AN AUTOMATIC PALLET-BOX FILLER for APPLES

Marketing Research Report No. 550

GRICULTURAL MARKETING SERVICE U. S. DEPARTMENT OF AGRICULTURE

Transportation and Facilities Research Division

PREFACE

This report presents results of research on designing, constructing, and testing an item of equipment for automatically placing apples into pallet boxes. It is the second report in a group to be published on contract research on designing and testing of pallet boxes for in-plant handling and storage of apples and other tree fruits. The first report is "Cooling Apples in Pallet Boxes," Mktg. Res. Rpt. No. 532. Other reports will cover: (a) Labor and equipment requirements for handling apples in pallet boxes; (b) evaluation of dumping methods for pallet boxes; and (c) packing-room layouts for sorting and sizing apples before storage.

Some of the results of this research are now available in summary form in AMS-236, "Handling and Storage of Apples in Pallet Boxes," and through the U.S. Department of Agriculture film entitled "Handling and Storing Apples in Pallet Boxes." A print of this film may be borrowed from:

Visual Aids Service
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Colorado State University
Fort Collins, Colorado

The research on which this report is based was conducted by the Fruit Industries Research Foundation, Inc. (now known as Food Industries Research and Engineering) under a research contract with the U.S. Department of Agriculture. Earl W. Carlsen, Herman Ryder, and Alvan Baum, all members of the foundation, conducted the research and prepared the material for this report.

This study is part of a broad program of continuing research to increase the efficiency of the physical handling of farm commodities during marketing. Application of this research and developments brought about by this research program on pallet boxes is now estimated to save many hundreds of thousands of dollars annually.

Other related reports covering handling, storing, and packing apples issued by the U. S. Department of Agriculture include:

Controlled-Atmosphere Storage of Starking Delicious Apples in the Pacific Northwest. AMS-178. March 1957.

Storage and Cooling Capacity in Apple Storages in the Wenatchee-Okanogan, Washington, District. AMS-196. July 1957.

An Experimental Packing Line for McIntosh Apples. An Interim Report. In cooperation with N.Y. State Dept. Agr. and Markets, Division of Markets, and Maine Agr. Expt. Sta., Dept. of Agr. Econ. AMS-330. August 1959.

Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses. Mktg. Res. Rpt. No. 49. June 1953.

Methods and Costs of Loading Apples in the Orchard in the Pacific Northwest. Mktg. Res. Rpt. No. 55. January 1954.

Innovations in Apple Handling Methods and Equipment. Mktg. Res. Rpt. No. 68. January 1955.

Handling Empty Apple Boxes in Pacific Northwest Packing and Storage Houses. Mktg. Res. Rpt. No. 71. June 1954.

The Effect of Apple Handling Methods on Storage Space Utilization. Mktg. Res. Rpt. No. 130. July 1956.

Comparative Costs of Handling Apples at Packing and Storage Plants. Mktg. Res. Rpt. No. 215. March 1958.

Apple Sorting Methods and Equipment. Mktg. Res. Rpt. No. 230. August 1958.

Heat Leakage Through Floors, Walls, and Ceilings of Apple Storages. Mktg. Res. Rpt. No. 315. October 1959.

Cooling Apples and Pears in Storage Rooms. Mktg. Res. Rpt. No. 474. September 1961.

Apple Handling and Packing in the Appalachian Area. Mktg. Res. Rpt. No. 476. June 1961.

Apple Packing and Storage Houses—Layouts and Designs. Mktg. Res. Rpt. (In preparation.)

Air Door for Cold Storage Houses. AMS-458. December 1961.

Packing Apples in the Northeast. Mktg. Res. Rpt. No. 543. (In press.)

Washington, D.C. November 1962

CONTENTS

SUMMARY

A present trend in the apple industry is to handle an ever-increasing percentage of the crop in pallet boxes. This change has made possible the introduction of cost-reducing mechanization. One of the more important innovations is the development of a pallet-box filler, which automatically fills apples into boxes after they are sorted and sized.

Two unsuccessful attempts were made to develop a workable filler; fortunately, the third attempt was successful. This filler, which employs a series of rotating disks and cones, properly padded to reduce bruising, gently lowers the fruit into pallet boxes. In the filling operation, the filler is first lowered into the pallet box. The apples are then fed into the filler by a conveyor and a chute which minimize the distance that the fruit must drop. The fruit moves in steps on the series of disks and cones to the bottom of the box. As the box fills, the filler raises gradually, until the box is filled. Then the flow of fruit is stopped and the filler rises above the box. The filled pallet box moves out from below the filler, an empty box is put in its place, and the filling cycle is then repeated.

The filler can be adjusted to accommodate most of the types of pallet boxes in use today, so that there should be no problem of technical obsolescence.

In performance tests, the filler handles almost seven standard-box (about 1-bushel) equivalents a minute, so that each pallet box can be filled in less than 5 minutes. Time studies show that only 7 minutes of labor are required to transfer 30 pallet boxes. With an adequate number of box fillers (and allowing some lag time for the worker), one worker could handle 1,500 standard-box equivalents per hour.

Patent No. 3,000,162 was granted for this pallet-box filler by the U.S. Patent Office, and assigned for public use to the Secretary of Agriculture, September 19, 1961.

The impact of the filler on the apple industry is significant. Pallet boxes alone save 20 percent in storage space. With this filler, presorting and presizing before storage could raise this saving in storage space to 35 percent, because it is estimated that about 15 percent of the crop would be removed from the fruit to be stored.

With apples presized, presorted, and refilled back into pallet boxes, operators of storages and packinghouses would have a complete inventory of their salable apple stocks. This information would contribute to a better marketing program, give consumers better quality apples, and hold down marketing costs.

AN AUTOMATIC PALLET-BOX FILLER FOR APPLES

Compiled by JOSEPH F. HERRICK, JR., *marketing research analyst*,[1] Transportation and Facilities Research Division, Agricultural Marketing Service

INTRODUCTION

The rapid expansion of the use of pallet boxes in the apple industry has brought about many changes in handling and packing operations, and made cost-reducing mechanization practical. One of the important innovations was the development of an automatic pallet-box filler. Such a filler should achieve low-cost filling of apples into pallet boxes, so that fruit can be sized and sorted before it is placed in storage. Presizing and presorting allow the removal of small and off-grade fruits, and thus make available more cold-storage space for marketable quality fruit. It also should facilitate treatment of the fruit with a scald-preventive chemical. Perhaps an even more far-reaching ramification will be the distribution of apples in pallet boxes to terminal markets. An automatic pallet-box filler would make this practical by keeping costs in the packing plant low and volume high.

In developing the pallet-box filler, three different designs were conceived, and operating models made. The first two were not successful. This report will deal primarily with the work on the third, a successful design.

The first design was a rotating disk with a "ladder" of baffles or padded steps (fig. 1). The baffles did not function as planned. The apples tended to roll to the sides and fall directly into the pallet box without making the gradual descent over the baffles. To eliminate this, a net was placed around the center cone and a cloth rim around the outer edge of each step. The cloth rim was ineffective, so the outer edge of each step was curved upward. This corrected the problem of the fruit falling prematurely from the steps. However, after repeated trials, no way could be found to keep the steps above the level of the filling fruit without such a large quantity of apples remaining on top of the steps that it became very difficult to rotate the disks. In other words, the collapsed steps formed too long a surface for the apples to roll off as the upper disk rotated.

To obtain more information on the run-off arrangement that would be desirable, a continuous cloth chute spiraling into the pallet box was tried as a means of gently lowering the fruit (fig. 2). This, too, was found to be impractical because a large quantity of fruit would tend to lie in the drag cloth as it was pushed upward by fruit passing into the pallet box.

