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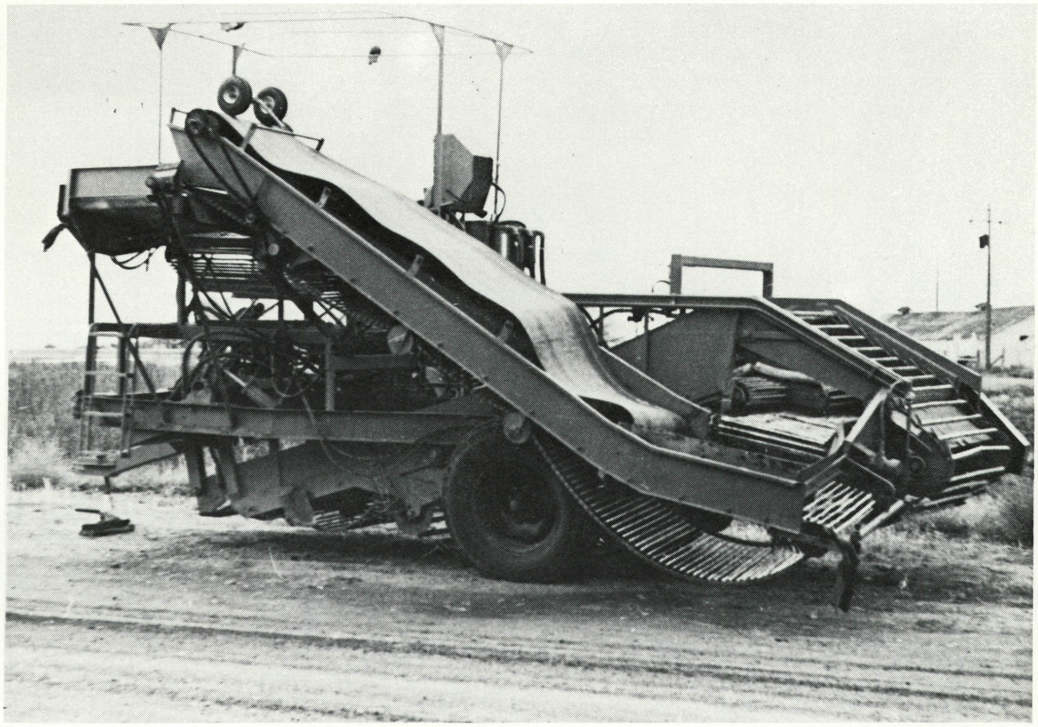
Fig. 1. The low damage harvester.



Modifications to Potato Harvesting And Handling Equipment That Can Reduce Bruising

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Bruising occurs when a potato receives an impact hard enough to cause cells to rupture. There are two general classifications of bruises — shatter, when the outer skin is broken, and black spot, dark discolored flesh not usually associated with a break in the skin. Both types of bruising can be caused by the same impact. Tuber condition generally determines which type of bruise will occur.

Significant injuries occur each time potato tubers are handled. Studies have shown we can expect the following percentage of potato tubers to be injured: *

Harvesting in the field (5 to 75%)	
digger	10 to 40%
rolling on chains and transferring between chain	5 to 20%
loading and unloading truck	10 to 30%
Piling into storage (5 to 40%)	
truck to piler hopper	5 to 25%
on piler	5 to 20%
drop from piler	0 to 30%
roll down pile face	0 to 10%
Removal from storage and packing for fresh shipment (15 to 45%)	
scooper	0 to 10%
loading piler	5 to 10%
drop into and removal from truck	5 to 20%
unloading conveyor and eliminator	0 to 15%
washing, grading, sizing and bagging	10 to 20%

*These percentages show the range of injury found in several studies. The percentages given for each segment do not necessarily add to the total because the data are not from the same study.

