apples from the washing tank into the hopper of *D*, the grader; *E*, a second conveyor receiving apples from the grader and carrying them to *F*, the apple bin on second floor; *G*, chutes from the second-floor bin to the paring table; *H*, parers.

supply two or more machines from one compartment. As the chutes are near the ceiling and over the worktable, they are out of the way. This arrangement has the obvious advantages that there need be no stoppage of machines because the supply of fruit is exhausted, the workroom is not obstructed by boxes of fruit waiting to be worked up, and the time of two or more men which would otherwise be spent in getting fruit ready for paring and distributing it by hand to the paring table is saved. The only expenditure of power is that necessary for running the elevator and grader. The entire arrangement is made clear by Figure 8.

The worktable.—The table at which the peeling and trimming are done is located in the first-floor workroom in the position indicated in Figure 4. It is placed 6 feet from the wall separating the workroom from the furnace rooms, thus giving ample room for passage behind it without interference with those working at the table. In a 4-kiln plant the table should be 54 feet long, thus allowing 4½ feet of space for each of 12 paring machines. This number of machines is larger than is necessary to keep the plant running at capacity, but it is advisable to provide at least 2 machines for use when others are temporarily stopped for repairs, while the additional table space will be extremely useful as a workbench for repair work. The paring table should be 4½ feet wide. Many operators employ 4-foot tables, but the additional width is of advantage in various ways. The framing of the table should be of 2 by 4 inch stuff, substantially braced, and the supporting legs of 4 by 4 inch material, spaced 4½ feet apart, so as not to be in the way of operators at the machines, and spiked to the floor. The table should be 42 inches high at the inner and 35 inches high at the opposite or outer side, where the trimmers work. This gives the table top, which is made of 2-inch boards, an inclination of 2 inches per foot of width toward the side at which the trimmers work, in order that peeled apples dropping from the forks of the paring machines may roll across the table to the trimmers' side, where a 4-inch strip nailed to the edge of the table and projecting 2 inches above it serves to arrest them. The height of the table is such that both parers and trimmers may stand at their work or sit on stools, as they may prefer.

The paring machines are placed along the higher side of the table, each machine being given a total working space of 4½ feet. Each machine is leveled and raised a few inches above the surface of the table by placing wooden blocks of suitable thickness solidly fastened to the table, beneath each leg, thus giving additional clearance for waste under the machine. It is also a good plan to place a short bit of board under each machine in such position as to form a sharply inclined plane upon which apples drop as they are pared, as the additional impetus thus given will aid materially in carrying them across the table. The chutes for delivering apples from the bin above are so placed that each delivers into a box placed at the left and about 12 inches from the machine it supplies. The main power shaft is suspended from the joists directly above the paring table and each machine is driven directly from it.

The table is supplied with two conveyors running throughout its length—one beneath it for removing peels and cores, the other, which is raised 6 inches above it, for carrying pared and trimmed fruit. Each conveyor consists of a wooden trough 8 inches wide and 5 inches deep, with a chain-and-slat belt of the type already described. In some plants successful use is made of belts of water and oil proof material supplied at intervals of 12 or 18 inches with cross cleats of some nonresinous hardwood, but such belts usually give more or less trouble through their tendency to slip, and their use is not recommended. At either end of the table the conveyors run over pulleys supplied with take-ups for adjusting the tension and return beneath the table. The conveyor for waste is placed 12 inches below the table, beneath and a little toward the inner side of the paring machines, and an opening 8 inches square is cut in the top of the table under each machine, permitting peels and cores to drop directly upon the belt beneath. A similar opening is cut on the opposite side of the table between each pair of trimmers. An inch strip nailed along the upper edge of this opening keeps apples from rolling into it, and a short inclined trough carries trimmings, which are pushed into it occasionally as they accumulate, into the waste conveyor.

The conveyor for pared and trimmed apples occupies the center of the table and is raised on posts, so that there is a clearance of 6 inches between its bottom and the top of the table. Pared apples drop from the machines and roll down the incline beneath the conveyor to the opposite side, where they are arrested by the edging strip. The trimmers then remove any bits of peel or other imperfections and toss the trimmed apples upon the conveyor. The elevation of the conveyor above the table keeps peels and waste out of it and also permits ready inspection and easy detection of careless work on the part of any trimmer. Details of construction of the table and arrangement of its equipment will be clear from an inspection of Figure 9.

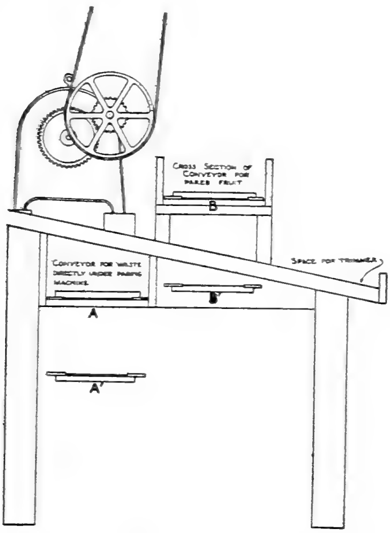

FIG. 9.—A section through the worktable.

At the end of the paring table the conveyors for apples and waste deliver into parallel elevators which carry them to the second floor.

These elevators are inclined 15 or 20 degrees from the vertical and are of the link-belt slat-and-bucket type already described. The conveyor for pared apples extends through the floor and nearly to the ceiling of the second story, where it delivers the fruit into a hopper from which it drops into the bleacher; that for peels and cores extends only far enough above the floor level to deliver the waste into a large box mounted on a hand truck, on which it is rolled into the kilns. In case peels and cores are not dried, but are pressed for cider or otherwise disposed of, the elevator to the second floor is not constructed, and the waste is taken directly from the end of the paring-table conveyor to be pressed or discarded as the case may be.

The bleacher.—The purpose of treatment of the fruit with the fumes of sulphur is primarily to prevent discoloration by oxidation in the air and also to bleach or remove such discoloration as has already occurred prior to the treatment. For this latter purpose sulphuring is not wholly effective, and for this reason it is imperative that fruit reach the bleacher in the shortest possible time after paring. For the further reason that contact of iron with the pared flesh greatly accelerates the rate at which discoloration occurs and also makes it impossible to remove it, the conveyors, elevators, and even the bleacher itself are so constructed that metal does not come in contact with the pared fruit. Bleaching was at one time carried out in sulphuring cabinets or boxes, in which the pared or sliced fruit was exposed in trays or shallow boxes to the action of fumes. This method was laborious; a longer time elapsed and as a result considerable discoloration occurred after paring and slicing and before exposure to the fumes, while it was difficult or impossible to secure uniform penetration of the fumes into the compact layers of slices. In consequence, all modern evaporators employ power-driven bleachers of the type here described.

A power bleacher is essentially a long, tightly constructed wooden box, 2 to 3 feet in width, 3 feet in height, and of a length proportional to the size of the plant, 5 feet of length being commonly provided for each 100 bushels of apples to be handled in an 8-hour or 9-hour working day, so that a plant of 600 bushels maximum daily capacity will require a 30-foot bleacher. Operators usually purchase the metal parts only from supply houses, which can furnish them for bleachers of any desired capacity, and build the box and wooden parts at the plant. The bleacher is suspended by hangers from the ceiling of the second-floor workroom, near the walls of the kilns, and high enough to be out of the way of workmen. Pared and trimmed apples are brought up by the elevator from the paring table and delivered into a hopper at one end of the bleacher, from which they drop to an endless belt conveyor, made of two lengths of link chain carrying hardwood slats, which occupies the bottom of the box and extends through its length, moving over a series of steel rollers placed 12 to 18 inches apart, to distribute the load and prevent sagging. By means of a worm gear this belt is made to move very slowly, so that 30 to 40 minutes are required for fruit to pass through the bleacher. The bleached fruit drops through a short chute directly into the hopper of the slicer, which is placed beneath the outlet end of the bleacher. Sulphur is burned in a heavy iron pan placed in a chamber provided for it at the apple-inlet end, or less commonly in a special sulphur stove placed on a wall bracket or suspended beneath the bleacher, the sulphur fumes being led into the bleacher by a short length of terra-cotta or heavy cast-iron pipe. Provision is made for their escape at the opposite end of the bleacher by a flue of terra-cotta pipe heavily cemented at the joints and extending well above the roof. The apple inlet and outlet are provided with curtains of heavy canvas, weighted to keep them in place and prevent the escape of the intensely irritating fumes into the room. For the same reason the box is built of well-seasoned matched lumber and all cracks are carefully filled with white lead, as are the joints about the pipe connections. The top of the bleacher is provided with hinged doors near either end to permit access to the interior, and these should be made to fit tightly. Figure 10 gives a clear idea of the construction of the bleacher, portions of the side wall and end being represented as cut away in order to show the interior construction.

The slicer.—Several power slicers, differing rather widely in construction, but alike in that they are durable and do satisfactory work, are on the market. The essential features are that the machine be strongly constructed, that it will not readily get out of order, that it has a daily capacity equal to or greater than the expected maximum demand upon it, and that it be capable of delivering a high percentage of perfect rings when operating at full capacity.

The slicer should be placed at the outlet end of the bleacher, so that the sulphured apples may drop directly into it. Both bleacher and slicer are driven by belts from a short countershaft placed above the inlet end of the bleacher and driven by a belt from the main drive shaft on the first floor. The machine should be raised sufficiently above the floor to permit a broad-wheeled hand truck, carrying a box 12 or 15 inches deep and having one side hinged so as to drop down, to be placed directly beneath the chute down which the slices pass. When the box becomes filled the truck is replaced by another, and the loaded truck is rolled into the kiln, the side dropped, and the contents spread upon the kiln floor. The lowered side of the box forms an incline down which the fruit runs without injury, which is an advantage, as the freshly sliced rings are easily broken, and unnecessary or rough handling at this time lowers the grade of the fruit by increasing the percentage of broken pieces. The loading of the kiln floor is begun at the corner farthest from the door, each truck load being spread as uniformly as possible to a depth of 5 or 6 inches by means of a broad-bladed wooden shovel and a wooden rake.

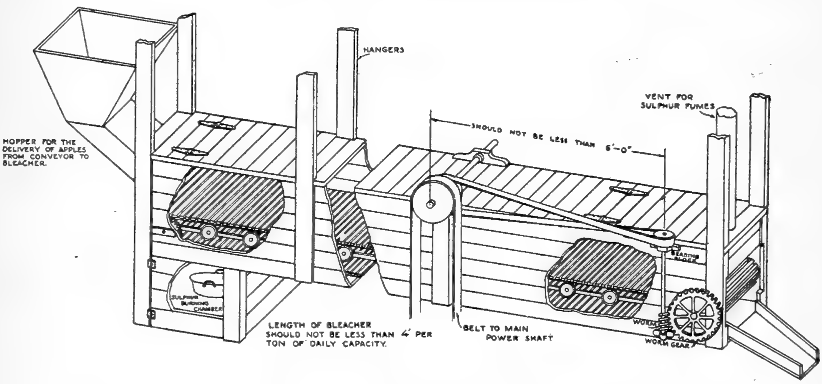

FIG. 10.—An apple bleacher.

In this arrangement of equipment the fruit passes rapidly through the various stages of preparation, a given apple reaching the bleacher within $1\frac{1}{2}$ to 2 minutes after it is placed upon the paring machine, thus eliminating the discoloration resulting from standing in the air. All transfers of the bulky material from floor to floor or about the building are accomplished by automatic power conveyors or by gravity, the hand labor involved being reduced to the actual operations of feeding peeling machines, trimming, and spreading the sliced fruit on the kiln floor. This work does not require great physical strength and is almost universally performed by women and girls.

THE PRUNE TUNNEL EVAPORATOR.

The term "tunnel evaporator," or "prune tunnel," as employed throughout the Pacific Northwest, designates a drying apparatus of a definite type, universally employed in the prune-growing districts of Oregon, Washington, and Idaho for the curing of that fruit. As it exists to-day it is the sole survivor from the early years of the prune industry of at least a score of devices for drying prunes, most of which were patented, as was the earliest form of the tunnel drier. It owes its survival and present popularity to the fact that it originally embodied two or three principles essential to the successful drying of prunes, and the expiration of the patents has resulted in gradual modifications and improvements at the hands of users.[2]

In contrast with the kiln, which is intended for use with apples and is not well adapted to the drying of most other fruits, the tunnel evaporator is an excellent general-purpose drier. The distinctive features of its operation which adapt it to the drying of prunes make it equally well suited to the handling of peaches, apricots, berries, apples, and pears, and it is quite generally employed for drying these fruits wherever they are commercially dried in prune-growing territory. That it has not come into use in districts in which apples alone are dried is due to the larger expenditure of labor involved in drying apples on trays.

In its essential features the drying chamber of the tunnel evaporator consists of a long, narrow compartment, with the floor and ceiling inclined uniformly from end to end, with a furnace placed below the floor at the lower end. The room is cut into a series of narrow chambers, the "tunnels," by parallel partitions extending from floor to ceiling. Warm air is admitted to each tunnel through an opening in the floor at the lower end and escapes through a ventilating shaft at the opposite end. The two ends of the tunnel have doors opening the full width and height. The material to be dried is spread on trays which are inserted on parallel runways at the upper end of the tunnel, pushed gradually along as the drying proceeds, and removed dry at the lower end. The inclination of the tunnel, aided by an arrangement of the trays to be presently described, facilitates uniform flow of air over the trays in all parts of the tunnel.

DETAILS OF CONSTRUCTION OF THE TUNNELS.