Another system of filling the pallet boxes was tried in which the pallet box rotated above the stationary filler. The least complicated method of filling—the ladder-type filling arrangement shown in figure 3—provided baffles over which the apples could roll. As the pallet box filled, the ladder was raised, and by a parallelogram arrangement which altered the slope of the steps as the ladder rose, the fruit was lowered into the box one short drop at a time. A number of different angles for the parallelogram and different methods of using drapes for retarding the flow of the fruit were tried. After extensive trials, it was found that it was difficult to get a uniform fill of fruit in the pallet box. The corners remained at a lower level than the center, so this method was abandoned.

These trials showed the need for first procuring uniform fill, and then perfecting the filling mechanism. A study of distribution of fruit in filling pallet boxes was made. A uniform distribution was obtained with a simple wooden frame model (fig. 4), by gradually changing the shape and number of baffles over which the fruit was fed.

Some of the types of baffles that were tried did not distribute the fruit. If the drag cloths were padded too heavily, the fruit would not roll off, because the cloth had to be flexible enough so that the fruit on top of the pad would be nudged off by the apples underneath as the pads rotated. However, to prevent bruising, the baffles had to be somewhat rigid, and required a considerable amount of padding.

The next baffles and pads that were tried were made of polyurethane, glued in place by canvas. By changing the shape of these pads, fruit could be deflected either outward or inward, and almost any desired distribution of fruit could be obtained. Because the polyurethane pads did not long hold their shape, a sheet metal core was built inside the pad. Bruise studies, however, indicated that the metal-cored baffles caused some bruising as they

[1] Compiled from the contractor's report.

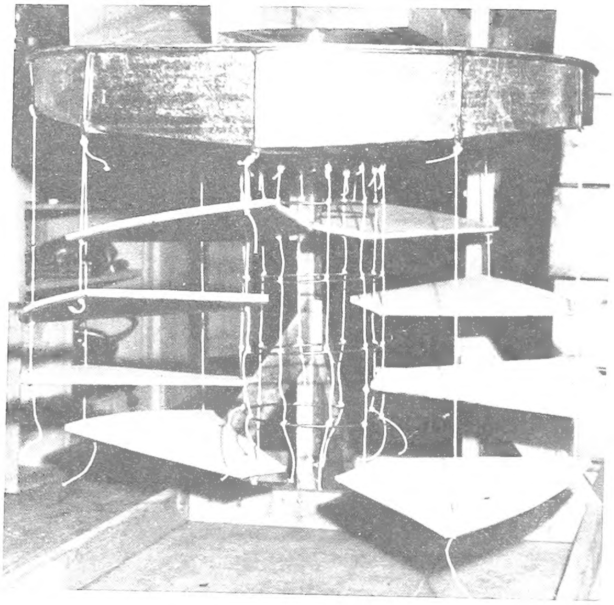

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Figure 1.—First pallet-box filler had a rotating disk and a ladder of baffles.

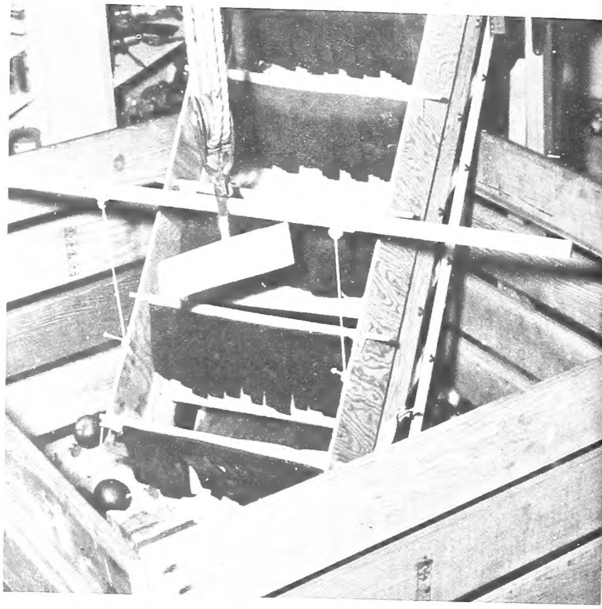

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Figure 3.—Ladder-filling mechanism with which the pallet box rotated during filling.

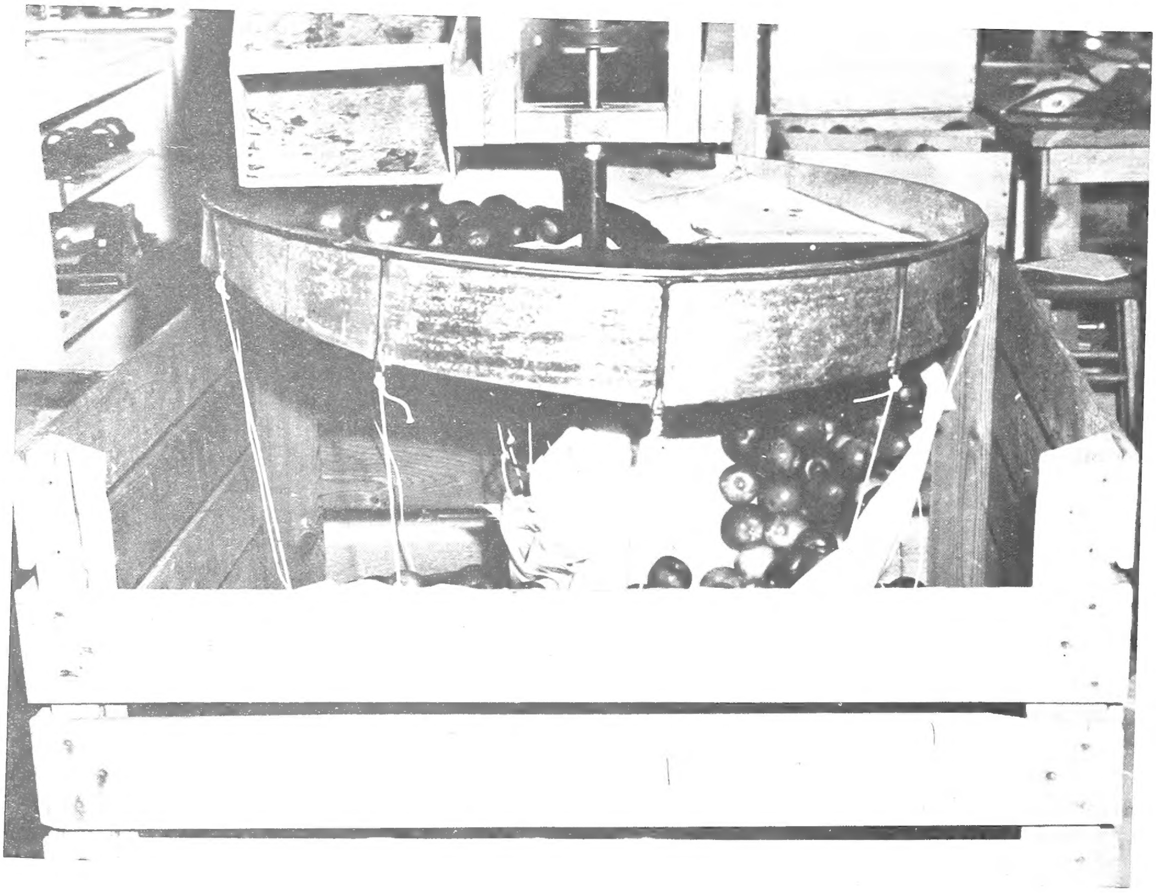

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Figure 2.—Test unit equipped with continuous spiraling cloth chute.

rotated over the fruit. To avoid this, the metal core was reduced in length, and the shape of the bottom baffle was maintained by canvas glued to the polyurethane. The fruit rolled on an extra, short length of heavy canvas at the end of the baffle so that it would reach the corners.