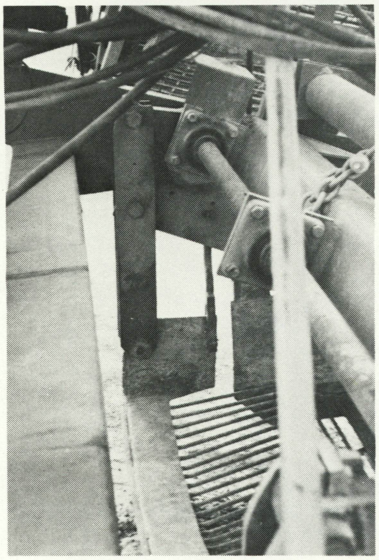


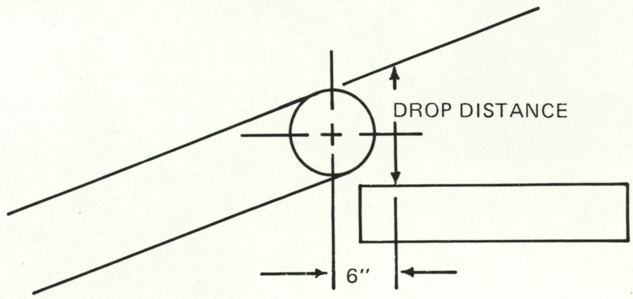
Fig. 2. The vibrating blade (above) oscillates about a rubber bushing in the center.

Fig. 3 Vibrating blade drive (left) showing pivot arm and eccentric.

Table 1. Drop distances for various harvesters in inches.

	Harvester*			
	Low damage	A	B	C
Primary to secondary	9.5	13.5	13.8	
Secondary to cross	7.0	13.2	12.5	17.0
Cross to side	8.2	11.0	11.8	11.5
Side to rolls or boom	7.2	11.0	13.8	16.0
Clod rolls to boom	5.0	6.5	8.5	-

*Harvesters A & B were manufactured after 1972. Harvester C, still in use, was manufactured in 1969.



Method for measuring drop distance at transfer points.

Field operations account for the most potato injury but other operations also contribute a significant amount. Injury from piling into storage can be from 25 to 60% as much as that from field operations.

Most of the potatoes injured during harvest and piling are removed during grading. The studies show that about 75% of the injury found in shipping containers is new injury. The injury found in shipping containers was generally slight and would not affect grade. It would affect customer satisfaction. Only about 25% of the potatoes harvested were injury-free when packed for fresh shipment.

Low Damage Harvester

An experimental "low damage" harvester was constructed at the University of Idaho Research and Extension Center, Aberdeen, to investigate the feasibility of modifying harvesters in areas known to cause damage (Fig. 1). Modifications were made to reduce the drops, reduce or eliminate rollback, reduce impact at direction changes, provide variable chain speeds to properly load the chains, and eliminate the sudden impact at the digger blade and primary chain. These principles, although applied to a harvester, could be used on other potato handling equipment.

Vibrating blade

The digger blade on the experimental harvester was designed to vibrate or oscillate forward and backward under the potatoes in the row. The oscillation is achieved by pivoting the blade about a rubber bushing in the center so one side moves forward while the other moves rearward (Fig. 2). The pivot arms slope to the rear below the pivot 20 degrees from vertical so the blade drops slightly downward as it moves forward. This helps carry material into the harvester.

Rods are fastened to the rear of the blade and extend beyond and above the lower end of the primary chain. The potato tubers are moved upward on the rods and are gently deposited on the primary chain. Sudden impact between the potatoes and the primary chain is thus avoided. The oscillating movement assists in soil separation and reduces the amount of tuber rollback which would normally be caused by agitation of the chains.

Building a vibrating blade and adding it to an existing harvester would require a rather complete shop. Extensive modifications would be required on the harvester. A drive for the vibrating blade must be provided and the harvester frame must be widened to accommodate the blade (Fig. 3). It would be more desirable for a manufacturer to design the vibrating blade into a new machine than to modify existing harvesters.

Drop heights reduced

Dropping the potato tuber from one chain to another can cause a significant amount of injury, so drop heights were reduced on the "low damage" harvester.

Table 1 compares drop heights for the low damage harvester and standard production harvesters. Drop distances at transfer points were measured by placing a straight edge on the discharge chain or rollers in the direction of travel. The vertical distance to the receiving conveyor, measured 6 inches from the head shaft of the discharge conveyor, was used as the drop distance. This method reflects more nearly the actual drop height between conveyors. The actual drop height between conveyors when the discharge conveyor imparts an upward trajectory is much greater than the vertical distance between the receiving conveyor and the highest point of the discharge conveyor. The 6-inch horizontal distance locates the most frequent impact point under usual chain speeds. Actual drop distance may vary from this. When

