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UNLOADING SOFT-FLESHED FRUIT FROM BULK BOXES

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IN MANY AREAS of the tree fruit industry, bulk boxes with 16 to 20 bushels capacity have replaced bushel containers. One major problem with bulk boxes has been the unloading of soft-fleshed fruits (firmness 10 lb. or less, as measured by the Magness-Taylor fruit pressure tester, 7/16 in. tip) destined for fresh market purposes and which are easily damaged by bruising and skin cuts or punctures.

McIntosh and Golden Delicious apples, removed from storage during the late winter and spring, suffer excessive mechanical damage when poured from bulk boxes by unloading devices[1,2] that tilt and invert the container. Hand picking of the fruit from bulk boxes is impractical and offsets any savings in costs previously attained by bulk handling.

The design and operating characteristics of a more gentle unloading method, a water submergence bulk box unloading machine, is described below.

EXPERIMENTAL

Initial tests demonstrated that apples would readily separate from a container submerged in water, and that the containers in general use would quickly fill or empty when vertically submerged or raised out of a tank of water.

A study of the mechanism by which fruit and container separate in a floatation system led to the conclusion that vertical submergence of the bulk box of fruit would be one of the most satisfactory approaches. When the box of fruit is lowered into the water, the fruit in the box behaves as a unit, rather than as individual apples. The

[1]Pflug, I. J. (1955). Pallet box dumper. Mich. Agr. Expt. Sta. Quart. Bul. 38: 43-46.
[2]Levin, J. H. and H. P. Gaston (1957). A bulk box dumper for handling fruit. Mich. Agr. Expt. Sta. Quart. Bul. 39: 557-563.

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mass of fruit, buoyed upward with a force equal to the weight of water displaced, follows the box into the water until the buoyant force equals the weight of the mass of fruit.

At this point, approximately 80 percent of the volume of the total mass of fruit will be submerged and the box and fruit will start to separate (this is assuming a specific gravity of apples of 0.80 which was calculated on the basis of 25 percent air space in the fruit and 15 percent soluble solids, Smock and Neubert[3]).

In practice, the top apples in a bulk box 30 inches deep extend about 6 inches above the water until the top of the box moves below the surface of the water. At this time the unit behavior of the fruit ceases to exist and the apples act more like a film of oil on water, in that they spread out into a single layer at the water surface.

A diagram of the unloading machine is shown in Fig. 1. The final design utilized a pneumatically operated carriage for vertically lowering the box of fruit in the tank (Fig. 2) and a wood roll conveyor for removing the fruit from the water and delivering it to the dryer (Fig. 3). The water in the tank was circulated to carry the fruit from the box to the conveyor. A fresh-water spray located above the wood roll conveyor was incorporated to rinse the fruit leaving the machine. A commercial absorber-drier with an air blast was used to remove the excess moisture from the fruit.

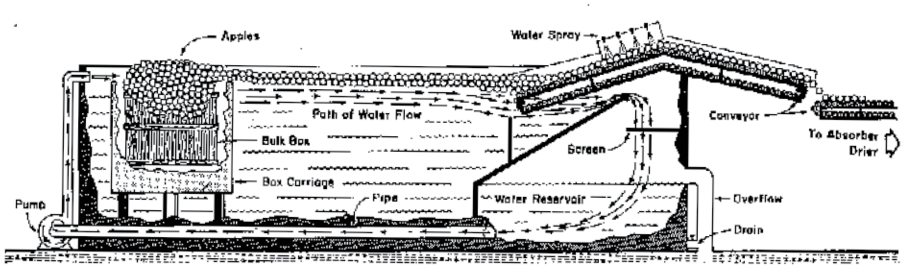

Fig. 1. Cross sectional diagram of unloading machine.

To date, no tests have been conducted where the excess moisture is removed from the fruit using a blower directly over a wood roll conveyor; however, since the fruit normally has a good coat of wax, it appears that there is a good possibility that this is all the water removal that is necessary.

[3]Smock, R. M. and A. M. Neubert (1950). *Apples and Apple Products.* Interscience Publishers Inc., New York City.

