U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1264
Rev. Mar. 1938

FARM MANUFACTURE of UNFERMENTED APPLE JUICE

UNFERMENTED APPLE JUICE, or sweet cider, is our most popular and least expensive beverage juice, and its manufacture on a small scale is a very widely distributed farm industry. It is now very largely a seasonal product, made and consumed during the period in which apples are plentiful, and practically unobtainable for the remainder of the year.

General understanding on the part of apple growers of proper methods for pasteurizing and preserving this juice would increase the production and use of sweet cider, thus offering greater opportunities for the profitable utilization of surplus and unmarketable apples, and providing a wholesome and refreshing beverage, already known to consumers, available for use at all seasons of the year.

In order that sweet cider made and preserved on the farm may become a staple product salable at a profit, increased attention must be given to selecting the fruit with reference to its maturity and suitability, and particularly to mixing or blending varieties in order to produce well-balanced, palatable juices of pleasing character.

Two methods for the preservation of the juice either on a small scale for home use or on a larger scale are discussed, and full directions are given for each step in the processes of pressing, sedimenting or clarifying, packing into final containers, and pasteurizing. The selection of equipment, its operation, and the care of the plant are also considered.

The purpose of this bulletin is to supply a fairly complete handbook which will enable any intelligent fruit grower without previous experience in cider making to produce an acceptable sanitary product of good quality.

Washington, D. C.

Issued May 1922
Revised November 1928
Slightly revised March 1938

FARM MANUFACTURE OF UNFERMENTED APPLE JUICE

By JOSEPH S. CALDWELL, *senior physiologist, Bureau of Plant Industry Division of Fruit and Vegetable Crops and Diseases*

CONTENTS

PRODUCTION AND USES OF SWEET CIDER

UNFERMENTED APPLE JUICE, or sweet cider, may justly be called the great American beverage. It is more generally popular and is made and consumed in much greater quantities than any other beverage juice. As the making of cider is regarded by fruit growers as the surest means of securing an outlet for surplus fruit, it is a very widely distributed farm industry, the total production fluctuating greatly from year to year with variations in size of the apple crop. In 1919 the production of cider on farms reported in the census was 13,365,805 gallons, with an additional 6,470,060 gallons converted into vinegar. The widespread character of cider making as a farm industry and its safety-valve relationship to the growing of fruit are indicated by the fact that this total production was reported from 216,617 separate farms, representing every State in the Union. For the same year the total value of cider and vinegar manufactured in commercial plants was $24,772,610. Comparable figures for production in more recent years are not available, either for farms or for commercial plants, but it seems probable that there has been a considerable increase in total production of cider on farms and in custom mills as well as in commercial plants.

While cider is in strong demand for use in the making of apple butter, jelly, and various minor products, the chief purpose for which it is employed is as a beverage. There are few individuals to whom good cider does not appeal, and the fact that apples are so widely grown in the United States should make it possible for consumers to obtain supplies irrespective of their location.

Unfortunately, this is not the case. Sweet cider is very largely a seasonal product, made only during the period immediately following the apple harvest and usually consumed within a few days. After the close of the pressing season it disappears from the market and is practically unobtainable except for the small quantities sold by the glass through soda fountains and drug stores. As a consequence, there is a large consumption of synthetic soft drinks in apple-growing districts and even in the families of apple growers.

The reason for this situation is that only comparatively few small-scale producers of apple juice practice the pasteurizing of their product, so as to make it available for use in a sweet condition at any season of the year. Either through ignorance of the methods to be employed in pasteurization or a misapprehension as to the difficulty and expense of the process, large quantities of apple juice are yearly allowed to ferment and ultimately to become vinegar, while its place as a beverage is taken by synthetic soft drinks. From an economic point of view it is a serious matter that large quantities of apples that might be converted into a wholesome, refreshing beverage available at all seasons are allowed to go wholly to waste.

The process of preserving unfermented apple juice is in reality very simple, as easily mastered as that of canning fruits and requiring no more special equipment. As in canning, success depends upon the strict observation of a few simple rules. In the following pages these rules are stated, with the reasons for them, together with considerable additional matter designed to aid the cider maker in producing the best possible product from the materials at hand.

USE OF TERMS

There is some confusion in the use of the terms applied to unfermented apple juice. The term "cider" has been in the past applied to the juice both before and after fermentation, usually with "sweet" or "hard" prefixed to indicate whether fermentation has not or has occurred, but the single word "cider" is also widely used for the unfermented juice. In England and France "apple must" and "apple juice" are terms used to designate the freshly pressed sweet juice, while the word "cider" used alone refers to a fermented product, our "hard cider." "Unfermented apple juice" has the merit that its meaning is unmistakable, but it is too long and clumsy for constant repetition. As this publication has nothing to do with fermented or "hard" cider, the terms "unfermented apple juice," "apple must," "apple juice," and "cider" are used interchangeably for apple juice in which the alcohol content is not more than 0.5 per cent.

USE OF CHEMICAL PRESERVATIVES

Many persons unfortunately have the erroneous idea that it is practically impossible to preserve apple juice merely by the use of heat and sealing, without the addition of some chemical substance to act as a preservative. This notion is entirely incorrect. Various chemical preservatives have been more or less used to prevent fermentation. Among these are salicylic acid, formic acid, benzoic acid, boric acid, sulphurous acid, and various compounds which upon being

added to the juice are decomposed to set free some one of these substances.

The Food, Drug, and Insecticide Administration, which is charged with the enforcement of the Federal food and drugs act, does not encourage the use of preservatives in food. However, under the terms of the act, sulphur dioxide and benzoate of soda are permitted in cider and other food under certain conditions. Sulphur dioxide may be employed in ordinary quantities if its presence is declared on the label, and benzoate of soda may be used if its presence and the amount are declared on the label. Many preservatives, such as salicylic acid, boric acid, and formaldehyde, are harmful, and cider or other food containing any of them is adulterated and, consequently, illegal under the act, even if their presence is declared on the label. Cider that is not shipped beyond the boundaries of the State in which it is manufactured does not come within the scope of the act but is, of course, subject to all regulations of the State in which it is made and sold.

It should be clearly understood that the use of any preservative in fruit juices is entirely unnecessary if the juice is properly pasteurized and sealed and that there is no preservative which when used in quantities permitted by the law or with ordinary regard to the health of the user will prevent fermentation in juices that have not been pasteurized and sealed or that are opened to the air after pasteurization and sealing. No chemical preservative of any character should be used, since its use is in any case either entirely ineffective or wholly unnecessary. Intelligent employment of the methods to be subsequently described will enable anyone to preserve fruit juices with an extremely small percentage of loss from infection with organisms producing fermentation.

ARRANGEMENT AND EQUIPMENT OF THE CIDER PLANT

The equipment used in cider making will vary so widely with the scale of operations and the purpose, home use or commercial sale, that such suggestions regarding its arrangement as are made must necessarily be of the most general character. Their objects are the securing of cleanliness and the elimination of unnecessary labor.

If only small quantities of cider are being made with a portable hand-operated press, the grinding and pressing may very well be done in the open near the kitchen door and the remainder of the work in the kitchen. If cider is being made at various times during the season, even in small quantities and with a portable mill, a definite place under a roof is a necessity, in order that the work may go on regardless of the weather. In choosing a place cleanliness is the first consideration, to which even convenience should be secondary.

If the room chosen must be used for other purposes than the making of cider, it should be kept clear of stationary bins and anything that will prevent the thorough cleaning of the equipment, walls, and floor. It should not be a part of the general storage room for fruits and vegetables, as such a room is heavily seeded with yeasts and spores of fungi, and juice pressed in it is extremely likely to become infected. A cement floor is preferable; if the floor is of wood it

should be tight and should be oiled to keep down dust. The walls and ceiling should be of such a nature that they can easily be kept clean, and there should be sufficient windows to give an abundance of daylight illumination in every part of the room. All doors and windows should be provided with properly fitting small-mesh screens to keep out insects.

The arrangement of the equipment should be determined by convenience and with the idea of eliminating unnecessary labor and repeated handling of the material. Even in the smallest plant a surprising saving of time and labor can be made by arranging the equipment so that the material moves through the various steps of the process in a straight line without returning upon itself or being carried back and forth across the room. The tank in which apples are washed should be placed just inside the door through which the apples are received, in order that they may be dumped directly into it and the empty crates stacked outside, thus keeping the room clear. The press should be near the washing tank, in order that washed fruit may be lifted from the tank directly into the hopper of a hand press or the elevator of a power-driven press. The barrels or tanks in which the freshly pressed juice is placed should stand on the opposite side of the press from the washing tank and within convenient reach, with an extra barrel or tank beside them for use in blending. If filtering, placing in containers, and pasteurizing are carried on in the same room, the arrangement of the equipment ought to follow the same plan, making it unnecessary to move the juice more than a foot or two in order to begin the next stage of its treatment. Such an arrangement minimizes the labor necessary and eliminates the delay and confusion that would result if workmen were moving fruit and juice back and forth across the room. It also makes it possible to prevent delays in handling the juice by making it easy to assign to each person a definite part of the work and to hold him responsible therefor.

CLEANLINESS

An abundant water supply is a necessity if the plant is to be kept in a clean, sanitary condition. The fruit brought into the plant carries with it great numbers of yeasts and decay-producing organisms, which become scattered over walls, floor, and apparatus. Every decaying apple, puddle of spilled juice, or fragment of pomace allowed to remain neglected in a corner furnishes food material in which such organisms may multiply. Press cloths, pails, and barrels that are allowed to remain wet with juice from day to day also become fruitful fields for the growth of such organisms, as do fragments of pomace adhering to the crusher or press. Many of these fungi, if left to grow undisturbed for a short time, form reproductive bodies, or spores, which become scattered everywhere in the room, with the result that many of them find their way into the juice. As the spores of many fungi are highly resistant to heat, they escape destruction during pasteurization and subsequently germinate and grow in the juice in the containers. While a few of the common molds are harmless, in that they merely consume sugar without producing substances having a disagreeable odor or flavor, many others utterly ruin any

juice in which they grow by producing disagreeable flavors. The loss of juice through infection with the spores of these fungi can be avoided only by the most thorough cleanliness. This is impossible when the room in which the work is done is also a storage place for fruit, empty crates and barrels, juice containers, and similar material. Fruit should be brought into the room only as it is worked up, and the crates or boxes in which it is brought in should be at once removed and the room generally kept clear of everything not actually in use, in order that all parts of it may be thoroughly cleaned. Pressed pomace, if not used at once for making apple butter or jelly, should be removed and stored elsewhere and never allowed to accumulate for more than a day.

All containers in which juice is temporarily stored should be provided with covers, preferably large squares of closely woven cloth, which may be washed when they become soiled or wetted with juice. Juice should never be allowed to stand in uncovered vessels, as infection with yeasts and mold spores from the air is certain to occur.

At the close of each day's work all the equipment should be thoroughly washed. A supply of water under pressure is a great aid, but merely washing off with a hose is not sufficient and must be supplemented by handwork. The apple grater always retains a mass of crushed fruit, and the pomace chute is lined with a layer of adhering material. In order to remove this, the hopper and pomace chute should be removed and washed in a tank of water and the grater cleaned by pouring water through it while it is running. The press and racks also should be thoroughly cleaned and the press bed and cider tank flushed out with plenty of water. The press cloths need special attention; they should not only be washed daily in cold water to wash out the juice and remove adhering pomace, but should also be placed in boiling water for a short time, to destroy any organisms present. Vessels in which juice is stored for settling should also be washed out every time they are emptied. If a filter, milk separator, or centrifuge is used, it must be taken apart and washed thoroughly. Lastly, the floor should be flushed with a sufficient quantity of water to carry off all spilled juice and bits of pomace and leave it thoroughly clean. Cold water used in abundance will suffice for the daily cleaning, but at least twice a week everything should be thoroughly cleaned with hot soapsuds, followed by rinsing with clear water.

SELECTION OF THE FRUIT

The necessity of employing intelligence and care in the selection of the fruit can not be overemphasized, for the quality of the product is largely determined by the fruit used. It is, of course, possible to make poor cider from the finest fruit by lack of cleanliness and the use of improper methods, but the most nearly perfect equipment and scrupulous care while employing the best methods will not enable one to make high-grade cider from poor raw material.

MATURITY

The first essential in the making of cider of high quality is that only fully matured, tree-ripe, perfectly sound fruit be used. An apple is in ideal condition for making into cider—that is, is "cider

ripe"—when about midway between "market ripe" and "dessert ripe," having attained full size and color and developed the flavor and odor characteristic of the variety. Such fruit has begun to soften very slightly, but is still too firm for eating out of hand.

If the cider maker is working up the product of his own orchard and can control the time at which the fruit is picked, the portion intended for cider making should be allowed to remain on the trees until fully mature. In most cases, however, the making of cider is incident to the primary business of growing apples for the market, and the material used is obtained by the grading out of the small, superficially blemished, or otherwise unmarketable fruit from the general crop as picked for market. Such fruit, though market ripe, is not sufficiently mature to produce an unfermented juice of the highest grade, and the quality and palatability of the product can be greatly improved by holding the fruit under proper conditions for two or three weeks, until it becomes "cider ripe."

If cull apples sorted out of fruit picked for the market are being used, or if necessity compels the harvesting of the crop before full maturity is reached, the quality of the product will be markedly improved by ripening or "sweating" the apples before they are pressed. This is best done by laying a false floor over the floor of a dry airy room or roofed shed by placing loose boards on pieces of 2 by 4 inch stuff to raise them above the floor and piling the fruit on the boards to a depth not greater than 3 feet. None but perfectly sound fruit should be placed in the piles, and the false floor should never be omitted, as it permits the circulation of air beneath the fruit. The fruit may remain in the piles for two to four weeks in good weather with advantage to the quality of the cider, but should be worked up before it has attained the degree of softness characteristic of prime condition for eating.

This treatment is very different from the too general practice of piling low-grade and partially decayed fruit in heaps on the ground in the orchard and allowing it to remain there until it can be worked up at leisure. Such treatment can only result in the loss of fruit and the making of an indifferent product. Rains spread the organisims of decay through the pile, and the fruit next the ground becomes covered with dirt and takes on earthy, foreign flavors from contact with the soil, with the result that the juice is poor in quality and flavor and difficult to sterilize. This slovenly and economically unsound method of handling fruit must be avoided by every cider maker who is ambitious to make a high-grade product.

Considerable quantities of windfall apples are made into cider, especially in those districts which are subject to heavy winds before or at the beginning of the picking season. Whether the practice is to be permitted or condemned depends in any particular case upon the degree of maturity which has been attained before the fruit falls from the tree. If the fruit is mature enough to be stored and ripened in the manner described it may yield an acceptable cider if so treated, especially if it be blended in grinding with larger quantities of more mature fruit. Partially grown, odorless, flavorless early windfalls in which the starch has not yet been converted into sugar are worthless for cider making and should never be used, as a small quantity of the tart, astringent juice will ruin a large volume of high-grade cider.

STORAGE OF FRUIT INTENDED FOR CIDER MAKING

It is readily possible to prolong the cider-making season over several months after the close of picking if provision is made for proper storage of the fruit. The factors which govern the keeping quality of cider fruit in either common or cold storage are identical with those governing the keeping of marketable fruit of the same varieties. There is the same necessity for the exercise of care in picking and handling the fruit, in cooling the fruit rapidly to storage temperature to check the ripening process, and in maintaining control of temperature and humidity in the storage house after it is filled with fruit. Also, there is the same necessity for a close watch upon the progress of ripening in the fruit, in order that overripening may not be permitted to occur.