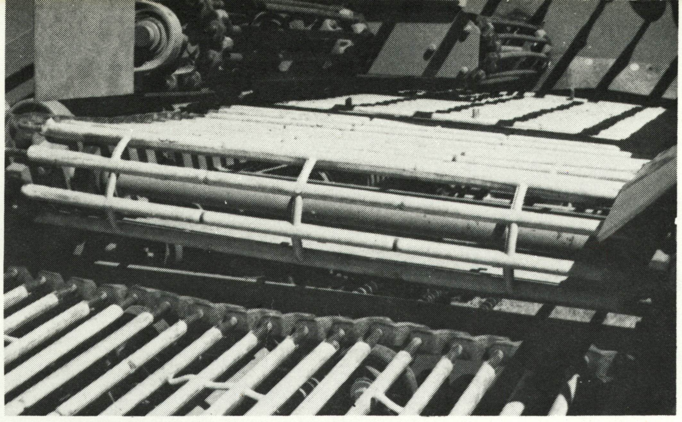


Fig. 4. Low drop heights at chain transfer points help the harvester handle potatoes gently.

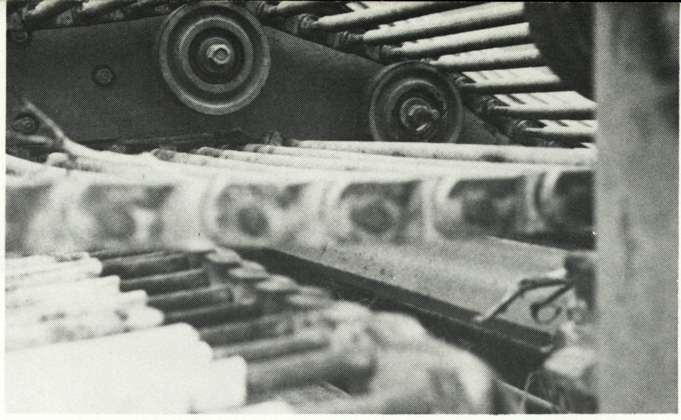


Fig. 5. Idler rollers were placed to change slope of discharge of the secondary chain.

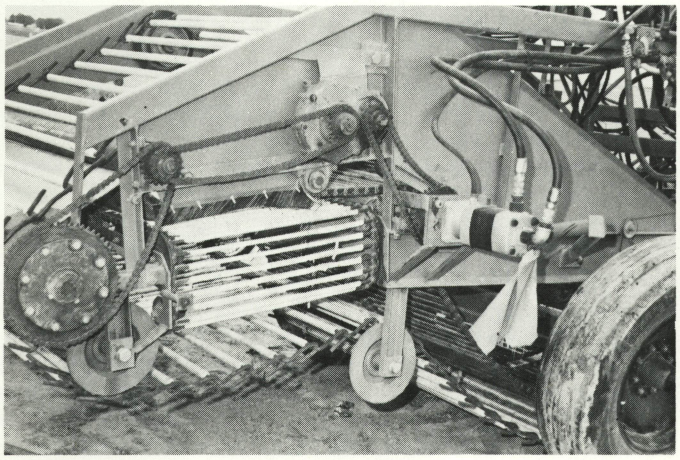


Fig. 6. Secondary and devining chain drive.

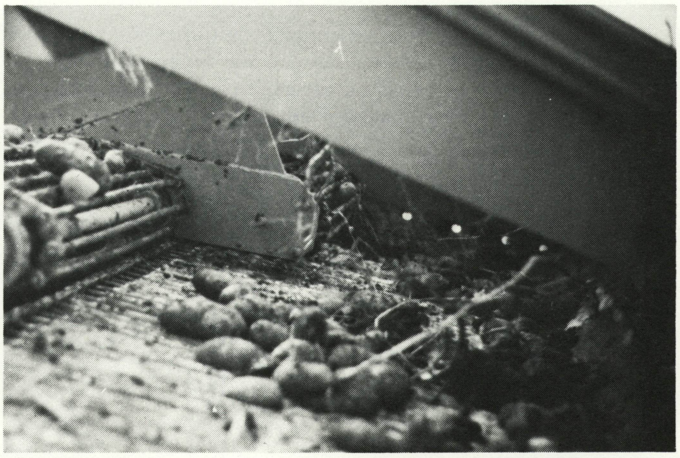


Fig. 7. Downward angle of secondary chain reduces impact on tubers discharged onto rear cross chain.

potatoes are discharged onto a roll table, one layer is always on the roll table, reducing the drop distance. On the other hand, a flighted conveyor with an upward trajectory will usually throw the potatoes upward so the distance from the apex of the trajectory to the receiving conveyor will be greater than the measured distance.

Harvester modifications to reduce the drop heights can easily be made on existing harvesters. This would require relocating head shafts, drives, cones, rollers, etc. (Figs. 4,5).