The bulk box submergence carriage shown in Fig. 2 is powered by two 5-inch bore, 48-inch stroke pneumatic cylinders. The carriage was fabricated from sheet metal to minimize weight; 3-inch standard black pipe was used to make the legs. The wood 3 x 6's at the bottom inside of the carriage (Fig. 2) were replaced with nylon-bushed roller conveyor track when this machine was installed in the packing line.

The conveyor for removing the apples from the tank was constructed of No. 55 agricultural chain with 2 5/8-inch wood rolls on

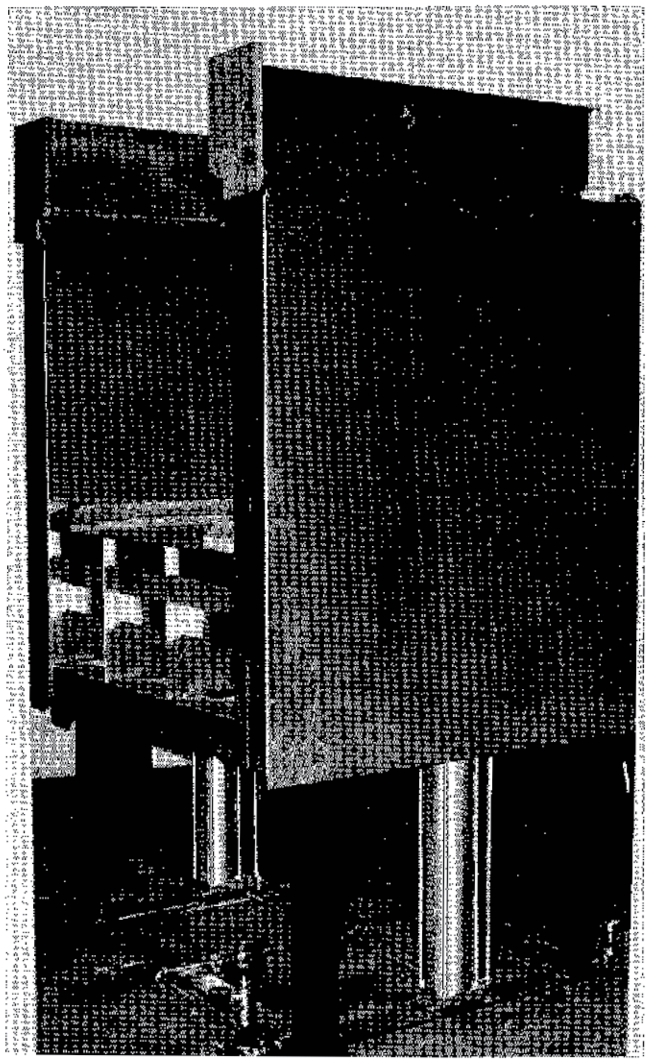

Fig. 2. Bulk box submergence carriage.