Tunnels are generally built in groups of three, heated by a single furnace. The prevailing size of the individual tunnel has been 20 feet in length by 6½ in height and 3 in width. For reasons which will be stated in considering the operation of the tunnel evaporator, it is strongly recommended that the length be increased to 23 feet, leaving the other dimensions unchanged. The floor and ceiling are inclined, as already stated, the inclination that gives the best results being one of 2 inches per foot of length. Walls and ceilings are of wood or galvanized iron, and the floor should be of galvanized iron, in order to reduce the fire risk. At the lower end of the tunnel an opening in the floor 3 by 3 feet in size admits heated air from the furnace room beneath. This opening is provided with a sliding door of sheet iron which can be closed when ashes are being removed from the furnace, in order to keep dust from rising into the tunnel. The ventilating shaft is located at the opposite higher end of the tunnel, extends entirely across the series of tunnels, and is 2 feet in width. A ventilator of the type already described in the section on the kiln evaporator, page 11, is very effective. The ventilating shaft should extend 6 or 8 feet above the roof of the building, and the

[2] The tunnel evaporator in one of its earlier forms came into somewhat general use in France under the name of the American, or Ryder, evaporator about 1890, and a somewhat improved form was patented in France under the name of the Tritschler evaporator prior to 1893. (Nanot, Jules, and Tritschler, L. Traité Pratique du Séchage des Fruits et des Légumes, p. 83–91, fig. 12–13. Paris, 1893.

partitions between individual tunnels should extend upward 3 or 4 feet into it, in order that winds may not interfere with the air movement through a part of the group of tunnels. The doors are made to fit accurately and are supplied with latches which close them tightly to prevent air leakage. Their height and width are equal to the inside dimensions of the tunnel, and they must swing back far enough to clear the opening completely.

In most tunnel evaporators the trays are supported by wooden runways made of strips 1 inch square, nailed to the partitions parallel with the floor of the tunnel, and extending from one end of it to the other. The strips are placed $3\frac{1}{2}$ inches apart from center to center, and the upper edges are planed smooth and carefully lined up with a straightedge in order that trays may be pushed along the runways with a minimum of effort. The lowest runways are placed 4 inches above the floor, while the last pair is 6 inches below the ceiling. This arrangement gives 18 tiers of trays. Each tier will accommodate 5 trays, each 3 by 4 feet in size, or a total of 90 trays, with a drying surface of 1,080 square feet for each tunnel. When properly spread, each tray will accommodate about 25 pounds of fresh apples or prunes, 16 to 20 pounds of berries, or 12 to 15 pounds of peaches or apricots. The capacity of a tunnel, therefore, ranges from approximately 2,250 pounds of prepared apple slices to about half this weight of prepared apricots or peaches at a single charge.

In a number of large plants the labor involved in handling trays is somewhat reduced by substituting trucks with a skeleton frame upon which trays are loaded for the runways just described. The trucks are made of such height as just to clear the tunnel ceiling and are provided with low wheels which run upon light iron tracks. They have not come into very general use for the reason that it is difficult to construct a truck which permits the trays to be "banked" or "offset" in the manner described in the section on the operation of the tunnel evaporator, while it is impossible to secure uniformity of drying at different levels of the truck unless this arrangement can be made.

THE CONSTRUCTION OF TRAYS.

The best type of tray is one made of wire netting and 3 by 4 feet in size, as larger trays can not be conveniently handled when loaded. The wire netting should be the best grade of galvanized screening obtainable, with meshes one-fourth inch square; a screen with one-fifth inch meshes is preferable if berries are to be handled. The frame should be made of wooden strips 1 inch square and should be double, that is, four strips should be nailed together to form a rectangular frame; a strip of metal box strapping or a piece of heavy wire should then be drawn tightly across the frame at the middle and nailed in place, and the wire netting is then nailed to the frame. A second strip of box strapping is then nailed in place over the first, and the edges of the netting are folded back and hammered down so that they do not project beyond the frame. A second set of wooden strips are now nailed to the first, thus giving a tray which can be used either side up. The box strapping reinforces the middle of the tray and prevents sagging of the wire, while there are no projecting ends of wire to injure the hands of workmen or cause difficulty in moving the trays along the runways.

The number of trays provided should be 40 or 50 per cent greater that the capacity of the tunnels. This will enable the day force to spread a sufficient number of trays of fruit to keep the tunnels filled during the night. The night attendant can keep the fires going, remove trays as the fruit becomes dry, and keep the tunnels filled, but he should not be expected to perform these tasks properly if no surplus trays are provided and his time is largely occupied with unloading and reloading trays.

THE OPERATION OF THE TUNNEL EVAPORATOR.

The construction of the tunnel gives it several features to which it owes its superiority over other commonly used types. Fruit is exposed in thin layers to fairly rapid air currents which flow freely over both upper and lower surfaces of the layers, instead of being forced to pass through a single thick layer of fruit, as is the case in the kiln, or through many superposed trays, as is the case in cabinet driers. Fruit is exposed at the beginning of the drying process to air of relatively low temperature and high humidity, thus avoiding injury from overheating, but is automatically transferred without rehandling into air of lower moisture content and higher temperature as the drying proceeds. The operation of loading the drier is continuous, since trays which have become dry are constantly being removed, thus permitting insertion of fresh material as rapidly as it is prepared and keeping the apparatus working at capacity. This is accomplished by an arrangement of the trays upon the runways. which the following description will assist in making clear.

Freshly prepared fruit is introduced only at the higher end of the tunnel. In charging the tunnel with fruit for the first time a rather moderate fire is started in the furnace, and trays are inserted one after another on the lowest runway and pushed down until the front edge of the foremost tray is just flush with the air inlet in the tunnel floor. If the tunnel is 23 feet in length as recommended in an earlier paragraph, the runways will hold five 4 by 3 foot trays. leaving the 3-foot opening of the air inlet unobstructed. The second runway is next loaded with five trays, but these are pushed down until the edge of the foremost tray projects 2 inches beyond that of the one on the first runway. The other runways are loaded in similar fashion, each tier of trays being made to project at its lower end 2 inches beyond that just beneath it[3] and consequently leaving a corresponding free space at the upper end of the runways.

When the tunnel is filled the edges of the tiers of trays project over the warm-air inlet, thus forming a series of baffle plates which break up the ascending column of warm air and force it to enter the spaces between the trays. Since the successive trays with their loads of material form partitions through which the air can not readily pass, it necessarily flows between the trays, thus coming into contact with the fruit above and below until it reaches the upper end of the tunnel, where its free escape into the ventilator is facilitated by the fact that the edge of each tray projects 2 inches beyond its neighbor next above. The movement of the warm air is also aided by the upward

[3] As a matter of convenience a diagonal line should be drawn or marked with paint on the side walls at either end of the tunnel, to indicate the proper position of the trays.

inclination of the trays. In consequence there is a rapid and unimpeded air movement throughout the whole apparatus.

The temperature of the air falls rapidly as it passes through the tunnel, as a result of the heat expenditure in vaporizing water, while the amount of water vapor carried by it of course increases. The difference in temperature at opposite ends of the tunnel is usually from 25° to 30° F. In consequence, the fruit at the lower end of the tunnel dries rapidly, while the rate of drying decreases steadily with decrease in air temperature toward the upper end. When the tunnel is first charged with fruit the trays nearest the air inlet become dry, while those next them still contain much moisture, and those at the upper end are scarcely well started to dry. While this delays starting, it is of advantage once operation is well under way. The dry

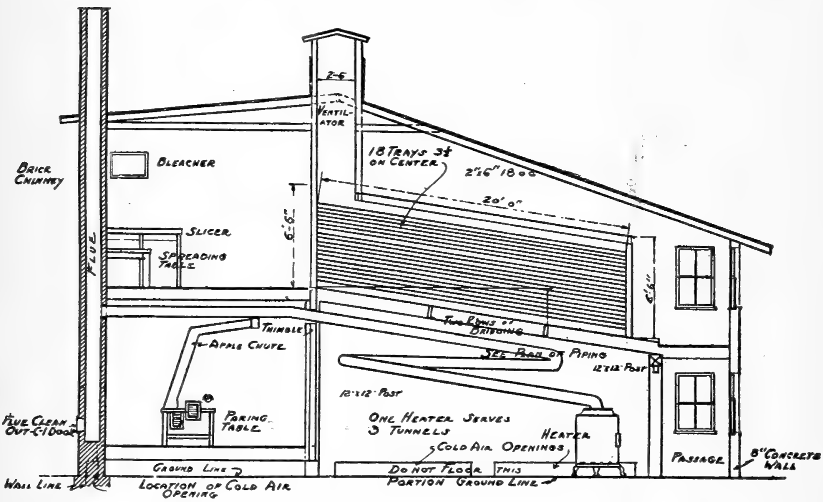

FIG. 11.—A section through the tunnel drier.

trays are removed at the lower end, the whole series moved down the length of one tray, and trays of fresh fruit inserted in the spaces thus made at the upper end. The heat supplied is now increased until the temperature at the lower end of the tunnel becomes as high as is safe to employ in completing the drying, since the fruit nearest the air inlet has lost the greater part of its moisture. The operation now becomes continuous; an exposure of one to three hours to the maximum temperature completes the drying of the fruit on the trays directly exposed to it, and as they are removed the whole series is moved down by the insertion of fresh trays at the upper end.

For maximum efficiency, it is essential that the baffle-platelike arrangement of the trays over the air inlet, termed by operators "banking" or "offsetting," be carefully maintained and that the trays on each runway be pushed closely together, so that the air is forced to move between successive tiers of trays. By so doing a uniform distribution of air movement through all parts of the drier, with a corresponding uniformity of the rate of drying, is effected. Until the device of banking came into use, the runways were completely filled from top to bottom, with the result that entrance and exit of air were greatly hindered, air movement was mainly through, rather than over, the trays, and great differences in temperature and in the drying rate between the upper and the lower portions of the tunnel existed, with the result that it was necessary to shift the trays from the upper runways to lower positions in order to hasten the drying. These defects of the older tunnel driers are entirely remedied by the expedient of giving the tunnel 3 feet of additional length and offsetting, or banking, the trays.

THE FURNACE ROOM.

For a group of three tunnels heated by a single furnace, as is the prevailing practice, the furnace room has a width equal to that of

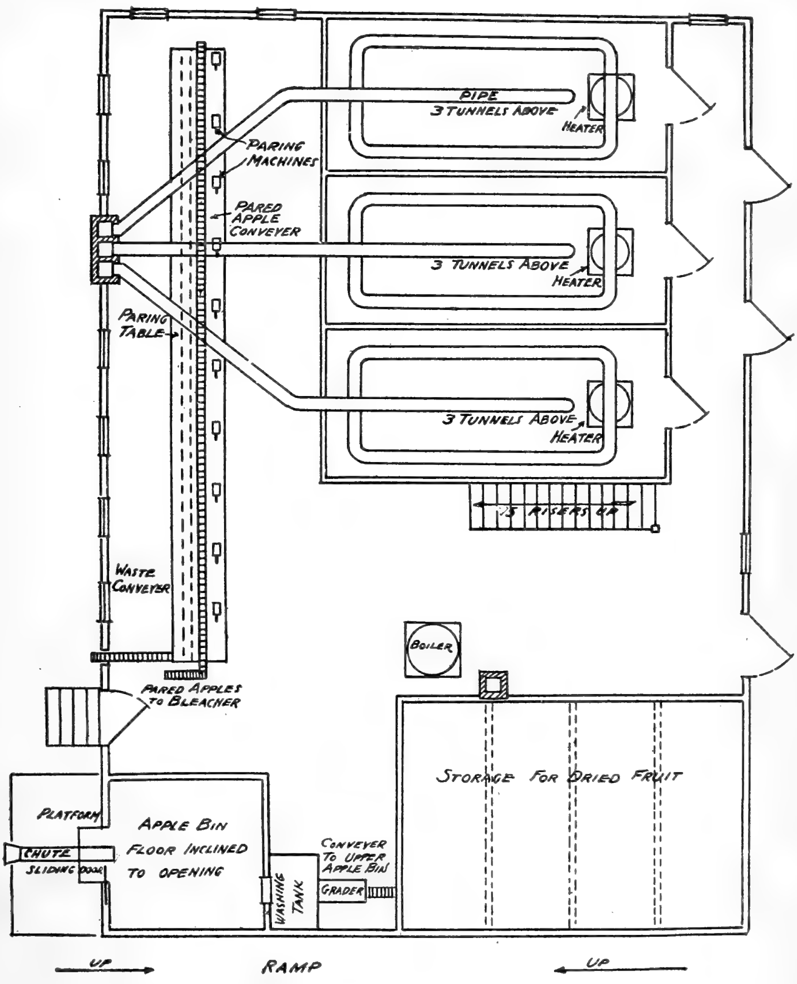

FIG. 12.—First-floor plan of the tunnel drier.

the group of tunnels and a length 2 feet greater. This additional 2 feet of length is given at the lower end of the tunnels and permits the furnace to be placed directly beneath the opening in the floor of the central tunnel, as shown in Figures 11 and 12. The height to the floor at this point should be 8 feet; as the ceiling of the furnace room is formed by the tunnel floors, which are inclined 2 inches per foot of length, the height of the ceiling at the opposite end of the room is 11 feet 10 inches. The walls of the furnace room may be of stone, brick, concrete, or metal lath and plaster; they should not be of wood, by reason of the nearness of the side walls to the furnace and the consequent danger of fire. Two air inlets 4 feet in length and 12 inches in height are provided in each of the side walls just above the ground level, with single inlets of the same size in the end walls and beneath the door of the furnace room.

The furnace is placed immediately beneath the floor opening of the central tunnel. The prevailing type of furnace in use in prune-growing districts where wood is the only available fuel is a large box stove, known as a hop-kiln furnace, equipped with heavy linings and of such size as to take 4-foot lengths of cordwood. Brick furnaces lined with fire brick are also used to some extent, and hard-coal furnaces of the type used in apple kilns may be employed where coal is available. Whatever the type of furnace, it is fitted with a length of heavy 10-inch or 12-inch pipe which rises to within about 4 feet of the floor level immediately beneath the center of the floor opening of the middle tunnel. It is fitted with a tee to which two lines of pipe are attached. These are utilized for heating the two lateral tunnels. Each line is carried from the tee to the center of the opening of the tunnel, where a drum 18 or 24 inches in diameter is sometimes used to give increased radiating surface. From this point the line of pipes is carried parallel with the side wall of the furnace room and beneath the floor of the tunnel to the opposite end of the room, where the two lines may be brought together before entering the chimney. The pipe is given an upward inclination toward the flue equal to that of the floor, and it is usually placed 18 to 20 inches below the sheet-iron floor. This arrangement of the pipes makes them effective in heating the side tunnels.

A MODIFIED TUNNEL EVAPORATOR.

