SARDINES

The sardine-canning industry of the United States is located in Maine and California. In Maine the small herring (*Clupea harengus*) is the basis of the industry, while in California the pilchard (*Sardinia caerulea*) is used.

According to Food Inspection Decision No. 64 of the United States Food and Drug Administration, any small clupeoid fish may be canned as sardines, but the word "sardine" on the label of the can should be accompanied with the name of the country or State in which the fish are taken and prepared. Anchovies are considered misbranded if labeled as sardines, because they are not classified as clupeoid fishes according to this decision.

MAINE SARDINES

FISHING AREA AND SEASON

The sardine-canning industry of the Atlantic Coast of North America is located in the State of Maine, and the adjacent Canadian Provinces of New Brunswick and Nova Scotia. The raw material used is the "sea" herring (*Clupea harengus*). Herring are taken off the Atlantic Coast as far south as Delaware Bay, but only in the above localities are the abundance of the catch and the size of fish such that canning operations are commercially practicable.

Herring travel together in large schools, and at certain seasons of the year are found in shallow water near shore, usually migrating over a more or less regular route and feeding on the plankton which is most abundant in these waters at the time. The fishing season commences about the middle of April and may extend to the first week of December, but most canneries cease packing before that time. During the latter part of the season the larger sizes of herring predominate which are not as desirable for canning as the smaller; a dependable supply is not available, and often the fish must be transported a greater distance. The length of the canning season is also governed by the probable market for the pack. The peak of the season is from about the middle of July to the first of September.

SECURING RAW MATERIAL

Herring are caught in two types of gear: (1) Weirs, which are enclosures or traps of a primitive type, located so as to block the line of travel in the feeding migration of the herring along the shore, and (2) stop nets used together with purse seines, a more

NOTE.—[FL–81. Canning sardines. Reprinted from Research Report 7, Fish and Wildlife Service, U. S. Department of the Interior. The complete report (366 pp.) is a reference book on commercial canning of seafoods and is obtainable from the Superintendent of Documents, Washington 25, D. C. Price $1 a copy.]

modern type of apparatus, with advantages over the weir in certain localities.

WEIRS

The older type of weir was very crudely constructed, with a framework of light poles driven into the bottom, sometimes supported by stones, with tree branches or brushwood woven in between the poles. More recently, heavy tarred cotton webbing has been used instead of brush.

A weir consists of two sections, first a "lead" or fence extending from shore and crossing the path of migration, terminating in a "heart" or oval enclosure. In some locations an opening is left at one side where the lead joins the heart, but in other places, where the fish may come in from both up and down the coast, the heart may be entered from either side of the lead.

Blocked by the lead, the herring try to find a way around and are led into the heart. Hook-shaped extensions into the base of the heart prevent the fish from again finding the opening, so they are held until they can be removed. A boat then enters, blocking the entrance with a piece of netting and concentrates the herring into a small space within a seine which is first laid out so as to take in most of the area within the heart and is then gradually hauled together forming a "bag." The fish are dipped from the bag into boats, which transport them to the cannery.

Weirs are used today along the Maine coast from Eastport to Rockland principally because strong tides and the nature of the shore make the use of nets difficult, but sardine canners in other areas of the coast have abandoned the weir and now use stop nets, together with purse seines in catching sardine herring. The stop nets are 100 fathoms long by 5 to 7 fathoms deep and ordinarily have a 1-inch mesh, stretched measure. Several "shots" or lengths of net usually are required to surround a school of fish. The nets commonly are made of 14-6 hawser-laid cotton twine, with a 5-inch border, top and bottom, made of heavier twine, and are tarred from time to time to preserve them. They are taken up two-fifths in hanging; that is, the length and depth are reduced by this proportion so that the net will not hang as a straight wall, but will "bag," making it more difficult for fish to escape.

SEINES

Nights during the "dark of the moon" in the summer and early fall, are considered best for seining sardine herring, as they come in shore to feed at that time. A small boat is sent out scouting in the evening for signs of herring—distinguishable only by an experienced "looker." Some of the indications of herring are: Silvery flashes in the water, flecks of foam on the waves, flocks of

gulls hovering and swooping, the presence of large predatory fish such as dogfish, and the "flipping" sound made by the herring as they "play" on the surface. This also causes flecks of foam on the waves. Days or even weeks may pass without the observation of signs of a school of herring.

When sardine herring are found the seine–boat captain determines the direction in which they are moving and makes an estimate of the size and probable number of the fish. This is very necessary, for if the fish are too large for canning, or if the school is small, time spent in catching them would be wasted. The herring are scouted until they reach a place where they can be trapped, usually a cove, or in the lee of a point of land, with a depth of water not exceeding 6 fathoms (36 feet) at high tide.

The seine–boat crew "makes one end of the seine fast to the shore, and leaves the balance of the seine necessary for the set in the dories. Then a small power boat is tied on to the dories and the seine is quickly towed out, imprisoning the fish, this power setting seldom takes over five minutes. The actual catching of the fish, however, is the smallest part of the labor, for from the time the fish are caught until they are loaded in the boat to be taken to the factory, there must always be someone watching them to see that they do not escape. The fish are usually caught at high tide, and about 6 hours later the seine, which has been stretched in a straight line from one headland to another across a small bay or inlet, must be worked around into a circle or pocket and this is where the real labor begins. * * * As soon as the pocket is made, it is necessary to put anchors and kegs out to keep the seine from collapsing and smothering the fish." (Bastow, 1938.)

The captain notifies the cannery when the herring are safely pocketed, giving the location and an estimate of the catch and size of the fish. The herring usually are held in the pocket at least 24 hours, because they are sometimes full of "feed" when caught. After 24 hours the digestive tract is empty and the fish are not as susceptible to enzymic deterioration on the way to the cannery. In addition the fish are "wild" and difficult to handle immediately after being pocketed in the stop net. If necessary, the fish can be held alive in the stop nets for 2 weeks in calm weather.

TRANSPORTING AND RECEIVING

When the cannery requires raw material, "carrying" or "run" boats owned by the cannery are sent to the spot where the stop net is pocketed. The carrier boats have a capacity of 40 to 60 tons of fish, usually loading and making the run to the cannery at night so that the cannery need not wait for fish during the day. It is also cooler at night and there is no possibility of the sunlight

adversely affecting the fish. Some fishermen may contract to deliver all of their fish to a single cannery for a period of several months, while others sell each catch to the highest bidder (Socony–Vacuum Oil Co., 1937).

When the carrying boat arrives at the stop net, a purse seine about 40 fathoms long by 6 fathoms deep is run inside the pocket. When enough fish have been surrounded, draw lines at the bottom of the seine are pulled so that the bottom is puckered together like an old fashioned bag–purse and the fish cannot escape. One side of the seine is made fast to the rail of the carrying boat and the fish are concentrated in the "bunt" or center portion by pulling the "wings" or sides of the seine into the seine boats. A power-operated dip net holding from 3 to 5 bushels is dropped into the churning mass of fish, then hoisted above the deck. The dip net is emptied by releasing a draw–string at the bottom. The first fish are examined to see if they are of satisfactory quality and free from "feed."

The carriers or collecting boats should have the fish hold divided into sections and only a shallow layer of fish should be loaded into each section. The distance from the fishing area to the cannery varies from less than one-half mile to a maximum of about 100 miles. Fish are usually brought in from the further limits, only at the end of the season when cooler weather permits arrival in good condition. No ice is used, because it would bruise the small herring, but if they cannot be landed within a very short time, salt is scattered on the herring as they are loaded into the hold. From 200 to 500 pounds of salt, or an average of 280 pounds, are used per hogshead of fish, which weighs about 1,200 pounds.

A large bucket holding approximately 500 pounds is used to unload the fish at the cannery. Each bucket is tallied without weighing, as holding a certain amount. A flume extends from the unloading point to storage bins, where the fish are held for a short time until used. The herring are brined in these bins if they have not been salted in the boat. The fish are carried along the flumes by a stream of water that both washes them and removes the scales and excess salt.