With these shaped baffles, fruit could be well distributed by using one shape for five of the baffles, and a different shape for the sixth. The sixth baffle was designed so that all fruit falling on it was directed into the center of the pallet box, to fill a void that would otherwise occur.

As the fruit rolled down through the baffles, it tended to strike the sides of the pallet box. To correct this, a drag cloth on the end of the baffle was curved upward (fig. 5). Thus, the canva would pad the drag cloth when it was at the side of the box and still leave the end open to fill the corners adequately.

Another modification to improve fruit distribution was adding extended rubber roses at the outer edge of the drag cloths. These small hoses supplemented the drag cloths in distributing the fruit evenly though the containers.

After a method of obtaining a good distribution of fruit was found, the method of lowering the fruit into the filler was studied, resulting in a design on which all the further testing was carried out. This filler might be called a "rotating disk filler" because of the type of construction (fig. 5).

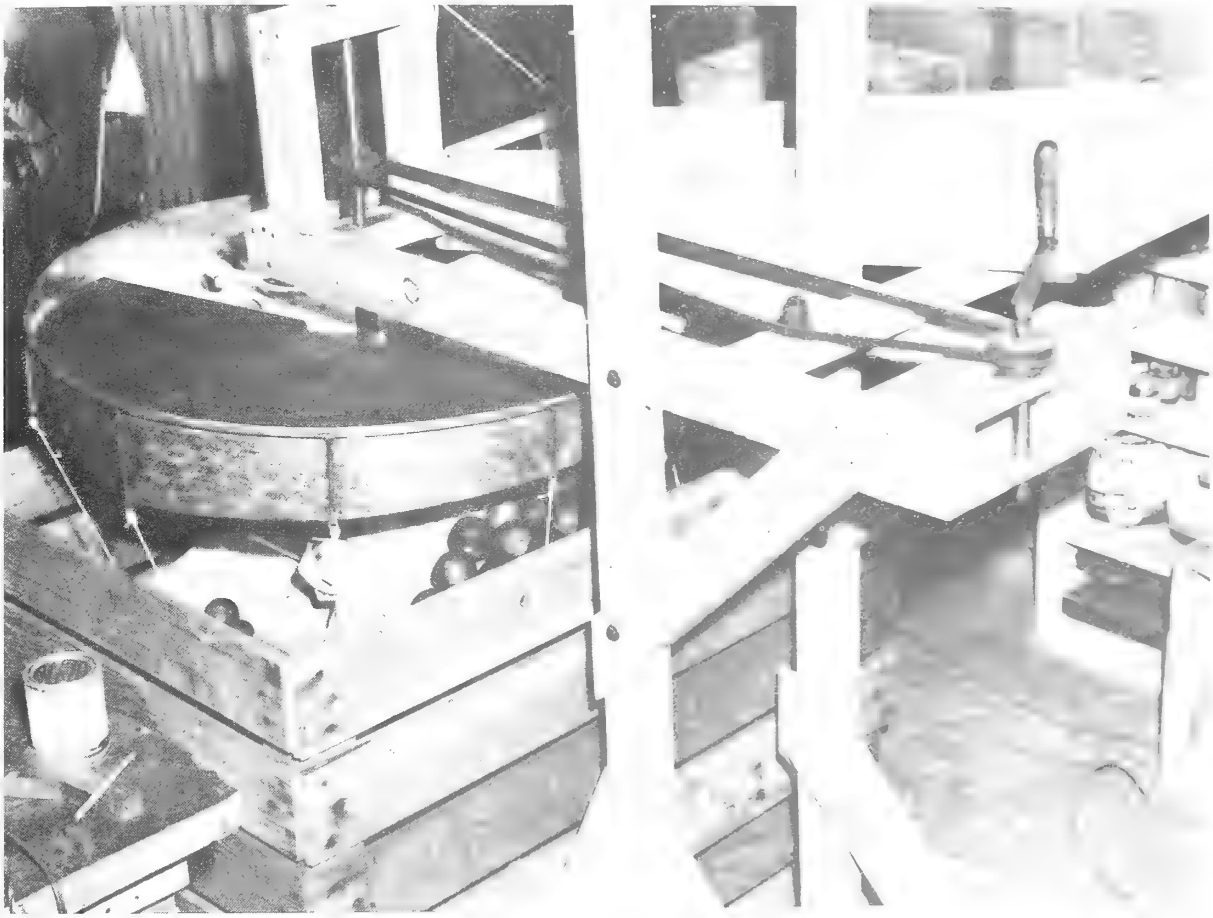

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Figure 4.—Wooden frame used for filling distribution study.

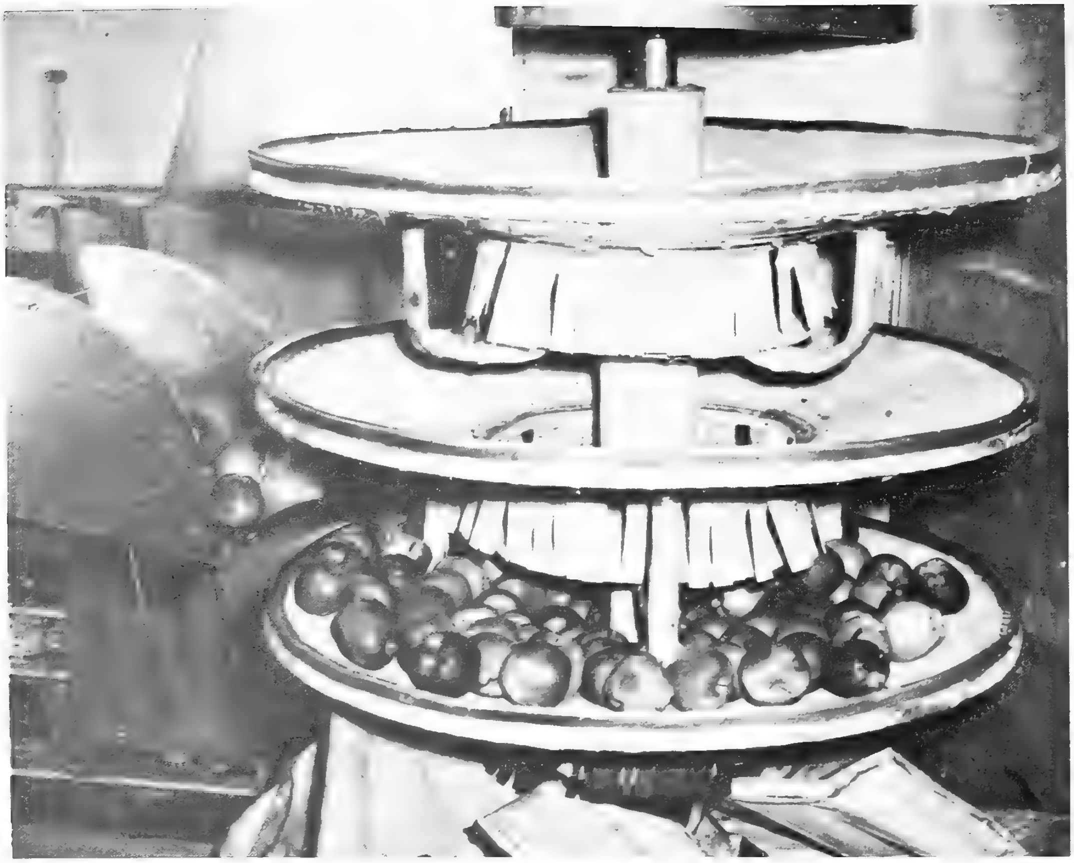

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FIGURE 5.—Rotating baffles used to distribute the fruit in the pallet box.

THE FILLER OPERATING MODEL

The simplest method of lowering fruit was by baffles that permitted the fruit to drop only a small step at a time. Investigation showed that this performance could be built into a rotating filler with the steps made in the form of disks or circles. The disks help distribute the fruit around the entire pallet box, and spread the fruit, so that there is less collision between fruits.

