AN ECONOMICAL PALLET BOX DUMPER FOR PEACHES

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AN ECONOMICAL PALLET BOX DUMPER FOR PEACHES

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ABSTRACT

In tests of an experimental pallet box dumper for peaches in a commercial packinghouse, workers found that the dumper could be economically feasible for small packinghouses that pack 300–500 bushels per hour. Two men, using efficient work methods developed in the tests, operated the specially designed dumping system at capacity, dumping approximately 480 bushels of peaches (24 pallet boxes) per hour. Injury to peaches was no greater than when dumped with present commercial systems. The system can be incorporated into existing packinghouses without major equipment or facility modifications.

INTRODUCTION

The pallet box has been used extensively in industry as a container for handling many different products and materials. Large quantities can be economically handled in unit loads with industrial forklifts or other equipment. Consequently, labor and equipment costs per unit handled are less with pallet boxes than with smaller containers that require manual handling.

Fresh fruit and vegetable growers were long reluctant to use pallet boxes because they thought that their perishable produce might be injured if handled in this way. Then the pallet box was used successfully for handling potatoes in about 1944, demonstrating its feasibility for handling fresh fruits and vegetables. Today pallet boxes are used for apples, citrus fruits, pears, cherries, grapes, tomatoes, and many other horticultural crops.

Pallet boxes were first used for handling peaches for the fresh market in about 1965, when several packers in Georgia and South Carolina replaced the traditional 1-bushel field box (fig. 1) with a 20-bushel pallet box (fig. 2) as a container for transporting peaches from the orchard to the packinghouse and onto the packing line.

Initially, packers faced two major problems in converting to pallet boxes. There was no satisfactory equipment for dumping peaches from pallet boxes onto the packing line. Also, packers did not know how handling in pallet boxes would affect peach quality. However, these packers found that no more fruit, and often less, was injured than when using field boxes, demonstrating that pallet box handling of peaches for the fresh market was feasible. This success stimulated an interest in this kind of handling throughout the peach industry. Subsequent improvements in dumping equipment and handling methods resulted in a rapid conversion to pallet box handling by other packers.

Results of a U.S. Department of Agriculture study[2] demonstrated the economic feasibility of pallet box handling. In this study, the labor and equipment costs for handling peaches from the orchard to the packinghouse and for dumping them onto the packing line using pallet boxes were compared with the costs for using field boxes. For a packinghouse operation with a production capacity of 750 bushels per hour, peaches could be handled in pallet boxes for approximately $0.03 per bushel less than in field boxes. Smaller packinghouse operations, with production rates of 300 to 400 bushels per hour, would have difficulty economically justifying the con-

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[2] Forbus, W. R., Jr. 1970. Handling peaches in pallet boxes. U.S. Dep. Agric. Mark. Res. Rep. No. 875, 18 pp.

FIGURE 1.—Traditional 1-bushel field box.

version to pallet boxes because existing commercial dumping equipment was designed to process 600 to 750 bushels per hour, requiring expensive forklifts. Consequently, the relatively high ownership and operating costs associated with existing pallet box dumping equipment prohibited efficient utilization by these smaller packers. Most packers with production rates in excess of 600 bushels per hour have converted to pallet boxes, but smaller packers have understandably been reluctant to do so.

The objective of this study was to develop an economical pallet box dumper for peaches that would be adaptable to commercial packinghouse operations with production rates of 300 to 400 bushels per hour. Though the number of smaller packers has declined in recent years, there are still many in operation, and they are important to the efficient marketing of fresh peaches. This work will permit these packers to reduce their operating costs by taking advantage of the economies obtainable with this improved handling technique.

Four types of pallet box dumping equipment that are commercially available for use with peaches were evaluated in selected packinghouses in Georgia and South Carolina under commercial operating conditions. The equipment evaluated encompassed the range of design features and specifications and dumping techniques available in commercial pallet box dumpers. Each type was evaluated for operating efficiency and the effect of its use on fruit quality. Production capacity, labor requirements, and operating costs were also determined for each type.

FIGURE 2.—A 20-bushel pallet box.

Based on the results of the evaluations, alternative pallet box dumping equipment designs were synthesized. The alternative designs incorporated only the design features of existing pallet box dumping equipment determined to be effective. Quarter-scale models of the alternative designs were constructed and tested under pilot-plant conditions. Based on the pilot-plant tests, the most commercially feasible design was selected for development.

A full-scale experimental pallet box dumper was constructed and tested under pilot-plant conditions during the 1970 peach season and was found to be commercially feasible. Next, a pallet box dumping system incorporating the experimental pallet box dumper was installed in the packing line of a commercial peach packinghouse in Georgia and tested for commercial feasibility during the 1971 and 1972 peach seasons. All peaches packed at this packinghouse during these seasons were dumped with the experimental dumper.

EQUIPMENT

The primary criteria for the pallet box dumper design were simplicity, economy, and adaptability to existing packinghouse equipment and facilities. The dumper was designed so that it could be installed in any packing line in which peaches are dumped either into a water tank or onto a belt table without making major modifications to the facility or layout. In this study the equipment was installed on a dump tank for both the pilot-plant and commercial tests.

The major components developed for this experimental pallet box dumping equipment are (1) a mobile forklift cage suspended from an electric chain hoist, which holds the pallet box during lifting, lowering, transporting, and dumping; (2) an overhead monorail conveyor system consisting of a 1-ton electric chain hoist trolley-mounted on an I-beam track above the tank, which moves the caged pallet box to and from the dumping position above the end of the tank; and (3) a stationary pivot rod, which serves as the axis of rotation for the caged pallet box during dumping.

The experimental pallet box dumping system (fig. 3) was installed on a concrete pad just outside the packinghouse. The packinghouse ceiling was too low to install the dumping mechanism directly on the dump tank in the existing packing line without making major modifications to the facility; therefore, one end of the dump tank of the experimental system abutted the end of the dump tank in the commercial packing line, which was located inside the packinghouse. The dumping device was removed from the existing dump tank, and all fruit was dumped with the experimental pallet box dumper.