GRADING THE RAW HERRING

The fish must be small to be suitable for canning. Fish fully developed in size do not make a product of satisfactory quality in this type of pack because the flavor is too strong, the texture too coarse, and the loss in packing too great. Herring canned as sardines vary in size from 4 to 10 inches. When taken for canning, they should have a fairly high oil content and should be free from "feed." The fish are graded on these factors.

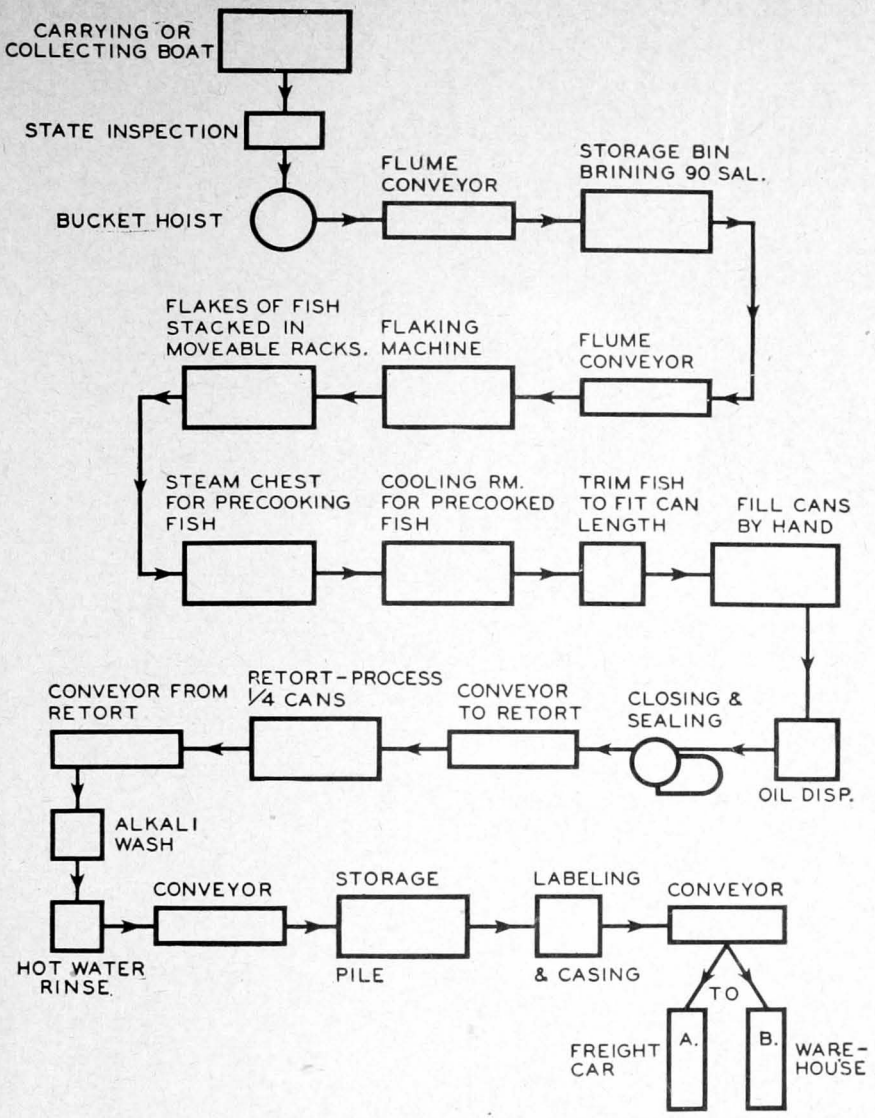

FIGURE 27.—Flow sheet of Maine sardine canning.

DRESSING OR CLEANING

Formerly the herring were dressed immediately after landing, principally to prevent any possible damage from fish containing feed, as immediate dressing inhibits loss through enzymic spoilage. This also has the advantage of reducing the amount of waste handled in preparing the fish for canning.

Only one large firm now dresses the fish as the first step and then only in certain packs. A few small canneries still dress the fish by hand before preparation for the can. Most canners dress

and trim the fish in a single operation, as they are filled into the cans. This is done when there are no indications of "feed" in the digestive tract.

If fish are dressed raw they are unloaded on tables. Workers stationed at either side of the dressing table seize three or four fish with the left hand, cutting off their heads in a single movement with a knife or with shears designed for the purpose. They then pull upward and outward in a second and almost simultaneous movement as the cut is completed, which removes most of the viscera with the head. The dressed fish are dropped into pans at the worker's side, while the offal is shoved through openings in the table into buckets or barrels. Both the cut fish and the offal are taken away from the dressing table at regular intervals. Unnecessary waste and poor workmanship are guarded against through periodic inspection of the dressing operation by the foreman and the State inspector.

PREPARING FOR THE CAN

BRINING

If the fish have not been salted when loaded into the boat, which is the usual practice, brining is the first step in preparation. The fish are salted or brined for two reasons, in addition to preserving the catch until it can be handled: (1) To flavor the canned product, and (2) to improve the texture, making the flesh firmer and not so liable to crumble in handling. The fish are brined in the tanks used for holding the raw material after landing. These are watertight bins made of wood and the usual dimensions of an individual tank are 5 feet long by 3 feet wide and 3 feet deep. Each tank holds from 45 to 50 bushels of fish, and a cannery installs a set of 6 tanks so that sufficient fish for a normal run may be landed at one time, making it unnecessary to hold fish in boats at the dock.

The brine is a very heavy salt solution, testing from 90° to 100° salinometer. Fresh potable water is used in making the brine but little attention is paid to the purity of the salt, although it is possible for chemical impurities in the salt to affect adversely the flavor of the product. The time required in brining averages 2 hours and varies from 20 minutes to 3 hours, depending on the size of the fish, whether they are whole, the degree of fatness, and the atmospheric conditions.

When the fish have absorbed sufficient salt they are drained and rinsed in fresh water. Sufficiency of brining is determined by appearance of the skin, which should not be wrinkled as that indicates overbrining, and by the degree of firmness, which is judged

through pressure with the fingers. The percentage of salt absorbed by the fish varies. If the fish are small a total salt content of from 2.5 to 3.5 percent is considered best in the canned product.

FLAKING

The fish are conveyed by flume and an endless slat-belt conveyor to the "flaking machine" on the second floor. Empty flakes are fed into the machine receiving a thin layer of fish from the conveyor and are then stacked in racks. The flakes are rimless trays, made with a framework of heavy iron wire, about one-quarter inch in diameter and are covered with quarter-inch-mesh wire screen. Some flakes are from 18 to 22 inches wide and about 3 feet long. Others are 30 inches square. The racks, which are equipped with small wheels, hold from 25 to 50 flakes each, with 28 as a customary average.

In the earlier days of the sardine industry, flaking was done by hand, and great pains were taken to see that no two fish touched. This is no longer considered necessary, the only requirement being that the fish must not be heaped but spread out in a thin layer. A flake will hold from about 100 to 125 herring, depending on size of fish and flake.

PRECOOKING

Precooking is required to produce the desired sardine flavor.

Steaming — The most widely used method of precooking is steaming. It is the cheapest method of preparation but it is admitted that the flavor and texture of the product could be improved. In the steam-cooking process, the filled racks are wheeled from the flaking machine to steam chambers at one end of the packing room. These chambers are oblong steam boxes, large enough to admit four racks and equipped with tightly fitting doors. Dry steam is admitted to the steam chamber at 100 pounds pressure. A blow-off valve of the chamber is left open to permit rapid steam circulation without building up a pressure. The fish are steamed from 8 to 20 minutes, depending on their size.