Concentric cones were designed to let the fruit down into the box one step at a time. At first it was thought that a shallow slope would retard the flow of fruit, so the cones and disks were built at a 45° angle (fig. 6). However, at that angle, the fruit dropped straight through, and it was difficult to get good distribution. Next, a 15° angle was tried. This angle, however, was so slight that some of the fruit rested on the cone, or disk, and with the rotating motion, centrifugal force kept the fruit on the disk. This fruit was struck by other fruit as it dropped onto the disk. A 22° slope was tried, but an 18° slope proved best. The objective was to keep the fruit on the disks long enough to be distributed evenly.

The polyurethane-padded disks were covered with canvas, to prevent the polyurethane from wearing as the fruit fell on it. The heavily padded center posts not only helped to prevent damage to fruit, but also distributed the apples more evenly in the pallet box.

Preliminary Bruise Damage Study

As the development proceeded, bruise-free fruit was occasionally fed into the filler, and a study was made of the condition of the fruit. The findings resulted in changes of design of the pads, baffles, disks, and in altering the way the fruit was fed to the disks.

At first it was thought that the conveyor belt could be used to feed the fruit directly onto the upper disk, but the drop proved to be too great. A chute was devised to break the fall of the fruit

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Figure 6.—Center cone of 45° slope first tried with disks for lowering apples. Upper cones and disks are removed.

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Figure 7.—Chute showing intermediate stage to break drop of fruit by an additional step. A belt drape has been thrown back to permit viewing of the chute.

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Figure 8.—Belt guard used to hold apples in the disks.

into two stages (fig. 7). Also, the fruit hit the edge of the disk as the disk rose to the level of the feed-in point from the chute. The chute was made so that it automatically lowered as the top disk approached the level of the feed-in point on the chute. This operation is described in more detail in the following section. This staging chute worked better with three disks than with the four that were being tested, so one disk was dropped from the design of the model.

Fruit often rolled from the disks to the floor, or dropped into the bottom of the pallet box. To prevent this, a large belt was mounted on the disk to act as a retaining wall (fig. 8). Although this adjustment was effective, it was simpler to mount a collar around each disk. A 3-inch strip of belting was fastened around the disks, giving them approximately a 1½-inch rim (fig. 9).

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Figure 9.—Three-inch strip of belting affixed to the disk, providing a 1½-inch collar around the outer edge.

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During the last stages of filling, when the pallet box was nearly full, the fruit flowing from the baffles frequently rolled off onto the floor. A ring lined with belting was attached to the bottom disk to act as a retaining wall. This ring, shown in figure 10, might also be designed in the shape of a square, to permit some of the last fruits to fill into the corners. The square would also facilitate the lineup of the pallet box during the change of boxes.

Strengthening the Design

As a result of the laboratory observations and trials, several changes were made in the chute. The chute was originally designed to be activated by a solenoid. Sufficient strength could not be obtained from the solenoid, and it also would have added considerably to the cost of the mechanism. Therefore, a mechanical means of operating the chute was developed, using rods that moved up and down with the filling mechanism.

The angle braces that supported the concentric disks were redesigned. Initially, the vertical supports between the center cone and the outer disk were close to the center cone. Fruit occasionally lodged behind these, and blocked the flow of fruit. Therefore, the supports were redesigned to extend outward from the center cone and support the outer disk from underneath. This arrangement, however, was unsatisfactory for the bottom disk, because it was also being used for accumulating fruit during changes of boxes, and the brace provided enough interference to jam the apples occasionally, when the load was to be released to begin filling a new box. For that reason, the last disk was supported from the top rather than from the bottom, as shown in figure 11.

An additional means of preventing the jamming, or bridging, of fruit as it was released by the bottom center cone was necessary. The shaft, on which the bottom cone rested, slips inside an outer tube on which the bottom cone is mounted. The closure is effected by moving the shaft upward about 2 inches inside the tube. The shaft and

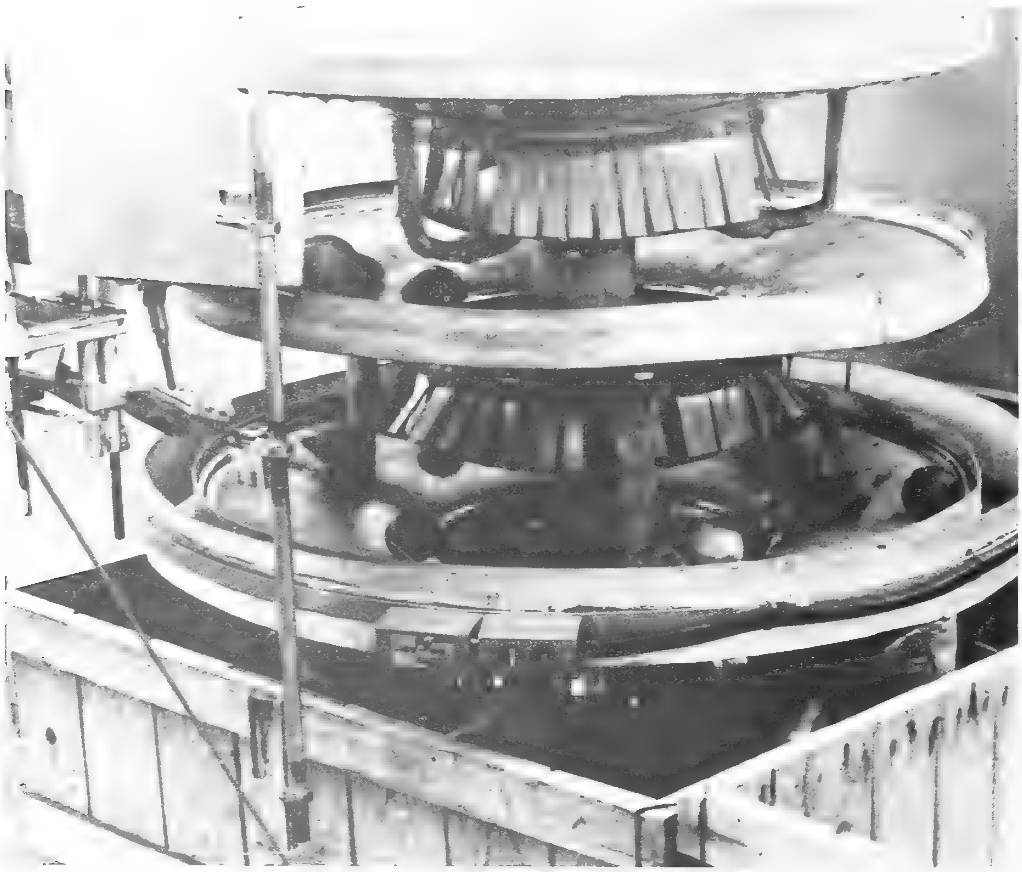

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Figure 10.—Ring at bottom prevents fruit from rolling off filler at last filling stage.

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Figure 11.—Brace supporting last disk covered with padding.

tube rotate together. This is accomplished by an outwardly projecting pin on the shaft extending through an inclined keyway, or slot, in the outer tube. The keyway, at first, was a straight slot, lengthwise, of the tube. Then later, when the keyway was made helical, the bottom cone twisted as it opened, and dislodged "jammed" fruits.