A modified form of the tunnel evaporator which has been developed at the Oregon Agricultural Experiment Station[4] has, it is claimed, a considerable advantage over the ordinary form in point of economy of fuel and increase in capacity for a plant of a given size. Its distinctive feature is an arrangement whereby the air is repeatedly reheated and recirculated over the fruit. This is accomplished by cutting an opening 2 feet square in the floor of each tunnel at its upper end and building a duct leading from this opening to a housing surrounding a fan, which is so placed in front of the furnace that it forces a current of air over the furnace and piping and into the air inlets at the lower ends of the tunnels. The air intakes in the walls of the furnace room and the ventilator at the upper end of the tunnels are provided with trapdoors, which may be closed or opened to any desired degree at will, and similar provision is made for admitting fresh air into the housing surrounding the fan. The furnace and piping are examined and made tight by cementing or stripping the joints. When the fan is started the trapdoors in the ventilator are

[4] Weigand, Ernest H. Improved Oregon tunnel drier. *In* Better Fruit, v. 17, no. 7, p. 7–8, illus. 1923.

closed, and air which has passed through the tunnels is consequently forced to return through the ducts to the fan, whence it passes over the furnace, to be again heated and driven over the fruit. As the temperature and humidity of the returning air rises, the fresh-air inlet into the housing of the fan and the outlet to the ventilator are partially opened, so that some fresh air is continually entering, while a portion of the moist heated air is allowed to escape. With proper attention to the adjustment of these openings, the temperature in the apparatus may be kept quite constant. It should not be allowed to exceed 160° F.

The additional cost of the fan and power for operating this form of tunnel evaporator is more than offset by the reduction in fuel consumption and the increased capacity of the plant. In drying prunes with air recirculation there is a rather serious disadvantage in that the fresh fruit at the upper end of the tunnels becomes overheated and consequently cracks and drips unless the temperature is kept at or below 150° F. This may easily be done either by moderating the firing or increasing the quantity of fresh air admitted to the system.

THE TUNNEL-EVAPORATOR WORKROOM AND ITS EQUIPMENT.

The size of the building necessary and the nature and amount of equipment needed in a tunnel evaporator depends primarily upon the nature of the fresh material to be handled. If apples are to be dried in considerable quantities, the workrooms must contain the equipment for handling, paring, bleaching, and slicing the fruit described in the section on the workroom of the kiln evaporator, page 17. To this must be added the apparatus necessary for preparing prunes, apricots, berries, and such other materials as it may be proposed to dry. If the plant is solely for the drying of prunes, or of prunes with the small fruits just named, as will be the case in districts in which apples are not grown, the equipment will, of course, be restricted to that required for handling these fruits. In the descriptions and plans which follow, complete equipment for preparing applies as well as other materials has been included; omission of apple-handling equipment in any particular case gives additional storage space and involves no rearrangement of the other equipment.

The number of tunnels to be constructed must, of course, be determined by the volume of fruit to be handled. By reason of the smaller floor space required by tunnels as compared with kilns, a plant containing 9 tunnels can be installed in a building 59⅓ by 42⅓ feet in size. Figures 11, 12, and 13 give plans for such a plant. As a single tunnel will accommodate approximately 2,000 to 2,500 pounds of fresh prunes or an equal weight of prepared apple slices (equivalent to 3,500 pounds of apples) at one loading, the capacity of a 9-tunnel drier is 9 to 11 tons of fresh prunes or 12 to 15 tons of apples at a charge. The plans presented may be modified to give the plant larger or smaller capacity, as desired, without alteration of the workroom arrangement.

On the first floor of the building the workroom contains the paring and trimming table, as indicated in Figure 12. The remaining space is in part occupied by the furnace rooms of the tunnels and in part by storage space. The furnace rooms are equal in width to the group of tunnels which they heat, but have 2 feet additional length, in order to permit the furnace to stand immediately beneath the lower end of the tunnel. The hopper type of inclosure about the

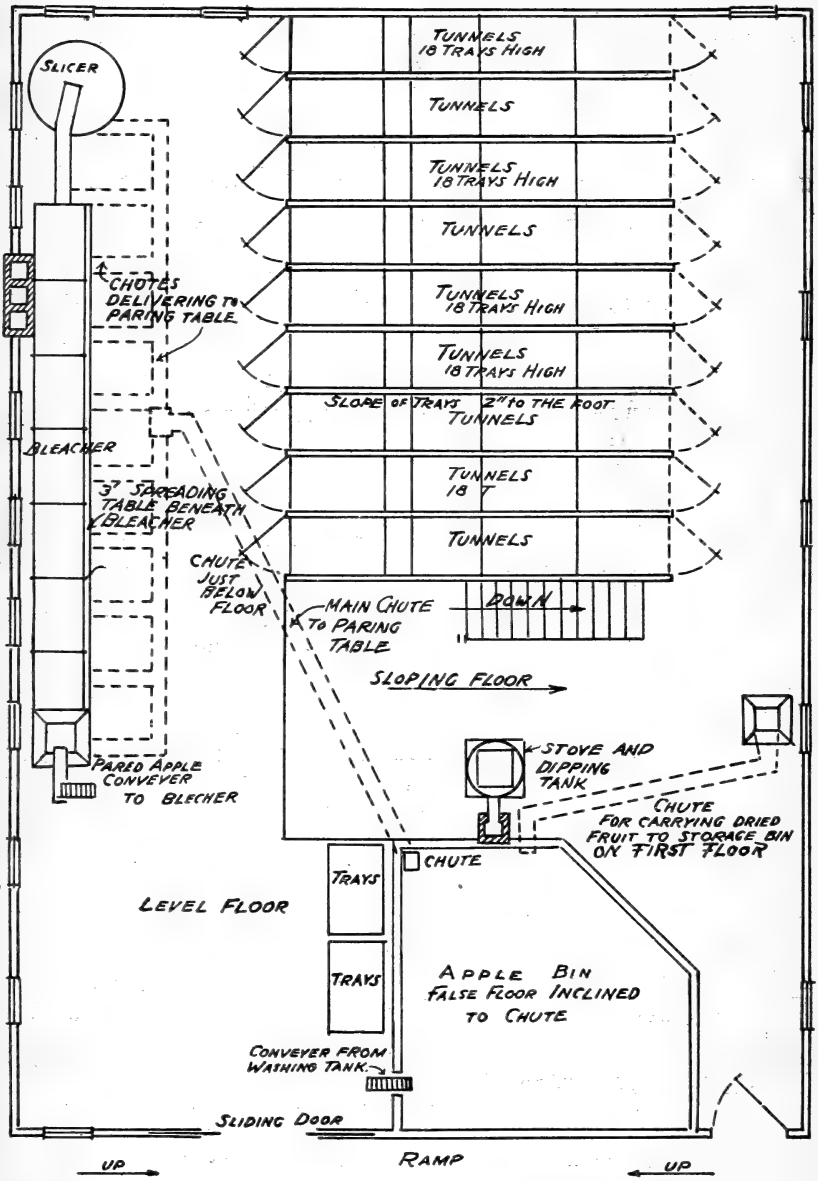

FIG. 13.—Second-floor plan of the tunnel drier.

furnace is not employed in tunnel evaporators; the furnace room is merely a rectangular inclosure having air inlets in the walls, as previously indicated. In the plans, Figures 12 and 13, three furnace rooms, each heating a group of three tunnels, are arranged side by side. The walls of the furnace rooms may be of any fireproof material; sheet iron is frequently used, but it has the disadvantage that the loss of heat by lateral radiation from such a wall is quite high. Some operators omit the walls about individual furnaces, but this practice is not to be commended, for the reason that uniform heating of the various tunnels can be secured only when the furnaces are separately inclosed. On the second floor, the tunnels occupy the position indicated in Figure 13. By reason of the inclination of the tunnels the floor of the workroom is at the level of the upper end of the tunnels, while that of the passageway along the lower end of the group of tunnels is at their lower level, with a flight of steps leading down to it from the workroom. A chute in the floor of this passageway permits the dumping of dry fruit from trays directly into the first-floor storage room.

The equipment necessary for preparing fruits other than apples is wholly located in the second-floor workroom. The impossibility of transferring loaded trays from floor to floor is obvious, while it is relatively easy to deliver fruit in bulk to the second floor by utilizing a hillside as a location for the building, by building a ramp up which wagons may drive to be unloaded, or by constructing an elevating device.

The complete equipment for handling prunes, peaches, apricots, and berries includes a sizer or grader, dipping and washing tanks and dipping baskets, a worktable for preparing peaches and apricots, a spreading or traying table, a sulphuring cabinet, and splitting knives and pitting spoons for handling peaches and apricots. Such other equipment as box materials, box-making machine, and press for packing and drying fruit may be used in common for apples and other materials.

The sizer, or grader, should be placed as closely as possible to the door through which fruit is delivered, as prunes, peaches, and apricots should be graded for size prior to their preparation for drying. The advantages are greater uniformity in the results obtained in dipping and in the case of prunes more uniformity in drying than is possible when fruit of all sizes is mixed together on a single tray. The sizing machine may be of any type which has sufficient range of adaptability to handle peaches and apricots as well as prunes. Several satisfactory machines for both hand and power operation are on the market, while many operators possess homemade sizers which do satisfactory work.

The dipping tank in which prunes are checked by dipping into a boiling lye solution preparatory to drying, with the washing tank in which they are washed free of lye, should be placed immediately adjacent to the sizer. As successful checking depends upon maintaining the lye solution actually at boiling temperature, the most satisfactory dipping tank is a heavy wooden box lined with galvanized sheet iron with soldered seams and heated by a steam coil supplied by steam from a small boiler. Such a tank should have three compartments, the first for containing the lye solution, while the second and third are filled with water for washing the fruit free from lye. Dipping baskets or boxes are made by nailing heavy, small-mesh, galvanized netting on a wooden frame. Such a box should not be larger than will contain 50 or 60 pounds of fruit, as a larger quantity will not be uniformly acted on by the solution. An overhead track with a carriage and pulley for raising and lowering the dipping basket and shifting it from tank to tank is easily arranged and quickly repays the work spent upon it in the saving of time and effort. An ample water supply for the washing tanks is a necessity, as the fruit must be washed free of lye after dipping.

For plants of large capacity, power-operated dipping machines consisting of two compartments, one containing lye, the other water, and supplied with an endless belt upon which the fruit is carried through the process, are obtainable, but the arrangement suggested is quite satisfactory. In small plants a large iron kettle heated by a stove often serves as a dipping tank, washing being done in galvanized tubs or similar vessels. The principal objection to such an arrangement arises out of the fact that the wash water is rarely renewed as frequently as it should be, often containing as much lye as the dipping solution, but proper attention to this detail will enable the user of such an extemporized outfit to make a satisfactory dried product. The spreading table is of such size that five or six trays can be placed side by side upon it, and it is of convenient height for standing erect while working. It should be so placed that fruit can be supplied directly from the dipping basket upon the trays, yet it should stand as near as possible to the passageway leading to the tunnel entrance. It should be well lighted, as the workers employed at it not only spread the fruit uniformly on the trays, but have the equally important task of sorting it to remove partially decayed and underripe fruit, since to permit such fruits to pass through the drier reduces its capacity and increases the labor of grading the dried fruit.

In some plants the traying table serves also as a worktable at which the splitting and stoning of peaches and apricots is done. If large quantities of these fruits are to be handled it will be necessary to provide additional table space for the purpose. In preparing peaches or apricots the tables serve as supports for trays. The women sit beside the tables, take fruits from boxes placed between them, split and remove the stone, and place the halves, stone cavity uppermost, upon the trays.

A sulphuring chamber is a necessity for treating peaches and apricots, which can not be handled through the power bleacher. The chamber consists of a tight wooden box of such dimensions as just to admit the trays used and of convenient height, supplied with a ventilator for carrying fumes through the roof, and equipped with a sulphur stove. The sides of the chamber may be equipped with runways upon which the trays may be pushed in one above another, but a much better arrangement is to have two or more low-wheeled hand trucks with flat tops the size of a tray. A truck is placed beside the spreading table and trays are stacked upon it as filled, pieces of 1-inch stuff being placed between them to hold them apart. When loaded the truck is transferred to the sulphuring chamber, the sulphur is ignited, and the door tightly closed. When the treatment is completed the truck is rolled to the door of the tunnels, unloaded directly into them, and returned to the spreading table for another load. These trucks serve also for transferring trays of dried fruit from the tunnels to the storage room, and their use saves much time which would otherwise be spent in transferring loaded trays about the plant by hand.

SMALL DRIERS OR EVAPORATORS.

Many persons produce quantities of fruit which are insufficient to justify the erection of an evaporator of the capacity here described, but which are of such quantity and value as to demand that provision of a small drying outfit capable of caring for the surplus be made. Farmers' Bulletin 984, Farm and Home Drying of Fruits and Vegetables, describes a number of inexpensive driers having capacities ranging from 100 to 2,000 pounds of fresh fruit daily. These evaporators are of such types that they can easily be built by any one who can use ordinary tools, and their construction and operation, the accessory equipment needed, and the preparatory treatment of the various fruits are fully described. As that bulletin is available for the use of individuals or groups of growers having small quantities of materials to be dried, it is unnecessary to describe small driers here.

TREATMENT OF THE VARIOUS FRUITS.

APPLES.

FRUIT SUITABLE FOR EVAPORATING.

There is an increasing demand for evaporated apples of the highest quality. The tendency has sometimes been to make quantity at the expense of quality. But prices are governed not only by the supply but also by the grade. The cleanest, whitest fruit, that is well cored, trimmed, bleached, ringed, and dried, is most in demand. Carelessness in any particular injures the product.

Primarily, the economic usefulness of an apple evaporator is through its utilization of grades of fruit which can not be marketed to good advantage in a fresh state, and it is these grades that are most often evaporated. But the magnitude of the crop also influences the grade of the evaporated product in a decided way. In seasons of abundant crops and low prices for fresh fruit, large quantities of apples that would ordinarily be barreled are evaporated, and the grade of stock produced is correspondingly improved. On the other hand, in years of scanty crops, when all apples that can possibly be shipped are in demand at high prices, only the very poorest fruit is evaporated, thus lowering the average grade of the output.