Dump Tank

The dump tank of the experimental system was constructed to specifications similar to those for commercially available dumpers. Peaches are dumped into the loading end of the tank, the end farthest from the packinghouse. Water in the tank is circulated to move fruit from the loading end to the discharge end of the tank, the end adjacent to the packinghouse. Peaches become alined in rows between rollers of the elevated roller conveyor (fig. 4) which extends to the bottom of the tank. The conveyor moves the fruit out of the tank and discharges it onto a gravity chute that delivers it into a tank in the commercial packing line. The surface of the gravity chute is covered with foam rubber to prevent bruising of the fruit.

The dump tank is 20 feet long and 5 feet wide. It is 3 feet 6 inches deep, except for the 5-foot section at the discharge end that slopes approximately 30°. A false bottom 22 inches below the top of the tank extends from the loading end for 4 feet 10 inches in the direction of the discharge end. The elevated roller conveyor is 17 feet long and 3 feet wide and equipped with a variable speed drive. The conveyor extends from the bottom of the tank, approximately 5 feet from the loading end, at an angle of approximately 25°, to a point 3 feet 6 inches above the discharge

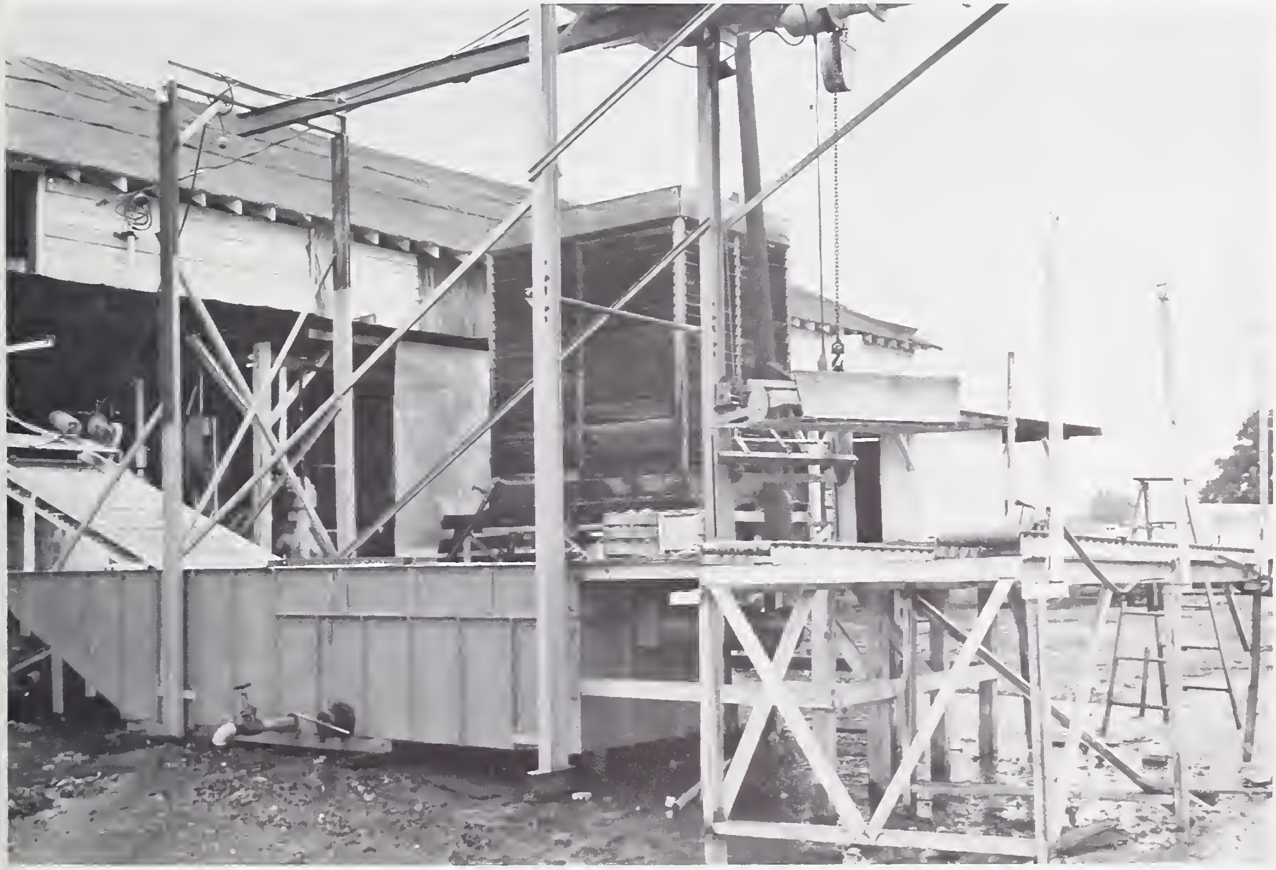

FIGURE 3.—Experimental pallet box dumping system as installed in packing line of commercial peach packinghouse.

FIGURE 4.—Elevated roller conveyor discharges peaches onto gravity chute that delivers them into dump tank of packing line.

end. The end of the false bottom farthest from the loading end of the tank touches the roller conveyor frame. Clearance between the false bottom and the rollers is about one-half inch. This minimum clearance insures that even those peaches moving along the false bottom of the tank will be picked up on the rollers. To facilitate pickup, peaches are channeled into an area the width of the roller conveyor by guide partitions (fig. 5) that extend from the false bottom to the top of the tank on each side.

Water flows in the tank from the loading end to the discharge end. The sump at the discharge end of the tank (see fig. 4) allows the water level in the tank to remain constant. Water is pumped from the sump through an 8-inch-diameter pipe along the side of the tank (fig. 6) into a distribution manifold in the loading end of the tank. The pump has a maximum capacity of 400 gallons per minute. The distribution manifold in the loading end of the tank can be seen in figure 3. Directional vanes in the distribution manifold distribute the flow of water evenly across the width of the tank. Water flows into the distribution chamber, an enclosure inside the tank wall at the loading end. Water flows from the distribution chamber through a 1-inch slot that runs the width of the tank at water level. This gives a maximum waterflow rate along the surface so that as peaches are dumped, they are immediately moved away from the loading end of the tank. This prevents bruises that could result from dumping peaches on top of those already in the tank.