The Machine

The resulting pallet-box filler was designed with three series of concentric disks and cones attached

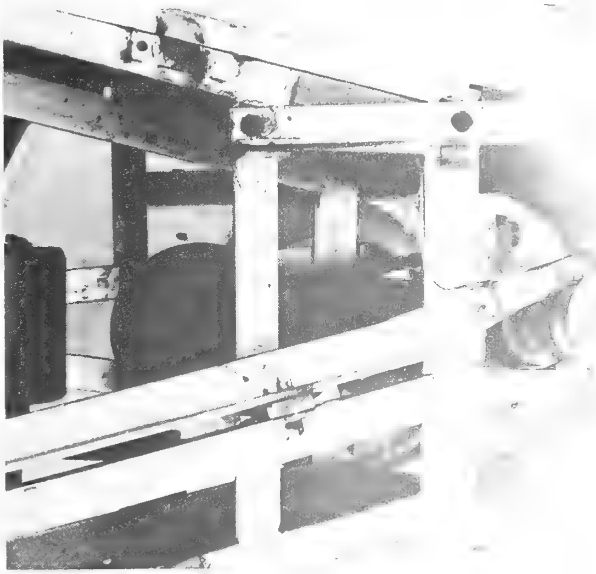

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Figure 12.—Housing for motor and gear mechanism as shown looking down in the machine.

to a rotating shaft. These disks fed apples onto a series of six baffles that distributed the fruit into the pallet box. The disks were continuously rotated during the filling operation by a motor and gear mechanism in a housing above the disks (fig. 12). The gear housing and the disks were raised and lowered into the box by a hydraulic shaft as pictured in figure 13.

The filling operation starts with the disks lowered into the pallet box to the point where the baffles ride on the bottom of the pallet box. Fruit coming from the sizer spills from the feed belt into a chute that is fitted to the circumference of the disks. As the fruit flows over the disks and cones into the pallet box, the baffles can gradually change their slope, because they are hinged on rods from the center shaft. Microswitches on two of these baffles are activated as the incline of the baffles is decreased. A happenstance high fruit would not cause the mechanism to rise, because both baffles have to be elevated at the same time. When the microswitches on these two baffles close, a solenoid activates a valve, and allows an additional amount of hydraulic fluid to force the shaft upward, elevating the filler about ½-inch at a time. This process of elevation continues until the pallet box is filled.

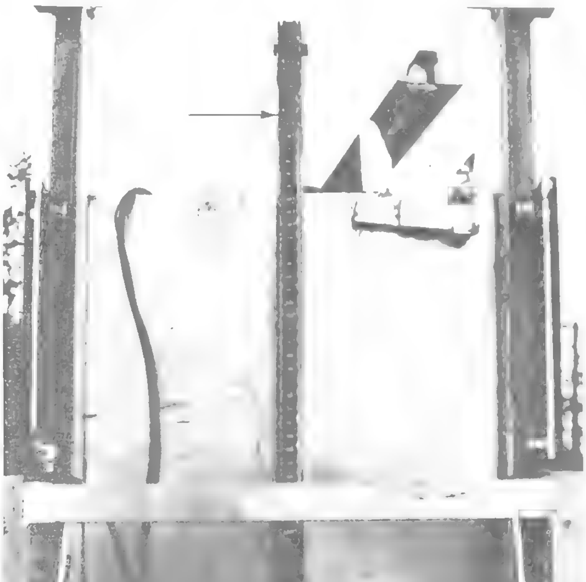

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Figure 13.—Hoist chain threaded over a sprocket, which is connected to a hydraulic shaft used to raise and lower the filler unit.

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Figure 14.—Lever which lifts center rotating shaft to close bottom disk.

When the final filling stages are reached, another microswitch is activated, which lifts the filling mechanism completely out of the pallet box. Just as this last stage of elevation commences, a block at the top of the filler frame presses against a lever which lifts the center rotating shaft approximately 2 inches (fig. 14). This closes an inner cone under the bottom disk so that the disk acts as an accumulation receptacle during the change of boxes. To avoid possible bruising damage by this closing mechanism, the bottom cone is padded much more heavily than the other center cones. In addition, the bottom inner edge of the lower disk is padded so that if fruit halfway through the opening is caught as the filler elevates, it will be held by heavy padding on both the top and bottom.

When the operator has removed the full box and moved an empty pallet box into place, he presses a control button which quickly lowers the whole filler mechanism into the pallet box and repeats the filling cycle.

The flow of fruit is unobstructed throughout the filling operation by synchronizing the relative positions of the chute and disks with the position of the conveyor. At the start, the lip of the chute is fitted onto the rim of the top disk. The disks are about 12 inches above each other, and as the box fills, they slowly rise. When the top disk reaches a position where its rim would obstruct the flow of fruit from the chute, the chute is automatically detached, and drops 6 inches, to a position 6 inches above the second disk. A step or ledge in the chute, heretofore hidden under the

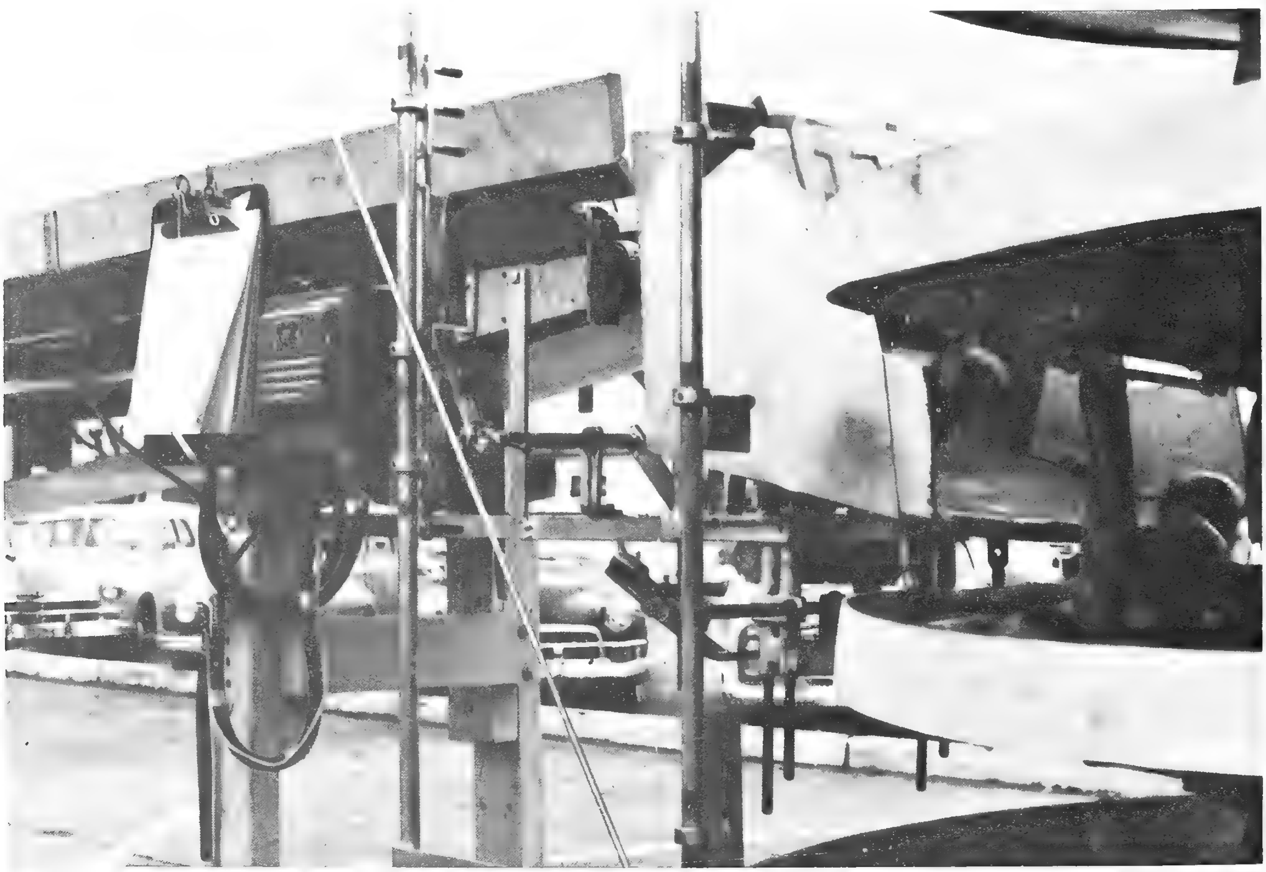

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Figure 15.—Chute positioned to feed fruit into bottom disk while pallet boxes are being changed.

conveyor, now appears to slow the drop of fruit to the optimum distance in the lengthened chute (fig. 7). As the second disk rises, the process is repeated with the third disk. As the pallet box fills further, and the filler rises, the chute moves upward, until the step rolls back under the conveyor.