It is clear, however, that the quality of the product as a whole is improving from year to year. Better methods of production, competition between producing districts, stricter grading rules for fresh fruit which result in much fruit having superficial blemishes but otherwise good, as well as fruit lacking in color, being sent to the evaporators, and an increased demand for the better grades of dried fruit on the part of consumers are causes which have played a part in producing this improvement.

The commercial grading of evaporated apples is based primarily on appearance rather than on dessert quality, and the fact that one variety may make a better flavored product than another is not considered. As a rule, a product of high commercial grade can be made from any sort which has a firm texture and bleaches to a satisfactory degree of whiteness. For the reason that they meet these requirements in a fair degree and are also available in relatively large quantities, a few varieties furnish by far the greater part of the commercial evaporated apples produced in this country. As a result of the fact that the Baldwin is the most important variety in the New York evaporator district, it furnishes the bulk of the output of that territory, Northern Spy supplying most of the remainder. In the Ozark region, Ben Davis is the variety principally used, while York Imperial is most used in the Virginia and West Virginia evaporators. In the apple district centering about Watsonville and Sebastopol, Calif., Yellow Bellflower is the principal variety used for drying, with Yellow Newtown ranking next. In the Washington and Oregon apple-growing districts no one variety can be said to lead; Jonathan, Winesap, Stayman Winesap, Esopus, Yellow Newtown, Grimes Golden, Rome Beauty, Ben Davis, Arkansas Black, Delicious, Wagener, and a number of other varieties contribute to the total in amounts varying with their relative importance in the various districts.

Studies of some 250 varieties of apples with reference to their comparative suitability for drying purposes and the market and table quality of the products which can be made from them have been carried on in the Bureau of Plant Industry. Some results of this work may be of service as a guide in the choice of raw material for those who intend to place their product upon the commercial markets. In what is said it should be understood that market quality, that is to say, the color and general appearance of the product, rather than the table quality, is the primary consideration governing the statements made.

In general, early varieties are unsatisfactory for evaporating purposes. The small size of the fruit of many varieties tends to lower the grade in which the product will sell. More difficulty is encountered in controlling discoloration during drying than is the case with late varieties, and the product is prone to "go off" in color and flavor rather rapidly in storage. By reason of the low content of solids the yield of dry product is lower than with late varieties, and the table quality is less satisfactory. For these reasons the drying of summer and early-autumn varieties with the intention of marketing the fruit through the usual commercial channels should be undertaken with considerable caution.

Among the autumn or winter varieties, the following may be recommended as making "white stock" of good market appearance and color: Ben Davis, Bentley, Black Ben, Bismarck, Brackett, Baldwin, Bughorn, Benoni, Carson, Catline, Doctor, Delicious, Dickey, Evening Party, Fallawater Sweet, Granny Smith, Gano, Imperial Rambo, Ingram, Jersey Sweet, Klickitat, Lawver, London Pippin, McIntosh, Monmouth, Milam, Munson, Pewaukee, Rome Beauty, Ralls, Santa, Statesman, Sierra Beauty, Springdale, Shannon, Shone, Stayman Winesap, Sutton, Talbert, Vandevere Improved, White Doctor, White Pippin, Winesap, Wolf River.

A second group differs from the first in that the varieties placed in it have a sufficient amount of pigmentation in the flesh to give the dry product a slight golden color, often very attractive. In some markets such fruit sells at slightly lower price than clear white stock, in others no such distinction is made. The light-golden stock group includes: Arkansas Black, Annette, Beach, Barnes Best, Butter, Red, Camak, Collins, Fameuse, Golden Russet, Gravenstein, Holland, Illinois Favorite. Kittagskee, Kinnard, Loy, Wolseley, Missouri Pippin, Maiden Blush, Martin, Main, Northwestern Greening, Northern Spy, Pinnacle, Paragon, Red Canada, Rabun, Sweet Orange, Scott Winter, Swaar, Steward Golden, Stark, Tompkins King, Vanhoy, Western Beauty, Winter John, York Imperial, Yellow Skin, and Yellow Bellflower.

A third group comprises apples which are more heavily pigmented and which in consequence yield rather distinctly dark golden dry stock. While marketable, such stock is discriminated against by most dealers either by offering lower prices or by assigning the fruit to a lower grade. Some of the dark golden stock varieties are Abernathy, Akin, Arctic, Arkansas (*Mammoth Black Twig*), Babbitt, Barry, Baker, Buckingham, Black Gilliflower, Buckskin, Clayton, Colorado Orange, Collins Keeper, Fink, Ferdinand, Gold Medal, Golden Noble, Golden Pippin, Haycock, Hendrick, Imperial, King David, Mason Orange, Peck, Pink, Peter, Rubicon, Ribston Pippin, Smokehouse, Schroder, Twofaced, Traders Fancy, Terry, Whinery, Walbridge, Washington Strawberry, and Zoar.

PREPARING THE FRUIT FOR EVAPORATION.

Paring.—The sizing and distributing system described in the section on the workroom automatically supplies any given paring machine with fruits which do not vary more than half an inch in diameter. It is necessary to adjust the machines to fruit of the particular size supplied. This is done by shifting the attachment of the coil spring on the knife head inward or outward until the tension is such that the knife takes off a thin uniform paring, without tendency to skip or to cut so deeply as to choke the knife. It may also be necessary to loosen the coring spoon and move it slightly in or out, in order to make it cut cleanly through the fruit, yet throw the pared and cored apple clear of the parings. One person should have entire charge of the adjustment and repair of machines, and when once properly adjusted no tinkering with the machines by others should be permitted.

The operator should be instructed to place every apple upon the fork stem end first, so that the paring is begun at the calyx, and to aim at securing perfect removal of the core by the spoon. All standard power-operated machines are supplied with pulleys of such a size as to run the machines at the rate of 30 apples per minute. An inexperienced operator will find difficulty in feeding a machine at this rate. It is better policy to insist upon careful work and to have operators gradually acquire the necessary speed than to slow down the machines at first and subsequently raise them to standard speed.

Trimming.—In paring the fruit more or less skin is usually left around the stem and calyx of the apples and any irregular places that may occur. There will be worm holes, decayed spots, and other blemishes which will detract from the appearance of the product if allowed to remain. Even bruises are objected to by the most exacting operators. Hence all such defects are cut out as soon as the fruit is pared if the highest grade of product is expected. This is done with a narrow, straight-backed, sharp-pointed knife, having a blade not more than 2½ to 3 inches long, as the use of a longer blade leads to wastefulness in trimming.

In order that high-grade fruit be produced, it is absolutely essential that the number of trimmers be sufficient to prevent the accumulation of pared fruit on the tables. Usually two trimmers are able to care for the fruit pared by one machine, but if the fruit be exceptionally small or of poor quality, a third may be needed. In any case it is necessary to keep the trimming table clear and to get pared fruit into the bleacher without delay, as fruit which has become discolored from standing in the air does not regain its original whiteness in the bleaching process.

Bleaching.—The fumes of burning sulphur are employed not only to make the fruit white where the freshly cut surfaces have become discolored by contact with the air, but to prevent further discoloration after it is sliced. Sulphuring also renders the fruit more readily permeable to moisture and consequently accelerates the drying somewhat. It also acts as a deterrent to insects which otherwise might deposit their eggs upon the fruit, either during the drying or subsequently in storage.

There have never been definite standards governing the bleaching as to the time required, quantity of sulphur necessary to accomplish the desired end, etc. The aim is to treat until enough of the fumes have been absorbed by the apples to prevent discoloration after they are sliced and exposed to the air. If it is found that the fruit is not retaining its clean, white appearance with the treatment that is being given, either the length of time that the fruit is kept in the bleacher is increased or more sulphur is burned in the customary time for bleaching. Due caution should be exercised, however, in this connection, inasmuch as the bleaching of desiccated fruits with sulphur fumes is open to criticism. The sale of fruit containing sulphurous acid in any considerable quantity is prohibited by the pure-food laws of some States, as well as being restricted in some of the foreign markets. Under the Federal pure-food law, restrictions are also established with a view to limiting the sulphur-dioxid content to reasonable bounds. (See p. 62.)

The usual practice is to start the sulphur fumes by putting a few live coals into the receptacle used for the purpose, then adding a small piece or two of stick brimstone. Before this has all been vaporized, more is added. This is continued as long as the bleacher is in operation, sufficient heat being generated to vaporize the sulphur without the further addition of burning coals.

When apples are dried whole, without slicing or quartering, they require less bleaching than if they are to be sliced, inasmuch as the interior of the fruit does not come in contact with the air.

The allotted time for bleaching, in a large number of evaporators from which information has been obtained, varies from 20 minutes to 1½ hours. The usual time appears to be about 45 minutes. In experimental work carried on in the laboratories of the Bureau of Plant Industry, in which lots of apples of approximately 100 varieties have been subjected to bleaching for various periods of time and with varying quantities of sulphur, it has been found that exposure to the fumes in a tight bleacher for 30 to 40 minutes, employing sulphur at the rate of 3 to 4½ pounds per ton of fruit, has been sufficient to preserve the color of the dry product under proper storage conditions for periods of 12 to 20 months. It is clear that the wide variations in the quantity of sulphur employed and in the time of exposure necessary which are reported by operators are due to such factors as variations in the completeness of combustion of the sulphur, the construction of the bleachers, or the care with which the work is done rather than to regional or varietal differences in the fruit employed. It is clear that in some cases the quantities of sulphur employed are excessive and the bleaching period unnecessarily long; a reduction in both respects to the minimum necessary to produce the desired effect would eliminate a ground for criticism of the product and at the same time effect a slight economy in production.

As a result of the criticism which has been directed against the practice of sulphuring, considerable effort has been devoted to attempts to find satisfactory substitutes for the sulphur treatment, and a very considerable number of treatments have been proposed by various workers. Those which have been most strongly recommended substitute for treatment with sulphur fumes, a short treatment by dipping into a solution. Among other substances employed are rather dilute solutions of sodium bisulphite, potassium bisulphite, sodium chlorid (common salt), sodium bicarbonate (baking soda), acetic and tartartic acids, and hydrochloric acid. A somewhat detailed study of these and a number of other proposed treatments has been made in the laboratories of the Bureau of Plant Industry, with the general result that none of these treatments can be recommended as an effective substitute for sulphuring. The employment of sodium or potassium bisulphite solution merely changes the method by which sulphurous acid is introduced into the fruit for one which is no more effective and even more difficult to apply with uniformity. The other treatments mentioned vary somewhat in the degree to which they prevent discoloration during the actual drying process, but are alike in that they do not prevent slow spontaneous oxidation and consequent darkening in storage unless used in such concentrations as to give readily perceptible flavor to the fruit. For this reason, and for the further reason that they confer no protection against the deposition on the fruit of the eggs of insects, it is scarcely possible that any of these treatments will displace sulphuring as a commercial practice.

Slicing, quartering, etc.—After bleaching, the next step in preparing the fruit is slicing, unless instead of being sliced it is quartered or dried whole, as is done to a limited extent.

The slices are one-fourth inch thick, and in the largest degree possible should be cut at right angles to the hole made through the axis of the apple when the core is removed by the parer, thus producing the rings, which is the form most desired. Other things being equal, that fruit is sliced the best which contains the largest proportion of rings, and this point is given more or less weight in grading the finished product.

To secure a high percentage of perfect rings, the slicer should have a capacity considerably greater than the maximum demand made upon it; the slicing knives must be kept in perfect condition: and the chute from the bleacher must be so placed that equal distribution of fruit to the two sides of the turntable occurs. It is impossible to do perfect work if fruit is delivered so rapidly that two or more apples are carried by a single cup, as the fruits can not then move freely enough to turn into proper position for slicing before reaching the knives. When it is desired to evaporate apples in quarters or sixths they are run through machines which cut them accordingly, the cutting being done in the opposite direction from the slicing; that is, in a direction parallel to the axis of the apple instead of at right angles to it.

If they are to be dried whole they are transferred from the bleacher directly to the drying compartment without further treatment.

EVAPORATING THE FRUIT.

When the fruit has been placed in the drying compartment of an evaporator, of whatever type it may be, it has reached the most critical stage in the whole process of evaporation, and it is here that the greatest care and skill are required to insure the best possible results.

Capacity of floor space and trays.—In the case of kiln evaporators, the sliced fruit is evenly spread on the floor to the depth of 4 to 6 inches. A kiln 20 feet square will hold the slices of 100 to 125 bushels of fresh fruit, depending upon the amount of waste in the apples and the exact depth to which they are spread on the floor. If the fruit is in quarters or is dried whole it may be somewhat thicker on the floor, since in these forms it does not pack down so closely as the slices do and hence does not impede the circulation of hot air through it if the depth is somewhat increased.

In other types of evaporators where the fruit is handled on trays the slices are seldom placed much more than 1 inch in depth. A tray 3 by 4 feet in size will hold about 25 pounds of slices, equivalent to three-fourths of a bushel of whole fruit.

The fruit is generally put on the floor of the kiln as fast as it is sliced, and the fire is started in the furnace below as soon as the floor is filled or, in many cases, before it is entirely covered.

Oiling the floors and trays.—It is a common practice to treat the floor of kilns occasionally with tallow or a mixture of equal parts of tallow and boiled linseed oil to prevent the fruit from sticking to it. This is done several times during the season, as conditions appear to make it advisable. Another practice with the same end in view is to scrub the floors thoroughly twice a week with water, using with it some one of the scouring soaps. This is preferred by some operators, who claim that oil or tallow discolors the fruit.

At each filling of the trays, where these are used, the surface of the wire netting is lightly wiped over with a cloth moistened in lard. This prevents the fruit from sticking to the netting and keeps it clean.

Temperature to be maintained.—There is no general agreement among operators as to the temperatures which give the best results in drying apples, and wide variations in practice exist without giving rise to any apparent differences in the appearance and market quality of the product. The prevailing method among operators of the kiln evaporator is so to regulate the fires for five or six hours after loading the kiln that a temperature of 150° to 160° F. will be registered by a thermometer placed in a cleared spot on the kiln floor. By reason of the rapid escape of moisture, the actual temperature of the layer of fruit will be much lower, the difference varying with the efficiency of the ventilators, but usually being 20 to 30 degrees. After five or six hours the fruit is turned and opened up so that the air passes through it more readily, and the fires are so regulated that the temperature, measured in a bare spot on the floor as before, rises to 165° to 175° F., but is not allowed to exceed the last-named figure. It is maintained as nearly constant as possible until the fruit has lost approximately two-thirds of its water, when the firing is somewhat slackened and the drying completed at a floor temperature of 150° to 160° F.