The dump tank is equipped with two 3-inch drain pipes with valves for draining the tank. One is located in the side of the tank along the bottom (fig. 3), and the other one is at the bottom of the sump underneath the sloped bottom of

FIGURE 5.—Guide partitions that extend from false bottom to top of tank channel peaches into an area the width of elevated roller conveyor.

FIGURE 6.—Water is pumped from sump through an 8-inch pipe to distribution manifold in loading end of tank.

the tank (fig. 4). A capped cleanout port 6 inches in diameter is located in the side of the tank adjacent to the drain pipe to provide access for cleaning leaves and trash from the tank and to facilitate draining of the tank.

Commercial dump tanks incorporate a leaf-eliminating conveyor for automatically removing leaves that accumulate in the sump; however, a leaf eliminator was not installed in the experimental tank. Leaves are collected instead on a catch screen suspended in the sump by hangers that hook over the top of the tank. The screen is periodically removed from the sump and the leaves discarded.

Operator Platform

The L-shaped operator platform (fig. 7) at the loading end of the tank has a plywood deck level with the top of the tank. It provides space for the operator to work and a place for stowing the mobile forklift cage. The overall width of the deck is 8 feet, and the distance from the loading end of the tank to the pallet box conveyor is 5 feet. A 3-foot by 3-foot catwalk along the left side of the tank provides space for the operator to stand and watch the peaches as they are being dumped, helping him to control the rate of flow of peaches into the tank.

Pallet Box Conveyor

Pallet boxes of peaches are moved to the dumper and empty pallet boxes are moved away by means of a 15-foot-long gravity roller conveyor. The pallet box conveyor is perpendicular to the length of the dump tank adjacent to the operator platform at the loading end. The conveyor bed is approximately the same height as the deck of the operator platform. The conveyor consists of two 15-foot-long sections of 10-inch gravity roller conveyor mounted 2 feet apart on a supporting structure. The conveyor bed is sloped one-half inch per foot in the direction of travel. Pallet boxes are positioned on the conveyor with the runners underneath each side of the box centered and supported by the rollers. The boxes can be pushed or pulled along the length of the conveyor with minimum effort.

Monorail Conveyor System

The primary components of the monorail conveyor system are the trolley-mounted electric chain hoist, the 6-inch I-beam track, and the track-supporting frame. An overall view of the monorail conveyor system is shown in figure 8.

The track-supporting frame consists of four 15-foot-long vertical members welded to the sides of the tank. The two vertical members at the loading end of the tank are 6-inch I-beams. The other two vertical members are 6-inch channels attached to the tank 10 feet beyond those at the loading end. The vertical members on opposite sides of the tank are connected at the top by horizontal 5-foot-long, 6-inch I-beams welded to them. Supplementary braces are 1-inch channels.

The track for the trolley-mounted chain hoist is a 20-foot-long, 6-inch I-beam mounted 11 feet 2 inches above the top of the tank. The track is centered over the tank and runs parallel to its length. The track is welded to the underside of

FIGURE 7.—Operator platform at loading end of tank.