When fruit is to be stored for subsequent pressing, the ripening or "sweating" treatment discussed in the preceding section should be omitted, and the fruit, after sorting over to remove decayed apples, should be placed at once in the storage room in field or lug boxes, so stacked as to permit free circulation of air. In so far as possible, varieties should be kept separate, and the storage behavior of the different varieties should be kept in mind as the house is filled, in order that short-lived varieties may be removed as they become ready for pressing without disturbing the others.

The apples may be removed for pressing as they reach the proper degree of maturity, or may be ripened as needed by removing them from the storage house to a warm room.

The cider maker who provides facilities for storing his fruit thereby gains a number of advantages. He is enabled to postpone the work until after the close of the picking and packing season, when labor is more readily obtained. He can secure fruit culled out in the course of packing, which is usually of better grade than orchard culls. The postponement of the work until cool weather decreases danger of loss of juice by fermentation during sedimentation. A very decided advantage is gained, if juice is being marketed fresh from the press, in that the product is placed on the market after other makers have ceased to operate and consequently finds increased demand at better prices.

SOUNDNESS

In districts which have a heavy infestation of bitter rot or the various soft rots, large quantities of specked and partially decayed fruit, unmarketable for other purposes, are used for making cider and vinegar. That the general quality of these products suffers as a result of this practice is beyond question. Anyone who attempts to make a first-class beverage by pressing partially rotten fruit is undertaking the impossible. It is possible, however, to make a fair product by working over specked fruit by hand, using a knife to remove every particle of decayed material together with a surrounding zone of sound flesh and washing the trimmed fruit very thoroughly to remove adhering bits of decayed material. Whether the labor involved is justified must be determined in any particular case by the available supplies and comparative costs of specked and sound fruit, the cost of labor, and other factors.

213158°—40——2

SUMMER AND WINTER VARIETIES

The manufacturer who operates in a small way will necessarily be limited in his choice of varieties of apples to use to those grown in his orchard or in the immediate vicinity. In most districts, however, a sufficient range of varieties is available to make possible some degree of selection. This selection is indispensable to the making of a high-grade beverage, for, while any apple which makes good cider has good dessert quality, it is by no means the case that all apples which are good for eating out of hand will make palatable, full-flavored cider.

Broadly speaking, the early-maturing or summer varieties of apples are not good material for making high-grade ciders. As a class they are characterized, as compared with the later-maturing varieties, by a low sugar content, relatively high malic-acid content, and fairly large amounts of tannin. Such fruit yields juices which are tart and astringent, with a bitter aftertaste that makes them unpleasant to most palates. Most of the early-maturing "sweet" varieties are so called for the reason that while they have little, if any, more sugar than others of their season, they are much lower in acid. Their juices are consequently insipid and lacking in the tartness desired by most people. For these reasons none of the summer varieties used alone will yield juice which comes up in palatibility and flavor to the standards set by discriminating users. The cider maker who is restricted to early varieties must resort to the mixing of two or three unlike varieties in order to obtain a product in which the proportions of sugar and acid are well balanced; and at best his product will be low in sugar content and lacking in what cider makers call "body." The cider maker who is free to choose between summer and winter varieties would do well to use the summer varieties for apple butters, marmalades, and similar products, employing his winter varieties in cider making, for the sake of the better flavor, higher sugar content, and greater food value of the product.

BLENDING

Blending or mixing the juice of two or more varieties is indispensable in the making of first-quality unfermented apple juice. To be acceptable to the user, a fruit beverage in addition to having the aroma and flavor characteristic of the fruit from which it is made must have the three constituents, sugar, tannin, and acid, present in amounts which bear a rather definite ratio one to another. The absolute quantities of these constituents may vary within wide limits without affecting the palatability of the product, provided the ratio they bear to one another is maintained. Very few apple or grape juices have these constituents present in such balanced proportions as to make the strongest appeal to the consumer; Concord grape juice and Winesap apple juice are among the few exceptional juices which would not be considerably improved for most palates by modification of either the acidity or the sugar content. If the tannin content of a juice is high in relation to its sugar and acid, as in many crab apples, the juices will be harsh and astringent; if the acidity is high, as in Oldenburg (*Duchess of Oldenburg*), Kentucky Red,

Okabena, Monmouth, Red Canada, and Milam varieties, the juice will be sour; while if the sugar content is high in relation to the other constituents, as in the Tolman Sweet (*Tolman*), McIntosh, Grimes Golden (*Grimes*), Delicious, and the so-called "sweet" apples, the juice will be more or less insipid and lacking in sprightliness. Moreover, apple varieties differ greatly in the amount of characteristic apple flavor possessed by their juices. Such ciders as are made from the Ben Davis, Collins, Northwestern Greening (*Northwestern*), and Alexander varieties may give very little suggestion that they were made from apples, while the juices of Roxbury Russet (*Roxbury*), Black Gilliflower, Northern Spy, and Ribston apples possess an agreeable aroma and a rich fruity flavor, even though some of them are deficient in other respects, which almost invariably find favor on the part of consumers.

For these reasons the maker who desires to turn out a high-grade product must devote considerable thought to the selection and blending of his material. The number of apple varieties in cultivation is so large and the various apple-growing districts differ so greatly in the kinds grown that the working out of a mixture of varieties that will yield a properly balanced well-flavored juice must be in each case a matter of experiment with the materials at hand. In such experimentation a few general principles will be of much greater value than any number of specific examples. In order to state such principles it is necessary to make a rough classification of apples into groups on the basis of their outstanding characters as cider material. In the classification here attempted the basis employed is the character of the fruit when in proper condition for making into cider, which differs considerably from the character displayed when it has attained prime eating condition.

(1) **Sweet-subacid group.**—Most of our widely distributed and popular varieties of apples are grown primarily for dessert use; hence they conform more or less closely to the ideal of an apple to be eaten out of hand. Consumers demand that an eating apple shall be free from astringency and neither distinctly sour nor markedly sweet, and in consequence the larger number of popular dessert varieties are in a group that ranges from very mildly subacid to subacid. Examples are the Baldwin, Esopus Spitzenburg (*Esopus*), Hubbardston, Fameuse, McIntosh, Northwestern Greening (*Northwestern*), Rome Beauty, and Stark. These apples and others of the subacid class when pressed at the proper stage of maturity yield juices that are sweet and of good flavor but are somewhat lacking in the acidity and tartness that discriminating consumers demand. Since the great bulk of widely grown home-orchard varieties, as well as most of the dozen leading commercial apples, fall in the sweet-subacid group, the cider maker, regardless of his location, will usually find that apples of this group form the great bulk of the material available to him. They may furnish him three-fourths to nine-tenths of his total volume of product and are consequently the basic stock with which he works.

(2) **Mildly acid to slightly tart group.**—A smaller number of popular dessert varieties are mildly acid to slightly tart. Winesap, Jonathan, Yellow Newtown, Stayman Winesap, Northern Spy, and York Imperial are the more widely grown varieties of this type. When pressed at the proper stage of maturity these varieties yield juices that stand nearest to the ideal in single-variety unfermented beverage juices, as they then have a degree of acidity and a suggestion of astringency which give the proper balance to their sugar content, while all of them are sufficiently high in apple flavor and aroma to be pleasing in these respects. Any of these varieties may be used to make a good single-variety juice, and any one or more of them may be advantageously used for blending with the juices of varieties of the sweet-subacid group to improve the balance by increasing the acidity and adding flavor. Any one included in the list if combined with any one or more mentioned in the basic-stock list

given under the first numbered paragraph might be expected to give a blend of good balance and acceptable quality.

A number of additional varieties of the acid or slightly tart group are not prominent as commercial varieties, but are more or less widely distributed in home orchards. Among these might be mentioned Arkansas Black, Babbitt, Collins, Lawver, Missouri Pippin (*Missouri*), Rhode Island Greening, Golden Russet, Red Canada, Milam, Okabena, Kentucky Red, Twenty Ounce, Walker Beauty, Wealthy, and Yellow Bellflower. These, with some others which might be named, make up a group varying widely in flavor and generally inferior in this respect to Winesap, Jonathan, and Grimes Golden, but agreeing with these varieties in possessing juices that are moderately to decidedly acid when pressed at the proper stage. Some one or more varieties of the group are necessary in the proportion of 5 to 20 per cent of the total for blending with the larger quantities of subacid stock used.

(3) Aromatic group.—A third small group of apples is of high value to the cider maker for the reason that, while their juices are not well balanced in sugar and acid, they possess exceptional fragrance and aroma and agreeable flavor which are carried over into the cider made from them. Among these, Delicious, Golden Delicious, Lady, Black Gilliflower, White Pearmain, Winter Banana (*Banana*), Ribston, Ortley, Roxbury Russet, McIntosh, Sops of Wine, and Bonum might be named, and with them the reader may place any local variety which is notable for its spicy agreeable flavor and especially marked aroma. Apples of this character may be designated as the aromatic or flavoring group. They are of special value to the cider maker who is ambitious to make juices of the highest possible quality, as the addition of 5 to 10 per cent of such fruit to his basic stock will give his cider a distinctive flavor and aroma which will greatly increase its appeal to consumers.

(4) Astringent group.—The most difficult constituent to obtain in making high-grade ciders is tannin. To find favor with the largest number of customers a cider must have a slight astringent aftertaste or "bite" upon the tongue, such as is given by Concord grape juice. Many of the seedling apples found growing without cultivation in the New England States have a tannin content which makes them highly prized for cider making. Our generally cultivated apples are so low in their tannin content that it is very difficult or impossible to obtain the required pungency and tang in a blend made up of dessert varieties alone. It may best be obtained by the addition of a small percentage of crab apples, if these can be obtained. Florence, Hibernal, Soulard, Red Siberian, Hyslop, Transcendent, Launette, Martha, and Yellow Siberian (also known as Golden Beauty) are examples of varieties desirable for this purpose on account of high tannin content. As their juices in most cases are also rather highly acid they have a twofold value for blending. From 3 to 5 per cent of crab-apple juice, which may be so harshly astringent and highly acid that drinking it alone is quite out of the question, will give an added tang and zest to the finest juice that it is possible to produce without its use. The securing of this quality will well repay the additional trouble and labor it may cost.

In the absence of available supplies of crab apples, the cider maker must make shift to find a substitute in the material available. The use of small quantities of market-ripe fruit in the blend is suggested. Most apples are rather astringent, some of them markedly so, at the stage at which picking for market usually occurs, and the ripening period shows a progressive decline in astringency and acid content. The use of a small proportion of hard-ripe or market-ripe fruits will give zest and tang to juices which would otherwise be sweet, bland, and characterless. These additions must be made with care and must be balanced by adding fruit of the aromatic group to give aroma and flavor, which will suffer from the addition of such underripe juice.

(5) Neutral group.—A last group of apples may be mentioned, not because they can contribute any desirable quality to cider, but in order to give a warning which their mediocre character makes necessary. A considerable number of apples, of which the Ben Davis, Black Ben, Gano, Willowtwig, Missouri Pippin (*Missouri*), Alexander, Wolf River, Buckingham, and Limbertwig are examples, owe their presence in orchards to the productiveness or hardiness of the trees, the market or storage quality of the fruit, or its fitness for culinary uses, rather than to dessert quality or high flavor. Apples of this type are so numerous and so generally distributed that they will usually be available in quantity at a lower cost than choicer varieties. This fact should not lead the cider maker, if he is ambitious to make high-grade cider, to substitute them largely or wholly for the better varieties of the "basic-stock" group. The juices made

from these apples are no better, often decidedly not so good, as the fruits from which they come, being characterless and devoid of distinctive flavor even when fairly well balanced in sugar and acid content. Consequently, they make no positive contribution to the product when used in blending, and care must be taken that their addition does not "flatten out" the cider and render it flavorless and unattractive. If one is using good basic stock he may add 10 or 20 per cent of the fruit of these varieties in order to give bulk, but must be very careful to balance them by making an increased addition of apples of varieties of the acid and aromatic groups.

From the preceding suggestions and the examples given, the cider maker who is reasonably familiar with the apples that he has available or can procure should be able to assign the various varieties to the groups—sweet subacid, acid, aromatic, astringent, and neutral. In classifying his material he must be guided, of course, by its character in the cider-ripe stage, as previously pointed out. Having classified the fruit, he is ready to make up his blend. It will be necessary to do considerable experimenting with small lots and to subject the results to critical comparison and testing. In this the best results are obtained by taking the various steps in the order here outlined.

Start by mixing together a quantity of the varieties which are to serve as basic stock, using each in about the proportion it will have in the total season's crop, and press them. The juice obtained will be fairly well flavored, but will be low in acidity and will therefore appear to be somewhat too sweet. Now press a quantity of the most sharply acid varieties available. Place equal quantities of the basic-stock juice in a number of tumblers, add to the first a small quantity, say 5 per cent of its volume, of the acid juice. To the second add a slightly larger quantity, possibly 8 per cent; add 10 or 12 per cent to the third, 15 per cent to the fourth, and so on through the series. Now sample the mixtures carefully and repeatedly, taking them sometimes in regular order, sometimes in haphazard fashion. Usually the palatability of the mixture will increase with each increase in the amount of the acid juice up to a certain point, beyond which the mixture becomes too tart and falls off in its appeal to the palate. If necessary, in order to locate this point with certainty, repeat the series, making larger or smaller differences in the proportion of acid used. When this point is determined, make a note of the amount of basic stock entering into the mixture and make up a quantity of the mixture to serve as material for further experiments. Divide a portion of the juice into small lots and by adding small quantities of crab-apple or other astringent apple juice ascertain whether the mixture is improved by the addition of a juice high in tannin and determine the proportion which gives the best results in improvement of flavor. Lastly, determine in the same manner the quantity of the high-flavored aromatic varieties necessary to add to the blend in order to give the resulting mixture the maximum appeal to the nostrils and palate.

As the next step in the process, bottle and pasteurize several samples, including those that are considered somewhat too acid and astringent as well as those regarded as well balanced. After they have been pasteurized and cooled, subject them to examination by tasting. It will be found that the samples that were considered best before pasteurization now seem somewhat too sweet, while those that were tartly astringent now seem best in flavor and balance. This is due to

changes that are brought about by pasteurization. Some of the cane sugar of the juice is changed to dextrose and levulose during heating, and the mixture of these simpler sugars is slightly less sweet to the taste than the equivalent amount of cane sugar. Also, some of the tannin and astringent materials are so altered by heating that they are no longer astringent. The net result of these changes tends to make the pasteurized juice taste sweeter than the unheated sample. This very important fact must be borne in mind by the maker of pasteurized cider, who should guard against the making of an insipidly sweet product by blending his fruit to make a juice that is a little too astringent to be pleasing before it has been pasteurized.

This seems like a rather laborious process, as in fact it is, but the cider maker who works carefully over his available material in the manner outlined will be well repaid, since he will be able to make a rather uniform, properly balanced product having the maximum appeal to the consumer, in contrast to the rule-of-thumb worker to whom apples are apples and whose apple juice is consequently only juice.

When the proportions of the blend have been established by test, blending may be accomplished by mixing the apples in the desired proportions prior to grinding or by pressing them separately and combining known quantities of juice either at the time of pressing or at a later period, as convenience may determine.