The racks are then moved into a long room, usually equipped with a blower fan and heating coils or with other mechanical apparatus for creating a current of dry, warm air, in which the steamed fish are cooled and the surface moisture is removed. This requires from 30 minutes to 2 hours, the length of time depending on the size of the room, size and amount of fish and efficiency of the apparatus. If the sardines are packed while still warm, most of them are broken into unusable fragments or the skin is loosened and they do not pack well in the cans. A temperature of 160° F. is considered the optimum for a drying room.

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Frying—In Maine, all precooking formerly consisted of frying in an oil bath and this method is still used to some extent. Under favorable conditions, frying resulted in an excellent product with a moisture content of about 65 percent, which is an optimum for canned fishery products. The moisture content in fish cooked by steaming is somewhat higher. The principal objection to frying is the high cost of oil. It is also necessary to change the oil at frequent intervals or the pack will acquire "off–flavors." The cooking oil becomes oxidized if it is used repeatedly over too long a period of time. The use of the oil bath is confined to a few plants today, generally for fancy–grade packs.

If the fry bath method is used, the racks are taken from the flaking machine directly to a drying room, where the fish are dried in a current of heated air at temperatures about 100° F. for about 2 hours or until the surface of the fish shows no indication of moisture. There is a loss in weight of about 12 percent in this drying procedure.

Frying takes place in shallow metal tanks with a closed steam coil set about halfway down. Although publications on canning state that the "fry bath" is filled with water to a level just below the steam coil with a top layer of oil for frying, Maine sardine canneries no longer use water. The reasons given for the use of water were to reduce the cost and so that waste could be drawn off through a valve in the bottom of the tank eliminating the necessity of draining the whole tank and filtering the oil. It has been found that a better–grade product is obtained if oil only is used.

The tank is filled with approximately 15 barrels of vegetable oil, usually winter–pressed cottonseed oil. The oil is changed frequently. The flakes of dried fish are passed by conveyor through the oil bath, which is heated to a temperature of about 230° F. at a rate which should insure that the fish are cooked sufficiently when they emerge.

The adequacy of cooking may be determined by breaking the tail fin of a cooked fish. It it snaps off and is brittle, the fish are done, but if the tail does not break cleanly, the cooking is not sufficient. The frying time varies from 4 to 6 minutes, depending on the size and condition of the fish. After frying, the flakes are again stacked in racks which are taken to the drying room, where the fish are dried and the oil drained off in a current of heated air from 1 to 2 hours.

One packer uses a method developed by Beard (1926) which consists essentially of drying and cooking the herring in a single operation by forcing blasts of hot air over the brined and flaked fish in an apparatus of the tunnel–dryer type. The time required

averages 15 minutes, with some variation depending on the size and condition of the raw material. This method is said to dry the fish more evenly and the moisture content is more easily controlled.

FILLING

When the fish are cool, the racks are wheeled to the end of the filling table. The first or older style of filling table arrangement consists of a long open framework about 5 feet high, supporting a double conveyor belt. Small tables with a worker on each side are set at right angles on both sides of the conveyor. A cannery packing a maximum of 2,500 cases per day will have about 60 packing tables and employ 120 hand packers to fill the cans. Women and girls are employed as packers. The flakes are transferred from the racks to the conveyor belt and are removed by the packers as needed. Each packer has a metal tray of empty cans.

Filling the cans requires considerable skill. Approximately the same number of equally sized fish must be packed in each can. They must be laid in so that only the silvery skin will show on opening the can, and in a firmly–packed layer since loosely–packed fish are liable to break. The cans are usually filled with sardines laid in longitudinally, with heads toward the ends of the can and tails over-lapping in the middle. In packing the larger fish the heads and tails are alternated to make an even layer. Very small fish are "cross packed," that is, laid in parallel with the ends of the can. The smallest sizes require especially careful handling.

More than 90 percent of the sardines canned in Maine are packed in the one–quarter size can which contains from 4 to 15 fish in the standard grades. Special packs may contain as many as 30 small fish. From 6 to 10 flakes of fish are required to fill each case of 100 one–quarter cans. Fish packing 11 or 12 to the one–quarter size can are considered the most desirable size.

The packers clip off the heads with a pair of shears, or if the fish have been dressed raw, trim off enough to fit them to the can. If the fish are small, only the heads are removed, if they are medium sized, both head and tail ends will be clipped; of the largest fish, only the tail portion is used. The loss in trimming varies from 15 to as much as 60 percent of the original weight. The average packer in Maine will pack about two cases per hour, but speed depends on the size of the fish.[8]

If the fish are small, 10 to 12 to the can, the yield per bushel, about 70 pounds, is from 1 to 3 cases of 100 quarter–size cans, while if they are larger, 4 to 5 to the can, from 0.8 to 1.5 cases

[8] National Recovery Administration. 1934. Hearing on the code of fair prices and competition. New England canning industry, p. 181. Washington.

may be expected. The most generally accepted estimate of yield is 20 cases per hogshead if the fish are small.

As each packer fills a tray of cans, it is removed by a workman who substitutes a tray of empty cans, carrying the full tray to a short conveyor feeding into the machine where the cans are filled with oil or sauce. Filling is paid for on a piece–work basis with the present rate of payment varying from 15 to 18 cents per case.

The second variety of filling table is a type widely used in hand filling other varieties of canned foods. It consists of a long table with a conveyor in the middle about 2 or 3 feet above the working level. The packers work in long rows down each side of the table. The flakes of fish travel on the top conveyor belt, while each can as it is filled is placed on the return conveyor running flush with the top of the table, to be carried immediately to the oiling and can–sealing machines. This arrangement apparently is more efficient than the first one described.

By far the greatest part of the pack is put up as "oil" sardines. Winter–pressed cottonseed oil customarily is used. Some fancy grades are packed in imported olive oil. Corn oil formerly was used to some extent but Maine sardines are rarely, if ever, packed in corn oil at present.

Two types of machines are used to add oil to the cans. In the first type, trays of 20 or 25 cans are oiled simultaneously. In machines of the second type, as each can passes through the filling machine it trips a lever, sending a jet of oil into the can. The oil is heated to 180° F. Oil is sometimes added to the cans before filling but this practice is being abandoned as it makes packing very messy, the canned product will not contain a uniform amount of oil and the loss through wastage is greater. The amount of oil used is set by law in the State of Maine at a minimum of 4 pounds per case, for the so-called "standard" pack, and at 5 pounds per case for "extra standard" and "fancy" grades.

Mustard sauce is sometimes used instead of oil, usually with fish of the larger sizes running from 4 to 5 to the one–quarter size can, or lots which may show rough handling. Tomato sauce is used in a few thousand cases of special pack Maine sardines. Some sardines are packed in a special spiced oil, made by adding oil of cloves or other essential oils of spices to cottonseed oil. A delicate spicy flavor is secured in the product, one relished in certain markets. Great care must be used in making up the spiced oil, as an excess of spice flavor will make the sardines almost inedible. A few small lots are also packed on special order with a spiced vinegar sauce; olive oil, pimiento and bay leaves; butter and bay leaves, or in other special "sauces."

EXHAUSTING AND SEALING

No heat exhaust or other method of obtaining a vacuum is used because of the heated oil used in filling. This is supposed to produce a sufficient vacuum. The filled cans are conveyed to a can seamer of the same type used in sealing corned beef or other "square" cans. These machines operate at a speed of 40 to 60 cans per minute.

In some canneries the cans drop from the sealing machine into large baskets made of perforated sheet metal which are lifted by hoists and carried to the retorts by an overhead trolley or are transported on low four-wheeled trucks. These methods rapidly are becoming obsolete, and have been abandoned by the larger canneries. Most of them now employ a belt-conveyor running from the can sealers directly to chutes into the retorts. Battering or distorting of the cans through falling is prevented by having the retort partially filled with water, which has a cushioning effect. When the retort is loaded with cans any water not displaced is blown out by steam. One canner uses retorts fitted with "fish-tail" chutes inside, along which the cans glide without becoming damaged.