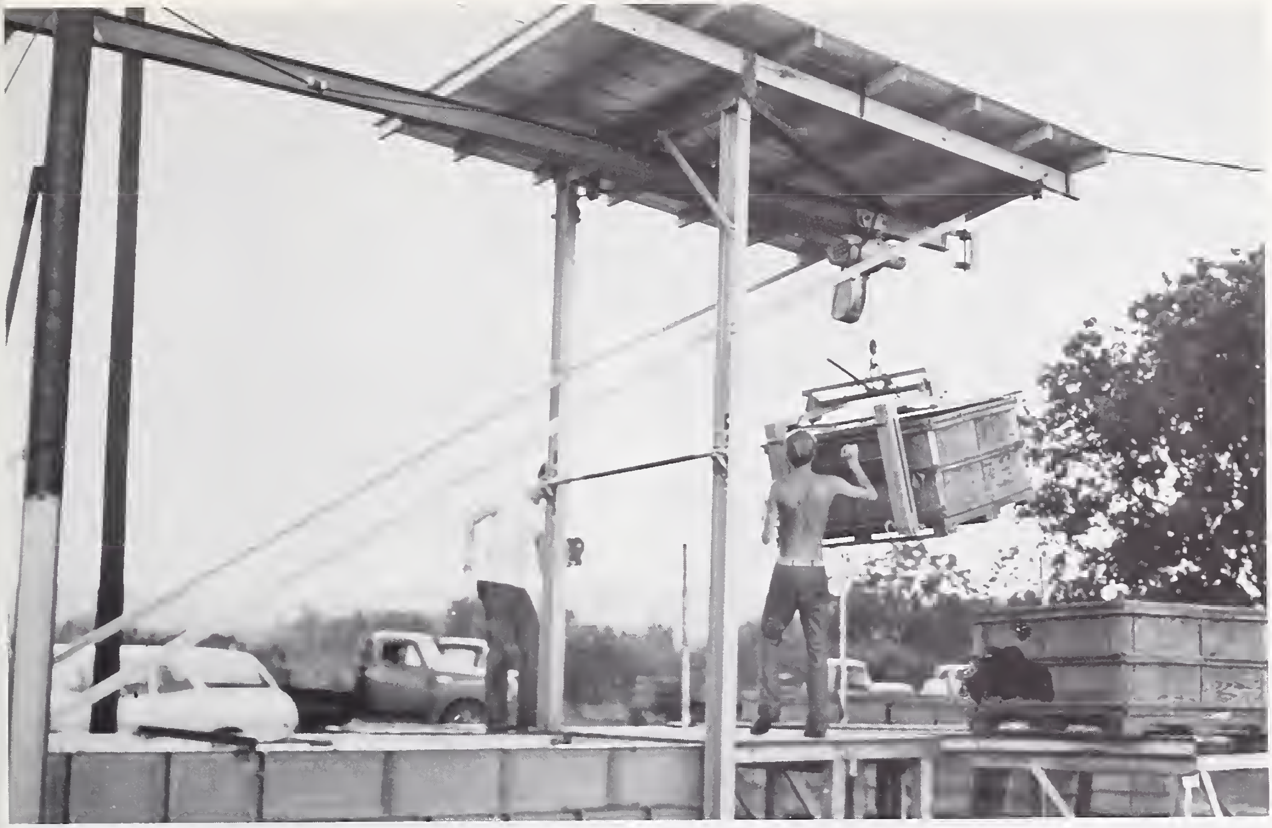

FIGURE 8.—Monorail conveyor system.

the horizontal I-beams of the supporting frame. The track extends 7 feet beyond the loading end of the tank. A stop at the loading end of the track prevents the hoist from running off the end. A second stop 2½ feet forward of the loading end of the tank prevents the hoist from advancing while it rotates during dumping.

The electric chain hoist used for lifting and lowering the mobile cage has a capacity of 1 ton. It is trolley mounted so that it can be moved back and forth along the track easily. The hoist has a chain 14 feet long with a hook attachment on the end for connecting it to the mobile cage. A pendant control with a 6-foot-long cable permits the operator to control the operation of the hoist while standing on the operator platform.

Mobile Forklift Cage

The mobile forklift cage developed for handling pallet boxes during dumping is shown in figure 9. The cage was designed to accommodate standard 48-inch by 48-inch by 24-inch pallet boxes that have a capacity of approximately 20 bushels of peaches. The primary components of the cage are the frame, the box-retaining clamp, and the box cover plate. (Detailed design specifications for the mobile forklift cage are given in figures 15 and 16.)

The C-frame includes two horizontal forks on the bottom, two vertical members in back, and two horizontal members directly above and parallel to the forks. The forks and the horizontal members directly above and parallel to them are of 1½-inch by 4-inch boxed channel construction. The two vertical members are 1½-inch by 4-inch channels connected by ⅛-inch by 2-inch angle members. A 1½-inch by 4-inch channel member connects the two top horizontal members at the front. All joints of the frame are welded.

The U-bolt connector which attaches the chain hoist to the cage is bolted to the center of the cross brace connecting the two horizontal members on top. This cross brace is located so that the pickup point is the center of gravity of the cage when a pallet box of peaches is being handled. Conveyor roller wheels, 2 inches in diameter, are installed on the forks to make it easier to move the cage on a flat surface. The two tilt hooks at the bottom of the cage in back were formed from

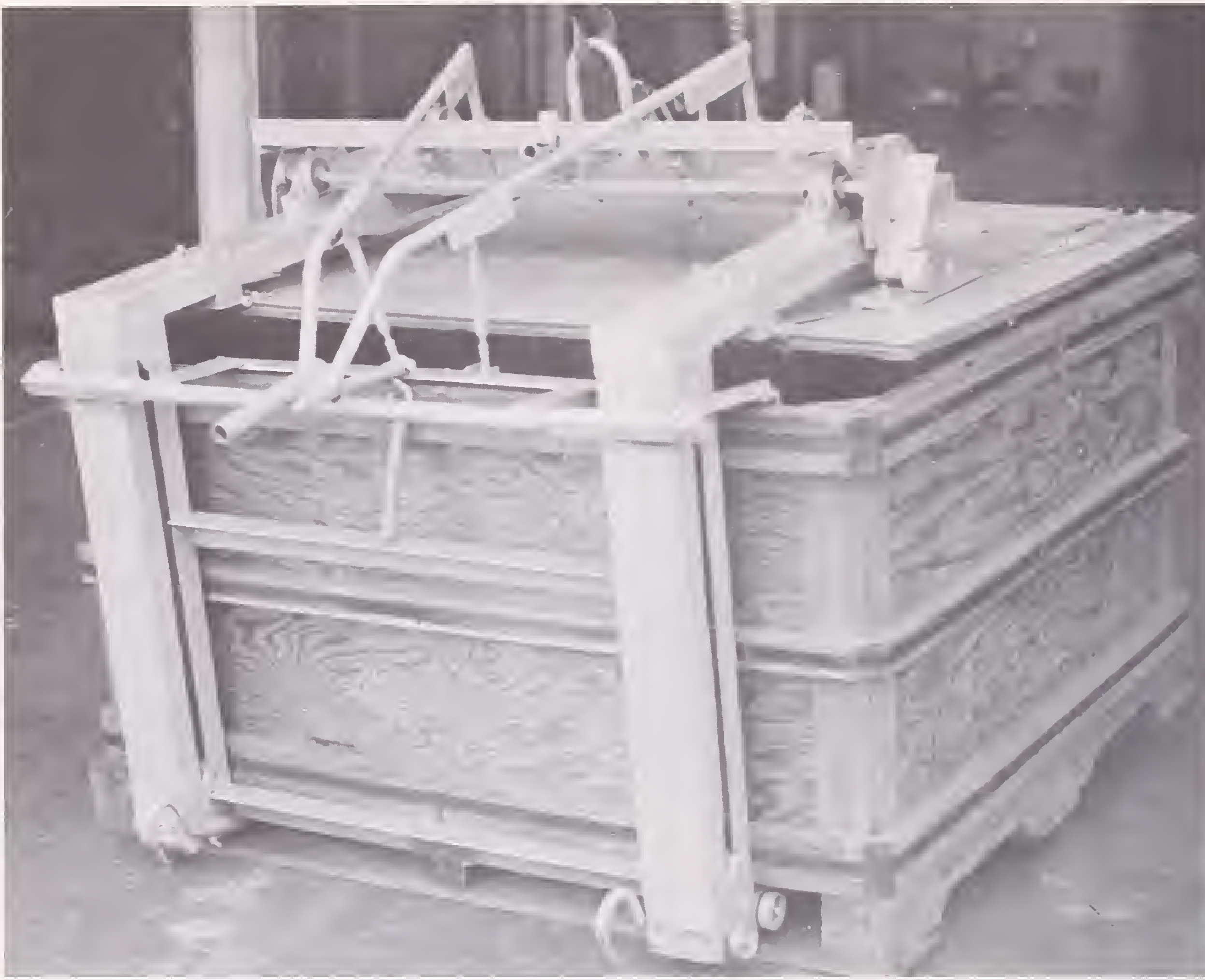

FIGURE 9.—The mobile forklift cage.

a $\frac{5}{8}$-inch-diameter rod and are welded to the vertical members of the frame.