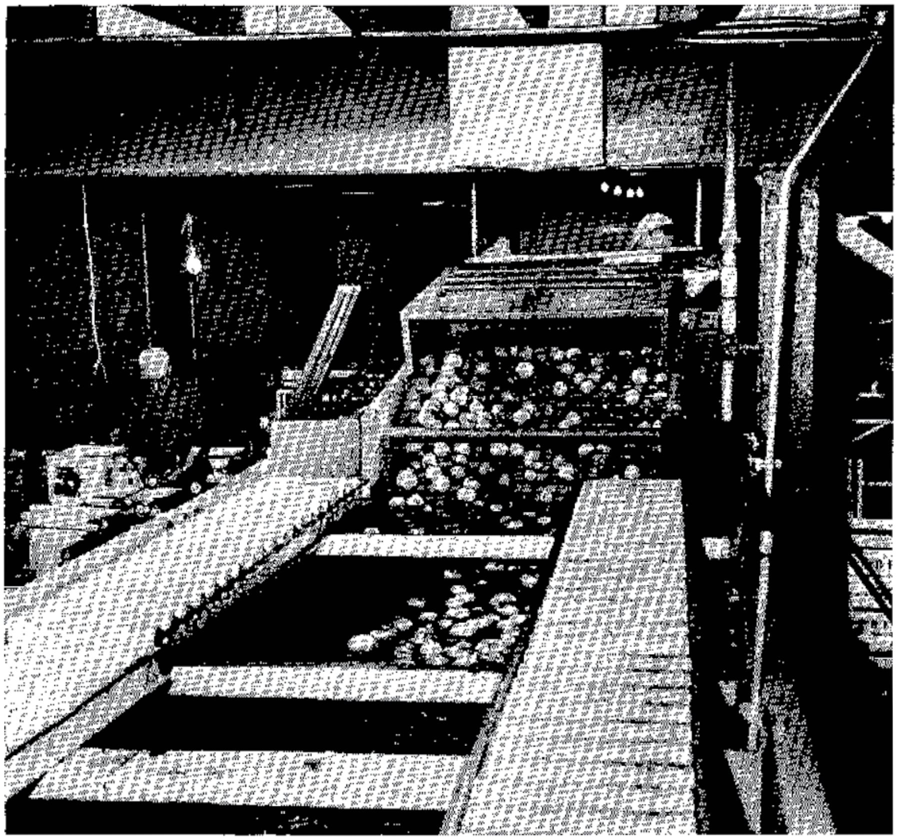

Fig. 3. Top view of unloading machine showing conveyor at end of water tank, fresh water sprays above conveyor and water flow pattern across the top of bulk box.

every other link (3 ¼ inches O. C.). The rolls were supported by hardwood boards; therefore, the rolls and fruit rotated as the conveyor advanced. Experiments were conducted using large apples to determine the conveyor angle. An angle of 17° was found desirable for the conveyor elevating apples out of the tank; however, the angle of the down side of the conveyor had to be reduced to 12½° to keep the apples from tumbling (angles are measured from the horizontal). The conveyor was 3 feet wide and 10 feet long; approximately 250 in. lb. of torque was required to start the conveyor.

The water tank width of 54 inches and depth of 72 inches were fixed by the dimensions of the submergence carriage. The length of the water tank was determined by the capacity of the grading line and the time necessary to change boxes since the area between the submergence carriage and the conveyor was for holding fruit to feed the grading line, while the empty box was removed and the full box moved into position.

The packing line had a design capacity of 300 bushel per hour (5 bu. per min.). It was estimated that 2 min. would be required from the time a box was empty until the next box was supplying fruit. Therefore, space in the machine for 10 bushels of fruit was required. Initial calculations were made assuming one crowded layer of apples in this area. It was found in practice that the apples will make a 4- or 5-inch deep layer if slightly crowded. A 20 ft. long tank was selected to satisfy these requirements.

A water reservoir was incorporated into the machine as shown in Fig. 1. Water from the reservoir tank was pumped to the box unloading end of the machine by a 5 HP centrifugal pump, capacity 500 gpm at 25 ft. head, where it was directed along the surface by a series of nozzles. The water flowed from the nozzles to the weir at the far end of the tank, creating a velocity the entire length of the water surface carrying the apples from the box to the conveyor.

The weir formed by the end of the partition separating the unloading tank from the reservoir maintained an approximately constant water level in the tank, even when a box was rapidly lowered into the water. The water displaced by the bulk box rapidly flowed into the reservoir over the weir that extended the full width of the machine.

The fruit-rinse sprays continuously add fresh-water to the system. Some of this water is needed to replace water carried out by the fruit; the remainder is eliminated by the reservoir overflow.

FRUIT BRUISING STUDIES

Limited tests for mechanical damage of apples handled through the unloader were made in April, 1960 with McIntosh and Golden Delicious apples removed from controlled atmosphere storage. Fruit free of bruises and other mechanical damage were carefully placed, with the aid of a specially constructed crib,[4] into the bottom and top quarter of loaded bulk boxes. Approximately three bushels of McIntosh, averaging 10.3 pounds in firmness, were placed into each of four bulk boxes of Golden Delicious, and a like amount of bruise-free Golden Delicious (firmness, 10.8 pounds) were placed into each of two bulk boxes of McIntosh and two boxes of Red Delicious apples.

[4]Burt, S. W. (1960). Personal correspondence.

The boxes were unloaded during the regular packing operation for the particular variety and the test fruit removed at three points; namely, from the water tank just ahead of the removal conveyor, at the end of the removal conveyor, and upon leaving the drier. These apples were placed into tray-pack cartons, returned to cold storage for one week and then examined for damage.