The practice just described can be commended in the light of experimental results obtained in the laboratories of the Bureau of Plant Industry. The reduction in temperature as the fruit approaches dryness is especially to be advised, for the reason that the temperature of the fruit, which is at first far below that of the surrounding air, gradually rises as drying proceeds and approaches that of the air when nearly dry. Hence caramelization of the contained sugar and breaking down or volatilization of flavoring substances, with resulting injury to the color and flavor of the product, is more likely to occur as the process nears completion. In work in which the temperature is under accurate control and can be quickly altered at will, temperatures considerably higher than those named have been employed in the earlier part of the drying without injury, but with the imperfect control of temperature and ventilation found in actual practice, the upper limits mentioned should not be exceeded. Some operators aim at maintaining a uniform temperature of 150° to 155° F. throughout the entire process, and a few operate at still lower temperatures. Such practice materially lengthens the time required for drying and cuts down the working capacity of the kiln without producing a corresponding improvement in the quality and appearance of the product.

In drying apples in the tunnel evaporator, most operators maintain an air temperature of 165° to 175° F. directly over the air inlet at the lower end of the tunnel, while the temperature at the base of the ventilating shaft will be 20 to 25 degrees lower. In consequence the freshly introduced fruit is subjected to a temperature of 145° to 150° F. at the outset, and this is progressively increased as the drying proceeds.

Turning the fruit.—To prevent the fruit from burning and from sticking to the floor by remaining in contact with it too long and to insure the most uniform drying that is possible, the fruit, in the case of the kiln driers, is turned occasionally. The interval between turnings varies with different operators, with the condition of the fruit, and with the degree of heat which is maintained. Some operators do not turn the fruit until five hours have elapsed after the furnace has been started, and this is to be commended as causing less breaking of rings, although it is a more common practice to make the first turning within two to three hours after the drying is begun, or even sooner. After the first five or six hours it is generally turned every two hours, and more frequently as the fruit becomes drier, until perhaps it may require turning every half hour when nearly dry.

The objects to be obtained by turning must be kept in mind and the fruit handled accordingly. It should be examined from time to time and turned often enough to prevent scorching or sticking and to insure uniform drying.

The instrument used in turning the fruit is a broad-bladed wooden shovel, with the handle so attached that the user may stand erect. A steel shovel can not be used, as contact with metal would discolor the fruit. The operator in charge of the kiln keeps a pair of rubber overshoes in a convenient place to be worn only when working in the kilns. Slipping these on, he begins turning the fruit by working along one wall parallel with the slats of the floor, throwing the fruit from a strip the width of his shovel back upon that next to it. On the return trip he fills this strip with the loosened fruit, leaving an exposed path which is filled as he returns, and so on until the opposite wall is reached, when he covers his path by walking backwards and drawing the fruit uniformly into the space. Stepping upon the drying fruit is thus avoided. Some operators employ movable walkways, consisting of a long board with short legs attached, which may be used to reach any part of the kiln from the door without disturbing the intervening fruit. When the fruit has lost most of its moisture, a long-handled wooden rake is of advantage for loosening any masses which are not drying properly.

A practice followed by some operators is of sufficient practical value to warrant mention. As the fruit in a kiln becomes nearly dry it is thrown to one side so as to leave one-half or three-fourths of the floor free. The loading of this area with fresh fruit then begins and is completed as soon as the dry lot is removed. Since the temperatures employed for beginning and finishing the drying are essentially the same, this practice permits continuous operation of the kilns.

In the case of other types of evaporators in which the fruit is handled on trays, no turning is required, although it may be necessary to open up compact masses if the spreading has been poorly done. Sometimes the relative positions of the trays are changed to make the drying more uniform, but if the offset arrangement of the trays in the tunnel is properly maintained this should be unnecessary. The absence of necessity for stirring or turning is one reason why the fruit dried on trays is generally of rather better quality than that from kilns. The repeated turning on the kiln floor is likely to crush and break the fruit more or less unless the turning is carefully done and the first turning is postponed until the fruit has lost enough of its moisture to be somewhat leathery, while in that which remains practically undisturbed on the racks the rings are maintained in better condition. The fruit also dries more quickly and is often more attractive in appearance.

The same general principles must be observed in tending the fruit where steam heat is used in place of direct hot air from furnaces.

Time required for drying.—The time necessary for drying fruit depends upon several factors. The more important are: Type of evaporator, depth to which fruit is spread, method of preparing (whether sliced, quartered, or whole), temperature maintained, conditions of the weather, and to a certain extent the construction of the evaporator.

The application of these several factors to the point in question readily follows. A good kiln evaporator should dry a floor of slices loaded to a depth of 5 to 6 inches in about 12 hours, 10 to 18 hours being the range of variation. Where the fruit is handled on trays, the time required is much shorter, but conditions are quite different from the kilns, as the fruit is seldom more than 1 or 1½ inches thick on the trays. For slices 5 hours is considered a reasonable time, with a range of 4 to 8 hours.

It is estimated that quarters will require from 18 to 24 hours in the average kiln, while the time for whole apples will range from 36 to 48 hours.

If the atmospheric conditions are heavy and damp, the drying is retarded. Under some conditions it is hardly possible to dry the fruit thoroughly. During windy weather, also, it is more difficult to regulate the heat, especially if the walls are poorly constructed and if hoppers about the furnaces are not employed, so that the draft of cold air into the furnace room can not be controlled. This applies especially to kilns heated by furnaces. It is claimed that steam-heated evaporators are less subject to the influence of climatic conditions.

When is the fruit dry?—Perhaps there is no step in the entire process that requires better trained judgment than to determine when the fruit is sufficiently dried to meet the requirements. Like several other steps in the process, it is largely a matter of experience, though there are certain general features which are capable of being reduced to words.

The fruit should be so dry that when a handful of slices is pressed together firmly into a ball the slices will be "springy" enough to separate at once upon being released from the hand. In this condition there will be no fruit, or only an occasional piece, that has any visible moisture on the surface. In a slice of average dryness it should not be possible to press any free juice into view in a freshly made cross section of it. In general, the fruit as it is handled should feel soft and velvety and have a pliable texture. This is a critical stage, since the slices may seem to possess these characteristics in the proper degree while warm, but after they are removed from the evaporator and have become cold they may be so dry as to rattle unless the removal has been very accurately timed.

The foregoing should represent as nearly as possible the average condition, but it can not be expected to be absolutely uniform throughout. Some slices—they should constitute only a very small percentage—will still plainly possess some of the juice of the apple; others—likewise, properly only a small proportion—will be entirely too dry, possibly dry enough to be brittle.

The curing or conditioning room.—When a quantity of fruit is considered dry enough it is removed from the kiln and put in a pile on the floor of the curing room. (Fig. 14.) Every day or two the pile should be thoroughly shoveled over to make uniform the changes which take place. Thus managed, the pile in a few days will become thoroughly homogeneous. The pieces that were too dry will have absorbed moisture, the superfluous moisture of other pieces will have disappeared, and the entire mass may be expected to reach the condition above described. When this condition has been reached, the batch may be added to the general stock in the storage room.

The conditioning room may be, and in most plants actually is, a portion of the second-floor workroom. It should be partitioned off from the remainder of the room, the windows and door should be provided with tight-fitting, closely woven screens to exclude insects, and the windows should be curtained to keep out direct sunlight, which would cause more or less discoloration of the fruit. If several varieties of apples are being handled, bins or compartment must be provided, in order that the fruit made from each variety may be kept separate from the rest, particularly if the products differ considerably in color. The room should be provided with a stove or other source of heat, in order that it may be kept at a temperature of 65° to 75° F. during the conditioning of the fruit.

If space permits, the conditioning room may also serve as a storage room in which the dried stock remains until it is boxed and sold. It is obviously bad business practice to store the dry fruit in the evaporator, as the danger of loss of the entire season's product by fire is considerable.

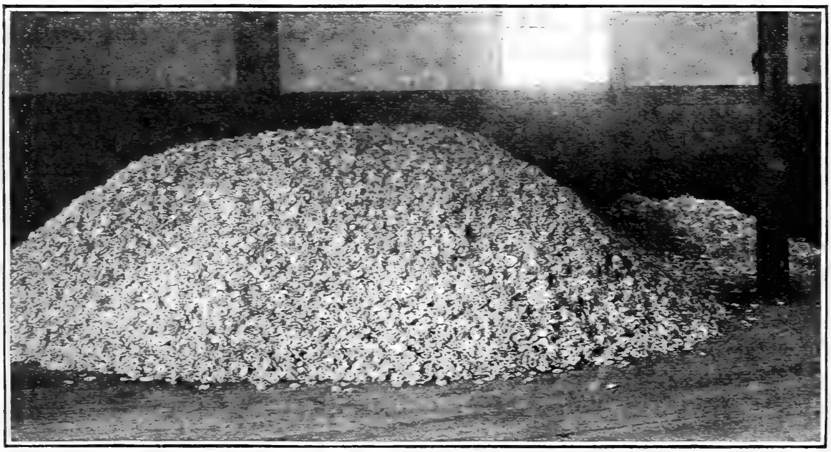

FIG. 14.—A pile of evaporated apples going through the sweating process in a curing room connected with a New York evaporator.

A much better practice is to employ a separate building located at some distance from the drier as a storeroom and to transfer dry stock to it as soon as conditioning is completed. Whatever the location of the storage room, the suggestions as to its construction given on page 57 should be followed.

HANDLING THE WASTE.

In the usual grades of apples taken to the evaporator there are many specimens that are too small to pare or which for other reasons can not be profitably used in this way. In the case of some of the larger evaporators which are operated in connection with vinegar factories, these apples, as well as all parings and trimmings, are sent to the presses for "vinegar stock," but in the smaller ones these portions are usually dried. When this is done the small fruit separated by the sizer is sliced without paring or coring, in a root cutter or chopper, and spread on the kiln floor. The depth of loading and the handling during drying is identical with that given for white stock. When peels and cores are dried, the fact that they do not pack closely makes it possible to load the floor much more deeply than with white stock, and less turning is necessary during drying. Chops and waste are usually dried to a considerably lower moisture content than white stock, and are quite frequently packed into burlap bags as soon as they are taken from the kiln. It is generally estimated that about one-third as much space is required to dry the parings and trimmings as is demanded for the "white fruit."[5]

"Waste" and "chops" are generally bleached, but are never passed through the bleacher which is used for the white fruit. Where they are dried in kilns, which is usually the case, a common way of bleaching is to burn the sulphur in the furnace room after the stock has been spread on the floor.

It is generally estimated that the waste from a given quantity of apples will pay the cost of the fuel for evaporating that quantity of fruit; that is, putting it on a bushel basis, the waste from a bushel will pay for fuel to evaporate both the white fruit and the waste from that bushel. While in some instances, when the price of such stock is low, this estimate may be too high, it not infrequently happens that it more than pays for the fuel.

PEACHES.

ECONOMIC CONSIDERATIONS.

At the present time an important economic factor enters into the general proposition of drying or evaporating peaches in the widely distributed peach-producing regions of the country.

For a number of years, which extended from the late seventies to the early nineties, large quantities of peaches were evaporated in Delaware and perhaps in some of the other older peach-growing regions. Twenty years or more ago one of the largest peach growers in the Fort Valley section of Georgia undertook to evaporate some of his fruit, but after operating a season or two the effort was abandoned as impracticable under existing conditions. For the past 25 years, however, practically no peaches have been evaporated for commercial purposes in this country outside of California. The reasons for this are largely economic. The peach-growing regions in the humid parts of the country are located more advantageously, as a rule, than are the peach-growing sections of California, with regard to the large consuming centers for the fresh fruit. This fact, of course, has to do with the logical working out of the best methods of disposing of the crop in different regions.

It is also true that the drying of peaches in California on a commercial scale is confined to a few varieties which are especially high in their solid content and hence give a larger yield of dry product than do the varieties grown in the humid regions.

Perhaps the most potent factors in the economics of the case, and especially at the present time, are relative cost of drying and relative selling price of the product. In all humid regions the first cost of the evaporator and the cost of fuel must be added to the expense of operation, in comparison with drying in California, since in that State peaches are dried, with few if any exceptions commercially.

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[5] "White fruit" is a general term used by operators and dealers to denote the grades used for culinary purposes, in distinction from "waste," which comprises the parings and trimmings, and "chops," which are composed of the apples that are too small to pare or are otherwise defective.

by exposure to the sun. The cost of handling may be more under California methods, but probably the difference is not great. As a fuel cost, roughly estimated, about 1 cord of wood or a ton of hard coal is required to produce a ton of dried fruit.

Whether in an earlier day the varieties available for drying constituted a factor favorable to some regions and adverse to others is unimportant now. The variety factor is fundamental at the present time. In California, the Muir and Lovell are planted on an extensive scale expressly for drying. These ripen in good sequence with each other and are yellow freestones with rather dry, fine-grained, firm flesh, characteristics which are essential in a good drying peach.

In the earlier day when peaches were being evaporated in the East, such sorts as Early Crawford, Foster, Oldmixon Free, Moore, Late Crawford, Stump, and others were used. It is obvious that the dried product as a whole would lack the uniformity that is now demanded by the trade. However, within the past 25 years the Elberta has come very largely to the fore in all humid peach-growing regions. So important is it, relatively, that in many of the peach-growing centers it is the only variety shipped in relatively large quantities for use in the fresh state.

While the Elberta is dried to a very limited extent in California, the quantity handled in this way is negligible compared with the Muir and Lovell. The Elberta has some characteristics of a good drying peach, but it may be questioned whether the dried fruit would be of sufficiently high grade and attractive enough in appearance to compete successfully with the dried fruit from the Pacific coast when placed on the market in large quantities. It follows, in view of the very extensive production of the Elberta in most peach-growing centers in the humid regions, in comparison with other sorts, that the great bulk of the fruit available for drying in those regions is of the Elberta variety. Under normal conditions the annual average of 30,000 tons, more or less, of dried peaches from California supplies the market demand. It appears evident that should a large quantity of Elbertas from other sections be dried, new demands or new markets for the product would have to be developed if the growers who dry their fruit are to profit thereby.