The box-retaining clamp and the box cover plate are operated simultaneously by the operating lever on the top of the cage (fig. 9). The two arms of the operating lever are welded together on the back and diverge toward the front of the cage. Short vertical members are welded to the top of the operating lever shaft below. The two arms and the vertical members connecting them to the operating lever shaft are of $\frac{3}{4}$-inch pipe. The $\frac{3}{4}$-inch-diameter operating lever shaft is mounted in pillow block bearings bolted to the cross brace connecting the two horizontal members on top. Raising and lowering the operating lever rotates the operating lever shaft.

The box-retaining clamp is the mechanism at the top and back of the cage. The device has three $\frac{3}{16}$-inch by 2-inch angle members that are rotated into position to clamp the box along the top at the back. A 2-inch leg of each of three angle members extends into the top of the box at the back and prevents the box from sliding out of the cage during dumping. The three angle members are connected to the 1-inch-diameter bushing that rotates on a $\frac{3}{4}$-inch-diameter shaft. The shaft is supported by two 4-inch-long bushings welded to the backs of the two vertical members of the frame near the top. Brackets welded to the angle member between the two vertical members of the frame are connected to plates on the arms of the operating lever by adjustable links having ball bearings. Raising the operating lever to the position shown in figure 9 lifts the angle members and releases the box. Depressing the operating lever rotates the angle members into position to clamp the box (fig. 10). The retaining spring connecting the clamping device to the cross brace between the two vertical members of the frame holds the clamping device in the locked position.

The box cover plate is approximately the same size as the opening in the top of the box. It is designed to fit snugly against the box opening to prevent peaches from spilling out before the box is rotated into position for dumping. The hinged door at the front of the box cover plate regulates and directs the flow of peaches during dumping. The door is held closed by small magnets until the box has been rotated approximately 90°. When the box is in position for dumping, the pressure of the fruit against the door opens the door, and the peaches roll gently out of the box into the water.

The back of the box cover plate is attached with hinges to the underside of the two top horizontal members of the frame. At the front it is suspended from the cross brace connecting the two top horizontal members with a retainer spring. A cam mechanism activated by the operating lever moves the box cover plate.

The two 8-inch-diameter camber disks are attached to the 3/4-inch-diameter camber disk shaft which is mounted in pillow blocks bolted to the tops of the two top horizontal members of the frame. Cam followers attached to the camber disks are in contact with bearing plates bolted to the cover plate. Brackets welded perpendicularly to the camber disk shaft are connected to plates on each arm of the operating lever with adjustable links having ball bearings. When the operating lever is raised (fig. 9), the brackets that are welded perpendicularly to the camber disk shaft are lifted, causing the shaft and camber disks to rotate in a counterclockwise direction. The cam follower moves on the bearing plate toward the front of the cage. This releases the pressure of the cam followers on the bearing plates, and the retaining spring lifts the cover plate away from the top of the box.

Lowering the operating lever (fig. 10) depresses the brackets on the camber disk shaft, causing it and the camber disks to rotate in a clockwise direction. The cam followers move on the bearing plates toward the back of the cage. The pressure on the cover plate causes it to move down and fit snugly over the opening of the box.

Stationary Pivot Rod

The stationary pivot rod is attached to the two vertical members of the track-supporting frame, 5 feet above and parallel to the loading end of the tank (see fig. 8). The pivot rod is a 5-foot-long, 1½-inch-diameter pipe with a 1-inch-diameter rod inside, supported by brackets bolted to the track-supporting frame. During dumping, the tilt hooks on the bottom rear of the mobile forklift cage engage the stationary pivot rod. The stationary pivot rod is the axis of rotation for the caged box during dumping.

OPERATIONS

In the commercial operation, empty pallet boxes were transported to the orchard by tractor-drawn wagons that held four pallet boxes each. The tractors were driven slowly through the orchard, and the workers in the picking crew transferred peaches from picking containers, as they were filled, to the pallet boxes on the wagon. When the pallet boxes were full, they were transported to the packinghouse. The forklift operator unloaded the arriving wagons and stacked the boxes in a temporary holding shed outside the packinghouse. He then loaded the wagons with empty pallet boxes, and the wagons returned to the orchard. The packing line did not begin operating until an adequate supply of fruit had accumulated in the holding shed to maintain an uninterrupted flow of fruit to the packing line throughout the day.

The forklift operator then moved a stack of two pallet boxes from the holding shed to the pallet box conveyor (which could hold three boxes, side by side) and deposited them, still stacked, on the upgrade end of the conveyor. He then removed the top box, pushed the bottom box to the center position on the pallet box conveyor, and placed the top box back on the upgrade end of the conveyor (fig. 11).

The dumper operator picked up the box from the center of the conveyor with the mobile forklift cage, inserting the forks of the cage in the opening between the bottom of the box and the runners attached to the feet of the box, pushing the cage forward until its back touched the back of the box (fig. 12). The box-retaining clamp and box cover plate were simultaneously positioned for pickup by depressing the operating lever on the cage.