Bruised fruit were classified as slightly, moderately, or seriously damaged according to the criteria employed by Burt[5] for the McIntosh variety; these degrees of bruising would eliminate fruit from U. S. Extra-Fancy, U. S. Fancy and U. S. No. 1, and U. S. Utility grades, respectively. The number of apples with stem punctures were recorded without regard to bruising. The percentages of damaged apples, according to variety, type, and degree of damage are summarized in Table 1. The values of damage at the end of the conveyor

[5]Burt, S. W. (1959). An experimental packing line for McIntosh apples. U. S. D. A., A.M.S. Report No. 330.

TABLE 1—Average percentage of fruit with bruises and stem punctures after unloading from bulk boxes (values for end of conveyor and end of drier are accumulated damage to that point)

Point of removal	Damage	Variety	
		McIntosh	Golden Delicious
Water	Slight bruising	25.3	18.5
	Moderate bruising	11.1	5.9
	Serious bruising	7.4	1.4
	Total	43.8	25.8
	Stem punctures	4.1	0.9
End of conveyor	Slight bruising	32.0	30.6
	Moderate bruising	12.4	12.4
	Serious bruising	7.4	7.4
	Total	51.8	50.4
	Stem punctures	7.7	0.3
End of drier	Slight bruising	31.0	36.1
	Moderate bruising	27.6	23.8
	Serious bruising	21.4	3.0
	Total	80.0	62.9
	Stem punctures	13.0	1.7

include the damage of unloading as well as conveying; the values of damage at the end of the drier include damage of unloading, conveying and drying.

Less than half of the McIntosh, and approximately one-quarter of the Golden Delicious apples, taken from the water before passing onto the conveyor were damaged. Most of this injury was slight bruising, and could have occurred to a considerable extent in the boxes before unloading. This factor, however, was not determined.

Bruising was increased slightly on McIntosh by passing over the conveyor and almost doubled for Golden Delicious; however, passage through the drier added much bruising to McIntosh and a relatively small amount to Golden Delicious. Further study to ascertain why the several components of the unloading machine cause differences in the amount of damage between varieties is desirable.

Stem punctures were not serious at any point for the Golden Delicious apples. The quantity of stem punctures for McIntosh, after removal from the boxes, was relatively low for this variety; it was approximately doubled by passage over the conveyor, and then almost doubled again through the drier.

The percentages of bruised apples in Table 1 may appear to be large; however, the percentage of apples showing serious bruising is relatively small. The amount of bruising incurred using this water unloader is only a small fraction of the bruising that occurs in a tilting type bulk box dumper.

DISCUSSION OF THE OPERATION

A side view of the machine is shown in Fig. 4. The machine has been fitted with conveyor track so that the tie-up time of the fork lift truck and box-changing time are minimized. In Fig. 4, an empty bulk box is being raised out of the tank, a full box is on the roller conveyor; in Fig. 5, this empty box has been pushed forward, out of the carriage and the full box pushed into the submergence carriage and is on its way down into the water. When the carriage is completely submerged, the empty box will be moved to the extreme right, where the full box is located in Fig. 4, on the conveyor track across the top of the carriage, shown moving into position in Fig. 6.

The pile of dry apples in Fig. 6 is being held out of the water by the apples below it, even though the box is below the surface of the water.

A plug valve was installed in the pump discharge line to permit variation of the water flow during an unloading cycle.

Fig. 4. Empty bulk box being raised out of water, full box is on roll conveyor awaiting unloading.