Most of the retorts used in processing Maine sardines are of the vertical type and have a capacity of from 65 to 120 cases. The packers who use conveyor systems in filling the retorts have modified the usual type of vertical retort, narrowing the top to a small opening about 1 foot in diameter. There also is a small door in the side near the base of the retort, 1½ by 1 foot, through which the cans drop onto a conveyor when processing is completed. Recording-chart thermometers are quite generally used and one cannery has installed retorts fitted with full automatic control.

Under the automatic control system at the end of the processing period, steam is turned off and sufficient compressed air to maintain the pressure is admitted. An automatically controlled valve admits cooling water until the temperature within the retort is about 100° F. This procedure permits more accurate control of processing, cools the cans more rapidly, reduces the possibility of over-cooking and also the amount of washing necessary to clean the cans after processing.

PROCESSING

A few packers still use the hot-water bath for processing. However, these packers are subject to occasional losses through swells caused by under-processing.

When cooked in a pressure retort, the process varies from 30 minutes at 240° F. (10 lbs. pressure) to 90 minutes at 220° F. (3 lbs. pressure). There is at present no agreement as to sufficiency of process although research laboratories recommend 45 minutes at 240° F. If an open hot water bath cook is used, the process for one–quarter size cans is from 90 to 120 minutes.

COOLING AND WASHING

When the cans are removed from the retort, they are rinsed in an alkaline cleaning solution, then in fresh hot water and are left in piles until cool and dry enough for labeling and casing. In a few of the older plants, shallow wooden tanks may be used for cleaning and washing. If this is the case, the cans are contained in the metal crates or baskets in which they were processed and the baskets are dipped into the tanks. In the more up-to-date plants the cans drop individually from the retort onto a conveyor, passing through the cleaning solution, then through sprays of hot water under pressure.

Sardine cans require thorough cleaning, as they are covered with a thin film of oil as they come from the retort or cooker. The method of cleaning formerly employed was to put the cans in a drum containing sawdust, tumbling the cans until the sawdust absorbed a portion of the oil, then wiping the cans after they had been removed from the drum. This method is rarely if ever used today.

LABELING AND STORAGE

The cans are usually labeled and cased within a day or two after packing although this depends to some extent on the degree of activity in packing. The women who fill the sardines into the cans also pack the cans in cases and perform some of the labor in labeling. Therefore, when possible, this portion of the operations is left for times when the packers would otherwise be idle. This policy aids in giving more continuous employment to the cannery crew.

The label may be embossed in the top of the can previous to use by stamping the lid with a die. Each can may then be placed in an individual pasteboard carton or cased without any additional label. Some cans are wrapped entirely in heavy paper by machine, with the label printed on that portion of the paper covering the lid. Some lots are wrapped in light paper of the semi-transparent or tissue type and a label is pasted over the paper on the top of the can by hand. Lithographed cans, with the label enameled on the can lid, are probably most widely used.

The cans are cased by hand in fiberboard cartons measuring 15½

by 9 by 8½ inches and holding 100 quarter–size cans (Fig. 28). The gross weight of a case of quarters is approximately 36 lbs. Certain canners do not use the standard case, but market one holding 96 quarters and also sell smaller cartons holding 24 quarters. Three-quarter cans with net contents of approximately 11 oz. are cased in cartons of 48 cans. This size can is now used entirely for "mustard" sardines and the amount packed in 1938 was 47,160 cases or 4 percent of the total (Fiedler, 1939). Sardines were formerly packed in "one-half" cans, but this size of container has not been used for several years.

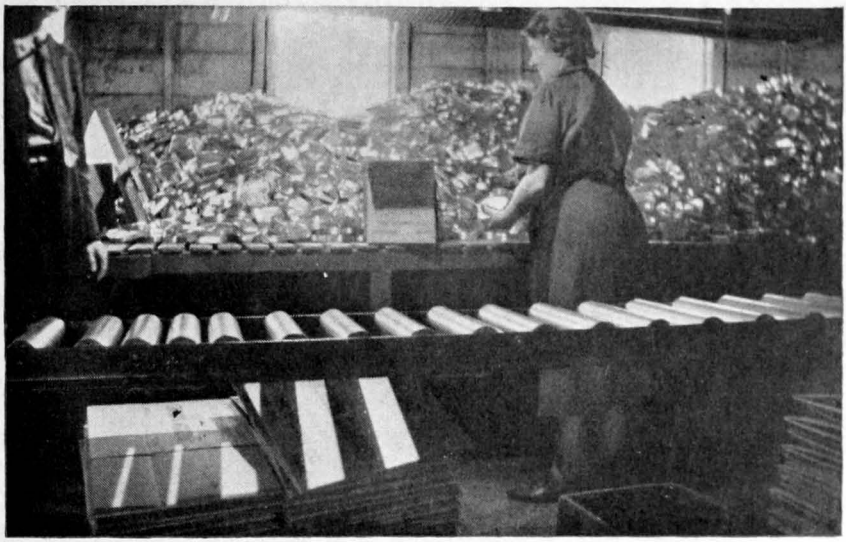

FIGURE 28.—Maine sardine canning; packing "quarter–oil" cans in cases.

Some packers do not store their pack; as soon as the cans are labeled and cased, they travel by conveyor directly into a railroad car on a siding outside the cannery door. A carload of sardines is 1,000 cases. The producer rarely holds the pack more than a few months. Every effort is made to dispose of the pack before the opening of the next season. This is not due to possible deterioration but the packing costs and selling prices fluctuate from year to year and as the packers generally operate on a narrow margin of profit, holding the pack in storage over too long a period may turn a small potential profit into a large actual loss.

INSPECTION

The sardine canneries of Maine are subject to a system of inspection administered by the Department of Agriculture of that State. The inspection system provides that an inspector shall be stationed in each cannery during the packing season, to examine all fish received before they are landed and to determine whether they

are fit for use. If 5 percent or more of the herring show the presence of "red feed" the inspector condemns the catch. It is also his duty to see that sanitary packing conditions are maintained and that the workmanship in packing is not careless.

The regulations specify the quality of cottonseed oil in which most of the sardines are packed. If cottonseed oil is used the law requires that it be "winter–pressed" oil. Samples are taken by the inspector from each lot of oil delivered at the cannery and these are analyzed by the state to prevent the substitution of inferior oils. The inspection system seems to be working quite satisfactorily and it has resulted in raising the quality of Maine sardines.

In contrast to the regulations for canning sardines in California, processing times and temperatures are not specified, nor is it necessary for the retorts to be equipped with recording chart thermometers and control instruments. Official grades have not been promulgated though a step has been taken in this direction in the regulation requiring a minimum of 4 fish in any "keyless" one–quarter and at least 5 in key–opening cans.

PACIFIC COAST SARDINE CANNING[9]

FISHING AREA AND SEASON

The sardine canning industry of the Pacific Coast utilizes as raw material the California sardine *(Sardinia caerulea)*, which is closely related to the species canned as sardine in France, Portugal, and Spain. It is known as pilchard in the British Empire. The range of this fish on the Pacific Coast extends from Vancouver Island south to the Gulf of Lower California. The canning industry is centered at San Diego, San Pedro, Monterey and in San Francisco Bay, Calif. While the fish are taken in quantity off Coos Bay, Columbia River, and Grays Harbor area of the Oregon-Washington coast, they are utilized almost entirely for reduction purposes. Some are canned in Astoria, Oregon, and a small quantity is canned in 1 pound tall cans in British Columbia as pilchards. With these exceptions, the sardine canning industry is located in California. The fishing area covers a radius of approximately 150 miles around each port.

The season when sardines may be taken for canning or reduction purposes varies with the respective areas and is based on the time of year when they are in prime condition. At present, sardines may be taken for packing from August 1 to February 15 in the northern California or the San Francisco and Monterey areas, and in the San Pedro-San Diego district from November 1 to March 30th inclusive.