The trolley-mounted chain hoist lifted the

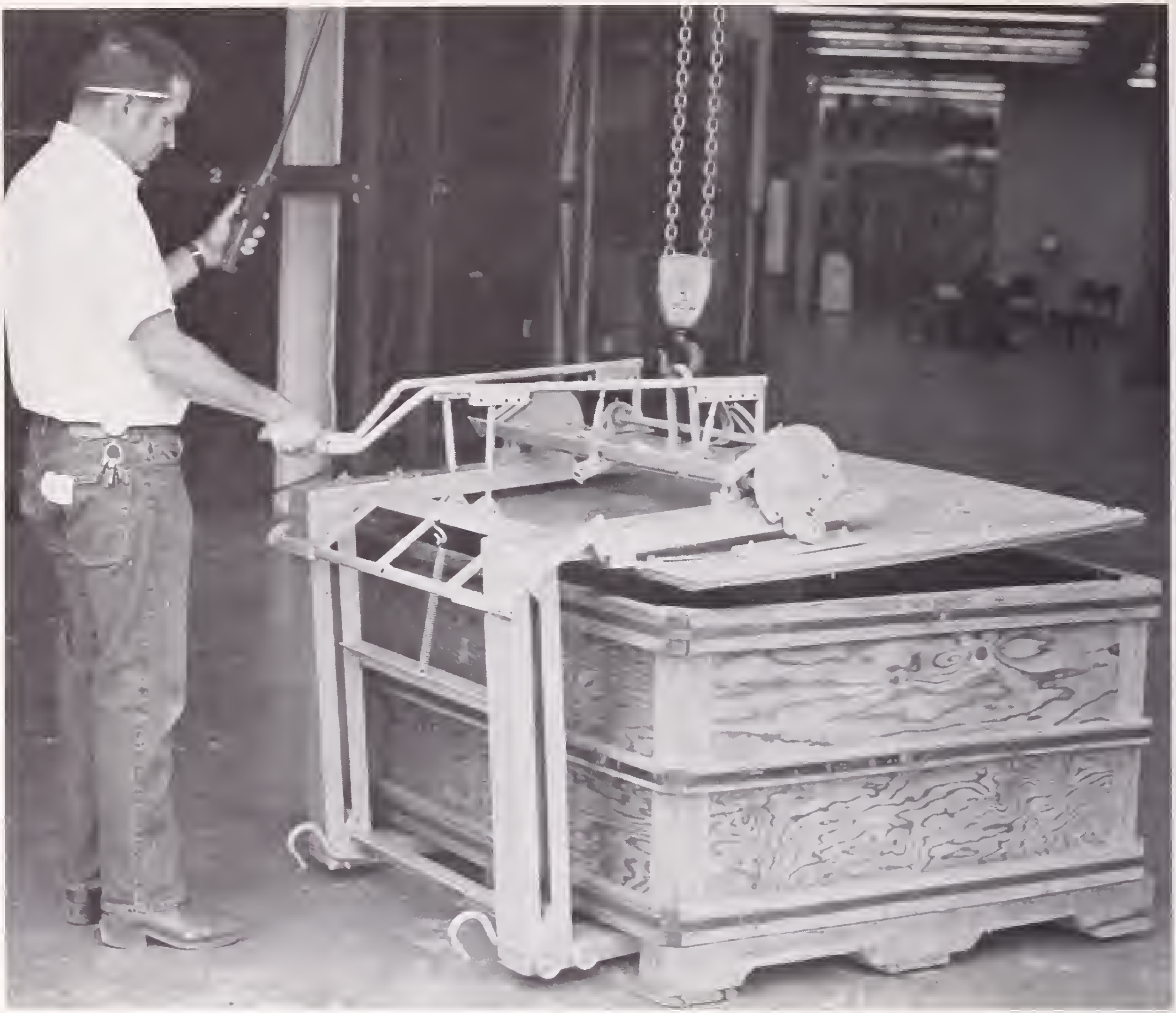

FIGURE 10.—Depressing operating lever engages box-retaining clamp and box cover plate.

caged box from the conveyor (see fig. 8) until the bottom of the cage was slightly above the stationary pivot rod at the end of the tank. At the same time the caged box was being lifted, it was turned 180° and pushed along the monorail conveyor track until the tilt hooks on the back of the cage were directly above the stationary pivot rod at the loading end of the tank (fig. 13). The hoist lowered the caged box, and the tilt hooks on the back of the cage engaged the stationary pivot rod. As the hoist continued to lower, the caged box rotated forward about the stationary pivot rod. When the box had rotated approximately 90°, the pressure of the fruit in the box against the hinged discharge door of the cover plate caused it to open (fig. 14), and the fruit rolled gently into the water.

When the box was empty, the hoist was raised to rotate the box back to an upright position and disengage the tilt hooks from the stationary pivot rod. The caged box was simultaneously turned 180° and pushed along the monorail conveyor track to a position directly above the pallet box conveyor. The hoist was lowered and the caged box was returned to the center position on the pallet box conveyor. The box-retaining clamp and box cover plate were disengaged by raising the operating lever, and the cage was pulled away from the box. The operator pushed the empty box to the downgrade end of the pallet box conveyor and then pulled the pallet box of peaches from the upgrade end of the conveyor to the center and dumped it in the same manner.

While the dumper operator was emptying the

FIGURE 11.—Forklift carries pallet boxs from temporary holding shed to pallet box conveyor.

FIGURE 12.—Mobile forklift cage picks up pallet boxes from center of pallet box conveyor.

second box, the forklift operator removed the empty box and stacked it in a temporary holding area. He then transferred two more boxes of peaches to the pallet box conveyor. By this time the second box from the previous stack had been dumped and moved to the downgrade end of the conveyor. Since there was space for only three boxes on the conveyor, the forklift operator always had to remove the second empty box from the conveyor before he transported another stack of full boxes from the holding shed.

This work method or routine allowed the forklift operator ample time to load and unload boxes and transfer boxes to and from the conveyor. A set method was necessary if he was to do everything effectively. Supplying the packing line with fruit took precedence over loading and unloading. When the forklift operator was loading or unloading wagons and the line needed peaches, he stopped and carried fruit to the conveyor.