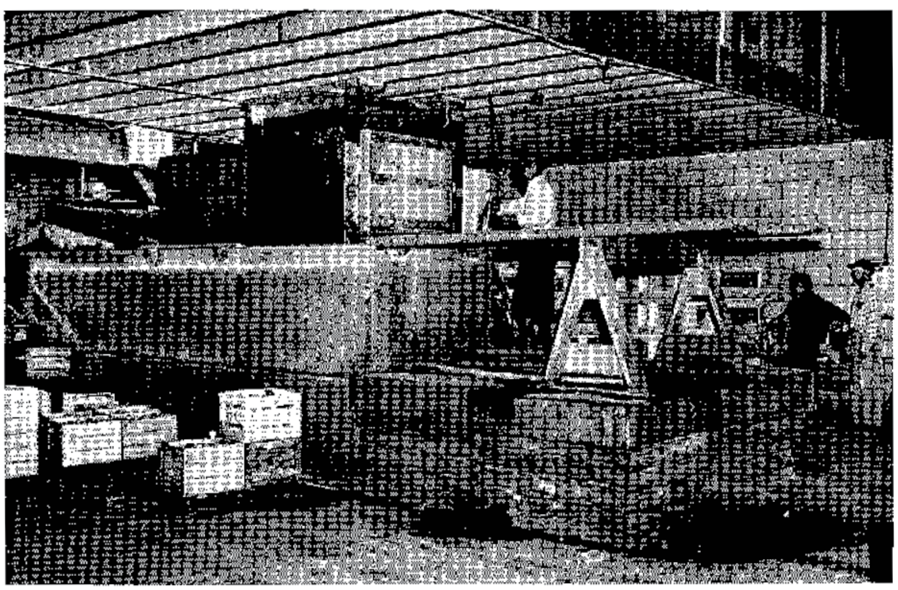

Fig. 5. Empty box has been removed from conveyor and full box pushed into submergence carriage and is on its way down into the water.

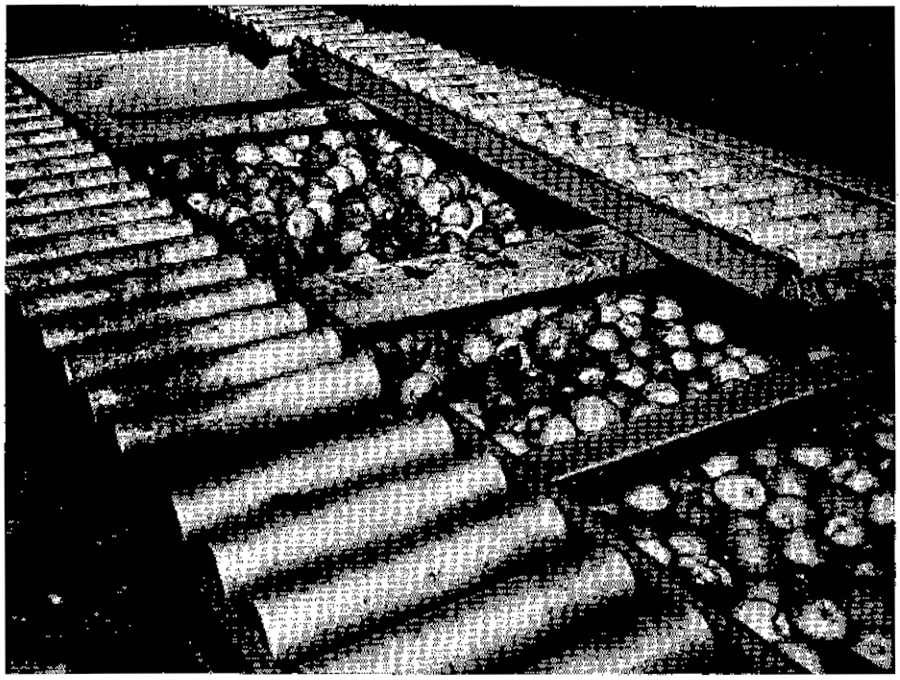

Fig. 6. Top apples (upper center) are lifted several inches out of the water by the buoyant force of the mass of fruit in the submerged bulk box.

This machine was put in use about December 1959, and by the end of the 1959-1960 storage season had been used to unload about 100,000 bushels of fruit. This method and machine have proved to be a satisfactory solution to the problem of removing soft apples such as McIntosh and Golden Delicious from bulk boxes, without excessive mechanical injury.

SUMMARY

The principles of operation and important design features of a machine for unloading bulk boxes of fruit by water floatation and transfer have been described and illustrated. The operating principle on which the design of this apparatus is based has proved to be sound through six months of severe field service. Bruising and skin puncturing of relatively soft apples were not excessive, but improvements in the design of the removal conveyor and drier would further decrease damage.

ACNOWLEDGMENTS

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