[9] This section prepared by O. W. Lang, George William Hooper Foundation, University of California and N. D. Jarvis.

FISHING GEAR AND METHODS

The sardine purse seiners follow the general lines of the purse seine vessels of the North Pacific but are usually larger and heavier, with carrying capacities up to a maximum of 160 tons. The maximum load is taken only in calm weather and when short distances from the cannery make it possible to carry a deck load.

The fishing gear first used with any great degree of success was the lampara net, introduced by Capt. Peter Ferranti of Monterey (Campbell, 1938). This net was used almost exclusively from 1905 to 1929, but is now almost although not entirely obsolete. It was followed by the "half–ring" and "ring" nets. The ring net is still important in fishing for sardines. However, the purse seine is now used most widely and approximately three-fourths of the catch is made with this net.

The typical lampara net is 170 fathoms long by 20 fathoms deep. The central portion of the net to a length of about 40 fathoms is made of strong, fine meshed twine and forms a bag for holding the sardines. The sections on either side of the bag are of larger mesh and made of finer twine, and are known as the wings. The webbing is "gathered" to a point at the ends of the wings.

The "half–ring" net is a lampara net with purse rings and a purse line along the lead line of the central section or about two-fifths of the net which forms a bag for holding the sardines. Gradually additional rings were added, until they extended to approximately two-thirds of the lead line, after which it was called the ring net (Fry, 1931). The method of fishing is the same as for the lampara net, except that the bottom of the bag portion can be closed more surely and with greater speed than the lampara net.

The sardine purse seine is from 200 to 250 fathoms long and 20 to 30 fathoms deep. The lower part of the net does not taper toward the ends. The mesh size is the same throughout, however, the size of the twine varies from heavy in the strip along the cork line, to fine in the section along the lead line. The purse seine may be either tarred or bark tanned. Tanned nets are lighter and easier to handle than tarred nets but require more frequent preservative treatments. The lead line is more heavily leaded than the lampara net. At intervals of about 6 feet, iron rings known as "purse rings" are attached to the lead line and the purse line passes through the rings. The total weight of a sardine purse seine will range from 2 to 4 tons (Tribby, 1936).

As a rule, in California sardines are seined only at night during the "dark of the moon" although they may be caught occasionally on moonlight nights and sometimes even in daytime. The schools of sardines are located by the phosphorescent areas produced by their movements near the surface of the water. From Oregon to

British Columbia day fishing is the rule. The method of purse seining does not differ greatly from that used in the Pacific salmon fishery.

TRANSPORTING AND UNLOADING

The sardines, if used for canning, arrive at the cannery 1 to 8 hours after capture. The Bureau of Cannery Inspection, California State Health Department, requires that fish canned from any boat load must be packed within 12 hours after the arrival of the fishing vessel. An exception is made if the fish are to be canned as "quarter oils."

The cannery inspector stationed at each cannery examines the sardines as they are unloaded for the presence of bruised, broken, soft, sunburned or otherwise unsuitable raw material. The con-

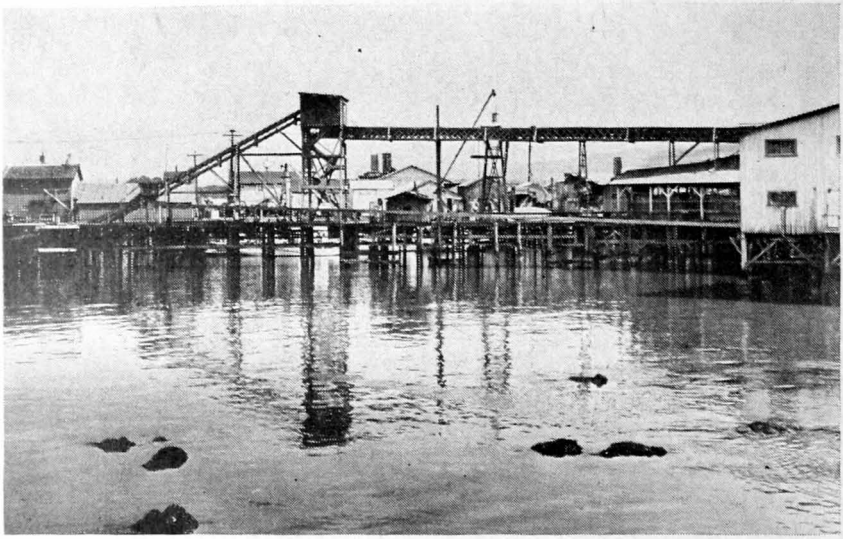

FIGURE 29.—Elevator and conveyor at a sardine cannery, Monterey, California.

dition of the fish is checked against the time and locality of catch as given in the captain's log. If the poor condition of the fish is thought to be due to over-loading, the supervising inspector of the district may limit the tonnage to be carried by the offending vessel. The packer decides whether the fish are to be used for canning or reduction purposes, unless the inspector finds that the load, or any portion, is unfit for canning. If the inspector decides that the fish are unsuitable for either canning or reduction he may terminate the unloading and order rejection of the balance.

Variations in type of water front and contour of shore line have made it necessary to adopt different methods for unloading in each packing center. The canneries in the San Pedro district are separated from the unloading dock by a street running along the water

front. Here the sardines, after being brailed from the boat into a hopper, are elevated about 30 feet (Fig. 30) and are then discharged into weighing buckets holding approximately 750 pounds. When a bucket is full, the weight is registered automatically by

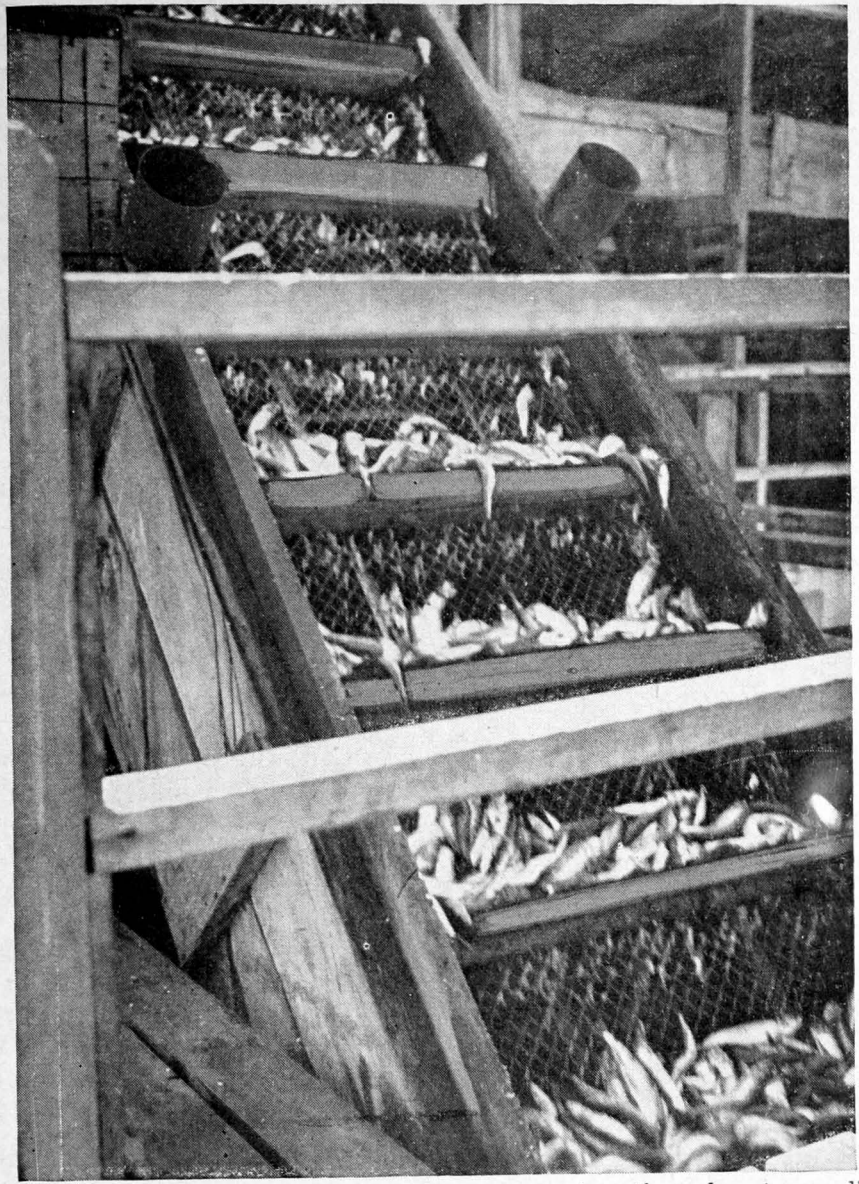

FIGURE 30.—Elevator from unloading pump to automatic scales at a sardine cannery, Monterey, California.

recording scales and the fish are emptied into a flume or onto a conveyor running at a slight decline into the cannery across the street. A stream of water transports the fish into the receiving tanks. The scaling machine or squirrel-cage washer is almost obsolete.