SORTING AND WASHING THE FRUIT

Sorting and washing the fruit are in a sense the most important steps in the whole process of cider making, for the reason that carelessness and lack of thoroughness in carrying them out will offset the results of the most painstaking care in other details of the work. The product can be no better than the material used, and to make a good product from unclean, unsound material is an impossibility. Sorting should precede washing, and should have as its purpose the removal of all visibly decayed and specked fruit. Attempts to salvage the sound portions of such fruit are generally inadvisable. A method sometimes used, that of attempting to wash out decayed portions of the fruit by subjecting it to agitation in a tank or under strong sprays of water, is ineffective. Much decayed material is left on the fruit, and the portions that are removed are broken up and smeared over the sound fruits, with the result that the flavor of the juice is affected and a heavy load of organisms is carried into it, making it more difficult to pasteurize. If decay is only beginning, it may be possible to remove it by trimming with a knife, but if this is thoroughly and carefully done it may cost more than the material saved is worth.

The problem of washing the fruit is complicated by the increasing use of sprays containing arsenic, fluorine, and lead, usually with oil or other "sticker" added, and by the necessity for continuing spray applications until relatively late in the development of the fruit in order to obtain effective control of the codling moth. The presence of spray residues upon fruit to be used for cider makes it imperative to employ washing methods that will remove such residues as thoroughly as would be necessary were the fruit to be sent to market.

Methods that have been found effective are described in Farmers' Bulletin 1752, Spray-Residue Removal from Apples and Other Fruits, which should be consulted by those unfamiliar with such methods. If a washer of the flotation type using hydrochloric acid as the wash solution is employed, the rinsing given the fruit in the rinsing tank is usually sufficient to free it of adhering acid. If the washer is of the tank type, especial care in rinsing and frequent changes of water in the rinsing tank will be necessary to prevent the fruit from carrying dirt and spores of fungi from the tank.

Sorting and washing should immediately precede pressing, so that there will be no opportunity for the fruit to become reinfected with decay-producing fungi. When convenience demands it, the fruit for a day's run of the presses may be conveyed to a clean bin and covered with a tarpaulin to exclude dirt. From the bin it can be delivered to the crusher, but the quantity of fruit thus prepared in advance should not be greater than can be worked up within the next day or two. In such cases the bin for storage may be located on the second floor, above the press, and the apples delivered to the crusher by a chute.

GRINDING AND PRESSING THE FRUIT

Grinding and pressing are practically one continuous operation, and for this reason the equipment is usually combined into one machine, which makers and dealers speak of as a "press." A great variety of such machines, ranging in capacity from 20 bushels to several thousand bushels a day, is on the market, and the cider maker will have no difficulty in finding one of a size adapted to his needs.

BARREL PRESSES

Small machines consist of a crusher and a screw press mounted in a frame and operated by hand. The crusher of such a machine consists of two corrugated steel rollers set side by side and turning toward each other, with a third flanged roller placed above them in the base of the feed hopper. The flanges of the upper roller catch the apples and press them against a metal plate that forms one side of the hopper, splitting them into pieces, which are then forced between the parallel corrugated rollers, which complete the crushing. The efficiency of such a crusher depends upon keeping the lower rollers set very close together by means of the adjusting screws. Unless this is done large bits of fruit will pass through with the cells intact, and the yield of juice will be low. The crushed fruit drops into a "barrel" made of wooden strips fastened to iron hoops, which is placed beneath the crusher. The press consists of a heavy iron screw mounted in a frame at the opposite end of the machine. When full, the "barrel" is pushed beneath the screw, a lattice of wooden strips being placed under it, a heavy circular wooden block is put on top, and the screw is forced down by the use of a lever. A press of this type is shown in Figure 1.

This "barrel" type of press has two rather serious defects. The physical effort required to force down the screw is very considerable,

and in order to obtain a pressure sufficient to give anything approaching the possible yield of juice the full strength of two or three men is called for. In consequence the extraction is usually very imperfect and the yield low. Also the pressure must be very gradually applied, or juice will spurt through the openings between the slats of the barrel, wetting the floor and the clothing of the operators. This may be prevented in part by nailing wide boards upon either side of the frame, but there is always considerable loss of juice

FIG. 1.—Hand-power cider press equipped with a "barrel" for holding the fruit. The pressing is very imperfect and the yield of juice low, while the oozing of pomace through the "barrel" makes the work unpleasant

unless the operation is very slow. When heavy pressure is applied or when the fruit used is somewhat soft, much pulp oozes through the openings of the barrel, with the result that the juice contains pomace.

RACKS AND CLOTHS INSTEAD OF BARRELS

For these reasons it is recommended that users of the barrel type of press discard the barrels and replace them by racks and cloths. (Fig. 2.) The quantity handled at a single pressing will be considerably increased, a better extraction of juice will be obtained in a

shorter time, and losses caused by the juice spurting through the barrel and difficulty due to the presence of pulp in the juice will be avoided. To make the change it is only necessary to make up 10 to 12 square wooden racks of such size that they will fit loosely into the bed of the press. (Fig. 3.) Each rack is made of hardwood strips, seven-eighths or 1 inch wide and five-sixteenths to one-half inch thick, cut to the proper length. Lay the strips on a floor, parallel and about one-half inch apart. Lay upon them at right angles a second set, equally spaced, and fasten them together with wire nails

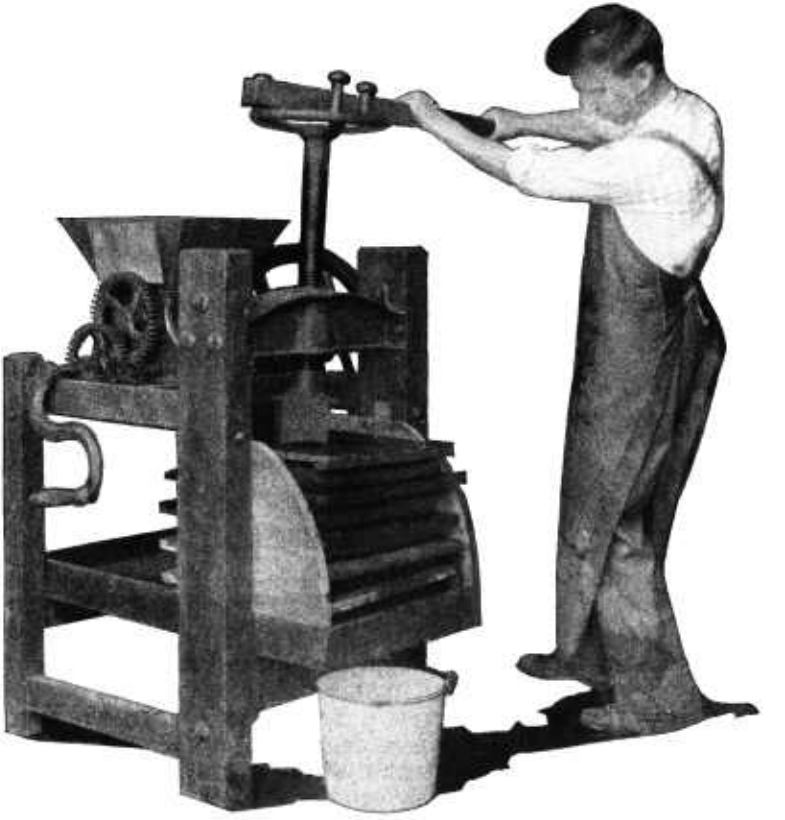

FIG. 2.—The substitution of racks and cloths for the barrel increases the capacity of the press and allows the operator to get out more of the juice in a shorter time and with less effort

or staples. This makes a rack with the two sides alike. Basswood, beech, elm, or some other hard wood that will not flavor the juice should be used. Now, cut four strips of five-sixteenths or one-half inch material, 2 inches wide, to a length 2½ inches less than the width of the racks; nail them together on edge into a square frame. This makes a bottomless box, called a form, which is placed upon each rack as it is filled, to support the cloth and furnish a guide in building the cheese.

Press cloths may be purchased of dealers in cider-making equipment at little expense. Fairly satisfactory cloths may be made from

burlap or from flour, grain, or coffee sacks, cut into squares one and one-half times as long on the sides as the racks with which they are to be used, boiled for one or two hours, and thoroughly rinsed before being used. In using racks and cloths, place a rack beneath the crusher, set the form upon it, lay on a previously moistened cloth in such fashion that the margins of the cloth are equal on all sides, and grind until the form is filled. Level off the mass of pomace as evenly as possible, fold over the margins of the cloth smoothly, remove the form, place a second rack upon the top of the cheese, replace the form, using care to see that the edges are directly over those of the first cheese, and repeat the process until a sufficient number of cheeses for a pressing have been made. Avoid making cheeses more than 2 inches thick, as thick cheeses do not drain thoroughly, and they cause more difficulty in pressing than thin ones, through their greater

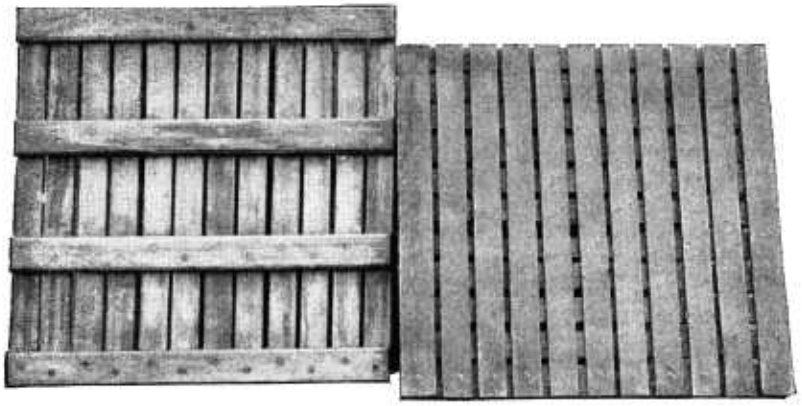

FIG. 3.—Good and bad types of racks. The crosspieces of the left-hand rack prevent uniform pressure on the cheese and cause strains which injure the press cloths

tendency to slip. (Fig. 4.) Apply pressure until rapid flow begins; then begin grinding and making up a second set of cheeses. At short intervals give the screw a few turns. When the flow has practically stopped run it down as far as the power available makes it possible to turn it. Keep it at that point until the second lot of cheeses is ready for pressing, when the first is usually sufficiently well drained to be discarded.

POWER PRESSES

Power-operated presses range in size from those requiring 2½ or 3 horsepower to operate and having a capacity of 8 to 12 bushels of apples at a pressing up to those having five or six times this capacity and requiring correspondingly increased power, but all are of the same general type and differ only in details of construction. (Fig. 5.) Instead of a crushing arrangement, such as is found upon small hand-power machines, the fruit is ground by a grater, which is mounted above the machine and fed with apples by a chain-and-slat elevator. The grater consists of a heavy steel cylinder, geared to revolve about 2,400 times per minute and grooved at equal distances

to receive the knives, which are six or more pieces of tempered steel three-eighths of an inch thick and having one edge cut to form teeth three-eighths of an inch square with intervals of one-fourth of an inch between them. The knives are adjustable by set screws, and should be set so that the teeth project not more than three-sixteenths of an inch above the surface of the cylinder. One side of the cylinder housing is made up of the concave, which consists of three or four heavy curved iron plates, each attached by its top to the housing and adjustable at the bottom end by a heavy spring. The plates of the concave should be so adjusted that the tips of the cylinder teeth barely clear them (one-sixteenth of an inch or less) when the cylinder is rotated. The springs at the lower end of the concave plates permit them to give way and allow stones or other hard objects to pass through without injury to the knives. When properly adjusted, a grater is much more efficient than any roller-crushing device, since each apple is carried down against the concave and held there while it is very finely shredded or rasped by the knives. The fruit is much more finely divided and has a much larger percentage of cells broken than when crushed between rollers, with the result that the yield of juice from a given quantity of fruit is at least 10 per cent greater.

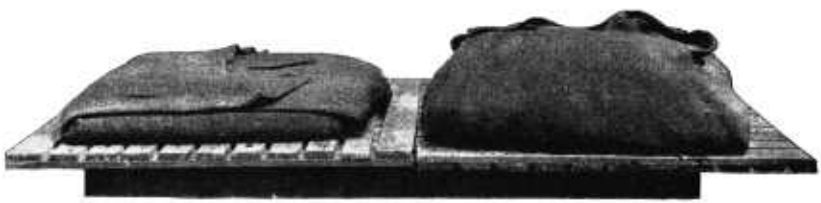

FIG. 4.—Good and bad cheeses. That at the left is uniform in thickness, well covered by the cloth, and will not creep or spread in pressing. That at the right is too thick and will spread out beyond the racks when placed under pressure, making the proper extraction of the juice impossible. The two cheeses were pressed after being photographed. The yield from the thin cheese was 64 per cent of the weight of the fruit used and that from the thick cheese 52 per cent

Practically all power presses now in use are of the hydraulic type. (See fig. 5.) In most of these the ram chamber is beneath the floor of the press bed and requires an excavation in the floor of the room to receive it. In such presses the movement of the ram is upward, lifting the cheese against a press block at the top of the frame. In others, the so-called "inverted" press, the ram chamber is at the top of the press frame and the movement of the ram head is downward, the load resting on a stationary press block which is a part of the floor of the press bed. In this type of press all parts are readily accessible in case of need. No excavation in the floor of the pressroom is required, which is an advantage in keeping the room clean and in good sanitary condition.

A second advantage of power-operated presses, in addition to the more efficient grating of the fruit, lies in the fact that much greater pressure is developed upon the cheese than it is possible to get with the hand-operated press; also the pressure is maintained constantly at the maximum for any length of time desired, as the press automatically follows up the shrinkage of the cheese due to drainage. The combination of greater force and uniformity of pressure gives a considerably better extraction than can be obtained by hand. It

is impossible to determine the increase in yield due to these factors apart from that resulting from the more effective pulping done by the grater, but as a general statement it is true that 125 to 135 gallons of juice per ton of apples represent the average yield when a hand press is used, while yields of 150 to 165 gallons per ton are the average with power presses giving working pressures of 100 to 160 pounds per square inch.

SUGGESTIONS REGARDING HYDRAULIC PRESSES

A few suggestions derived from practical experience with hydraulic presses may be of service to inexperienced operators.

Do not attempt to operate a press of the hydraulic type without equipping it with a pressure gauge, and do not risk damage to the

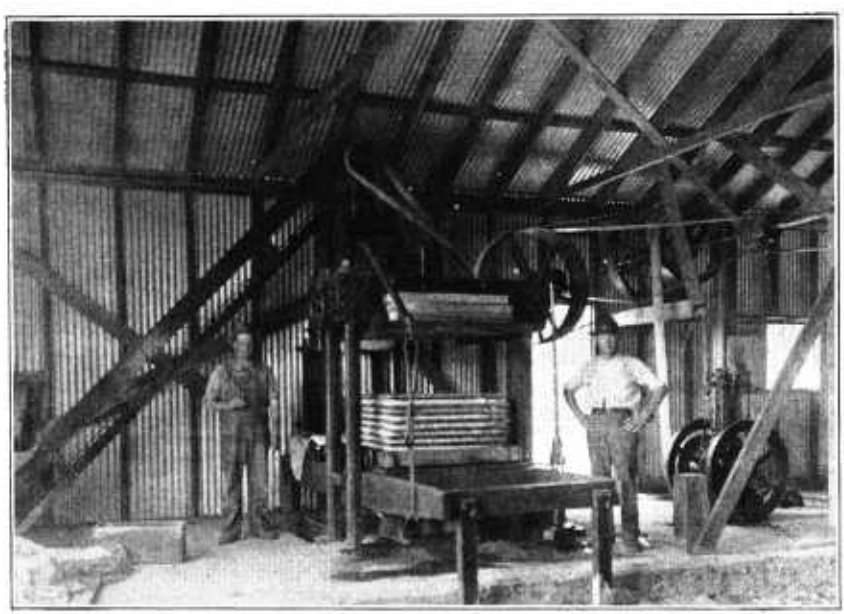

FIG. 5.—A hydraulic cider press operated by power

mechanism by forcing the pressure above the safety limit. Many small presses have no gauge, but have a safety valve, operated by a lever and counterpoise, which opens when the pressure has attained the maximum. It is not unusual to find weights added to the counterpoise in order to increase the pressure. Such a practice throws upon the hydraulic mechanism a strain that it was not designed to endure and involves serious danger of bursting the pressure chamber and possibly injuring the operator. The safe and practical way to increase the pressure is to cut down the size of the cheese by making a smaller form, thus exerting the full pressure of the ram head upon a smaller area. For example, a certain press had a form 40 by 40 inches in size, giving an area of 1,600 square inches, upon which it delivered a pressure of 100 pounds per inch, or a total of 160,000 pounds. By cutting down the form to 32 by 32 inches, giving

an area of 1,024 square inches upon which the same total pressure was exerted, the pressure upon each square inch of the cheese was increased to 156 pounds. The change reduced the load which could be handled at a pressing to two-thirds the former capacity, but also reduced the time necessary for pressing a load from 35 minutes to 25. Consequently, the quantity of fruit that could be handled through the press in a day was decreased less than 10 per cent, while the yield of juice obtained per ton of fruit was increased from 141 to 162 gallons, or 15 per cent.