FIGURE 13.—Mobile forklift cage on monorail conveyor system.

TEST PROCEDURES AND RESULTS

The experimental pallet box dumper was installed in the packinghouse prior to the 1971 peach season. During the early part of the season, before the packinghouse began operating at capacity, preliminary studies were made to determine the labor requirements for the manual operations involved in the dumping system. The time required to carry out all machine-controlled operations was also determined. Efficient work methods and operating procedures were developed, and the workers assigned to operate the system were trained. The tests were not initiated until the system had been operating at full capacity for a 2-week period, permitting the workers to become proficient in performing their duties following the work methods and operating procedures developed. Minor modifications and adjustments to the equipment were also made during this period.

Time studies of the dumping operation were made during the peach seasons of 1971 and 1972 to determine the production capacity of the experimental pallet box dumping system. The time required to perform all the manual and machine-controlled activities involved in dumping a pallet box of peaches with the equipment was determined by a time study using a stopwatch. The elapsed time for avoidable and unavoidable delays that occurred during each study was also determined. A minimum of 5 dump cycles were timed in each study, and a total of 20 time studies were made during the 2 years of testing.

The time study data were analyzed, and the standard time for dumping a pallet box of peaches with the experimental system was determined. The standard time included the time required to perform the entire dumping operation plus allowances for delays and operator fatigue.

During each time study, a random sample of peaches that had been dumped with the equipment was collected from the packing line. The researchers conducting the study and the packinghouse foreman examined every fruit of the sample for bruise injury that could be attributable to the dumping equipment. The results of

FIGURE 14.—When cage has rotated 90°, the peaches push open hinged discharge door in cover plate and fall into water in tank.

these examinations were confirmed by the Federal-State inspector assigned to the packinghouse.

During the 2-year test period, it was determined that a crew of two workers was required to operate the experimental pallet box dumping system at capacity. In the routine worked out as efficient and effective, the forklift operator unloaded wagons that hauled pallet boxes of peaches to the packinghouse, loaded the wagons with empty pallet boxes for return to the orchard, moved pallet boxes of peaches to the pallet box conveyor that supplied the dumper, and removed empty pallet boxes from the conveyor after they were dumped. The pallet box dumper operator picked up pallet boxes of peaches from the pallet box conveyor with the mobile forklift cage, dumped the peaches into the dump tank, and placed the empty pallet boxes back onto the conveyor.

The time studies made during the test period showed that the standard time for dumping one pallet box of peaches with the experimental dumper by the method described in this report was 2.50 minutes. Based on this standard time for one dump cycle, 24 pallet boxes of peaches could be dumped in 1 hour. The production capacity of the experimental dumper operating under commercial conditions would be approximately 480 bushels of peaches per hour.

During the tests, no bruises that could be attributed to the dumping equipment were detected on the fruit. Packinghouse management confirmed that the incidence of fruit injury was no greater during the test period than that experienced during previous years.

CONCLUSIONS

A pallet box dumping system incorporating the experimental dumping equipment that was developed and tested in this study was found to be commercially feasible. Such equipment would be economical to own and operate because the design principles are simple and the equipment can be incorporated into existing packing lines without major equipment or facility modifications.

This equipment is primarily adaptable to low-volume peach packinghouse operations that pack 300 to 500 bushels per hour. In the past, a number of the smaller packers who operate at this rate have been reluctant to convert to pallet box handling because they could not economically justify installing and operating the commercially available pallet box dumping equipment, designed to operate efficiently at 600 to 700 bushels per hour.

The 480-bushel-per-hour production capacity of the pallet box dumper developed in this study is adequate to meet the requirements of these low-volume peach packinghouse operations. Although the equipment developed is not available commercially at the present time, the design specifications for the essential components are given in detail in this publication. Packinghouse operators can use the equipment design specifications, work methods, and operating procedures described here to develop efficient and economical pallet box handling systems for their particular operations.