At the last filling stage, the chute continues to feed fruit into the bottom disk which has been closed while the full box is removed and the empty pallet box is moved into filling position. While the filling mechanism is being lowered into the empty box, a gate is momentarily raised at the head of the chute holding fruit back onto the belt for a period of about 6 seconds. As soon as the filling mechanism is at the bottom, the retarding gate drops to allow the fruit to flow into the chute.

The chute mechanism is operated by a series of fingers and plates on two shafts that move up and down with the filling mechanism as pictured in figure 15. The stops on one of these shafts control the gate at the head of the belt that is moved into position as the pallet box lowers. The other stops control the staging of the chute as the pallet box is filled. Figures 16 through 19 illustrate the cycle of filling a pallet box with the filler.

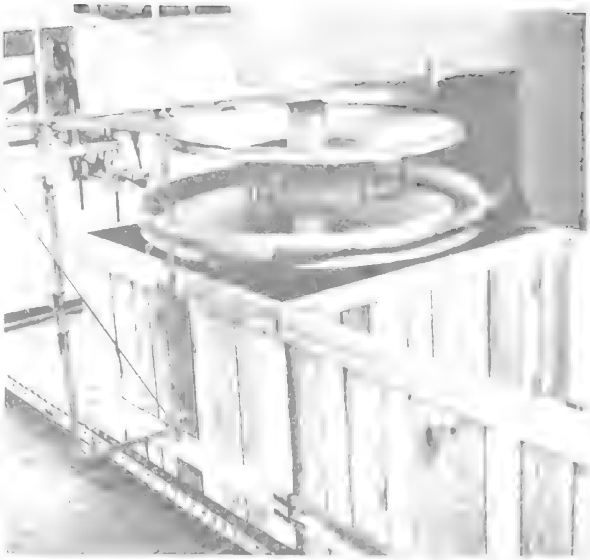

Figure 16.—Empty pallet box ready for filling; filler lowered inside box.

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Figure 17.—Pallet box nearly filled; filler raised.

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Figure 18.—Filled pallet box which has just been moved from under the filler unit.

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Figure 19.—Filler in raised position ready to be lowered into pallet box.

TESTING THE FILLER

Many trials were made with the filler in the process of the development work and these resulted in the changes described above. After completion of these initial trials, experimental and commercial pallet boxes were used in two different layouts with five different types of commercial boxes to determine the capacity of the machine and to learn the ability of the machine to operate under sustained commercial conditions.

Right-Angle and Straight-Through Layouts

The pallet-box filler has been so designed that it can be used for either a right-angle or a straight-through layout. That is, the boxes can either be fed in from one side and out to the front, or they can be moved underneath the filler and straight out the opposite side. These layouts are shown diagramatically in figure 20.

Neither type of layout complicates the equipment installation. The only difference in the filler would be the arrangement of the roller conveyor for moving the boxes in and out and for the attachment of the shafts that control the staging of the chute. For a straight-through layout these shafts are attached to the front of the filler (fig. 21). For the right-angle layout, the shafts for controlling the stage in the chute are at right

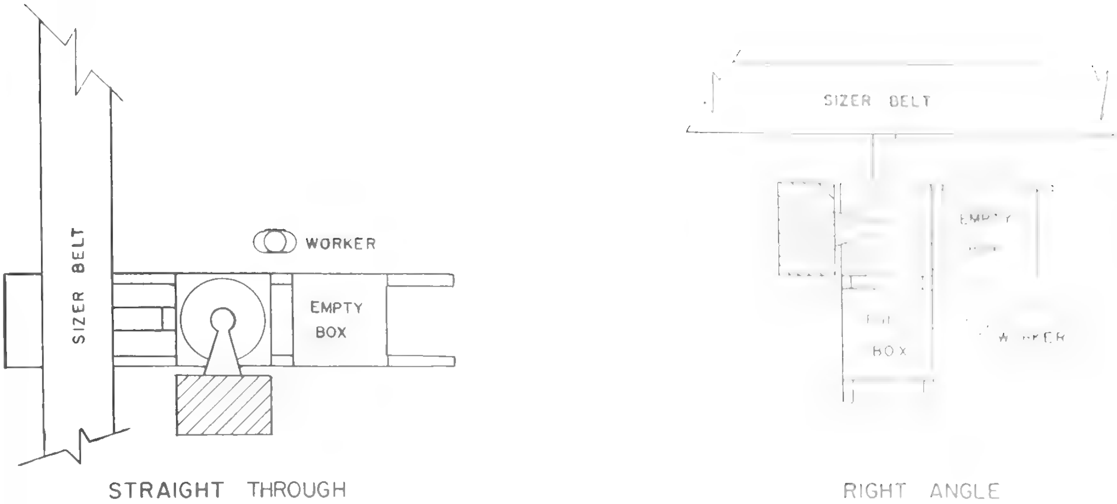

Figure 20.—Straight-through and right-angle layouts for use of the pallet-box filler.

angles to the gear housing of the pallet-box fillers as shown in figure 22.

No difficulty was experienced in feeding the pallet boxes in either installation. It initially required about 20 seconds to change the box, but after the operators became more proficient, this time dropped to 14 seconds for the straight-through layout and 16 seconds for the right-angle layout. This time included the time of lowering the pallet-box filler into the empty box.

Tested With Five Types of Commercial Boxes

Four or more pallet boxes of five different commercial types were tried with the filler. No difficulty was experienced, except that one box needed to be placed a little more carefully than others, because it had slightly smaller inside dimensions. Observations indicate that there will be no difficulty in handling pallet boxes of even greater variety of design. Adjustments now can be made on the filler that would permit using pallet boxes up to 30 inches in outside height and 25 inches in inside depth. Any shallower box could be used equally well by resetting the stops for the last cycle which closes the gate in the filler and elevates it.

With a side-lift box, it would be necessary to move the disks 4 inches lower into the container; again, stops on the machine could be adjusted to take care of this. However, should pallet boxes of greater outside height than 30 inches be used, the machine would need a longer shaft than the one used here.

Performance of the Filler

The pallet-box filler was operated at maximum capacity on several occasions. In a sustained 30-minute run, the filler averaged one pallet box every 5 minutes. The fastest filling of a pallet box during this period was 4.05 minutes, so that the machine could reasonably be expected to oper-

Figure 21.—Pallet-box filler set up for a straight-through layout with shafts controlling staging to the front (left) of the housing.