At Monterey an 8-inch pipe extends along the bottom of the bay from the cannery to a point approximately 150 yards offshore and opens into a rectangular hopper at the surface of the bay. Spaces are left between the boards forming the sides of the hopper so that water flows in and out. The purse seine boat ties alongside the hopper into which the fish are brailed. Fish and water are sucked into the cannery by a powerful pump. The high velocity at which the fish are transported by this method serves to wash and scale the sardines very effectively. On receipt at the cannery, they are weighed as described in the preceding paragraph and flumed to the receiving tanks. The sardines are usually allowed to remain here until a sufficient supply has accumulated to permit canning operations without interruption. The general custom is to unload for approximately one hour before starting the packing operations.

DRESSING AND WASHING

A sliding door near the base of the receiving tank is lifted and fish are permitted to flow as needed onto a table or trough connected with the cutting machine. The sardines are fed by hand, head first and backs up, into a deeply slotted conveyor belt, the slots being just wide enough to hold the bodies of the fish. The sardines are carried past a revolving circular blade, which severs the backbone and cuts the head almost off but leaves it attached to a thin strip of belly flesh. The conveyor then passes a whirling paddle or revolving brush which completes the heading operation, pulling out the entrails attached to the head, with a strip of belly flesh.

Two other slightly different types of machine are in use. In one the circular blade is adjusted so that the head is cut off squarely and completely. The fish then passes a vacuum apparatus which removes the viscera by suction. In the other machine, the head is completely removed and a revolving burr is plunged into the body cavity, reaming out the viscera. This burr is perforated and during the time it is operating, water at high pressure is forced out the end, flushing the body cavity.

California sardines are no longer cut by hand, with the exception of small fish to be packed in quarter-oil cans. Unlike Maine sardines in the small size container, small California sardines are headed and cleaned before, not after pre–cooking.

The cleaned fish drop from the conveyor into an iron box at the end of the cutting machine. When the box is full a checker trips a lever which releases the contents into a flume. This box holds approximately 25 pounds of fish. He then punches a card hanging by the machine feeder, as cutting is a piece-work operation. If the sardines are not to be packed in 1- or ½-pound ovals, other

machines may be attached to the end of the packing table which cut the sardines into container–length pieces, or this operation may be performed when the fish are cleaned and headed. Fluming the cut fish causes less damage to the flesh than other conveyor systems and also washes off the blood.

PREPARING FOR THE CAN

Methods described for handling, cutting and conveying the sardines are essentially the same in all packing plants. From this point on, however, the operations vary materially and where such standard procedures as brining and drying were universally employed at one time, they are now used only for the oil fry or raw vacuum style of packs.

BRINING

The cleaned and eviscerated fish are flumed to the brining tanks. After being filled with fish, the flume water is drained and a dense salt solution of 80° to 100° salinometer is added. Brining requires from 60 to 90 minutes. Mechanical agitation or intermittent stirring by an attendant is necessary during this time if the salting is to be uniform. Brining makes the texture more firm, extracts the blood, removes slime which adheres to the fish even after washing, and provides a means of temporary storage, so that the sardines may be held in good condition.

DRYING

The purpose of drying is to extract sufficient surface moisture so that during the ensuing oil fry the skin will not become ruptured and peel. The brined fish are flumed to a wire mesh conveyor leading to a tunnel-shaped tumbler drier. These driers are usually 50 to 75 feet long, 7 to 9 feet wide and 10 to 14 feet high, containing 6 to 8 endless wire mesh belt conveyors, with alternate runs, staggered and traveling opposite directions. The sardines are conveyed to the top run and after traveling the length of the drier they drop 6 to 8 inches directly below to the staggered conveyor which is moving in the opposite direction. This process is repeated until the sardines are discharged to a conveyor which transports them to the fry vats or to the next step in the canning operation.

A current of warm dry air is blown through the drier taking up moisture. The moisture–laden air escapes through air ducts or the open end of the drier. The time of drying varies with drier construction, velocity and temperature of the air and condition of the fish, with the latter factor perhaps the most important.

When sardines are properly dried, the loss in weight is from 4 to 6 percent at a drying time varying from 60 to 90 minutes at 90° to 100° F.

OIL FRY

The standard pre-treatment method was formerly the oil fry; while it is seldom used, it is not obsolete and is demanded in certain markets. Essentially it is the same as the fry cook formerly used in packing Maine sardines and probably originated from this source. The fry troughs are built on the same plan as those used on the Atlantic coast, but are wider and longer, averaging 70 feet in length. The tank is filled with water to a level of 2 to 3 inches below the steam coil and above this level with destearinated sardine oil. Cottonseed oil or occasionally peanut oil was formerly used. However, since large quantities of oil were required which could not be reclaimed for other purposes, it was finally displaced in favor of the natural sardine oil which serves the same purpose and is reclaimed at little expense. Sardine oil is never used for frying more than once.

To speed up handling and to economize on floor space, the drier and fry vats are usually placed parallel and in close proximity to each other. A short conveyor carries the sardines from the drier to a point where the fry baskets are filled and placed in the fry vat. The discharge end of the fry vat leads directly to the cooling platform. A thin layer of fish is placed in baskets with dimensions of 36 by 18 by 4 inches. A basket 18 inches square and 4 inches deep is also used. An endless chain conveyor transports the baskets through the fry vat. The vat temperature at the beginning of the fry is usually 180° to 200° F. while the final temperature approximates 230° F. Large "pound oval" sardines are sufficiently cooked in 7 minutes while the smaller fish packed in "quarter oil" cans require about 5 minutes. Cooking is judged sufficient when the meat is free from blood and the backbone may be separated readily from the flesh. The baskets on emerging from the cooker are stacked on movable racks and placed on the cooling platform to drain.

The sardines are cooled from 12 to 15 hours, depending on atmospheric conditions. Fifteen ounces of cooked fish are packed in 1-pound oval or 7 ounces in ½-pound oval cans. Other can sizes or shapes are not used in the fry pack method. An open steam exhaust from 12 to 15 minutes at 210° F. follows packing. The steam condensate and the oil rendered from the sardines are removed by an automatic draining device in which the cans are slowly inverted and then righted. This is followed by saucing and sealing operations.

RAW VACUUM PACK

Approximately 1 ounce of tomato or mustard sauce is added to each empty 1-pound oval can. The cans are conveyed to the packing tables where they are filled with 15 ounces of brined and dried raw fish. An additional ounce of sauce is added as the packed cans pass to the vacuum sealing machines. The covers are loosely clinched and the cans conveyed through the rotary valve into the vacuum sealing chamber where a vacuum ranging from 18 to 22 inches is drawn during the sealing operation. An internal vacuum from 3 to 5 inches is thus secured in the filled cans. The packing procedure is simple, efficient and the cost is low. One disadvantage may be cited, namely, a tendency toward loose and slack filled containers.