Special care must be exercised in packing the cylinder of a press of the usual upward-thrust type in order to make sure not only that there is no leakage and loss of power but also that the ram is properly centered. If this is not done, the ram head will bear against one of the guides as it rises. The resulting friction not only cuts down the pressure delivered upon the cheese and reduces yield, but it strains the press frame and may result in breaking out the bolts by which the head is attached to the ram, or in other damage.

The oil chamber of the pump must be kept filled with oil of the type and grade recommended by the press manufacturer and kept closely covered in order to exclude water, juice, and dirt. Water or juice which gets into the oil chamber ultimately finds its way into the ram chamber, where it rusts the shaft, rots out packing, and causes leakage.

When pressure is put upon a fresh cheese, allow it to increase until something like half or two-thirds the maximum pressure has been developed; then trip the valve and allow the press to maintain the pressure without increase for a few minutes. When rapid flow has ceased, set the counterpoise at safety and allow the press to develop maximum pressure. By following this method one avoids the strain on the cloths which would result from putting full pressure on the cheese before drainage had begun, and is freed from the disagreeable spurting of juice and oozing of pomace that would otherwise occur.

Go frequently over the conveyer which elevates apples to the grater, looking carefully for split conveyer slats, loosened nuts, or broken bolts. Many breakdowns occur from the dropping off of a conveyer bolt or slat, which passes on into the grater and breaks the knives. A careful inspection of all set screws and bolts at frequent intervals will pay dividends in the increased life of any machine, and especially is this the case with a press.

RE-PRESSING THE POMACE

Whether re-pressing the pomace will prove profitable depends upon the thoroughness with which the first pressing has been done and upon the use which is to be made of the pomace. If the plant in addition to making cider manufactures apple jelly, the pomace may profitably be used for this purpose without re-pressing. If it is to be discarded or used as stock feed, it may be found worth while to re-press it, especially if the press used is one which develops a working pressure of 100 pounds or less per square inch.

For preparing pomace for re-pressing, a pomace picker, a device for tearing the compact cakes into pieces, is a necessity. Press manufacturers offer them in several sizes, but an ordinary mechanic can make a very effective device. The picker consists of a wooden cylinder, 10 to 14 inches in diameter, of a length equal to that of the

press cakes with which it is to be used. Teeth made of an iron rod, one-half inch square and finished with a point or screw thread at one end, are driven into the surface of the cylinder in rows or lines extending spirally around it, with the square ends projecting 1½ or 2 inches above the surface. The cylinder is mounted at the base of a wide feed hopper, and the side of the hopper toward which it revolves is studded with similar teeth. The apparatus may be set near the press and geared to the main power shaft and the cakes of pomace dumped directly into the hopper as they come from the press, the broken cakes being received in a bin, from which they can be shoveled to the press platform for re-pressing.

In re-pressing pomace, particularly with a small press or one which has a maximum pressure of 100 pounds per square inch or less, it is an excellent plan to have a smaller form to use especially for this purpose. It should be made enough smaller to give a working pressure of 150 to 160 pounds per square inch, as the increased yields of juice obtained will pay for the longer time required to handle the material with the lowered capacity.

OBTAINING COLOR FROM THE POMACE

Many consumers express a decided preference for deeply colored golden brown ciders over others of equal quality but of lighter color. It is within the power of the cider maker to control in some degree the depth of color which the juice possesses. The color of cider is due to chemical changes in the fruit which set in as soon as the material is brought into contact with the air by crushing. Some of the colored products, together with the colorless compounds from which they are formed, are carried into the juice in pressing, and the deepening of the color of the liquid continues for some time when in contact with the air. The same changes go on more rapidly in the pomace, as shown by its change of color, by reason of the large surface which is exposed to the air. When pomace is re-pressed after standing a few hours, the juice obtained is much deeper in color than that from the first pressing and at the same time somewhat more astringent by reason of its higher tannin content. The maker who finds that his customers show a preference for deeply colored juices may meet the demand by re-pressing a part or all of the pomace after allowing it to stand for some hours exposed to the air and using the juice thus obtained to blend with the first pressed juice to deepen the color. If this is done, great care must be taken to protect the pomace by storing it in a covered bin until it is re-pressed, and re-pressing must never be delayed until fermentation of the pomace has begun. If the weather is quite cool, pomace may be held for 24 hours without danger. In warm weather it can be held only a few hours, but the higher temperatures accelerate the oxidation processes which produce the coloration, so that the same degree of color may be obtained in the shorter period.

If it is difficult to obtain the desired suggestion of astringency in the product, it will be found advantageous to place some of the pomace in a suitable vessel or tank, add enough freshly pressed cider to wet the mass thoroughly, allow it to stand for an hour or two, and re-press. This treatment extracts color and tannins more thoroughly than merely re-pressing without the addition of juice. It is to be

preferred to the practice of some makers, who grind the fruit and allow it to stand in tanks or barrels overnight, or for 24 hours, before pressing. This method of handling the material is said to "bring out the flavor," but it is not clear that it accomplishes this more effectively than the treatment here suggested, while it is open to several objections. The repeated handling of the crushed fruit is laborious and difficult, and unless the temperature is low and can be kept under control fermentation will set in; consequently such treatment can not be recommended.

USES OF APPLE POMACE

Under ordinary working conditions a ton of apples yields about 700 pounds of pomace. In most cases no systematic attempt is made to utilize this material; some of it may be consumed by stock, but in large part it is allowed to decay unused, either near the plant, where it constitutes a nuisance, or at a distance after the proprietor of the plant has been put to the expense of having it hauled away.

While the subject can not be discussed in detail, it may be briefly pointed out that apple pomace has a number of uses. One of these is as a food for stock. For feeding purposes it is most nearly comparable in composition and digestibility to corn silage and is regarded by authorities as having a feeding value approximately equal to that of corn silage. As it may be kept in good condition for several months in a silo, covered pit, or compact covered pile, its value for feeding purposes justifies attempts to preserve it for such uses when no other means of utilization is feasible.

If the plant, in addition to cider, also manufactures apple butter and marmalade or cider jelly, more profitable use can be made of the pomace. When cooked until soft and passed through a colander or cyclone the pomace is freed from peels, seeds, and cores, and the resulting pulp may be used in making apple butter or marmalade. As pectin, the constituent of fruits that causes their boiled extracts to set into jellies upon the addition of sugar, is only very slightly soluble in fruit juice, the pomace from a ton of apples contains a large part of the pectin of the entire fruit. Consequently, pomace may be cooked with water, re-pressed, and the water extract added to cider preparatory to boiling it down into jelly. There is a limited demand for dried apple pomace for use in the manufacture of commercial concentrated pectin, and the cider maker who does not make other profitable uses of his pomace and has a drier available may find it advantageous to dry his pomace for sale to such manufacturers, provided his production is large enough to enable him to ship in carload lots.

HANDLING THE JUICE

SEDIMENTATION

As rapidly as the juice is expressed it should be placed in temporary storage vessels to permit sedimentation. Sedimentation is always necessary, since the freshly pressed juice contains considerable quantities of finely divided pomace which will separate out on standing, and it is necessary to free the juice from this material as completely

as possible. To obtain rapid and complete sedimentation the juice should be placed in deep, relatively narrow containers rather than in shallow, broad vessels. For small quantities, deep earthenware jars or old-fashioned cylindrical churns are ideal containers. For larger quantities oak barrels of 30 to 40 gallons capacity, with one head removed, are excellent. They must be very thoroughly cleaned with boiling water, and if possible with live steam, prior to being used, and steaming or washing should be repeated at intervals of not more than two days during the season. They should be placed in the coolest room of the building and should be raised a foot or more above the floor by means of trestles, to facilitate siphoning off the juice from the sediment. They should be provided with covers of denim or some other closely woven cloth to exclude dirt; these should be thoroughly washed in hot water two or three times a week, and after being allowed to become wet with cider they should never be used until they have been washed.

The coarser particles of pulp should be removed as completely as possible before the cider is placed in the sedimentation vessels. This may be done by using a straining cloth, which may be fastened in place over the barrel by means of a hoop. The cloth used should be open enough in texture to permit the juice to pass through quite readily; the use of closely woven cloths in an effort to remove finer particles is useless, as they clog very quickly, yet fail to remove a great deal of fine material which will separate by sedimentation if given an opportunity to do so.

The barrels should be filled one at a time to within 6 or 8 inches of the top, covered closely, and allowed to remain undisturbed during the sedimentation period. The length of time necessary for settling will depend upon the character of the juice; most juices made at the proper stage of ripeness of the fruit will settle fairly satisfactorily overnight or in 12 to 15 hours, but in the case of some sweet, full-bodied juices, and especially with soft, overripe fruit, 24 to 36 hours may be necessary. Whether time enough can be given to permit complete settling will depend upon conditions. If the juice can be kept at a temperature of 50° F. or less, it may be held for 24 to 72 hours, if necessary, without danger of appreciable fermentation. If the weather is warm and no means of artificially controlling the temperature is available, it may not be possible to hold the juice for more than six hours or overnight before fermentation sets in. In such cases it is a good practice to have the sedimentation vessels only partially full, thus shortening the distance through which particles must pass in settling and correspondingly reducing the time allowed for the process. It should be understood that sedimentation is at most merely a convenient method of getting rid of material which can be removed in other less simple ways, and it should never be pushed to such an extent as to endanger loss of juice through fermentation.

SIPHONING OFF THE JUICE

When settling has been completed the juice must be drawn off without disturbing the sediment. This is most conveniently done by using a piece of rubber hose as a siphon. An added convenience which guards against drawing sediment into the siphon is made by bending

a piece of glass, copper, or brass tubing about 12 inches long into a J shape, making the short arm of the J about 3 inches long. Slip the long arm into the end of the rubber tube and lower it into the container until the base of the J rests on the bottom with the open end of the tube up. Then start the siphon, which will draw off the juice to within 3 inches of the bottom without stirring up the sediment.

The sediment that is left behind may be handled in one of several ways, depending upon the facilities available and the scale of operations. If the work is on a small home scale, the residues from the sedimentation vessels may be collected, filtered through several thicknesses of closely woven cloth, and used for vinegar. If on a larger scale, they may be poured together and a further quantity of juice siphoned off after permitting settling to occur, if the temperatures prevailing are such as to prevent fermentation. If a filter is available the sediment may be passed through it separately from the siphoned juice, though filtration of such material is usually a very slow, troublesome process.

BLENDING THE JUICES

If juices of several varieties ripening at the same time are to be mixed to obtain a uniform product, as previously described, the work may be most conveniently performed at this point, the various juices being mixed in previously determined proportions as they are siphoned off from the sediment. The blending tank may thus serve as a container from which the juice is drawn for further treatment, as explained in the next paragraph. The detailed methods to be employed in blending, as well as the advantages of the process, have already been discussed. If juices of varieties ripening at different periods are to be mixed, the work is done at a later period, as mentioned on page 32.

CLARIFIED AND UNCLARIFIED JUICES

If placed directly in containers and pasteurized after being blended, the resulting product would throw down a more or less heavy sediment in the containers, but this sedimentation would be quite incomplete and enough finely divided material would remain in suspension to give the liquid the familiar tawny yellow color and turbid, more or less completely opaque appearance of fresh cider. Such juices invariably have an altered flavor, usually termed "a cooked taste," due to the effect of heating upon the suspended material. While large quantities of cider of this character are consumed, it is not attractive to many people, and it is clear that a larger demand for commercial cider, as well as increased home manufacture, would result if the product could be made more attractive to the eye. Various methods of treatment designed to bring about this result have been more or less generally employed with varying degrees of success, but the product always falls considerably short of being a truly "clarified" cider. A method of treatment developed in the laboratories of the Bureau of Plant Industry of the Department of Agriculture offers an improvement over others in that by its use it is possible to completely remove suspended solid materials from the

213158°—40——4

liquid before pasteurization, with the result that the pasteurized juice remains perfectly clear and transparent and does not deposit any sediment in the container. What is possibly still more advantageous, juices that have been freed of suspended material before being pasteurized do not develop any "cooked taste."

The decision as to the method of handling the juice to be employed in any particular case must be made at this point. Consequently the various methods of clarification that have been proposed will be discussed in outline, after which the two general methods of handling that are regarded as feasible will be described in detail, in order that the individual operator may make an intelligent choice between them.

CLARIFICATION BY HEAT TREATMENT

When the method of clarification by heat treatment is employed the juice is transferred directly from the settling tanks into containers, which are sealed and pasteurized, or it is passed through a continuous pasteurizer into containers, as described in a subsequent section. In either case the application of heat causes the formation of a considerable coagulum, which gradually settles to the bottom of the container, where it forms a rather unsightly layer that readily becomes stirred up when the container is disturbed. In order to get rid of this sediment it is customary to siphon off the juice after sedimentation becomes complete, fill it into final containers, and pasteurize it again. This method is laborious and time consuming. At best the coagulation by heat is very incomplete, and the juice is quite opaque, owing to the presence of much suspended matter. These facts have led most large-scale makers to adopt other methods of clarification in an attempt to reduce the labor and cost of handling and secure a more attractive product.

CLARIFICATION WITH THE CENTRIFUGE

The use of centrifugal force to bring about a mechanical separation of finely divided solids from cider has been suggested. The ordinary cream separator has been used for the purpose with fairly good results; somewhat better separation is obtained with special high-speed machines of the supercentrifuge type. When a separator is used, the juice is brought to it directly from the press, passed through the machine once or twice, bottled, and pasteurized. While juice so treated is very much clearer than untreated juice, the material removed from the juice soon clogs the machine and makes frequent cleaning necessary; also, much of the material that is coagulated by heat is not removed from the juice even by repeated passage through the machine, and consequently comes down as a rather unsightly coagulum in the container after pasteurization, while enough material remains in suspension to make the juice rather turbid. For these reasons the use of a centrifuge with freshly pressed juices is rather unsatisfactory, although fairly good results are obtained when juices that have previously been pasteurized and allowed to settle are passed through the machine.