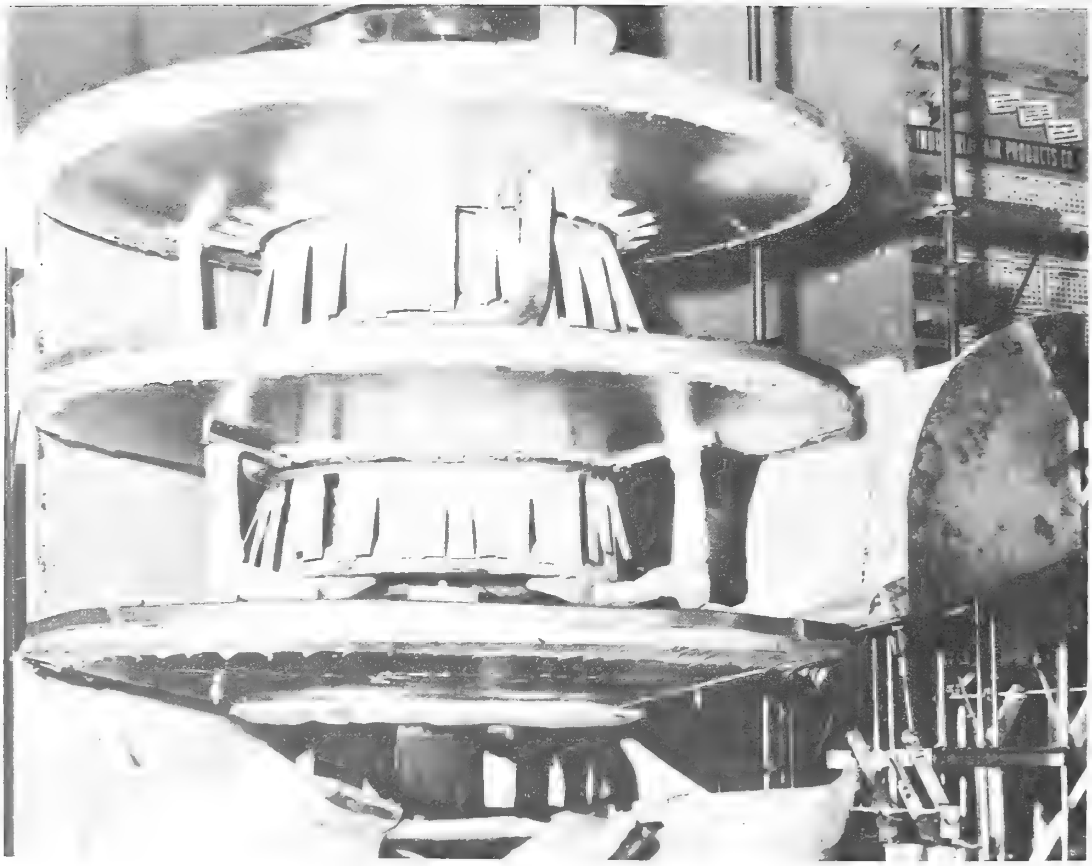

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Figure 22.—Pallet-box filler set up for a right-angle layout with shafts (right) controlling staging of the chute at right angles to the housing.

ate at 6.77 standard-box (about 1-bushel) equivalents per minute.

The capacity of the machine could be altered somewhat by changes in design. In this installation, the belt feeding the pallet-box filler was 10 inches wide. A 12- or 14-inch-wide belt would fill the box even faster, and at the same time permit running the belt at a lower speed, which might lessen bruising of the fuit. The limiting factor in the high-capacity operation is the amount of fruit that can be accumulated in the bottom disk during the change of boxes. If the machine is fed too rapidly, the holding capacity is insufficient. Should the machine be used where high capacity will always be the rule, a return-flow belt or rotating disk could be installed to accumulate fruit on the conveyor system before feeding it to the filler. Another solution would be to synchronize a system of stopping and starting the belt conveyor with the operation of the filler.

Over a sustained operating period of 4 hours, the pallet-box filler performed satisfactorily, except that some difficulty was experienced with the gate at the head of the chute during the lowering of the mechanism into empty pallet boxes. Apples lodged underneath the upper lip of the gate which was bent over to give a smooth surface on top and padded with polyurethane so that apples would not be damaged. The gate was redesigned to give a uniform surface that would not be obstructed by fruit. Results of the tests indicate that during the period needed to change the pallet box it would probably be better to stop the belt which feeds the fruit to the filler rather than close the gate to cut off the flow of fruit. This could be accomplished with a simple switching system.

Operating Over 4-Week Test Period

At the time the design was completed, the packing season had advanced to the point where only a few packinghouses were operating on an intermittent basis, depending upon the market for fruit. A simulated commercial packing operation for feeding the machine was tested (fig. 23). This test included emptying fruit from pal-

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Figure 23.—Overall view of setup used for dumping and filling operations for the 4-week test period.

let boxes into a submersion-type dumper and moving the fruit by means of a conveyor belt (that simulated a sizer) to a belt conveyor which moved the fruit into the filler (fig. 24). The capacity of the dumper was large enough so that any desired flow of fruit could be obtained (figs. 25 and 26). This arrangement permitted the machine to be operated on a more continuous basis than at a commercial plant where the flow of fruit might have been intermittent, depending upon the way fruit was peaking at various sizes. During most of the test, the filler was being fed at a rate of 150 standard loose box equivalents or more per hour, which was estimated to be approximately the flow that might be expected in one of the peak sizes in a presizing packing line that would be

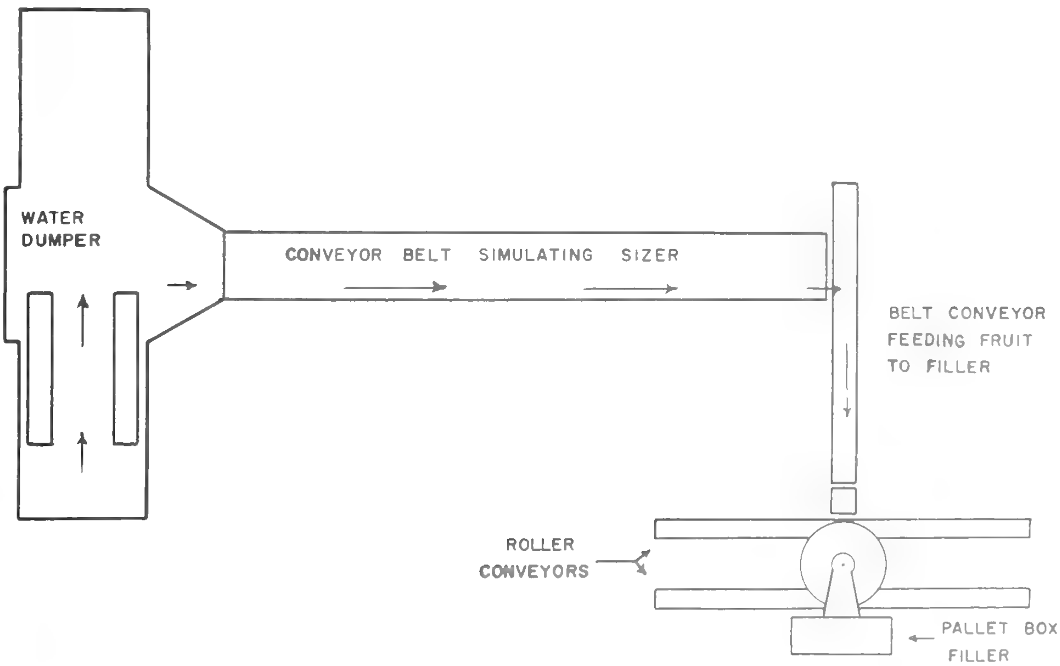

Figure 24.—Layout of equipment used for dumping and filling operations for the 4-week test period.

BN 15709–X

Figure 25.—Start of water dumping of pallet box.

running at a rate of 750 box equivalents an hour. At times during the run, fruit was fed at varied rates, which simulated shifts in the peak of sizes of fruit in a typical packing operation.

During the sustained run some weaknesses showed up in the filler—especially in the chute mechanism where some of the pins were not heavy enough or were not securely anchored. The canvas covering the polyurethane padding absorbed water and shrank, throwing the outer rim of the chute out of shape. The surface was given a coat of waterproof paint and the outer ring replaced. As the drag cloths at the end of the baffles became wet, their shape changed slightly so that the corners of the pallet boxes were not filled as well as before. This weakness was corrected by reinforcing the outer edge of the drag cloth. During a 4-week period of testing, the pallet-box filler was in continuous operation at a higher rate than that of commercial conditions, averaging one pallet box every 5.76 minutes.