BROILED PACK

Approximately 16 ounces of raw cleaned sardines are packed into 1 pound oval cans. The filled containers travel for 45 minutes through hot air ovens with temperature ranging from 320° at the beginning to 350° F. at completion of the cook. The heat source is a fire box connected directly to the oven very much like one constructed for a high pressure boiler. The fuel is either oil or gas and the flames are thermostatically controlled. A high velocity fan assures an even temperature distribution. When broiling is completed the cans are drained, sauced and sealed.

PRECOOK PACKS

The various methods of precooking now used for the greater portion of the California pack of 1-pound oval sardines result in products differing markedly from either the oil fry, the oven broiled or raw vacuum packs. The majority of these methods involve prolonged heat treatments in continuous steam exhaust boxes after the cans are packed (Fig. 31). All steps in the canning procedures must be continuous from the time the sardines are first delivered until they are canned.

The exhaust treatment or precook may be interspersed with one or more draining operations following which the cans may be subjected to dry hot air or superheated steam to overcome excess moisture in the final canned product. All precook methods are modifications of the fry pack. Longer exhaust periods eliminated the costly frying procedure and the time necessary to cool the sardines so that they might be packed without crumbling. It was also found that drying and to some extent brining could be eliminated since the flesh became moisture-laden in precooking and a considerable amount of salt absorbed through brining was lost when the cans were drained.

In the precook packs, 16 ounces of raw cleaned fish are filled in 1-pound oval cans. The cans must be overfilled in order to avoid a slack fill since a shrinkage of 1 to 2 ounces occurs during precooking and draining. The cans then pass to various types of continuous steam exhaust boxes where they are precooked from 30 to 45 minutes at 210° F. This is followed by draining after which the cans are sauced and sealed. In certain canneries the condensate, moisture and oil cooked out of the fish may be eliminated by one or two draining operations during the cook, later followed by a final draining.

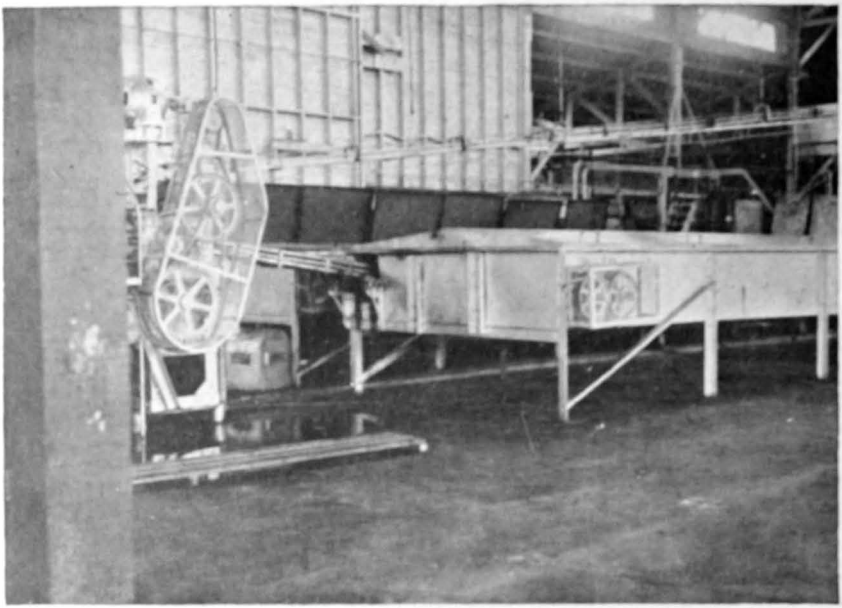

FIGURE 31.—Steam exhaust type of precooker, California sardine cannery.

A second style of precook consists of a 20- to 25-minute steam exhaust at 210° F. following which the cans are drained and given another cook in super heated steam at temperatures of 220° to 230° F. In a third type of precook the cans pass through a vertical steam exhaust box containing a series of gas jets at the bottom. The cans require approximately 35 minutes for completion of the cook. The temperatures secured in different sections of the box are variable and range from 220° to 240° F.

DRAINING

Several draining mechanisms are in use. One consists of a series of oval plates the size of a 1-pound oval can lid, on a revolving chain conveyor, in which the plates are timed to meet and grip the cans as they emerge from the exhaust box. A can drained

in this machine completes a 360° revolution in a relatively short time. Another draining mechanism consists of an endless chain conveyor suspended on two pulleys. A second chain conveyor surrounds the inner conveyor. It is spaced by angle–iron supports with sufficient clearance to permit the cans to travel in between the conveyors. The cans enter the drainer, which may be 6 to 15 feet long, and travel its lower circumference in an inverted position. Added draining is also secured as the cans are inverted and then righted on the circular portions of the pulleys.

FILLING WITH SAUCE

The precooked and drained cans pass under a saucing device which adds 2 ounces of tomato or mustard sauce to the 1-pound oval can and 1 ounce to the ½-pound oval or the 9-ounce rectangular can. The saucing mechanism usually consists of a quick acting gate valve above the conveyor in which the orifice is calibrated to deliver the proper amount of sauce. In another type of machine a small reservoir holds the amount of sauce to be delivered. The cans trip a lever as they travel along the conveyor and the sauce is released. Tomato sauce is usually heated to 150° F. while mustard sauce is added cold since heating causes coagulation and separation of the mustard.

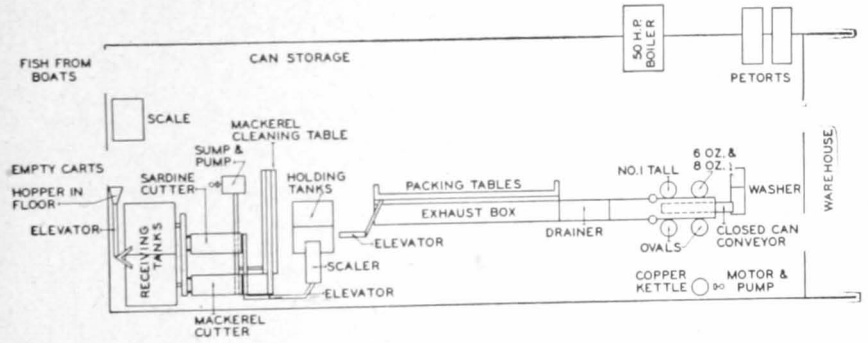

FIGURE 32.—Floor plan showing equipment layout of a California sardine and mackerel cannery. (Courtesy, Standard Steel Corporation.)

SPECIALTY PACKS

SARDINES IN BRINE

This pack consists of fish which have been cleaned and packed into cans, followed by a long exhaust or precook, with a hot brine added just prior to closure. Other pre–treatment methods may include smoking but in any method of preparation the fish are seldom thoroughly cooked before brining and closing. Two sizes of cylindrical cans are used, the 6-ounce paste (202 x 309)

and the No. 1 tall (301 x 411). The 6-ounce paste can is packed with smaller cuts of fish to a fill weight of 5 ounces. The No. 1 tall can is better adapted to the larger sizes but may be and is used for the smaller cuts as well. The fill weight in this can is 17 ounces of cleaned raw fish. The exhaust time for the 6-ounce can is approximately 5 minutes while for the No. 1 tall, 20 to 35 minutes at 210° F. is necessary to produce the desired shrinkage. A circular plunger attached directly to the closing machine and slightly smaller in diameter than the can, depresses the can contents to secure the necessary head-space. A hot 4-percent salt solution is then added and the cans are sealed.

SARDINES IN OIL

Small sardines are cleaned, brined and dried, then fried in oil as previously described. These fish, having little or no natural fat, tend to absorb the oil from the fry bath. After cooling sufficiently so that they will not crumble in filling, 3½ ounces of fish are packed in the ¼ pound (404 x 300½ x 014) can and from 7¾ to 8 ounces in the ½ pound (410 x 307½ x 103) key open cans. After an exhaust of approximately 7 minutes at 210° F. the cans are drained, and ¾ to 1 ounce of cottonseed or olive oil is added to the ¼-pound can and 1½ ounces of oil to the ½-pound can. The cans are then sealed and processed.