DETAILS OF DRYING.

The kiln type of evaporator, which as previously noted is largely used in drying apples, is not suited to peaches, the characteristics of the fruit being such that it can not be handled well in the large bulk that is necessary to make the use of a kiln economical. Any of the cabinet or tunnel types where the fruit is spread in a thin layer on trays may be used in evaporating peaches.

The fruit to be evaporated should be of a uniform degree of maturity and fully ripe, otherwise the finished product will lack uniformity. Immature fruit does not make a good dried product. Moreover, the rate of drying is governed in part by the size of the pieces; hence it is an advantage if the fruit that is placed on any one tray is fairly uniform in size. For this reason all fruit should be passed over a sizer adjusted to separate it into three or four sizes.

PREPARATION OF THE FRUIT.

The first step in the actual preparation of the fruit is to split it open to remove the pit. This is done by cutting completely around the peach in the line of the suture with a sharp knife. The cut needs to be complete, since any tearing of the flesh will be apparent in the evaporated product, making it less attractive in appearance than it otherwise would be.

If the fruit is to be peeled,[6] the paring should be done before the fruit is cut open for the removal of the pit. Paring is done by hand, as a rule, when the practice is followed, sharp, straight-backed knives with blades 2½ to 3 inches long being satisfactory for this purpose. Paring machines have been designed for peeling peaches, but they do not appear to be much used.

A much more economical method is to employ a lye solution for peeling, as is the practice in the commercial canning of peaches. A solution of proper strength is made by dissolving 1 pound of ordinary concentrated lye (containing 96 per cent sodium hydrate) in 10 to 16 gallons of water. The solution must be actually boiling. Fruit contained in a suitable crate or basket is plunged into the boiling solution and allowed to remain 60 to 90 seconds, the exact time necessary depending upon the variety and degree of ripeness of the fruit. It is then transferred to cold fresh water and agitated to wash off the loosened peels and to free the fruit from the lye, after which it is split and stoned, any blemishes or adhering bits of peel being trimmed off by the splitters. The equipment necessary for lye peeling is identical with that for dipping prunes, described on page 51.

After the pits are removed the fruit is treated to the fumes of burning sulphur in much the same manner that apples are treated and for the same purpose. The fruit should pass to the bleacher with the least possible delay after it is split open, in order to prevent discoloration. Because of the character of the fruit, however, it should not be handled in large bulk during the bleaching process, as is the practice with apples. The best method is to place the trays on which the fruit is to be dried upon the worktable, and have the women who split and stone the fruit lay the separated halves, stone cavity up, closely side by side in a single layer upon the trays. Two women may spread the prepared fruit upon one tray placed between them. As rapidly as the trays are filled they are transferred to a bleacher of the type described on page 34.

Experimental data obtained in the laboratories of the Bureau of Plant Industry indicate that color and appearance of practically all of the more important commercial varieties of peaches can be as well preserved by exposure for 30 to 35 minutes to the fumes of sulphur burned at the rate of 6 to 8 pounds per ton of whole fruit as by the

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[6] Practically all evaporated peaches found on the market are dried without peeling. While there is a considerable demand from consumers for a peeled evaporated peach, producers have hesitated to attempt making such a product because of a practical difficulty. When fruit is peeled and treated with the fumes of burning sulphur for a prolonged period, juice escapes from the tissues into the stone cavity and to the outer surface and drips away. As this juice is rich in sugar and flavoring substances, the weight and quality of the product is lowered by its loss. This loss does not occur when the peel is not removed, as the liquid can not pass through it. Experiments in the laboratories of the Bureau of Plant Industry have shown that when sulphuring is continued only for a sufficient time to secure preservation of color, peeled peaches can be treated without any loss of juice. Operators consequently have it in their power to produce a peeled sulphured dry peach of good quality, provided they guard against excessive exposure of the fruit to sulphur fumes.

use of larger quantities or more prolonged exposure, or both. When the fruit is peeled, so that penetration occurs from both surfaces rather than from the stone cavity alone, the time of exposure may be reduced to 20 to 25 minutes. With the drier firm-fleshed varieties, such as the Lovell, Muir, Salwey, and a few others which are grown for drying purposes in California, somewhat more prolonged treatment is necessary to insure good penetration, but there is no question that exposures for 3 to 10 hours are needless and productive of no useful result. The operator should determine by experiment the minimum time which will give satisfactory results with his particular equipment and raw material and carefully avoid overexposure and excess in the use of sulphur.

HANDLING PEACHES IN THE EVAPORATOR.

The bleaching completed, the fruit is ready to be placed in the evaporator. Care must be exercised in transferring the fruit in order that the halves may remain cup side uppermost, thus preserving any juice which may have collected in the stone cavities during sulphuring.

The temperature at the outset should not be allowed to exceed 140° F., and it may be increased to 165° F. for finishing. As the trays are pushed down to the lower end of the tunnel, the fruit should be turned over or stirred to promote uniformity in drying.

The length of time required to dry the fruit will vary with the equipment, the efficiency with which it is managed, the weather conditions at the time evaporation is being carried on, probably to some extent the weather conditions during the development of the fruit, and more especially the weather conditions during the few weeks immediately prior to picking. The variety is also a very definite factor in the time required for drying. Beers Smock and other comparatively dry-fleshed sorts may be in condition for removal in 5 to 7 hours; others, under the same conditions of operation, in 6 to 8 hours, while very juicy varieties may need to remain in the evaporator from 12 to 15 hours. Obviously, however, such sorts as the latter are not desirable for drying, unless they possess other qualities which give them some peculiar value.

Good judgment, which develops only with experience, is necessary to determine just when the fruit is in a proper state of dryness to be withdrawn from the evaporator. In general, the fruit should possess the same physical properties as apples when evaporated. It should not be possible to bring free moisture to the surface upon squeezing a freshly cut surface tightly between the fingers; the fruit should have a velvety, springy, pliable texture, and when a double handful is tightly pressed together the pieces should immediately fall apart when the hands are relaxed.

When the fruit comes from the evaporator, as in the case of apples, there will be some pieces that obviously contain too much moisture; others will be so dry and hard that they will rattle when they are handled. By placing them in a pile of considerable size and working them over several times during a period of a week or two, as is done with apples (see p. 43) the entire lot may be brought to a uniform moisture content. When this stage is reached the fruit is transferred to the storage room, where it remains until it is packed for the market.

APRICOTS.

The dried apricots found in the markets are wholly a California product, as the fruit is not dried in commercial quantities elsewhere. For the convenience of the occasional operator who may desire to evaporate small quantities, an outline of the method to be followed is given here.

The treatment of apricots is essentially that given to peaches. The fruit is graded into three sizes for the sake of securing uniformity in drying, split and stoned, placed upon trays, stone cavities uppermost, as closely as possible, precisely as recommended for peaches. The sulphuring of the fruit must be begun as promptly as possible and is continued for two to two and one-half hours if it is desired to secure a uniformly translucent golden-yellow dried fruit, although one hour's treatment will give sufficiently thorough penetration to prevent discoloration. The same precautions are necessary in the handling of trays, in order to avoid loss of juice, as are recommended in the case of peaches. The temperatures to be employed are those recommended in the case of peaches, as are the criteria for determining when the fruit is dry and the subsequent treatment in the conditioning room.

PEARS.

The drying or evaporation of pears in the humid regions has not received sufficient attention to establish any definite methods or rules of practice. Dried pears form one of the smaller though important products in the dried-fruit industry of California, where the drying is very largely by exposure to the sun rather than through the use of artificial heat. Of the varieties more commonly grown in the humid regions the Bartlett and the Seckel are the only ones which make a product of such quality as to compete in the markets with the California sun-dried pears, which are almost wholly composed of the Bartlett variety.

Usually the fruit is cut lengthwise into halves, pared, the stem and calyx removed but the core left in. If the fruit is very large it may be quartered or cut into other smaller sections to facilitate drying.

Bleaching is necessary, as with apples and peaches, in order to secure an attractive-looking dried product. For equally good results it is necessary to continue the bleaching for a considerably longer period than with apples and to use larger quantities of sulphur; an exposure of one to one and one-half hours, using sulphur at the rate of 8 to 10 pounds per ton of fruit, is believed to be sufficient. If the fruit is placed in a weak salt solution (1 per cent) as soon as it is peeled and kept there until it is spread on trays, the time of exposure to sulphur fumes may be reduced to 20 to 30 minutes.

The same general qualities described in connection with apples and peaches will indicate when a lot of fruit is ready to be taken from the evaporator, and upon removal it is handled in the same way.

CHERRIES.

Cherries occupy very much the same place as pears, so far as commercial drying in humid regions is concerned, and they are hardly more important in those regions where sun drying prevails. However, both sweet and sour cherries are dried by artificial heat as well as in the sun to a limited extent.

The fruit may be pitted or not before drying, but the best product is made when pitting precedes drying, though of course large quantities of juice are lost in the operation unless some provision is made for saving and utilizing it in some way. No bleaching is necessary. In other respects they may be handled much as raspberries are handled. The evaporation of this fruit is discussed on a later page (see p. 54).

PRUNES.

The question "What is a prune?" is frequently asked. The answer is simple. A prune is merely a plum having certain varietal qualities not possessed by other plums. The final, distinguishing quality or character is ability to dry without fermenting while the pit still remains in the fruit. If a plum can not be dried without fermenting unless the pit is removed (as is true of most varieties) it is not a prune. Therefore it may be said that all prunes are plums, but not all plums are prunes. As a matter of fact, all of the prunes of commercial importance belong to the *domestica* or European group of plums. None of the native or Japanese varieties are dried for market purposes, though there are certain native plums which are used locally in this way to a limited extent.

The commercial drying of prunes in this country is carried on in Oregon and California, and to some extent in certain localities in Washington and Idaho. The quantity dried in other States is so small as to be negligible. In Oregon, Washington, and Idaho the drying is done in evaporators, while in California sun drying is largely practiced, though evaporators are rapidly coming into general use.

Most of the dried prunes offered to the trade consist of two varieties—the *Italian*, grown largely in Oregon and Washington, and the *Agen*, or, as it is much more commonly called, the *French* or *Petite*, grown in California. A few other varieties are dried in small quantities, but they are unimportant as compared with the ones named.

Prunes for drying, like other fruits, should be fully ripe. The common practice is to permit them to remain on the trees until they drop of their own accord or fall with a very light tapping of the branches with poles. The fruit is then gathered from the ground and placed in lug boxes or other convenient receptacles and taken to the evaporator. Sometimes the fruit that drops naturally is picked up at three or four different times, and then poles are used to complete the harvest. Since the sugar content of prunes increases rapidly in the last week or 10 days prior to their fall from the tree, to allow them to ripen and fall of their own accord obviously gives a higher yield of better quality product than is obtained when they are shaken from the trees. For this reason, and also because ripe fruit checks very much more readily than immature fruit, the prunes which have fallen of their own accord should be kept separate from the less mature fruit.

While the details of handling the fruit at the evaporator vary considerably with different operators, a composite course is about as here described.

SIZING THE FRUIT.

The fruit is emptied from lug boxes or other receptacles upon the grader, set to separate the fruit into four or five sizes, which are kept apart through the subsequent treatment. Sizing well repays the labor, since more uniform checking in the dip and greater uniformity in drying, with a corresponding decrease in the percentage of "bloaters" and "frogs"[7] is thereby secured.

DIPPING THE FRUIT.

The fruit is dipped in a lye solution, the object of which is to remove the wax from the fruit and to produce a very fine checking of the skin. If this is not done, the moisture in the fruit can not escape readily, and the fruit in drying will not assume the shrunken condition that is desirable. Instead, many "frogs" or "chocolates," as they are variously called, i. e., fruits which do not assume the desired shrunken condition, will result. Such fruits have to be graded out and are worthless, or nearly so, as dried prunes.

The lye solution is made by dissolving ordinary high-grade caustic soda or caustic potash in water. The strength at which it is used varies from a pound in 10 or 12 gallons of water to a pound in 25 or 30 gallons of water, depending upon the variety (some requiring a stronger solution than others to accomplish the end in view), the ripeness of the fruit (fully ripe, fallen fruit requiring shorter treatment than that which has been shaken or beaten from the trees), the temperature at which the solution is maintained, the length of time the fruit is immersed, etc.

Ordinarily the lye solution is maintained at the boiling point, the tank in which it is contained being placed over a furnace or supplied with steam coils in such manner as to maintain the desired temperature, as described in the section on equipment, page 33.

When the solution is maintained at this high temperature, it is necessary to hold fully ripe fruit in the solution only a few seconds, though the time varies to some extent with different varieties. The operator soon learns to determine by the appearance of the fruit the necessary length of time under the temperature and other conditions that are being maintained. If the solution is too strong, or if the fruit is immersed for too great a length of time, the slight checks in the skin will become definite cracks in the fruit. This should be avoided, as fruits which are definitely cracked will lose much of their sugar by dripping and consequently will not make a desirable dried product.

Immediately after dipping, the fruit should be transferred to a bath of clear water and rinsed free from lye. The wash water should

[7] The terms "bloaters," "frogs," and "chocolates" are variously used to denote fruits that do not dry properly, but remain plump and retain certain other undesirable characteristics. "Bloaters" (California Exp. Sta. Bul. 114) have been designated as large, fully ripe fruits which ferment slightly in drying, producing a small amount of gas which prevents them from shrinking. "Frogs" are usually small, poorly developed fruits which for some reason will not respond properly to the lye solution. The skin does not become checked, and they do not dry properly. If a tree is very heavily overloaded and the fruit correspondingly small and poorly developed, much of the fruit from it is likely to "frog" when dried.

be constantly renewed, or two vessels of wash water should be provided, as suggested on page 34, as the fruit carries considerable quantities of lye into the wash water.

In addition to the dipping, the fruit, in some instances, is passed over a perforator, which in brief is an inclined plane provided with very small pin points, in order to slightly puncture the skin of the fruits as they pass over it. The pricking of the skin in this way serves the same purpose as the checking of the skin mentioned above in connection with the dipping. Where the perforator is used it is not necessary to carry the dipping quite as far as where it is not used, though the lye solution should completely remove the bloom from the fruit. While formerly much used, perforators are now rather generally discarded, because the breaking off of needles in the fruit was not an infrequent occurrence, and when lye dipping is properly done, perforation is unnecessary.