CLARIFICATION BY FILTRATION

Paper or wood-pulp filters of the type used for the filtration of wines and vinegars have been used for filtering freshly pressed juices, but with results of a rather unsatisfactory and disappointing character. Freshly pressed apple juice contains considerable quantities of pectins and gummy substances which are arrested at the surface of a pulp or paper filter, forming a dense slimy layer which is almost impervious and quickly stops the action of the filter. For this reason, most cider makers who have attempted to use filters of this type with freshly pressed juice have abandoned the attempt. While the filtrate obtained is fairly clear, the clogging of the filter occurs so frequently that a very large filtering surface and a correspondingly high labor cost makes the method too expensive for practical use. When pasteurization followed by storage to permit sedimentation is practiced, the decanted juice may be passed through a pulp filter prior to bottling and final pasteurization, as the operation is then much less difficult.

CLARIFICATION WITH PRECIPITATING AGENTS

Wine makers have long added to wines such materials as tannin and gelatin (isinglass), white of egg, casein, and blood in order to clarify them. When such substances come into contact with the liquid the chemical reaction results in the formation of a bulky, flocculent precipitate which is distributed throughout the vessel, gradually sinking and carrying down with it much of the finely divided material in the juice. The use of such means of clarification is extremely unsatisfactory for fruit juices. The precipitation is very slow and incomplete, necessitating the holding of the juice in cold storage to prevent fermentation, and the flavor of the juice is modified both by the removal of some of its natural flavor and by the development of foreign and disagreeable flavors. Unless the added material can be completely removed, which is usually difficult or impossible, the danger of spoilage of the juice by the growth of organisms in it is considerably increased. For these reasons the use of such materials with fruit juices can not be too strongly condemned.

CLARIFICATION WITH INSOLUBLE AGENTS

Certain insoluble substances, finely ground and thoroughly mixed with the liquid, are also much used in clarifying. By reason of the very large total surface offered by the great number of fine particles, much of the suspended material in the liquid is attracted to the surfaces of the particles and carried down by them as they settle. Examples of such materials are Spanish clay, which is used by wine makers; fuller's earth, extensively used in bleaching and clarifying oils and fats; and animal charcoal and various vegetable carbons, used in clarifying and decolorizing cane and beet juices in sugar making. Rather extended studies of these various materials with reference to their adaptability for use in clarifying fruit juices have been carried on in the Bureau of Plant Industry. All are open to serious objection, as they remove a large part of the characteristic flavoring substances of the juices. Carbons have the additional dis-

advantage that they are very effective decolorizing agents and almost wholly remove coloring substances as well as flavor from juices treated with them. For these reasons none of the materials mentioned can be recommended as suited for use with fruit juices.

COMBINATION TREATMENTS

By way of summary of the foregoing discussion it may be pointed out that none of the first four treatments discussed when used alone gives entirely satisfactory results. Consequently, manufacturers of pasteurized cider on a large scale, in an attempt to produce juices relatively free from sediment and fairly uniform in appearance, have made various combinations of two or more treatments. What is probably the most satisfactory of these composite methods for ordinary home use will be described in detail, as many makers, by reason of possession of the necessary equipment, personal preference, or other causes, will desire to use it. This is called method 1. The description is followed by a statement of a newer method developed in the laboratories of the Bureau of Plant Industry, which is called method 2.

PRESERVATION BY METHOD 1

After the juice has been freed from pulp by settling and has been blended to give the desired flavor, the subsequent steps in the process consist of filling the juice into containers and pasteurizing it; storing it until the coagulum produced by heating has settled; decanting or siphoning it off; passing it through a pulp filter, milk separator, or centrifuge, if available; filling it into the final containers; and pasteurizing it. These steps will now be discussed in detail.

PASTEURIZATION FOR STORAGE

The purpose of pasteurization for storage is the protection of the juice against fermentation while gradual sedimentation in storage is occurring. It may be carried out in one of two ways: Either by filling the juice into containers which are then sealed and subjected to pasteurizing temperatures in a water bath or steam box, or by passing the juice through some form of continuous pasteurizer into sterilized containers which are immediately sealed. In either case the essential feature is that the juice is brought to 170° F. and subsequently protected from exposure to the air.

PASTEURIZING IN CONTAINERS

Containers.—When small quantities of juice are being preserved for home use, ordinary glass fruit jars of the quart or half-gallon size are excellent containers. The jars used should not be of the screw-cap type; any of the various lightning-seal or other glass-topped types that do not permit contact of the contents with metal may be used. Crown-cap bottles, such as grape-juice bottles, are also good, but their small capacity makes their use rather laborious. In case somewhat larger quantities are to be handled, glass jugs of 1 or 2 gallons capacity, made to be closed with crown caps, are highly satisfactory and cheaper than any other containers of equal capacity.

Glass carboys of the straight-walled type, holding 3 to 5 gallons, such as are used for table and medicinal waters, are rather expensive and difficult to obtain, but stand sterilizing temperatures well and are much to be preferred to carboys of the pear-shaped type, which are usually so thin walled that there is heavy loss from breakage in heating and handling. In the absence of more suitable containers any good-sized bottles which can be fitted with corks may be successfully used.

Washing and sterilizing.—Whatever the nature of the containers, they should be thoroughly washed, with the caps or tops which are to be used in sealing them. After being washed, both the jars and tops must be sterilized. This is most conveniently done by placing the jars on their sides in a wash boiler or other good-sized vessel, setting it on the stove, pouring in enough cold water to completely cover the jars, bringing the water to boiling, and keeping it at that temperature for 10 or 15 minutes. It is a good plan to sterilize the containers and covers just before they are to be used and to take the sterilizing vessel off the fire and allow the containers to remain in the water until they are used. If bottles which are to be closed with corks are used, corks which are free from cracks and openings and which are a little larger in diameter than the necks of the bottles should be selected. Melt a quantity of paraffin, drop the corks into it, put a bit of board on top to keep them beneath the surface, and keep the paraffin hot for an hour or more in order that the corks may become thoroughly filled with it. A better method is to keep the corks in the hot paraffin until used, lifting them out as needed and placing them directly in the bottles. In filling the containers it is necessary to remember that considerable expansion occurs when a liquid is heated from ordinary room temperature to pasteurizing temperature; for example, a rise of temperature from 60° to 170° F. produces an expansion of very nearly 2.7 per cent in volume. Allowance must be made for this expansion in order to avoid bursting the containers by the production of excessive pressure during heating.

Sealing.—As rapidly as the containers are filled they should be closed and sealed. In the case of fruit jars, carefully selected, previously sterilized rubber rings should be put in place and the tops clamped down. Crown-cap bottles or jugs should be capped. If bottles or carboys closing with corks are being used, the corks, previously boiled in paraffin and preferably lifted directly from hot paraffin, are set in place and pushed down loosely. Such bottles are put in the pasteurizer with the necks projecting above the water and must be sealed at once after being pasteurized. This is done by pushing down the cork, which will be somewhat softened, until it is slightly below the level of the top and completing the seal while the juice is still hot by pouring paraffin over the top.

It will be noted that the sealing of containers before pasteurization is recommended. There are three reasons why this recommendation should be followed wherever the type of containers used makes it possible. A minor reason is that the sealing of hot containers is an unpleasant and hurried task attended by some danger of loss of juice and of injury to the operator by breakage. A more important reason is that the substances which give the characteristic odor or bouquet to the apple juice are partially lost when the juice is heated

in open containers to 170°F. In sealed containers the escape of these volatile substances into the air is prevented and they are reabsorbed by the juice as it cools. At the same time access of air to the hot juice, which would permit oxidation processes that may have an effect upon flavor, is prevented by sealing. For these reasons juices should never be pasteurized by heating in open containers when it is possible to avoid it, and when it is necessary the container should be of such a form that the surface of the juice exposed to the air is as small in area as possible. Most important of all, the portion of the jar which is above the water level does not reach the temperature of the bath, and any organisms present on cap and rubber or on the inner surfaces of the jar may escape destruction. Sealing and inverting wets these surfaces. Unless care is exercised in selecting a good quality of rubber rings for fruit jars an occasional jar may be lost through "blowing" the rings, but good rings will withstand the pressures developed at pasteurization temperatures.

Pasteurization.—The essential feature in pasteurization is that the juice be heated to a temperature sufficiently high to destroy the organisms that would otherwise cause fermentation and spoilage. Heating to 170° F. for 10 minutes will do this, but it must be borne in mind that in heating a sealed container considerable time is required for penetration of the heat to the center of the container, and that this period will be proportional to the size of the container. In pint jars or bottles this time will be about 5 minutes; in quarts and half gallons, 10 and 15 minutes, respectively; in 1-gallon bottles, 20 minutes; 2 gallons, 25 minutes; and 5 gallons, 45 minutes. In order to determine the length of time for which it is necessary to hold the temperature of the pasteurizing tank at 170° F. after it has reached this point, add 10 minutes to the figures given above for the size of the container being used and keep the bath as nearly at 170° as possible for that length of time. As no injury to the juice results from being kept at this temperature for moderate periods, it is a better plan to exceed the time slightly than to risk shortening it. Care should be taken, however, that the temperature is not allowed to rise above 170°, or injury to flavor will result.

When the required time is up the heat should be turned off and the jars of juice allowed to remain in the pasteurizer until they have cooled sufficiently to be handled, when they may be removed, examined for defective seals, and stored. If it is necessary to remove the jars while hot, great care must be taken to avoid loosening the seals by rough handling. The containers should be again examined for leaks as they become cool, since the contraction of the cooling juice produces a partial vacuum which may cause leakage. For reasons stated on page 40, the containers should be allowed to become thoroughly cooled before they are stored.

Pasteurizing equipment.—For pasteurizing juices in bottles on a small scale an ordinary tin wash boiler is perfectly satisfactory. A false bottom or a rack must be used to raise the jars above the bottom, to permit the circulation of water beneath. A few light wooden strips cut to the proper length and nailed to short crosspieces may be placed in the bottom of the boiler. A small hole should be made in the lid of the boiler to admit a long-stemmed thermometer, which

should be hung so that the bulb reaches to within 2 or 3 inches of the bottom of the boiler.

When ready to begin work, put the boiler over the fire with the false bottom in place, add a small quantity of water, and fill the boiler with bottles or jars, laying them on their sides or inverting them. This insures the destruction of any organisms present on the caps or lids by keeping the liquid in contact with them during the heating. Add enough cold water to cover the topmost jars completely; put on the lid with the thermometer in place, and raise the temperature gradually to 170° F.

If the juice is to be made on a larger scale, a steam-heated pasteurizing tank or pasteurizing room is a necessity. Pasteurizing tanks have the advantage that they may be built at low cost, but this is more than offset by the disadvantages involved. In its simplest form a pasteurizing tank is merely a tight wooden box, preferably provided with a lid to keep in the steam and lined with soldered sheet iron or copper to prevent leaks. It is provided with a steam coil for heating, a slatted rack to support the containers, and a reliable thermometer to permit control of the temperature. Satisfactory heating may be obtained by the use of waste steam by running a perforated exhaust pipe into the box beneath the false bottom and allowing the steam to escape into the water. If this is done, care must be taken that the perforations are so placed that jets of steam can not strike directly upon the bottles. Slatted crates of such a size that they may be conveniently handled are filled with bottles placed on their sides or inverted, and stacked closely in the tank. When the tank is filled, sufficient water is run in to cover the crates, the steam is turned on, and the temperature brought to the desired point as rapidly as possible without causing breakage. After this temperature is reached, a very slight flow of steam will maintain it fairly constant. At the end of the period the tank is partially emptied to permit removal of the crates of bottles. Before the tank is again loaded, sufficient cold water must be run in to bring the temperature low enough to prevent breakage. In consequence, considerable time is required to bring the tank to pasteurizing temperature after each filling. A further disadvantage is the wetting of floors and of clothing of workmen which occurs in lifting and handling the crates. Consequently, a pasteurizing room should be built in every case in which the volume of material to be handled will justify the expense.

The pasteurizing room is merely a chamber of convenient size, heated by perforated steam pipes and closed by a door that is practically steam tight. It may be of wooden construction, in which case the framing should be of 2 by 4 inch pieces placed not more than 16 inches apart. The lumber used for ceiling and siding should be 1 inch thick, tongued and grooved, and the grooves should be filled with a thick paste of white lead as the boards are put on, to assist in retaining the steam. Two thicknesses of 1-inch lumber so treated, with a layer of tarred paper between them, make a very satisfactory wall. For long-continued service it is well to avoid the warping that results from exposure of wood to the action of steam by making the walls and ceiling of cement supported by expanded metal lath and by making the floor of concrete. The door should be double or triple thickness, heavily reinforced with iron strips to prevent warping, and

provided with an efficient closing device of the type employed on the doors of cold-storage chambers. A small vent provided with a door should be placed in the ceiling to permit displacement of the air by steam when beginning pasteurization and to allow the steam to escape when pasteurization is completed. The steam pipes should be laid upon the floor and covered by baffle plates so that steam jets from the perforations may not strike directly upon the containers. The steam line must be controlled by a dependable valve. A cannery-type thermometer, with a dial placed outside the chamber and a flexible metal tube leading through the ceiling or wall and ending in a bulb which may be inserted in a container of juice, is a necessity.

In beginning a pasteurization, the vent in the ceiling should be opened and allowed to remain partially open until the temperature shown by the thermometer rises to within 10 to 15 degrees of pasteurizing temperature, when it may be closed. This aids in securing uniform heating throughout the room, which may be somewhat difficult to obtain unless this method is employed.

In a small pasteurizing room fairly satisfactory results are obtained by placing the containers of juice in slatted crates which are stacked one upon another. If any considerable quantities are to be handled, low-wheeled trucks having three or four decks upon which bottles or jugs can be set directly from the capping machine should be provided. Trucks of the grooved-wheel type are to be preferred, since a light track laid in the floor of the pasteurizing room will allow them to be run in or out without striking door or walls. The pasteurizing room may be made of such size as to accommodate one or more trucks at a time, and by providing a sufficient number of trucks to permit of one set being filled while another is being pasteurized and a third being unloaded in the storage room, the room may be kept operating continuously.

The time during which juice is to be held at pasteurizing temperature is the same whether the pasteurizing is being done in water or in steam.

PASTEURIZING WITH A CONTINUOUS PASTEURIZER

A continuous pasteurizer consists essentially of a coil of aluminum or block-tin pipe, equipped with a valve, through which juice can be passed by gravity from a tank. The coil is placed within a sheet-iron cylinder, which is fed with steam or hot water from a boiler, or it may be placed in a wooden tank or barrel filled with water and heated by a steam pipe. The aluminum coil has a side arm near the outlet for receiving the bulb of a thermometer, which shows the temperature reached by the juice as it passes through the coil. By regulating the flow of steam or other source of heat supplied to the cylinder surrounding the coil and manipulating the valve on the juice line, the heating and rate of flow of the juice are so regulated that the thermometer in the coil shows a constant temperature of 170° F. The hot juice is received directly into previously sterilized carboys, which are closed immediately with corks previously boiled in paraffin and sealed by pouring hot paraffin over the tops. Casks are sometimes used, in which case they must be treated with repeated changes of hot water, to remove all soluble materials from the wood, after which they are thoroughly sterilized

with live steam and painted with hot shellac, to make them leak tight prior to use. As rapidly as they are filled they are closed with tight bungs previously boiled in paraffin, and the sealing is completed with applications of hot paraffin. It is needless to say that casks must not be roughly handled in being moved about after they have been filled, as such treatment will greatly increase the loss from broken seals, which is likely to be considerable when casks are used, even under the most favorable conditions. The further fact that it is impossible to observe the progress of sedimentation in casks or barrels and difficult to draw off the juice without disturbing the sediment makes the use of such containers inadvisable.