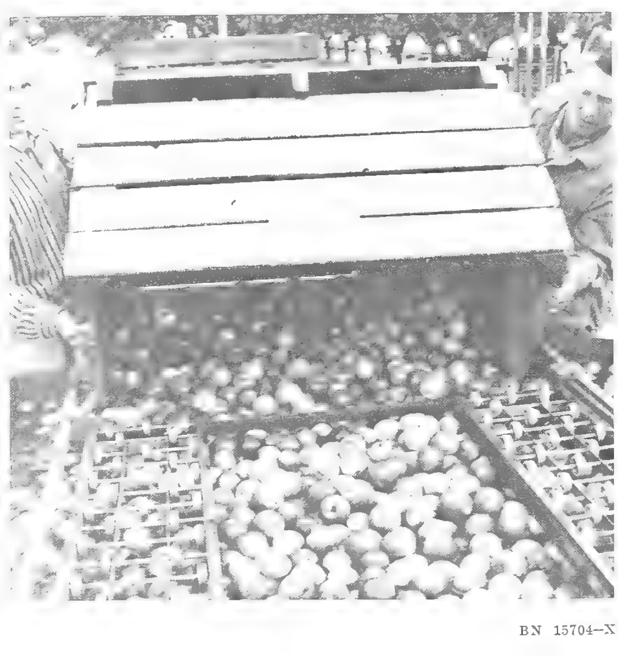

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Figure 26.—Pallet box being turned over almost completely emptied and about to be placed upside down on the roller conveyor.

Bruise Study

A study of bruise damage with the pallet-box filler was made by placing bruise-free apples onto the belt conveyor that fed into the filler. These apples were of the Delicious variety, sizes 138 through 113.

The filler was tested with two different types of boxes, a maximum-cooling box and maximum-bruise-prevention box. Preliminary bruise studies indicated that most of the bruise damage occurred to the first apples that were fed into the box. They were brushed across the bottom of the box by the bottom baffles bumping them more than the apples that followed them. The maximum-bruise-prevention box had a smoother bottom, which should have a tendency to eliminate such bruising. Half of the apples in each of the two pallet boxes were examined individually to determine the amount of bruising, which is shown in table 1.

The bruising caused by the pallet-box filler at the time of the tests was higher than that which might be expected when running freshly harvested orchard-run fruit. It is during the fall harvest that the filler would be in commercial use; at that time the fruit tests 16 pounds or higher. However, a pressure test of the fruit used in this bruise study averaged only 10½ pounds, and the fruit was at 86° F., during the tallying period. The fruit quickly softened further. It is quite possible that some of the bruises tallied actually occurred from the weight of fruit in the box on quickly deteriorating apples.

The average overall bruising on the apples studied was 21.5 ¼-inch and larger bruises per 100 apples. Most of the areas of the pallet boxes inspected averaged near this 21.5 bruise figure; however, the bottom apples showed a large increase in bruising—78.8 bruises per 100 apples. The number of apples touching the bottom is relatively small, so that even this severe rate of bruising does not have a great effect on total bruising. The smooth-bottom box, in these tests, appeared to permit more of this bottom-layer bruising than did the maximum-cooling pallet box.

Time-Study Results

The amount of labor required to attend the pallet-box filler proved to be nominal. A box could be changed by one man in as short a time as 14 seconds. For a packing line to run 750 standard-box equivalents an hour, 30 pallet boxes would be changed per hour. This would require only 7 minutes of actual labor per hour. It would, however, be necessary for the operator to move

Table 1.—*Bruises found on apples during pallet-box-filler study*

Position in pallet box	Apples inspected	Bruises per 100 apples: ¼-inch bruises	[illegible]-inch and larger bruises	Total bruises
	Number	*Number*	*Number*	*Number*
Side	174	10.1	9.9	20.0
Bottom	212	55.1	23.7	78.8
Corner	36	22.4	6.7	29.1
Interior	1,675	5.9	8.3	14.2
Weighted average		11.5	10.0	[illegible]

from one filling station to the other and to be at the station a little in advance of the time the box needed to be changed. It therefore has been assumed that 1 minute would be required to change each box. The total labor requirement to tend a box filler under these assumptions would be 30 minutes per hour, or, one worker handling 1,500 standard-box equivalents per man-hour.

In a commercial packinghouse operation, where as many as six fillers would be operating simultaneously, on occasion, two pallet box fillers would need to be attended and boxes changed at the same time. This difficulty could be avoided in either of two ways. Either pallet boxes could be removed before they are completely filled and then leveled by hand afterwards, or an additional worker could be employed. If an additional worker were employed and two men tended the fillers, labor costs would still be relatively low compared with those of existing filling methods.

The labor of tending the pallet-box filler with lift trucks, while it is not directly part of the packing operation, has been calculated. If one pallet box at a time is moved by the forklift truck operator over a distance of 280 feet, 1.36 man-hours would be required per 1,000 box equivalents. If two boxes are lifted and handled at a time, the man-hour requirements would decrease to 0.71 man-hour per 1,000 box equivalents. In the latter case, the layout would need to be altered only to the extent of making the roller conveyors feeding into and out of the pallet box filler 4 feet longer, so that two empty boxes could be positioned at one time for feeding the filler and two full boxes could be accumulated for later handling.

PATENT GRANTED

After satisfactory tests with the pallet-box filler, the United States Department of Agriculture filed for a public-use patent for this item.

Patent No. 3,000,162 was granted by the U.S. Patent Office and assigned to the United States of America as represented by the Secretary of Agriculture, September 19, 1961.

A copy of Patent No. 3,000,162—"Pallet-Box Filler" may be obtained by writing the Patent Office, United States Department of Commerce, Washington 25, D.C. and paying the usual fee of 25 cents per copy.

IMPACT OF THE PALLET-BOX FILLER

The impact of a workable pallet-box filler on pallet-box designs and standardization, storage-space utilization, and apple marketing programs and practices should be quite significant.

Use of a pallet-box filler requires that pallet boxes have approximately the same dimensions so that the filler can be adjusted to do the most satisfactory job.

Use of pallet boxes permits the holding of about 20 percent more fruit than standard boxes on pallets in the same storage space. However, if presorting and presizing were done (and the pallet-box filler provides this capability) the storage space would be used only for marketable fruit. Culls, subsize fruit, and off-color fruit would not go into storage. If this sort-out amounted to 15 percent, this space would then become available for quality fruit, which is the equivalent of providing an increase in storage space. Thus, the shift to pallet boxes from standard boxes handled on pallets, and the sizing and sorting of fruit before storage, would make possible a saving in storage space of about 35 percent.

With apples presized, presorted, and refilled back into pallet boxes before storage, the operators of apple storages and packinghouses would have, for the first time, a complete inventory of their on-hand stocks of apples. Separations could be made by grade, size and variety, providing plant operators with the information they need to carry on a good merchandising program. Filling orders as they are received would be more readily accomplished. Advertising programs could be arranged to promote those sizes and qualities that provide the highest returns at the time when the demand for specific sizes or qualities is the greatest.

During the 1961 harvest season, at least two firms in the Pacific Northwest were reorganized to size and sort fruit before storage. This apparently is the beginning of what could become standard practice throughout the more important apple producing areas.

The contributions of the pallet-box filler to fruit-packing-equipment design are small compared to the cost reduction and changes in marketing practices that will be brought about by the use of fillers of this or other design. Not only can handling costs be kept low, storage space be saved, and other advantages result, but there are also the possibilities of selling graded and sized fruit in wholesale quantities to firms specializing in finish packing, or to terminal market wholesalers or operators distributing directly to retail stores. Thus, the added advantages of developments of pallet-box filling will benefit the consumer as well as the grower.

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