Combination machines are on the market which include equipment for dipping, washing, perforating, and sizing the fruit, and in which the fruit is automatically passed from one operation to the next. Where extensive operations are concerned, such an equipment is essential, but smaller, more simple equipment involving all handwork serves the purpose very well for small-scale activities.

The foregoing paragraphs describe the methods of checking the fruit at present in use. It has been shown by investigators at the Oregon Agricultural Experiment Station[8] that it is possible to dispense entirely with the use of lye and to secure satisfactory checking by the use of boiling water alone. It is necessary that the water be actually boiling, hence the tank used should be large enough so that the water will not be cooled below the boiling point by the vessel of fruit. The treatment requires 20 to 60 seconds, the exact time depending upon the ripeness of the fruit. By reason of its greater simplicity and economy, and its equal effectiveness, hot-water dipping should entirely replace the use of lye.

After dipping, the fruit is spread on trays of the type already described on page 26. A single layer of fruit only should be placed on the tray, but care should be taken to fill it completely, as partially filled trays interfere with proper distribution of the air currents. It is then ready to be placed in the evaporator.

HANDLING PRUNES IN THE EVAPORATOR.

It is obvious from the foregoing that an evaporator of the kiln type is not suitable for use in drying prunes. Any of the types in which the fruit is placed in thin layers on trays or racks as described above can be used. As a matter of fact, the tunnel type has at the present time almost completely displaced stack, cabinet, and various other types of driers which were formerly used for the drying of prunes. Figure 15 shows the exterior of a tunnel evaporator in Oregon. The dipper and other equipment used in preparing the fruit for drying is housed in the annex with a shed roof.

Considerable must be left to the operator's judgment with regard to the temperature at which the evaporator should be maintained. If it is too high in the beginning there is danger of the fruit bursting

[8] Lewis, C. I., Brown, F. R., and Barss, A. F. The evaporation of prunes. Oreg. Agr. Exp. Sta. Bul. 145, 36 p., 28 fig. 1917.

open, in which case the loss of sugar by dripping will seriously lower the quality of the dry product. As nearly as can be stated in definite terms it is safe to start with a temperature of 130° to 140° F., gradually raising it until the fruit is finished at 155° to 165° F.

As with other fruits, the time required in which to dry prunes varies with conditions, but from 24 to 30 hours is a conservative average.

The fruit is dry when the skin is well shrunken in the manner familiar to all users of prunes. The texture should then be firm but springy and pliable enough to yield readily when pressed in the hand. The drying should not continue until the individual fruits rattle as they are brought in contact with one another in handling. It is true, however, that when the bulk of the fruit has

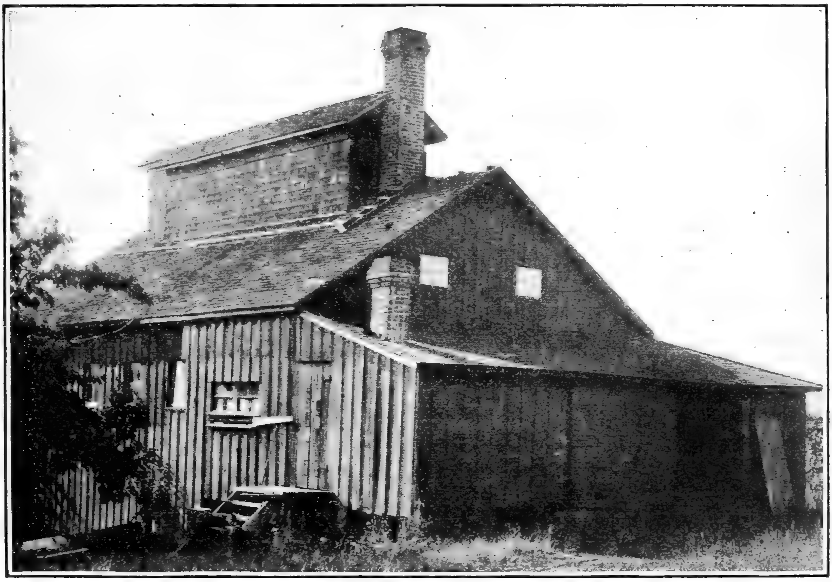

Fig. 15.—Exterior view of a prune evaporator in Oregon. The dipper and sizer are placed in the annex with shed roof. The compartments in which the fruit is dried are in the main part of the building.

reached the proper degree of dryness some specimens will be too dry while others will contain an excess of moisture, as is the case with other fruits. The condition is equalized in the same manner as with apples and peaches, by placing the prunes in a pile when they come from the evaporator, and working them over from time to time until uniformity of product is reached. This may require from several days to two or three weeks.

Instead of piling the fruit in bulk, it may be put in boxes of convenient capacity to handle and poured from one to another every day for a time while the fruit is curing or conditioning. Before the fruit is conditioned, however, the "bloaters" and "frogs" should be removed.

In drying, prunes shrink in weight on an average about three to one, i. e., about 3 pounds of fresh fruit are required to make 1 pound of the dried product.

The treatment given the Silver prune, which is dried in a small way in some sections, is identical with that of other prunes, with the addition that the fruit is sulphured to preserve the color. The sulphur treatment is given after the fruit has been dipped and spread on the trays. The fruit is left in the sulphuring chamber only 15 to 20 minutes and is then at once transferred to the drier.

SMALL FRUITS.

The small fruits are evaporated or dried to a limited extent only, with the exception of the Logan blackberry, which is a commercial factor in the fruit industry of the Pacific coast, and black raspberries, which are dried on a more or less extensive scale, principally in New York. Other small fruits, such as red raspberries, blackberries, strawberries, and blueberries, and perhaps still others, are dried sometimes for home use, but they are rarely seen in the market. These fruits may be dried by essentially the same methods as the more important ones above mentioned. These methods are briefly described here.

BLACK RASPBERRIES.

In some sections, the kiln type of evaporator is largely used in drying raspberries. The ones built in recent years have been constructed in general according to the plans described and illustrated in the first part of this bulletin, but the older evaporators do not have the hopper above the furnace. Evaporators of the tunnel and other types are also used, in which the fruit is handled on racks or trays with galvanized-wire netting bottoms.

Before the fruit is placed in the kiln, the floor is usually covered with muslin, burlap, or some other kind of loosely woven fabric, for the purpose of preventing the fruit from dropping through the spaces between the strips of which the floor is made, or sometimes galvanized-wire netting with $\frac{1}{8}$-inch mesh is used instead of a fabric.

As with all other fruits, raspberries for drying should be fully ripe. Much of the fruit is harvested by batting—a method whereby a wire hook is used to draw the canes into the desired position, allowing them to be lightly beaten with a wooden paddle which knocks the fruit into a device so arranged as to readily catch it as it drops. An expert hand picker under favorable conditions will hardly average more than 125 quarts a day, while in harvesting by the batting method $7\frac{1}{2}$ or 8 bushels is a fair average.

The manner of operating an evaporator in which raspberries are being dried is substantially the same as when other fruits are being handled. Where an evaporator of the kiln type is used, the fruit is spread on the floor from 4 to 5 or 6 inches deep, depending largely on the variety. Firm berries, such as the Ohio, can be placed considerably deeper than the softer, more juicy sorts, such as the Farmer. Where evaporators other than those of the kiln type are used the raspberries are spread in a thin layer on the trays, a tray 3 by 4 feet in size carrying about 11 or 12 quarts of fruit. The temperature should be 135° to 140° F. at the outset of drying and may be increased to 150° to 155° F. as the fruit becomes almost dry.

As it begins to dry, the fruit passes through a soft stage, which, however, lasts for only a comparatively short time. After this stage is passed and as soon as it can be done without mashing the individual fruits, the contents of each tray should be turned over occasionally to insure as far as possible uniformity in drying. Turning may be done with a small wooden-toothed rake or wooden scoop. In the tunnel evaporator, turning is postponed until the fruit has reached the lower end of the tunnel.

The length of time required to hold the fruit in the evaporator depends upon the same general factors that determine the time for other fruits—the weather conditions, type and management of the evaporator, and the variety of the berry. Some varieties dry quicker than others under the same conditions. Then, too, first pickings of the fruit frequently contain more moisture; hence, they require a longer time in which to dry than the later ones, particularly if the end of the berry season is accompanied by a drought, as is frequently the case. Employing the temperatures here recommended, it is possible to dry berries in the tunnel evaporator in six to eight hours, the trays being spread with 1 quart of berries to the square foot. On the kiln, a layer of berries 4 to 5 inches in depth will require 10 to 12 hours.

Under some conditions, the rate of drying and consequently the length of time the fruit remains in the evaporator, is made a matter of convenience to some extent. For example, the conditions in one region where large quantities of black raspberries are dried are such that it is convenient to place the fruit which is harvested during the day on the kiln floor late in the afternoon. The furnace is at once started, running the heat at once as high as the operator thinks the fruit will stand. The fruit is turned early the next morning and again in the middle of the forenoon, and by 3 or 4 o'clock in the afternoon it is ready to go to the curing room, the heat having been allowed to subside somewhat during the latter portion of the time. Upon the removal of the fruit, the kiln is again ready for another "run" with the fruit harvested during the day. While it might be possible to dry the fruit in a shorter period of time, this program is a convenient one under some conditions.

It is estimated that a ton of hard coal will dry about a ton of berries, but the quantity varies from half a ton to 2 tons of coal to a ton of fruit, depending on the variety, condition of the fruit, and other factors.

Experience alone will enable the operator to tell with certainty when the fruit is dry enough to be removed from the evaporator. When this stage is reached, some of the fruit will be dry enough to rattle; there will also be fruits (the proportion should be very small) obviously containing too much moisture. The bulk of the fruit should be of such a texture that it will stick to the hand somewhat if squeezed tightly, while yet the individual fruits can not be forced into a mushy condition; or another test may be to carry the drying as far as possible without reaching the point where the fruit will rattle as it is handled over on the trays. The fruit is then removed from the trays and conditioned in the same manner as apples and other fruits by being placed in bulk on a smooth, clean, tight floor where it is handled over each day with a scoop or other suitable implement for a period of perhaps two or three weeks. During this time the fruit is becoming uniform throughout with regard to moisture, and the drying progresses to the point where the fruit can be stored safely without danger of spoiling.

The curing room should be an airy, well-ventilated place. The fruit, if handled in bulk, may be placed in piles from 6 to 18 inches deep. However, some advantages are claimed for the method of handling the fruit in boxes having a capacity of a bushel or so, during the period of curing. In this way the fruit can be aerated thoroughly by pouring the contents of one box into another.

The variety, condition of the fruit, and other factors influence the shrinkage in drying. It requires, on an average, a little over 3 quarts, or about 4 pounds, of black raspberries to make 1 pound of the dried product. In a rainy season it may require 4 quarts to make a pound of dried fruit, while near the end of the season, when the berries are small, 2 quarts of fresh fruit will yield a pound of the dried product. Other estimates put the shrinkage at about 2½ pounds of the Ohio variety to a pound of dried fruit, while it requires about 3½ pounds of the Farmer for 1 pound of the dried product. Four or five quarts of red raspberries are required for a pound of evaporated fruit. Red raspberries, however, are rarely dried.

LOGAN BLACKBERRIES.

The Logan blackberry is grown extensively only in the Pacific Coast States, and naturally it is in those States that particular attention has been given to the utilization of the fruit. Lewis and Brown, of the Oregon Experiment Station, have reported results of investigations in evaporating it. In that State both stack (or prune tower) and tunnel types of evaporators have been used in drying the berry, with preference for the latter, provided that the tunnels do not exceed 20 to 23 feet in length.

In drying Logan blackberries in the tunnel evaporator, the furnace should be so regulated that the air temperature at the upper end of the tunnel does not exceed 130° F., while that at the lower end does not rise above 150° or 155° F. Employing the temperatures named, the time required for drying ranges from 16 to 20 hours, varying with the weather conditions. As these berries are considerably larger and more juicy than black raspberries, it is readily understood why they do not dry as quickly as the latter.

The manner in which Logan blackberries are handled will affect the weight of the dried product, but on an average 1 pound of dried fruit is made from 4½ to 5½ pounds of fresh fruit.

It is advised to remove the fruit from the evaporator while it is still hot; otherwise the berries will stick to the trays. When cool the fruit is transferred to the conditioning room and stirred daily for 10 days to 3 weeks, after which it may be stored in bulk in the same manner as other fruits.

OTHER SMALL FRUITS.

Strawberries, blackberries, blueberries, huckleberries, and other small fruits are sometimes dried in very limited quantities. No special mention of details is needed in this connection, since the methods already described for black raspberries and Logan blackberries may be used in handling other fruits of similar character.

STORING THE DRIED PRODUCTS.

In many plants the storage room is a part of the evaporator building adjacent to the conditioning room, or even continuous with it. This arrangement is permissible if it is the practice in the plant to pack and dispose of the fruit as rapidly as it is made. It is exceedingly bad practice if the run of the entire season is to be completed before packing and shipping begins or if the fruit is to be held for a favorable market after the close of the drying season. The value of the product for a season may be considerably greater than that of the building and its equipment, and the risk of loss from fire is therefore very considerable. There is also great danger of infestation of the entire stock of dry product by insects when fruit is stored adjacent to the workroom, since these pests are attracted by the drying fruit and may easily gain access to the storage room through doors carelessly left open, or through defective screens or cracks in partitions. For these reasons it is strongly advised that the storage room be located in a separate building, far enough from the evaporator to minimize the fire risk.