STORAGE FOR SEDIMENTATION

After the first pasteurization the juice must be stored, in order to permit the settling of the material coagulated by the heating. This process may require from two or three weeks to twice as many months, as the rate varies widely with the character of the juice, the size of the containers, and the temperature of the storage room. It occurs most rapidly and completely when the juice is kept at fairly constant and moderately low temperatures. A cool, dark cellar, which can be protected against freezing, is an ideal storage room. The containers should be transferred to the room immediately after pasteurizing, stored on shelves or racks in order that the juice may be siphoned off without the necessity for moving or lifting them, and left undisturbed until sedimentation is complete. They should be examined from time to time, in order to detect any breakage of seals or the beginning of fermentation.

In some cases the cider maker may have an opportunity to sell his pasteurized cider in bulk for immediate consumption, especially if he is located near a large city or industrial center. Pasteurized cider in bulk usually sells at rather low prices as compared with the bottled product that has undergone further treatment, but immediate sale in bulk may in some cases yield a fair margin of profit. Nearness to markets, amount of competition, labor supply, storage facilities, the character and extent of equipment available, and the comparative demand for bulk and bottled cider are some of the factors which must be considered in deciding whether the product shall be disposed of as soon as pasteurized or whether it shall be subjected to further treatment.

DECANTING OR SIPHONING OFF

When sedimentation has become complete, as shown by the formation of a rather compact layer at the bottom of the container and uniform clearness throughout the liquid, the juice is ready for further treatment. The nature and extent of this treatment will vary with the quantity to be dealt with and the equipment available. If only small supplies for home use are made, the cider may be used as needed without further treatment, merely by decanting or siphoning it off from the sediment. If this is to be done, small containers should be used, as fermentation will promptly occur in the unused portion left in a container that has been opened. If the cider is intended for sale, removal of the coagulum and repacking in small final containers are necessary. The first step in the process is the

removal of the juice from the storage containers with as little disturbance of the coagulum as possible, either by decanting and pouring off or more conveniently by the use of a siphon made as described on pages 22–23. No matter how carefully the work of siphoning or decanting may be performed, the juice will not be perfectly clear, for the reason that a portion of the suspended material is not coagulated by the heat employed in pasteurization. This material is in the form of extremely fine particles so light that they do not settle, no matter how long the liquid may be allowed to remain undisturbed in storage. Consequently the cider will appear murky or turbid and will be more or less dull and opaque when viewed in a tumbler held against the light even when quite free from particles large enough to be visible to the eye. Fastidious consumers object to such ciders on the ground that they are "muddy" in appearance, and for this reason various methods are employed in attempts to increase the clearness and brilliancy of the product. Several of these methods are outlined in the following paragraphs. The choice of the method to be used will depend in any particular case upon the quantities to be handled and the facilities available.

If juices of two or more varieties which ripen at different periods are to be used in making a blend, so that mixing of the freshly pressed juices was not possible, the blending should be done at this time. The details of blending have already been given. When juices differing considerably in character are mixed, as when a juice high in acid content is added to a sweet or subacid juice, the mixture may become somewhat more turbid and opaque than the separate juices and may throw down a small quantity of precipitate on standing. This is a result of the change in acidity and tannin content of the mixture. The reactions are quickly completed, and such blended juices clear up quite as satisfactorily as single-variety juices by the methods of treatment now to be described.

CLARIFYING BY FILTERING OR CENTRIFUGING

The simplest but at the same time the least effective method of clarifying the juice is to strain it through cotton or cloth. When only small quantities are to be handled with limited equipment this method may be used. A large piece of canton flannel, folded so as to give three or four thicknesses, may be stretched over the top of a vessel or suspended by the corners after the fashion of a jelly bag and the juice poured through it. As the effectiveness of such a filter depends upon the gradual filling up of the openings in the cloth by particles from the juice, it is usually necessary to pass the juice through such an arrangement three or four times in order to make any very decided improvement in the clearness and brilliancy of the liquid. The chief value of such a simple straining process lies in the fact that it removes any portion of the sediment which may have been stirred up in taking the juice from the storage containers.

For handling larger quantities of juice, pulp filters are very generally employed. These are of two general types. In one type the filter may be described as a heavy-walled wooden tub provided with a false bottom upon which the wood pulp that is used as a filtering

medium is packed to a depth of 1½ to 3 inches. Juice is delivered from a supply tank through a pipe equipped with a float and cut-off, so that a constant level of liquid is maintained on top of the filter pulp and is drawn off at the bottom of the filter by a line of pipe connected with a suction pump. The filter pulp, after repeated washing in hot water, is packed into the filter wet, the juice turned on, and the pump started. The first filtrate is discarded until pure juice comes through. Like the jelly bag, the efficiency of a pulp filter depends upon the gradual filling up of openings in the filtering medium by particles from the juice. Consequently, the first juice which comes through should be returned to the supply tank and bottling begun only when the juice comes through clear. Lack of care in packing the filter, and particularly in getting close contact between the pulp and the wall of the tub, is sometimes responsible for a slight seepage, which produces persistent turbidity of the filtrate, and it is a good plan to work around the edge of the filter with a rammer after the pump has been started in order to close up any slight openings which may exist.

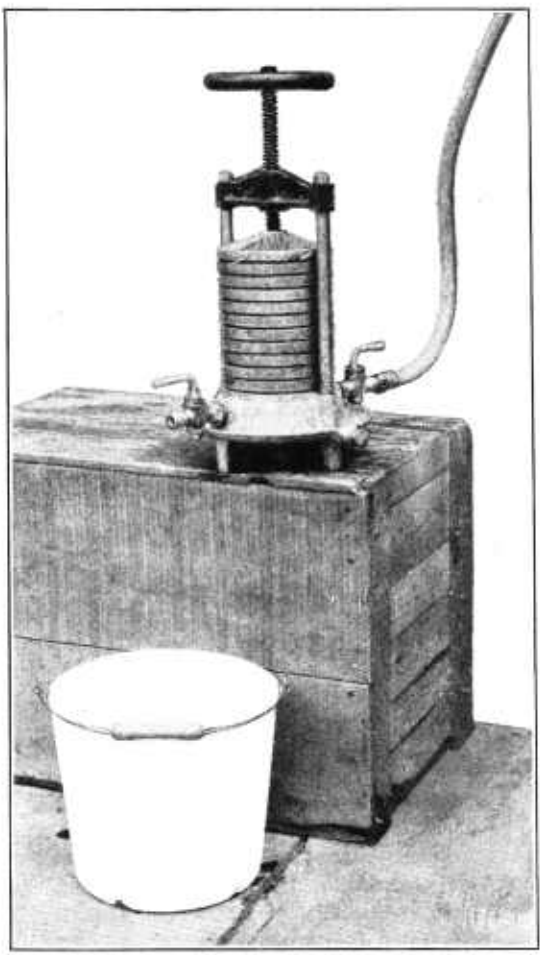

FIG. 6.—A type of filter in which the juice is forced through disks of wood pulp. Each of the 10 disks is a separate filter, giving a large working surface in a compact portable apparatus

In another type of pulp filter a series of tinned or silvered plates, each of which carries an independent filter disk made of pulp, is arranged one above the other and fed by gravity through a feed pipe from a supply tank. (Fig. 6.) This type of filter has the advantage that it gives a large total filtering surface within a very small and compact apparatus, and it can also be used to handle very small quantities or to finish up the last of a batch by using only one or two filtering disks. As it is fed by gravity, the rate of flow through the

filter depends upon the height of the supply tank above the apparatus, which should be placed in a basement or ground-floor room and supplied by a pipe or hose from a tank on an upper floor. When a force pump capable of giving a pressure of 12 to 20 pounds per square inch is available it may be substituted for the gravity-feed arrangement.

A milk separator, clarifier, or supercentrifuge may be used for clearing the juice, in case such an instrument is available. In passing through the machine a portion of the suspended material is thrown out by centrifugal force and adheres to the wall of the bowl. The efficiency of the treatment depends upon the degree of force developed, and consequently high-speed machines, running at 20,000 to 40,000 revolutions per minute, will produce better clarification than the usual types of separators running at lower speeds. Whatever type of machine may be employed, it should be operated at the full speed recommended by the makers.

FIG. 7.—Good types of containers. The 5-gallon bottle is a satisfactory storage vessel. It must be sealed with a paraffined cork. The gallon and half-gallon jugs and the pint and quart bottles which are sealed with cork-lined metal caps are good final containers. A satisfactory inexpensive device for applying caps is seen in the foreground of the picture

No matter what method of clearing is employed, whether filtration or the use of a separator or centrifuge, a perfectly transparent water-clear product is not obtainable by these methods. The juice will have a somewhat smoky or murky semiopaque character, owing to the presence in suspension in it of exceedingly fine particles which can not be removed by centrifuging or filtration. These treatments, if properly performed with good equipment, have the very great advantage, however, that they remove from the juice such larger floating particles as would ultimately unite and fall out to form a sediment upon the bottom and sides of the bottle after the final pasteurization. As the presence of such sediment in bottles is a rather serious handicap to the sale of cider, through the generally existing although entirely erroneous impression that it consists of dirt and is proof positive that insanitary methods have been employed in handling the juice, any treatment that will prevent its formation in the final container is well worth while.

CHOICE OF FINAL CONTAINERS

In the selection of containers in which the finished product is to be placed (fig. 7) there is very much less choice than in the selection of storage containers. Since the latter containers are not to be handled and are opened only when the contents are to be transferred to final packages, the primary consideration is capacity, and almost any container that can be sterilized and made air-tight and does not expose the liquid to contact with metal will serve. The situation is quite different with respect to the final package. If intended for home use it must be of such size that the contents may be at once used after opening, or a part of the contents will be lost. If intended for sale, the same consideration applies, and the package must stand shipment and repeated handling without serious danger of breakage of the seal, while it must also be made attractive to the eye through labeling.

Jars and bottles.—For strictly home use, pint and quart fruit jars or the smaller sizes of crown-cap bottles may be used. Where the juice is to be sold there are two possibilities—crown-cap bottles ranging in size from half pint to quart, which are suitable for general use, and 1-gallon and 2-gallon crown-cap glass jugs for the soda-fountain and ice-cream parlor trade, in which the juice is transferred to the fountain before it is served. Whether bottles or jugs are to be used will depend in any particular case upon the relative demand for cider in the two forms of containers. Containers employing corks should never be used as final packages for juices intended for sale. The use of crown caps necessitates a machine for capping bottles. Such machines are on sale in a great variety of types, ranging from a very simple hand device to large-capacity automatic machines, so that it is easy to secure a capper suited to the individual needs.

Kegs and barrels.—While there was formerly a considerable trade in cider in bulk in kegs and barrels, and some demand for juice in such containers still exists, it is clear that they can not be used with success in the future. It is possible with intelligent care in selecting barrels and in every step of the processes of filling and sealing to put up sweet cider in barrels with a very small loss from fermentation, although cider so packed is likely to have a somewhat unpleasant "cooked taste," for the reason that the large package retains heat for many hours after it is filled. The chief difficulty with the bulk package arises after it comes into the hands of the retailer. The quantity contained is sufficient to serve the needs of the average soda fountain for several days; hence the barrel is opened daily in order to refill the fountain receptacle. At each opening it is exposed to infection with yeasts, and as very few retailers have cold rooms the conditions are usually such as to permit fermentation. Benzoate of soda can not be depended upon to prevent fermentation in a container that is being opened repeatedly so that there is free access of air. Consequently, some portion of the contents of the barrel may undergo fermentation before the barrel is emptied. The bacteria that form acetic acid are less susceptible to the effects of sodium

benzoate than are the ordinary yeasts and frequently develop in benzoate-treated cider to a sufficient extent to spoil its flavor.

Glass jugs.—Crown-cap glass jugs of 1 or 2 gallons capacity satisfactorily meet the demand for a container of moderate size and cost. They have several advantages, since they are readily capped by machines, the contents are protected against contamination by metal, and the contents are visible at all times, thus protecting the producer from shipping and the dealer from accepting moldy or fermenting juices. The jugs are returnable, are readily cleaned, and may be used repeatedly. The disadvantages are that they add materially to the weight of the package, thus necessitating heavier and more expensive crates and increasing the shipping costs, while the transportation charges on returned empties are also considerable. There is a certain unavoidable loss from breakage in sterilizing, pasteurizing, and handling glass containers. Lastly, the larger sizes of glass jugs cool rather slowly, so that there may be danger of developing a "cooked taste" from prolonged high temperature.

Tin containers.—Tin containers are mentioned only in order to express a caution against their use as packages for fruit juices, as experience has shown that they are unsatisfactory. When fruit juices are put up in ordinary plain tin, the acids of the juice, aided by the oxygen dissolved in it, attack the tin and produce rather extensive corrosion. The dissolved metal enters into combination with tannins and other constituents of the juice, producing alterations in color and flavor which render the juices distinctly uninviting. Cans covered with a single coat of lacquer have also proved to be unsatisfactory. The coat of lacquer is rarely absolutely perfect and is usually more or less abraded in the processes of manufacture and sealing, leaving small areas of metal exposed. The attack of the juice is localized upon these areas, with the result that the wall is quickly cut through, a process known as "pinholing." For these reasons, neither plain nor single enameled cans can be considered as satisfactory containers for fruit juices. In an attempt to reduce losses from pinholing, double-enameled cans, made from special grades of tin plate and protected by a double coating of lacquer, have been developed. They are extensively used for the packing of highly corrosive fruits, such as cherries and berries. The best grades of double-enameled cans represent a very great advance over single-enameled cans in the completeness with which the metal is covered, but they are subject to mechanical injury of the lacquer coating in passing through the sealing machine and to pinholing at such injuries.

Heating the juice to 180° F. in steam-jacketed kettles, followed by filling into the cans hot, sealing, and processing, or exhausting the cans at 160° to 170° F. for 15 minutes followed by immediate sealing and processing, have been recommended as means of reducing corrosion and perforation in cider. Such treatments expel a considerable part of the oxygen present in the juice and to a corresponding degree reduce the corrosive activity of the juice. In case any portion of the metal is exposed, pinholing will ultimately occur.

Cans are undergoing steady improvement as a result of the large amount of research being done, and the production of a metal container that will be satisfactory for fruit juices is not impossible.

At the present time, however, the preserving of cider even in the best double-enameled cans on the market involves considerable risk which should be understood by anyone considering the use of such containers.

PACKING IN THE FINAL CONTAINERS

As rapidly as the juice is filtered or passed through the separator it should be placed in the final containers. Promptness in handling the juice at every stage of the process after the storage containers are opened is, of course, a necessity, since the liquid is subject to contamination by yeasts and fungous spores from the air and will undergo fermentation and spoilage by these organisms as readily as freshly pressed juice. Therefore, the containers in which the juice is to be packed should be selected, sterilized, and made ready for use before the opening of the storage containers is begun.

The sterilization of bottles or jugs preparatory to use is carried out in the same fashion as that of the storage containers, by placing them in cold water which is brought to the boiling point and held at that temperature for some minutes, the caps or tops being subjected to the same treatment.

If small quantities for home use are being bottled, the filling may be done by means of a funnel, which should be sterilized by boiling, as are bottles and caps. In filling bottles or jugs with a funnel care must be exercised to avoid underfilling and at the same time to allow sufficient space for the expansion of the liquid during pasteurization.

If considerable quantities are being packed, a bottle-filling machine is a necessity. This machine consists of a rectangular supply tank with a number of filling tubes. These are siphons, each of which is equipped with an automatic cut-off device that can be adjusted to stop the flow at any desired point, thus filling all containers exactly alike. The operator merely removes filled containers from the filling tubes and replaces them with empty ones, passing the filled ones on to the capping machine. The machine should be placed beside the filler, and the containers should not be allowed to remain open after they have been filled.