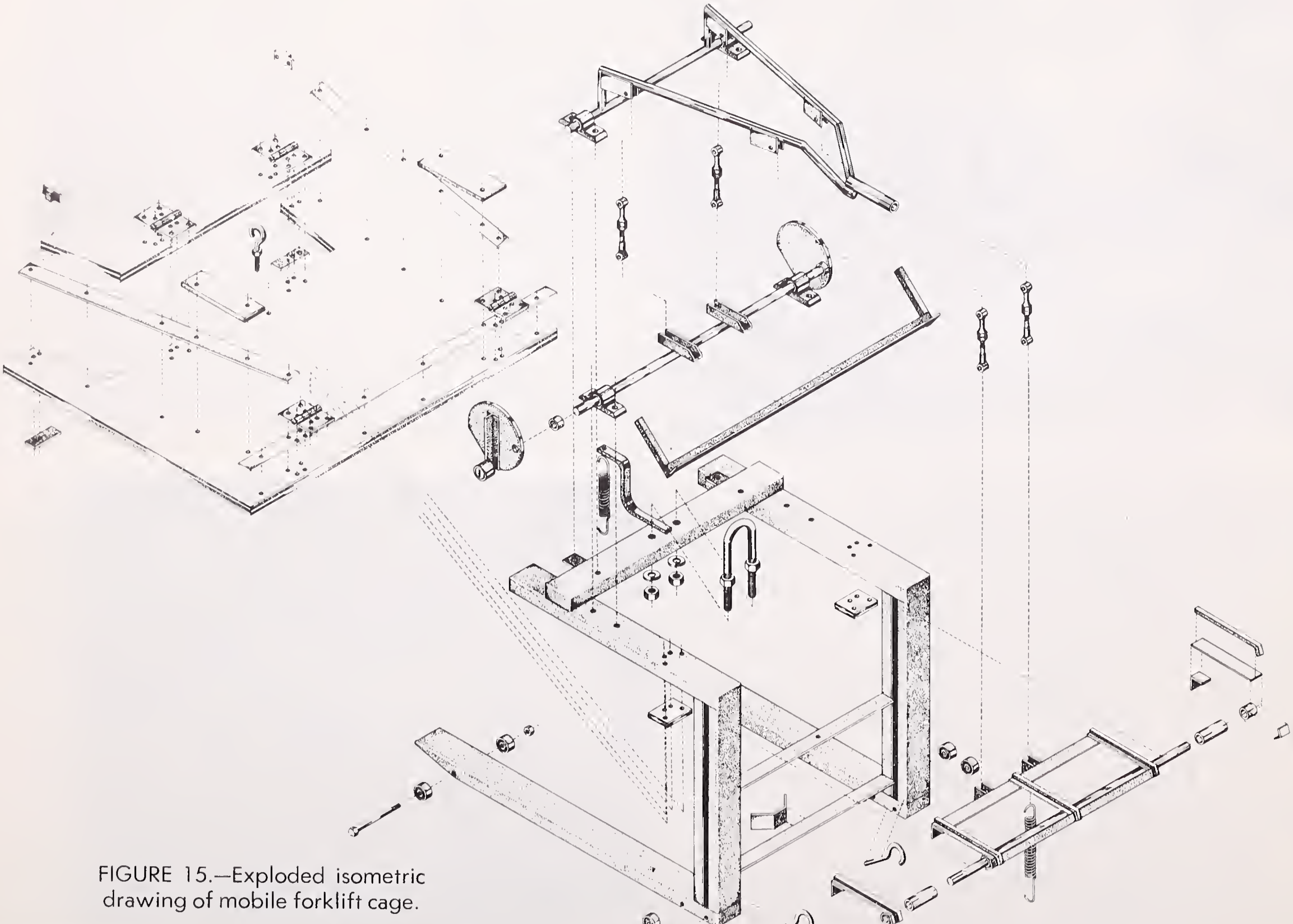

FIGURE 15.—Exploded isometric drawing of mobile forklift cage.

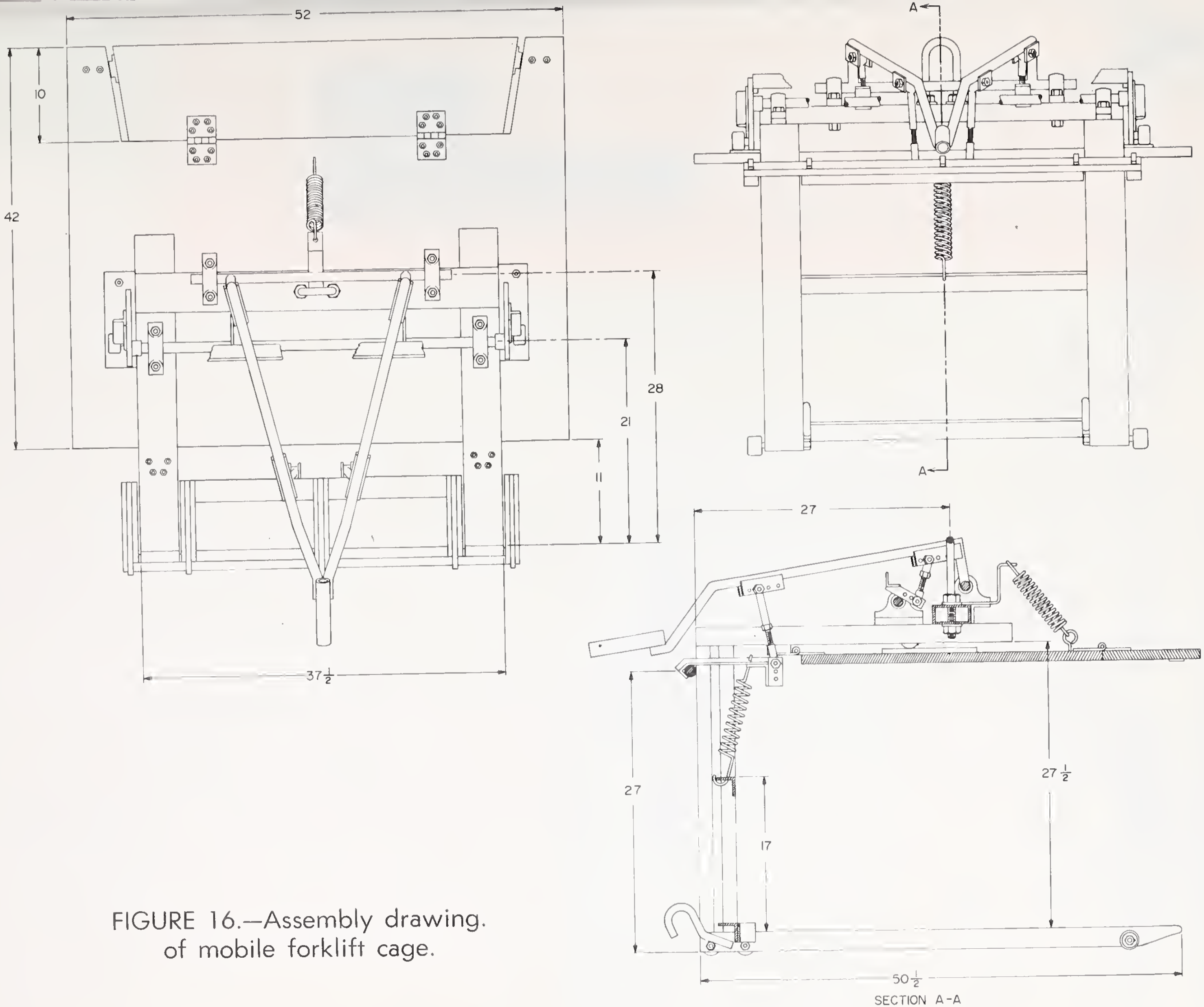

FIGURE 16.—Assembly drawing. of mobile forklift cage.

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