Whatever its location, special care should be taken in building the storage room to make floors, walls, and ceiling perfectly tight, as cracks permit entrance of insects and provide shelter for them after they have entered. While some operators make all walls double, this is not necessary if a good grade of properly seasoned matched lumber is used and due care is taken in putting it on. The windows and doors must be provided with accurately fitted screens of heavy, close-meshed mosquito screening; those of the windows should be fastened immovably in place, while those of the doors should be provided with springs to insure prompt closure. The windows should be fitted with shades made of a good grade of opaque material, and as direct sunlight causes discoloration of dried fruits, the shades should be kept down except when work in the room is actually in progress. Adequate provision for ventilation must be made. This can usually be had by partially raising windows along one side of the room while those on the opposite side are lowered from the top. If for any reason this is not possible, floor and ceiling ventilators should be provided. They should be permanently screened and fitted with tightly closing doors, in order that the room may be made practically air-tight when it is necessary to fumigate it. Sudden and extreme changes of temperature and humidity, either upward or downward, should be guarded against by closing the ventilating openings tightly for a sufficient time to permit the room temperature slowly to adjust itself to the changed conditions outside. If the fruit has been sufficiently dried and properly conditioned before being brought into the storage room, such fluctuations of atmospheric humidity and temperature as will occur in the storage room in the course of 3 to 12 months will not noticeably affect it. The fruit at the surface of the mass, if properly cured, will slowly take up moisture during prolonged periods of rainy weather, but will lose the added moisture when dry weather again sets in, the greater part of the mass remaining unaffected.

The room should be provided with a sufficient number of bins to make it possible to store the different varieties and grades of dried stock separately. If the room can be made of sufficient size to permit the work of packing to be done inside it and to allow the storing of the packed boxes until the fruit is finally sold, it will be highly advantageous, as much of the insect infestation of dried fruits is due to exposure of the boxes after they have been packed.

PREPARING EVAPORATED FRUITS FOR MARKET.

While the packing of dried fruits for the trade is conducted largely as a business which is distinct from evaporating or drying and a large proportion of the product passes out of the hands of the operator before it is packed for shipment, it should help the one who makes the product to know in a general way how it is handled by the packer. Some of the methods in use are here briefly described.

PACKING EVAPORATED APPLES.

GRADING.

In handling evaporated apples, three grades are generally recognized, which are commonly designated as "fancy," "choice," and "prime." Two other grades, which in reality are special grades, are also sometimes recognized, viz. "extra fancy," and a lower grade than prime—usually called prime with some distinguishing prefix, frequently the name of a locality.

The standards demanded for these various grades are about as follows:

"Fancy" is a very white, clean stock, free from all pieces of skin and other objectionable portions which should be removed in trimming, and with a good proportion of the slices in rings.

"Choice" denotes a grade intermediate between "fancy" and "prime," not quite clean enough for "fancy," yet more nearly free from imperfections than the "prime" grade demands.

"Prime" must be a good stock, well cured, and of a generally attractive appearance. It must be comparatively white and mostly free from undesirable portions, but stock having a small percentage of such defects is usually put in this grade.

"Extra fancy," as the name implies, is a fancy grade that is exceptionally fine. It must possess all the qualities mentioned in describing that grade in a marked degree. At least 85 per cent of the slices should be rings.

So-called "facing stock" is obtained by selecting perfect rings of large size and perfect color from extra-fancy stock.

The grade below "prime" is the stock that has been so carelessly handled and is so unattractive in appearance that it can not maintain the standard of "prime." It is packed for an entirely different and much poorer class of trade than any of the other grades.

METHODS OF PACKING.

Evaporated apples are in suitable condition to pack when they have passed through the curing period and the individual pieces have all acquired a uniform degree of moisture.

The package largely used in marketing evaporated applies is a wooden box which holds 50 pounds of fruit when the contents are firmly pressed into it. Pasteboard cartons, holding 1 pound, or half a kilo (1.1 pounds) for certain export trade, are also more or less used.

In packing, the side of the box intended for the top or face is packed first, as in packing fresh fruit in boxes or barrels. The first step in packing, therefore, is to face this side.[9] The facers are slices which are perfect rings. These are usually selected from a quantity of fruit which contains a relatively large proportion of them; they are then placed on thin boards which are slightly smaller than the top of the box, inside measure, overlapping one another in rows, lengthwise of the board. Figure 16 shows such a board of facers. The facers are put in place by inserting the board on which they are arranged into the box, which is first lined with paraffin paper, and then with a dexterous movement of the hand flipping the layer of rings against the inner face, or the bottom, which is to become the top of the box.

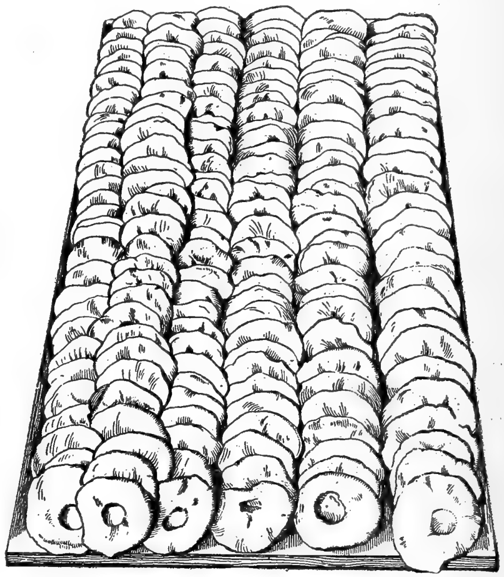

FIG. 16.—A "board" of facers.

After facing, the box is filled by placing over it a bottomless box provided with cleats to hold it in place, setting the whole on the scales, and filling loosely with fruit to the required weight. The box is then transferred to the platform of a box press, and the fruit is forced down until the upper box can be lifted off and the bottom nailed on. The cartons usually are filled by hand. Figures 17 and 18 show 50-pound boxes of dried apples as they appear upon being opened.

Experiments have shown that lining the boxes completely with double layers of paraffin paper, the sheets being so placed that the joints in the first layer are covered by the second, greatly reduces the danger of insect infestation by making it impossible for moths to gain access to the fruit after it is packed. As the cost of such lining is slight, it should come into more general use than is the case at present.

PACKING PEACHES, APRICOTS, AND PEARS.

Dried peaches, apricots, and pears are usually packed in wooden boxes holding 25 pounds. They are packed, as a rule, without any special attention to grading. The package is faced, in effect, much the same as described above in packing evaporated apples, though the pieces are placed by hand rather than by a facing board.

If they have been well dried and contain the proper amount of moisture, the pieces are pliable when they are ready to come from the curing room where the moisture has become uniform throughout

[9] During the war period the practice of facing packages of evaporated fruit was discontinued, but it has now been generally resumed, at least for the better grades of fruit.

during the curing, or sweating, process. In this condition the product may be packed for the trade without further treatment.

However, if the fruit has become so dry that the individual pieces are not pliable, they will not pack well in the boxes. To put the fruit in good condition to pack it may be treated in several different ways with the end in view of making it pliable so that it will compress readily into the boxes.

The method most commonly employed in the past consists of dipping the fruit in water long enough to moisten the outside. The water used may be cold, tepid, or in some cases it is used boiling hot. Sometimes a little salt is added. The fruit is then spread 2 or 3 inches deep on trays and lightly sulphured, after which it is dried slightly before packing if considered necessary. It is sufficient, commonly, to permit the fruit to remain in a dark room for 24 hours after dipping if it has not absorbed too much water in the dipping. This treatment usually softens the fruit enough to make it pack well and is said also to prevent the development of any insect larvæ or eggs or of fungous diseases with which the fruit may have become infected while in the curing room.

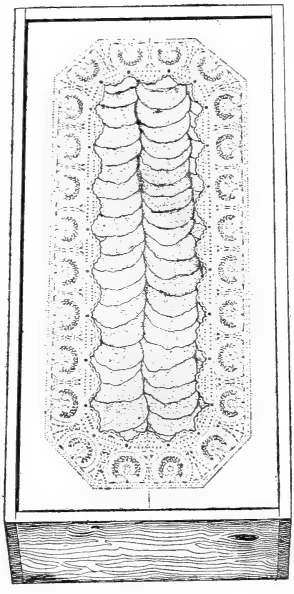

FIG. 17.—A 50-pound box of "fancy" evaporated apples with cover removed.

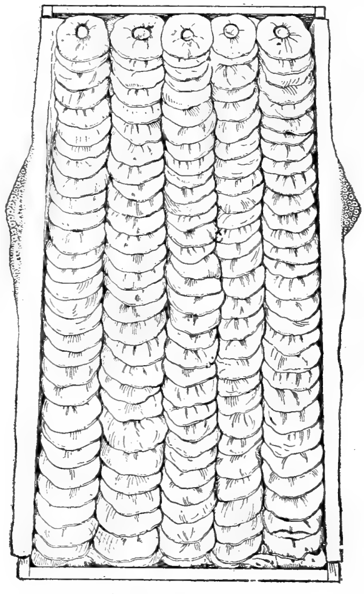

FIG. 18.—A 50-pound box of "fancy" evaporated apples with cover and paper lace removed.

A good deal of care needs to be exercised in sulphuring the fruit at this time—just before it is packed. It is claimed that most of the complaints which have been made in regard to the sulphuring of these fruits are due to excessive treatment just before they are packed rather than to that which they receive before they are dried, and it is clear that an excessive treatment with sulphur has often been employed to prevent fermentation in fruit to which large quantities of water have been added by soaking prior to packing.

Experimental data obtained in the laboratories of the Bureau of Plant Industry indicate that treatment of the fruit with live, dry steam in preparation for packing is in every way preferable to dipping in water. The fruit is loosely spread on trays to a depth of 2 or 3 inches, the trays are inserted into a tight box built like an ordinary sulphuring box, and steam is turned in through a perforated pipe at the bottom of the box. A treatment of 2 to 4 minutes will raise the temperature of the fruit to 180° F., which will destroy any insect larvæ or eggs which might be present and will at the same time render the fruit sufficiently pliable to permit it to be readily packed. The absorption of moisture is very slight, less than one-half of 1 per cent, and as the steaming itself sterilizes the product, sulphuring is neither necessary nor desirable.

PACKING PRUNES.

As in the case of other fruits, the packing of prunes should not be begun until the fruit has remained in the conditioning room, with frequent stirring, for 2 or 3 weeks.

Prunes are graded as to size before they are packed, the different grades being designated as 30's to 40's, 50's to 60's, 90's to 100's, etc., the figures indicating the approximate number of fruits in a pound; thus "40's to 50's" means a grade in which 40 to 50 fruits average a pound in weight.

In packing, the boxes are faced as in the case of other dried and evaporated fruits. The fruit is prepared for packing in various ways, all of which have the same objects in view, which are the softening of the individual fruits so they will pack well when compressed, the improvement of the appearance of the fruit, and the guarding against the development of insects.

The fruit is softened by dipping in solutions variously made up according to the preferences of individual packers. Some use a solution made by dissolving common salt in water at the rate of 1 pound to 20 gallons; glycerin, 1 pound to 25 gallons, is also used; many operators employ a solution containing 1 pound of glycerin and 8 ounces to 1 pound of salt in 30 gallons of water.

The salt solution is cleansing and leaves the skin bright and attractive. The glycerin gives a gloss to the skin. The solution is usually kept hot while dipping is in progress and should preferably be kept at the boiling point. The fruit should remain in the solution only long enough to become heated sufficiently to make it pliable enough to pack.

In one method of dipping, the fruit is passed through a revolving cylinder processor placed in a horizontal position and in the bottom of which the dipping solution is carried. The interior of the cylinder is so constructed that as it revolves it carries the prunes around with it. Thus they are in the solution only a portion of the time required to pass the length of the cylinder, which occupies but a very few minutes. Steam is constantly passed into the cylinder, so that when the fruit is not in the solution it is in a hot steam bath. Passing out of this apparatus, the fruit is placed for a short time where the surplus moisture drains away, and the fruit is then packed, commonly while still hot.

The dipping and heating of the fruit not only softens it so that it packs well, but it destroys any organisms with which the fruit may have become infected in the curing room.

LAWS RELATING TO EVAPORATED AND DRIED FRUITS.

Food Inspection Decision 176, issued by authority of the Secretary of Agriculture on May 28, 1918, contains a definition and standard for evaporated apples, approved by the joint committee on definitions and standards, which is as follows:

> Evaporated apples are evaporated fruit made from peeled, cored, and sliced apples and contain not more than 24 per cent of moisture as determined by the official method of the Association of Official Agricultural Chemists.

As this decision is adopted as a guide in the enforcement of the food and drugs act, it takes precedence over the earlier standard of not more than 27 per cent of moisture, and evaporated apples will be considered as "adulterated," if found to contain more than 24 per cent. The official method of determination of moisture content above referred to consists in drying a sample of the material to constant weight in a current of hydrogen or in a vacuum oven.

The pure food laws of many States also apply in regard to the presence of sulphurous acid, sulphites, or other perservatives in food products. In addition, most of the food laws contain definitions of adulteration which include a statement regarding the presence of a filthy, decomposed, or putrid vegetable substance.

A California statute, approved March 20, 1903, requires that all fruit, green or dried, contained in boxes, barrels, or packages, and offered for shipment in the State, be so labeled as to designate the county and immediate locality in which the fruit was grown, but a decision of the supreme court of the State declares this law to be unconstitutional.

The Board of Food and Drug Inspection under the pure-food law enacted at the first session of the Fifty-ninth Congress relative to the quantity of sulphur dioxid permissible in evaporated or desiccated fruits ruled under date of March 5, 1908, in food-inspection decision 89, amending decision 76, that—

> No objection will be made to foods which contain the ordinary quantities of sulphur dioxid, if the fact that such foods have been so prepared is plainly stated upon the label of each package.
>
> An abnormal quantity of sulphur dioxid placed in food for the purpose of marketing an excessive moisture content will be regarded as fraudulent adulteration, under the food and drugs act of June 30, 1906.

The attention of all interested persons, especially exporters, should further be called to the fact that "the Governments of Prussia and Saxony, in order to unify the practices of inspectors of desiccated fruits, have issued decrees fixing the limit of sulphurous acid in desiccated fruits at 0.125 per cent." [10]

The presence of sulphurous acid in desiccated fruits, and also of zinc in fruit dried on galvanized-wire racks, has frequently been criticized in foreign markets and has been the source of unfavorable judgment, resulting in more or less agitation favoring laws restricting or prohibiting the sale of such fruit.

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[10] Notice to exporters of desiccated fruits. (Food Inspection Decision 7.) *In* U. S. Dept. Agr., Bur. Chem., Food Inspection Decisions 1 to 25, p. 17. 1916.

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