Most of the difficulty with the growth of molds or yeasts in juices in bottles or jugs is due to imperfect sterilization of the crown caps. These should be sterilized in boiling water just prior to use, and unnecessary handling or exposure to the air after sterilization should be avoided. A properly made crown cap should have a lining of compressed composition cork or compressed glazed paper not less than three thirty-seconds of an inch thick and should stand heating to boiling point without softening or showing signs of going to pieces. A disk of tin foil or glazed paper cemented upon the inner surface of the cork lining gives an added security.

Some crown caps on the market have a lining which, instead of being made from compressed ground cork or paper, is merely a disk cut from a thin sheet of cork. Such caps are worse than useless for sealing vessels which are to be pasteurized, as the contraction of the juice after heating draws in air through minute openings in the cork, thus carrying yeasts or spores into the container.

The proper sealing of crown caps on the bottles or jugs is a very important step in the process, and the capping machine must be

carefully watched to see that it is doing its work properly. It is well to take a few containers at random from time to time and remove the caps for examination. If the machine is doing its work properly, every cap should be driven down with sufficient force to compress the lining and leave a distinct sunken ring in it when the cap is lifted. The cap should be so firmly crimped against the glass of the neck that it is impossible by exerting all one's force to turn it with the fingers. Unless the machine is sealing the caps in this manner it should be repaired or discarded, as the loss in spoiled juice may amount to several times the cost of a new machine.

CARBONATING JUICE BEFORE BOTTLING

Many people prefer juices which have been carbonated prior to bottling, as the sharpness and "tingle" of such juices is considered to give them increased palatability. Carbonation consists in exposing the juice to carbon dioxide under pressure until no more will be absorbed and immediately sealing the containers. Carbonated soft drinks are bottled by machines which charge the bottles with the gas at any desired pressure and seal them. Since such beverages are not pasteurized subsequent to sealing, there is a tendency to use high pressures, in the belief that heavy carbonation aids in preventing the growth of any organisms that might be present in the liquid. In the case of fruit juices it is inadvisable to charge heavily, for the reason that little of the flavor of an actively effervescing juice is perceived by the consumer. Also, since such juices must be pasteurized subsequent to carbonation, a heavy charge will be productive of considerable breakage or blowing of seals during the heating process.

In the absence of special equipment for carbonating juices, fairly satisfactory results may be obtained with small quantities by the use of a beer keg or other heavy-walled tight container with which a cylinder of compressed carbon dioxide can be connected by a regulating valve and a length of heavy-pressure hose. Fill the barrel completely with juice, close the faucet, and gradually admit carbon dioxide, rocking or rolling the barrel at intervals for 10 or 15 minutes until the pressure on the gauge of the cylinder stands steadily at 15 pounds. Then draw off, bottle, and seal as rapidly as possible, opening the gas inlet occasionally, so as to keep the pressure in the barrel at 15 pounds.

Carbonation is usually confined to the smaller sizes of bottles; containers of 1 gallon or more are rarely carbonated, since the juice is transferred to the magazine of the soda fountain and charged in the glass, if desired, as it is served.

As the quantity of carbon-dioxide gas that a liquid will absorb increases very rapidly as the temperature of the liquid decreases, carbonation is most effective when carried out with juices at a temperature of 40° F. If the plant has facilities for cooling the cider to this temperature, the work may be done at any time; otherwise, carbonating and bottling should be postponed until cold weather gives proper temperatures. In no case should the operation be attempted without having a reliable pressure gauge so placed on the line through which the gas is led into the container that it is within constant sight

of the attendant, as the rapid expansion of the liquefied carbon dioxide may otherwise burst the container and cause injury to the operator.

FINAL PASTEURIZATION

As rapidly as the juice is bottled and sealed, with or without carbonation, it should be transferred to the pasteurizer. Pasteurization has already been discussed in detail in connection with the treatment of the freshly pressed juice in storage containers, and it will be unnecessary here to do more than point out a few precautions to be observed. The bottles or jugs should be placed on their sides or inverted in the pasteurizing tank, covered completely with cold water, and slowly heated.

It is important that the temperature reached in this pasteurization should not quite equal that employed in the first pasteurization. The reason for this caution is that not all the material that can be coagulated by heat is thrown down by the first pasteurization. Some of it remains in suspension in the liquid even after the most careful filtering. If the juice is again heated to a temperature higher than that used in the first pasteurization some of this material is coagulated and comes down as a precipitate, marring the appearance of the finished product. To guard against this, the processing temperature used in the final pasteurization should be 5 degrees lower than that first used. As 170° F. has been recommended for pasteurization in storage containers, the treatment in the final containers should be at 165° F. It should not be allowed to exceed this temperature nor be unduly prolonged, else further precipitation may occur. The temperature of the pasteurizing tank should be brought up to this point and held as nearly constant as possible for the period of pasteurization. This period is determined by the size of the container and should be the same as that recommended for the container of the same size in the first pasteurization.

In the cast of juices which have been carbonated prior to bottling, the temperature may be lowered somewhat and the time of heating correspondingly extended. The reason for this difference is that the juice has been charged with all the carbon dioxide it can absorb while cold. As the temperature is raised the solubility of the gas in the juice is greatly reduced, with the result that a very considerable gas pressure develops as the temperature goes up. If the juice were heated to 170° F., this pressure would become so great as to burst the containers. Since the destruction of organisms by heat depends upon the time during which heating is continued, as well as upon the temperature that is reached, this difficulty can be avoided by employing a temperature of 150° in pasteurizing carbonated juice and maintaining this temperature for twice the length of time recommended for uncarbonated juice. Thus, for pint bottles the total time for which the water of the pasteurizing tank is kept at 150° should be 25 minutes; for quarts and half gallons, 30 and 35 minutes, respectively. With carbonated juices it is certain that an occasional bottle will burst under the pressure developed during heating; consequently, it is well to place the bottles during pasteurization in crates which can be covered and to avoid handling the bottles until they become cool; otherwise the operator may be injured.

COOLING AFTER PASTEURIZATION

It is very important that containers be thoroughly cooled as quickly as possible after pasteurization. If they are transferred from the pasteurizer into boxes or cases which are at once stacked in a storeroom, the contained heat will escape very slowly. The writer has seen a case in which gallon jugs, pasteurized at 165° F., were placed at once in paper lined, wooden crates holding six jugs each, which were stacked in a compact block, 6 crates wide, 10 long, and 4 deep, in one end of the workroom. Forty-eight hours after stacking, the temperature of the juice at the center of the stack was 122° F. While this juice was perfectly filtered, the prolonged heating resulted in the development of turbidity and the throwing down of a precipitate which made refiltering necessary. The installation of arrangements for prompt cooling of the jugs as they were taken from the pasteurizer put an end to the difficulty. Containers must never be stored until they have cooled to room temperature.

LABELING

Some cider makers label and pack their product directly from the pasteurizer as soon as the bottles have become cool enough to permit handling. This is not a good practice. Even with the most careful oversight of every stage of the process, a small percentage of defective caps or nicked bottles will be used. In such cases the bottles are not perfectly sealed, and organisms are drawn in along with air as the juice cools, with the result that spoilage occurs. When the juice is packed at once, such imperfectly sealed packages escape detection until they reach the consumer, who receives an unfavorable impression of the maker and resents having paid for something that is unfit for use. This can be avoided by storing the juice after pasteurization for 10 days or more and observing it at intervals during that time, as any mold growth or beginning of fermentation will usually become evident within that period. It may then be labeled and crated.

Before deciding upon the wording of his label, the prospective cider maker should communicate with the Federal Food, Drug, and Insecticide Administration and with the authorities of his own State so as to inform himself as to the laws and regulations with which his label must comply. The laws of the various States with respect to the labeling of cider show considerable differences and in some cases call for information not required by the Federal food and drugs act. In addition to the information required by law, it is permissible to give any additional facts which it is desired that consumers should know, and the maker who is putting forth every effort to produce a standardized product of high grade should give some additional information. For example, the variety from which the juice is made may be named, or the fact may be stated that the juice is a blend of several varieties, which are named. If the juice is filtered, carbonated, or given other special treatment, this fact may also appear, while a statement that strictly sound apples were used, if true, is an advantage.

An artistically designed, attractive label has a very considerable value in catching the eye of the buyer. The juice put up by a given

maker may be quite distinctive in quality and flavor, but unless it bears a label which arrests attention or a name which is easily remembered the consumer has no clue by which he can find that particular product in the market again. Consequently, the producer who feels a pride in his cider should guard against the use of a stock label that does not differentiate his package from those of other makers. If the expenditure of a little thought and money will devise a label that will attract attention at first sight and make the product easily remembered and found again, the investment will be a paying one. The maker of high-grade cider should insist upon putting out his product under his own name and should not use stock labels bearing the name of a jobber, as the identity of his juice is thereby lost.

PRESERVATION BY METHOD 2

While the method outlined in the preceding pages gives very satisfactory results, it is time consuming and laborious. The juice must be twice pasteurized; it must have storage space where the temperature is under some degree of control during the period of clarification, which necessitates keeping on hand a large number of containers; and there is a considerable proportion of loss due to fermentation and to repeated handling and consequent breakage. For these reasons considerable effort has been devoted to devising methods of treatment of unfermented fruit juices that will eliminate as much of the labor of preparation as possible without sacrificing the quality or palatability of the product. A method developed in the laboratories of the Bureau of Plant Industry is regarded as combining several highly desirable features. It makes the entire process of preparation of a juice, from pressing the fruit to the pasteurization of the juice in the final containers, a practically continuous process, eliminates the necessity of pasteurizing the juice and holding it in storage containers for clearing, lessens the loss from breakage and the cost of production by reducing the handling necessary, and enables the maker to put the finished product on the market within a few days after pressing begins. At the same time it produces a clear, sediment-free product without the use of costly special equipment and without the loss of the characteristic flavor and beverage quality of the juice.

The steps in the treatment of the juice by the new method are as follows: The juice is pressed, allowed to stand for 12 hours or over night to settle, decanted from the sediment, and blended if necessary. It is then raised to a temperature of 130° to 140° F. and mixed with diatomaceous earth (also called kieselguhr, diatomite, and, improperly, infusorial earth) at the rate of 6 to 8 pounds per hundred gallons, thoroughly stirred, and immediately filtered through a thin layer of diatomaceous earth supported by a closely woven cloth. The clear juice is placed in the final containers as it comes from the filter, sealed, and pasteurized, which completes the work. The details of the process will now be stated.

MIXING THE JUICE WITH DIATOMACEOUS EARTH

In pressing, sedimenting, siphoning off, and blending, the juice is handled precisely as in method 1. Instead of placing the blended juice in storage containers for pasteurization and storage, as in that

method, the juice in the blending tank or other good-sized open tank is warmed to 130° to 140° F. and treated with diatomaceous earth. The dry earth, previously prepared for use by the method outlined in a subsequent paragraph, is weighed out and slowly shaken into the juice, which is vigorously stirred meanwhile. It is essential that the earth be added to the juice in a finely divided condition, avoiding lumps, in order that it be equally distributed through the tank. An ordinary flour sifter is an excellent device from which to add the earth. If the plant is equipped with power, a small power stirrer may advantageously be used to agitate the liquid; if power is not available, the liquid should be very thoroughly stirred by hand, and the stirring should be repeated two or three times before filtration begins. As the efficiency of this treatment depends upon bringing the particles of the earth into contact with the floating matter of the juice, which becomes attached to the surfaces of the earth particles, repeated and vigorous stirring of the mixture is not a process to be omitted or carelessly performed. From 10 to 15 minutes should be allowed for this stage of the work, after which the juice is ready for filtration.

FILTERING THE TREATED JUICE

The treated juice now has suspended in it innumerable fine particles of the earth, each more or less completely covered with a layer of gummy or slimy material derived from the juice. These particles are, for the most part, extremely thin, slightly curved, saucer-shaped or boat-shaped bits of silica, with a small percentage of smaller irregularly shaped fragments produced by the crushing of the larger pieces. The next step in the process is to pass the juice through a filter capable of holding back these fine particles, which will retain all the suspended matter and give a perfectly clear liquid.

Suction or gravity pulp filters of the usual type, such as were described in connection with method 1, do not give satisfactory results with juices that have been treated with earth. The reason is that the finer particles of earth at first pass through the pulp, giving a cloudy filtrate. They then gradually choke up the openings in the pulp and build up on the surface a slimy, gummy layer which almost entirely stops the passage of liquid; consequently, the filtration is extremely slow and soon stops entirely.

The most effective method of filtration for such juices is to pass them through a thin layer of diatomaceous earth supported on rather closely woven cloth. The particles of earth form a meshwork having excessively fine openings through which the juice must pass, and any floating particles which enter these passages become attached to the surface of the earth particles and are held there. In consequence, the actual filtration takes place through a layer of earth for which the cloth serves merely as a support.

FILTER PRESSES

Two general types of filter press are well adapted to the filtration of juices through films of diatomaceous earth. In one of these, the plate-and-frame filter press, the filtering units are rectangular wooden or metal devices, suggesting unglazed window sash in general

appearance. These units are of two kinds—namely, the plates, over each of which a filter cloth is tightly stretched, and the frames, which alternate with the plates. In operation the series of alternate plates and frames are driven together by a powerful screw, binding the edges of the filter cloths between the surfaces of the plates and frames. The liquid to be filtered is pumped into the hollow frames, each of which is bounded by two surfaces of filter cloth, passes through the cloth into the plates, and flows off through stopcocks at their lower edges. Filtration continues until the accumulation of material removed from the juice has filled the frames, when the operation must be stopped and the press cleaned. In some types of press the construction is such that water can be forced into the press in a direction reverse to that of the movement of juice, thus washing the sludge off the cloths and out of the frames. If the press is not provided with an arrangement for back flushing, as this method of cleaning is termed, it must be opened, cleaned by hand, and the cloths replaced by a new set.

In the second general type of filter press there are no frames. The plates that carry the cloths are arranged side by side within an inclosing shell into which the liquid to be filtered is pumped. Each frame or leaf, as it is called, is inclosed within a tightly stretched bag of filter cloth which is sewn on and which remains in place until long use or accident makes replacement necessary. A connection at the base of each leaf delivers the filtrate into a receiving manifold which also serves as a support for the leaves. When clogged the cloths are cleaned by opening the press, dropping out the accumulated cake, and washing the cloths by back flushing through the delivery line. Such a press has an advantage over the plate-and-frame type of press in that the whole filtering area of every leaf is accessible to inspection merely by opening the shell. Repairs may be made to any one without disturbing the others, or a leaking leaf may be shut out of the system by closing the stopcock on the outlet line and operation continued until the next period for cleaning.

SUCTION FILTERS

Another type of filter that may be employed with fruit juices is operated by suction, not by pressure. It consists of a series of skeleton plates or leaves, each completely covered by a bag of filter cloth and connected to a manifold by a delivery tube. It has no inclosing shell but is submerged in a tank of liquid which is drawn into the leaves by suction applied to a manifold. This type of filter has the same advantage of accessibility of all parts pointed out for the last type, and its simplicity makes its cost somewhat less than that of a plate-and-frame filter of equal capacity.