SARDINE FILLETS

Sardine fillets may be packed in oil, smoked, in a sweet spiced sauce or "natural." For this pack the sardines must be large, mature, firm of flesh and in prime condition. The increased popularity of fillet packs has prompted the design of rather unique filleting machines although in the past this operation was performed by hand. If cut by machine the whole sardines are placed ventral side up into grooved depressions of a conveyor. A circular blade completely severs the head and on passing the blade a timed finger removes the cut fish toward 2 circular blades which separate the flanks or fillets.

Another type of filleting machine consists of 2 belts arranged in a "V" shape into which the sardines are placed ventral side up as previously mentioned. The whole sardines are firmly held between the 2 belts and are carried to 2 circular blades which remove the fillets. The fillets then travel by flume to either brining or holding tanks.

The fillets may or may not be brined, depending on the packer. If the canning operation includes brining, the fillets are immersed in a 20- to 22-percent salt solution for approximately 30 minutes.

They are then packed in 9-ounce (300 x 404 x 108) rectangular machine-drawn cans, to an approximate net weight of 7 ounces. The fillets are placed in 2 layers separated by "30-pound" vegetable parchment liner with 6 to 8 fillets per can. Packing is followed by an exhaust of 20 minutes at 210° F. and after draining, the cans are sealed. If the fillets are not brined, dry salt is added prior to sealing. Various types of sauce may also be added.

SMOKED FILLETS

There are two procedures for packing smoked or "kippered" sardines. In the first method the whole fish are brined from 60 to 90 minutes in a 20-percent salt solution. The fillets are then cut and arranged on flakes or wire trays 18 inches wide by 24 inches long. These flakes are then placed on a conveyor which carries them into a vertical type continuous smoke house, in which the smoke is evenly distributed by a blower. The fuel is California oak smothered in tan bark, the smoke house temperature varies from 100° to 110° F. Smoking requires approximately 90 minutes and after a short cooling period the trays are taken directly to packing tables where the fillets are placed in 9-ounce rectangular cans. An exhaust of 20 minutes at 210° F. then follows. The cans are drained and either cottonseed or olive oil, tomato sauce or a sweet spiced sauce is added before sealing.

In a second method the fillets are brined for approximately 30 minutes in a 20-percent salt solution containing garlic and other condiments. They are then carried into a tunnel-shaped continuous smoke house equipped with a blower which distributes the smoke. The smoke is produced by burning oak wood or manzanita roots. After packing in 9-oz. rectangular cans the containers are conveyed through a continuous gas heated oven for approximately 20 minutes. A sauce is then added and the can is sealed.

SMOKED SARDINES IN TOMATO SAUCE

After evisceration the sardines are brined in a 20-percent salt solution for approximately 45 minutes. They are then smoked, packed in 9 oz. rectangular cans, sauced and sealed.

SEALING

All cans are sealed in automatic closing machines (Fig. 33). Oval and rectangular cans require a special type of seal. An attachment to the sealer embosses a code onto each can cover identifying the canner, packing date, style of pack and retort batch.

WASHING

The sealed cans are conveyed from the sealing machine into the can washer. The washed cans fall into perforated retort baskets or crates which are usually constructed to fit the contour of the retort. No attempt is made to stack the cans since it has been found that sterilization is more uniform when the cans are piled loosely in the baskets. From the standpoint of efficiency of sterilization, stacked cans correspond to a continuous cylinder

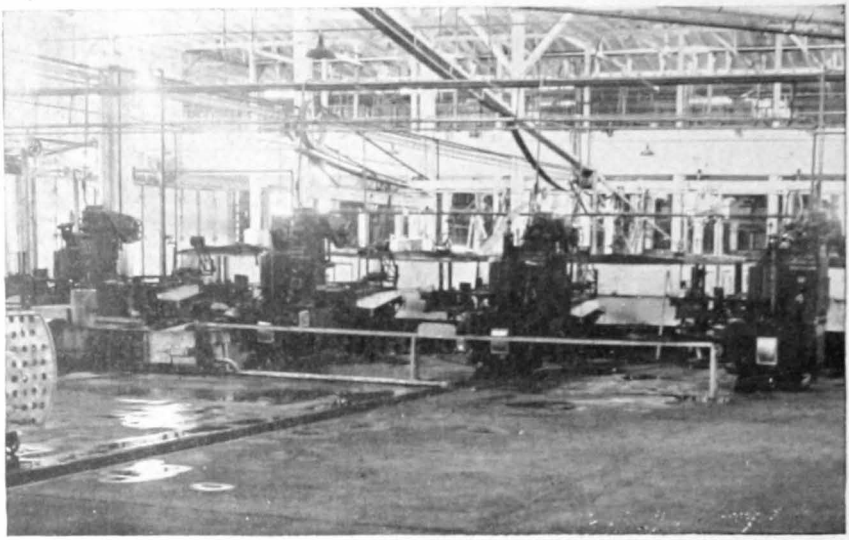

FIGURE 33.—Battery of can sealing machines, California sardine cannery.

divided by a series of baffle plates, which in this instance are the can covers or ends. A cylinder of this type, therefore, becomes more difficult to sterilize.

PROCESSING

The crates are rolled into horizontal retorts equipped with recording chart thermometers and other equipment required under regulations of the California Bureau of Cannery Inspection (State of California, 1935). The processing times specified by the Bureau of Cannery Inspection are as follows:

Type pack	Can size	Initial temperature (° F.)	Processing time in minutes at		
			230° F.	240° F.	250° F.
Brine	6 oz. paste	70	100	55	40
	6 oz. paste	130	95	50	35
	6 oz. paste	150	95	50	30
Brine	No. 1 picnic	70	115	75	60
	No. 1 picnic	130	105	70	50
	No. 1 picnic	150	100	65	50
Brine	No. 1 tall	70	125	90	75
	No. 1 tall	130	110	80	65
	No. 1 tall	150	100	75	60
Brine	No. 10	70			
	No. 10	130			
	No. 10	150		240	210
Oil	"quarter"		75	30	15
Oil	"half"		90	45	25
Mustard or tomato sauce	½-lb. oval	70	110	55	40
	½-lb. oval	130	105	50	30
Mustard or tomato sauce	½-lb. oval	150	100	50	30
	1-lb. oval	70	130	75	55
	1-lb. oval	130	120	70	50
	1-lb. oval	150	115	65	50
Filleted sardines with "30 lb." parchment separating layer	9-oz. rectangular	70	130	75	55

INSPECTION AND EXAMINATION

In California a State inspector of the Bureau of Cannery Inspection is stationed at each cannery. It is his duty to inspect the raw material prior to canning and to remove representative sample cans from each code packed during the day. These are later examined at the field laboratory of the inspection service. No pack is released into the channels of trade until the requirements of this Service have been met. The examination includes a determination of freshness of the raw material, the presence of bruised fish, "honeycombing," "green feed," and adulterations such as entrails. No attempt is made to establish grades although particular attention is directed toward the workmanship in packing and the suitability of the raw materials. The odor is determined as in the examination of salmon. Data concerning the cutting report of the laboratory may be obtained from table No. 12.

A complete production record is maintained by each packing plant. The recording thermometer charts together with the production record are examined by the inspector. This examination covers the retort process time and the temperature. The number of cases and cans incorporated in each batch code must correspond to the production record as well as to the notations on the recording thermometer chart. The production record as well as the recording thermometer chart must also show the full process time at the respective sterilization temperature and equivalent pressure. When all of these requirements have been met the inspector releases the day's pack for shipment. If any defect is observed a "restraining order" is issued prohibiting shipment of the pack until the