PREPARING THE FILTER FOR USE

In any of these types of press, successful operation at maximum capacity depends upon laying down upon the cloths at the outset a thin, uniform film of diatomaceous earth and upon the presence of a small proportion of the earth intimately mixed with the cake as it is built up on the filtering surface. The coating of the cloths

is best accomplished by suspending the earth in a tank of water and pumping this through the press. Each subsequent tank of juice has a smaller quantity of earth thoroughly stirred into it before it is pumped into the press. The constant deposition on the surface of the earth in mixture with the gummy, slimy materials removed from the juice has the effect of keeping the mass open and porous. Without such addition, the surface of the cake will promptly become coated with a film of slime which will slow up and ultimately stop filtration. Consequently, it is essential that the tank supplying the filter should have an efficient stirring device to keep the earth uniformly suspended in the juice. The pump supplying the filter should be provided with an air chamber in order to prevent pulsation, which will pack the cake and decrease the rate of filtration. It should be of a type that will not be subject to wear of moving parts by the diatomaceous earth; pumps that depend for their efficiency upon the accurate contact of thin-walled blades with the wall of the pump chamber soon become useless by reason of the abrasive effect of the earth. The feed line into the press should be supplied with a stopcock at its outer end, so that all air may be driven out of the press when operation is begun; otherwise air pockets may prevent the coating of a portion of the cloths with earth. These pockets will be gradually replaced by juice as the air escapes, with the result that the filtrate through the bare cloth will be cloudy.

SELECTION AND CARE OF FILTER PRESS

Satisfactory service on the part of a filter press depends primarily upon the care employed in its construction and secondarily upon the care given it in use. No amount of subsequent attention will bring about satisfactory results with a press that is defective in construction, nor will a mechanically perfect press remain so unless intelligent care is given to it. An attempt will be made to indicate some of the structural features that are essential to the satisfactory performance of a press and also some of the precautions to be observed in caring for the machine. While these will be familiar to experienced operators, they are not always obvious to persons just beginning work with a press.

Since all fruit juices contain organic acids that attack and dissolve iron, with resulting injury to the color and flavor of the juice, press makers are restricted to the use of wood or of acid-resistant metal, such as aluminum, for those parts of the press with which the juice comes in contact. In order to prevent leakage, the surfaces of the plates and frames must be true planes, making such accurate contact that the edges of the filter cloths are evenly held between them to form water-tight seals that will withstand pump pressures of 15 to 30 pounds. Metal plates and frames are machined with the requisite accuracy and do not warp, hence give little trouble from leakage, but are made in only the smaller sizes. They are very much more expensive than wooden plates and frames. To be satisfactory, wooden plates and frames must be made from carefully selected stock and must be built with all the accuracy of the finest cabinet work. Even when originally so made, they are subject to warping and cracking as a result of alternate wetting and drying. A season crack scarcely

wide enough to admit the edge of a sheet of paper, or a joint with edges which are just perceptibly uneven to the finger tips, is quite large enough to cause persistent leakage of unfiltered juice. Leaks due to such causes or to slight warping of a plate so that its whole surface is not in close contact with adjacent frames may necessitate the refiltering of an entire season's output of juice. In consequence, the plates and frames should be minutely inspected upon receipt from the manufacturer. Any that show roughened or uneven surfaces, open joints, splintering along the joints, warping, or cracks or other defects in the wood should be returned to the manufacturer with a demand that usable parts be supplied in exchange. When any that appear defective have been weeded out, those that appear to be satisfactory should be dressed with press cloths, placed in the press, and subjected to test by coating the cloths with filter earth and pumping water through the press until the gauge registers the maximum pressure at which the press will be operated in service. While the press is being operated at full pressure go over every joint and surface minutely for leaks. The cloths will behave like lamp wicks when they are first wetted, so that some seepage will occur through them at the outset, but this will soon cease. Any leakage which persists after the first 10 to 15 minutes of operation calls for close examination to locate the cause and for possible rejection of the defective member.

Having ascertained that the press units are mechanically perfect when received, the operator should keep them in this condition. In order to do this it is necessary to keep the plates and frames in the press and under considerable pressure from the screw at all times except when they are actually being cleaned. If this is not done, warping of some of the members will occur, and it will be impossible to make the press tight. At frequent intervals during the season an examination of all joints of the plates and frames should be made in order to locate any which have become uneven. Such uneven joints are to be expected, since no one can select four pieces of wood that will swell and shrink at the same rate or to the same degree when built into a frame. When found, such a joint must be smoothed down by very careful planing, followed by the use of sandpaper until the surface is a perfectly true plane with the sides of the frame.

At the end of the season's run or at any time when the press is not in constant use, the plates and frames should be carefully washed, returned to the press, and put under heavy pressure in order that they may dry slowly and as a whole. As often as possible, the screw should be given another turn, in order that no warping may occur.

Press cloths will require occasional removal for washing, even in presses equipped for cleaning by back flushing, as the cloth gradually becomes clogged by particles driven deeply into it. Thorough scrubbing in a tub or washing machine loosens much of this material, and drying in a rotary drier in a blast of hot air removes a large part of it. In the absence of such facilities, drying on a line in the open air, followed by thorough shaking or light beating, will be found satisfactory. Under no circumstances should the cloths be ironed. The new cloth has a nap made up of projecting fiber ends, which aids materially in holding the film of filter earth in place as it is formed.

Drying in an air blast or in the open, followed by beating, "raises the nap" more or less perfectly; ironing would flatten the nap against the surface, making the cloths less porous and giving no support to the earth film. Slipping of the film and exposure of the bare cloth may then occur, with a cloudy filtrate as the result. The cloths should be permanently marked in some way before they are washed in order that they may always be placed on the press with the same side out, as reversal of a cloth will mean washing out any adhering particles into the filtered juice.

After they have been washed and dried, the cloths should be carefully looked over for broken threads. Frayed selvages should be trimmed smooth, and if the press is one that is fed through a line passing through openings in the cloths, the margins of these openings should be carefully trimmed. Loose threads tend to form tangles which cause a local thickening of the cloth, rendering a tight closure between plate and frame impossible. If it becomes necessary to repair the feed opening in a cloth, care must be taken that the edges are not folded over in hemming, for the same reason.

Watchfulness as to details in caring for a press is all important. Given a well-built filter press at the outset, the degree of attention paid to its care will determine whether it continues to render efficient, trouble-free service for years or becomes a source of endless exasperation and expense through developing leaks after a few weeks of service.

When only small quantities are to be handled, very satisfactory results can be obtained with a bag filter. The bag filter should be made of closely woven denim or flannel and should have the form of a rather tall cone. The seam should be double, to guard against leakage. To make it ready for use, the bag is thoroughly wetted, suspended by the top from supports, and filled with a fairly thick suspension of diatomaceous earth in water. As the water drains through, it leaves the inner wall of the bag covered by a thin layer of the earth. Water is run through until any particles of earth which may have found a way through the cloth are washed off. The filtering of the juice may then be begun. As the only force driving the liquid through the filter is the weight of the juice in the bag, filtration is, of course, rather slow, and it is well to make the bag a tall narrow cone and to keep it full of liquid in order to hasten the filtration as much as possible.

The juice that passes through a properly prepared diatomaceous-earth filter is perfectly transparent and without murkiness or cloudiness, and it remains so after bottling and pasteurizing. Samples prepared in this way have been kept for more than six years without developing haziness or throwing a sediment. When a freshly prepared filter is started up, the first liquid coming through usually is not clear, as fine particles wash through the cloth. The filtrate should, therefore, be returned to the filter until it comes through entirely clear. The color of the filtered juice is not affected by the treatment, as properly prepared diatomaceous earth does not remove the dissolved coloring matters. The color consequently depends upon the varieties of apples used and the length of exposure of the juice to the air.

The juice should be bottled, sealed, and pasteurized as rapidly as it is filtered. The details of these processes have already been given and need not be repeated here; but the necessity for prompt and thorough cooling after pasteurization can not be overemphasized.

HEATING THE JUICE TO AID FILTRATION

Heating the juice before filtering, and passing it through the filter while hot, has a number of advantages. Filtration is much more rapid with hot juices, and if bottling and sealing are promptly done the containers reach the pasteurizer while still hot and the time required to reach pasteurizing temperature is correspondingly shortened. Heating also brings about a clumping together of the finely divided material suspended in the juice to form larger masses which are more readily held back by the filter. This process of massing together to form aggregates goes on more rapidly the higher the temperature is raised, but the temperature must not be carried too high or alteration of flavor will occur as a result of the driving off of some volatile flavoring constituents by the heat. In experiments with a large number of apple juices it was found that no appreciable loss of flavoring constituents occurred when juices were heated to 140° F. in an open tank heated with a steam coil and kept at that temperature for 10 minutes. In another series of experiments juices were brought up to 160° in a glass-lined steam-jacketed tank provided with a tightly fitting cover and run into the filter as soon as this temperature had been reached. No alteration in the flavor of these juices was perceptible. The tanks employed were equipped with efficient motor-driven stirring devices, so that no local overheating of the juice could occur. The filtration of juices heated momentarily to 160° was no more rapid than that of those brought to 140° and held at that point 10 minutes before being passed through the filter, and the filtered juices were perfectly and permanently clear in both cases. When the juice was held for some time at 160° prior to being filtered, there was some loss of volatile constituents and the filtered product had a slight suggestion of "cooked" or baked-apple taste. Since nothing is to be gained by employing the higher temperatures, while there is some risk of injury to the flavor of juices, it is strongly recommended that juices should not be heated to a temperature higher than 140° prior to filtering. The juice should be held at this temperature for 10 minutes before being turned into the filter in order to aid in the coagulation of the suspended particles.

The heating tank should be equipped with an efficient stirring device to prevent overheating about the heating coil and to secure thorough mixing of the diatomaceous earth with the liquid. The tank must be provided with a dependable thermometer so placed that it is constantly under observation by the workman in charge of the heating process, who should be instructed to cut off the steam immediately and run in cold juice in case the temperature at any time rises above 140°.

PREPARATION OF DIATOMACEOUS EARTH FOR USE

Diatomaceous or siliceous earth consists of the cell walls of microscopic 1-celled plants, diatoms, which exist in a great variety of

forms in both fresh and salt water and in damp soils. The wall about each individual consists of two parts, which fit together like the top and the bottom of a pill box, and is made of silica. Extensive deposits of this earth are found in various parts of the United States. A number of these deposits are being worked, as the earth has many industrial uses, the principal ones being as an abrasive and metal polisher, as an insulating and sound-deadening material, as an absorbent for nitroglycerin in the manufacture of dynamite, and as a clarifying agent in the manufacture of cane sugar.

The earth comes upon the market under various names; among these may be mentioned kieselguhr, infusorial earth, infusorial silica, fossil flour, diatomite, tripolite, and tripoli powder. The material as found on the market has been subjected to grinding and screening; hence it can be obtained in various grades of fineness from the manufacturers and from chemical and agricultural supply houses. In experiments conducted in the Bureau of Plant Industry it has been found that the grades of fineness known as 150 mesh and 200 mesh, which means material that has passed through screens having, respectively, 150 and 200 openings to the inch, are most suitable. Most companies offering diatomaceous earths for sale now have special grades intended specifically for use in filtering juices. These have been specially treated to remove organic and inorganic impurities that might affect the quality and flavor of juices filtered through them. Only earths so treated should be used.

SUMMARY OF METHODS 1 AND 2

This detailed discussion of the various steps in each of the processes of preparation, with a description of the apparatus employed and with practical suggestions as to its use which may be of service to the inexperienced, has necessarily resulted in making both methods appear very much more complicated than is really the case. For this reason the following outline summary of the two processes is appended. The procedure is divided into steps; it will be noted that steps 1 to 6 and 10 to 13 are identical for the two methods.

SUMMARY OF THE PROCESSES FOR PREPARING UNFERMENTED APPLE JUICES

STEPS COMMON TO BOTH METHODS

(1) Select sound, well-matured, properly ripened fruit.
(2) If different varieties are available at the same time, blend them in proper quantity to give a well-balanced cider of good flavor.
(3) Wash and sort the fruit, trimming or discarding all specked or partially decayed apples.
(4) Grind and press, subsequently re-pressing the pomace, if desired.
(5) Place the juice in deep containers in a cool room overnight to allow the settling out of the pomace.
(6) Siphon off the juice from the sediment.

STEPS USED WITH METHOD 1

(7) Place the juice in suitable sterilized containers, seal with sterilized tops, and submerge in cold water in the pasteurizer. Bring the temperature up to 170° F. and keep it at that point for the prescribed time. Or (second method) pasteurize at 170° F. by passing the juice through a continuous pasteurizer, placing it in sterilized containers, and sealing immediately. Cool as quickly as possible.

(8) Store the juice in a cool, dark room until settling is completed (two weeks to four months). For home use, juice may be left without further treatment until used, if preferred.

(9) *a.* Siphon off from the storage containers.

b. Blend, if juices pressed at different periods are being used.

c. Clarify further by passing through a pulp filter, milk separator, centrifuge, or flannel filter bag.

STEPS USED WITH METHOD 2

(7) Transfer the juice to a suitable vessel or tank, slowly add properly prepared diatomaceous earth at the rate of 6 to 8 pounds per 100 gallons, and stir very thoroughly. Heat the juice to 140° F. to aid in filtering.

(8) Prepare the filter by passing a suspension of diatomaceous earth in water through a filter press or bag filter so as to form a thin layer of earth on the filter cloths.

(9) Filter the juice, stirring the supply tank occasionally in order to prevent the sliming and clogging of the filter.

STEPS COMMON TO BOTH METHODS

(10) Place the juice as filtered in previously sterilized final containers, seal, and submerge the containers in cold water in the pasteurizing tank.

(11) Pasteurize for the prescribed period at 170° F. for method 2, or 165° F. for method 1.

(12) Remove from the pasteurizer, cool as quickly as possible, and store in a cool room for 10 days or more.

(13) Label and pack.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	HENRY A. WALLACE.
Under Secretary	CLAUDE R. WICKARD.
Assistant Secretary	GROVER B. HILL.
Director of Information	M. S. EISENHOWER.
Director of Extension Work	M. L. WILSON.
Director of Finance	W. A. JUMP.
Director of Personnel	ROY F. HENDRICKSON.
Director of Research	JAMES T. JARDINE.
Director of Marketing	MILO R. PERKINS.
Solicitor	MASTIN G. WHITE.
Land Use Coordinator	M. S. EISENHOWER.
Office of Plant and Operations	ARTHUR B. THATCHER, *Chief.*
Office of C. C. C. Activities	FRED W. MORRELL, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Office of Foreign Agricultural Relations	LESLIE A. WHEELER, *Director.*
Agricultural Adjustment Administration	R. M. EVANS, *Administrator.*
Bureau of Agricultural Chemistry and Engineering.	HENRY G. KNIGHT, *Chief.*
Bureau of Agricultural Economics	H. R. TOLLEY, *Chief.*
Agricultural Marketing Service	C. W. KITCHEN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Commodity Credit Corporation	CARL B. ROBBINS, *President.*
Commodity Exchange Administration	J. W. T. DUVEL, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Farm Credit Administration	A. G. BLACK, *Governor.*
Farm Security Administration	W. W. ALEXANDER, *Administrator.*
Federal Crop Insurance Corporation	LEROY K. SMITH, *Manager.*
Federal Surplus Commodities Corporation	MILO R. PERKINS, *President.*
Food and Drug Administration	WALTER G. CAMPBELL, *Chief.*
Forest Service	EARLE H. CLAPP, *Acting Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Division of Marketing and Marketing Agreements.	MILO R. PERKINS, *In Charge.*
Bureau of Plant Industry	E. C. AUCHTER, *Chief.*
Rural Electrification Administration	HARRY SLATTERY, *Administrator.*
Soil Conservation Service	H. H. BENNETT, *Chief.*
Weather Bureau	FRANCIS W. REICHELDERFER, *Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1940

For sale by the Superintendent of Documents, Washington, D. C. - - - - Price 10 cents