Return side drive

Drop heights from the secondary chain to the rear cross chain and from the side elevator chain to the clod rolls were reduced by providing a return side drive which keeps the chain in tension as it goes around the head shaft. The receiving conveyors can then be within about 1 1/4 inches of the return of the discharge conveyor without the problem of chain entanglement which can occur if the chain goes slack as it comes off the head shaft (Figs. 4,5). The drive sprockets on the head shaft were removed and smaller diameter rollers were used.

Return side drives could be provided on existing machines. The return side drive is placed on the outside of the chain and therefore requires the drive rotations to be reversed (Fig. 6).

Staggered loading of the rear cross

To use the full capacity of the rear cross, the secondary chain discharges were staggered (Fig. 4). The row furthest from the side elevator discharges onto the back half of the rear cross; the near row discharges onto the front half of the rear cross. Using the full width of the rear cross allows a slower chain speed and more uniform loading with a reduced rearward slope on the chain.

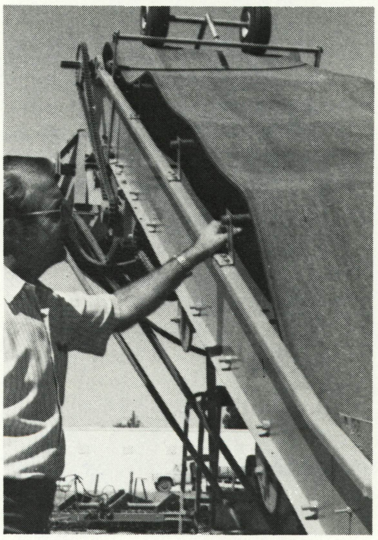


Fig. 8. Anti-roll belt on side elevator (right) permits removal of flights, prevents rollback and helps remove dirt.

Reduced impact at direction changes

The slopes of the discharging chains were reduced by passing the chain over the idler rollers just ahead of the head rolls (Fig. 5). The chains are thus angled downward so the potatoes are discharged toward the receiving conveyors rather than up and away from them (Fig. 7).

Auxiliary rollers to change the discharge direction can be added to existing machines. The head shaft must be relocated; otherwise the chain angle would be increased to accommodate the auxiliary roller.

Anti-roll belt to replace flights

Removing the flights from the inclined side elevator made possible shorter drops at the transfer points, both on and off the elevator, since flight clearance was no longer necessary.

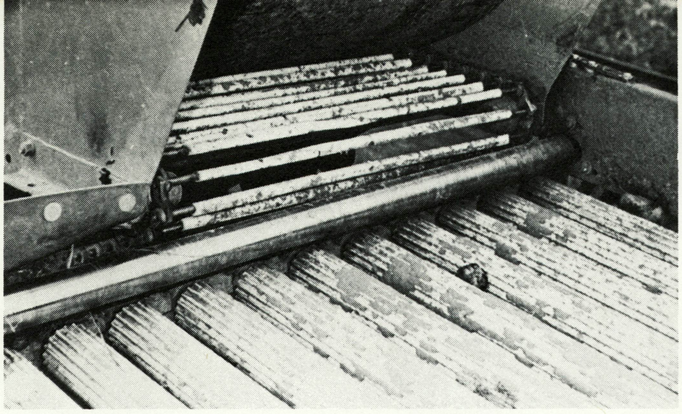


Fig. 9. Trash eliminator roll at discharge of side elevator. Note the short drop made possible by eliminating flights from the elevator chain.

An anti-roll belt, which is an endless belt with no tail pulley (Fig. 8), was added to help elevate the tubers without rollback. The anti-roll belt lays between the sides of the side elevator and is driven by a head roller and two friction wheels. The belt holds the tubers against the chain and prevents tuber roll back. The belt also helps break clods and eliminates dirt.

The anti-roll belt could easily be added to the side elevator on existing harvesters. The flights would be removed and the drops at each end of the conveyor reduced to take advantage of the absence of flights. Direction of the belt head roll is opposite that of the side elevator chain. The belt and chain travel at the same speed.

Trash eliminator roll

Many problems experienced in harvesting and handling potatoes are associated with foreign material. A smooth 2 1/2 -inch diameter roller was placed between the discharge of the side elevator and the roll table to prevent the elevator chain from pulling tubers from the roll table (Fig. 9). The roller was powered in a reverse direction at about 250 rpm in such a manner that weeds, vines, and similar trash were pinched between the roller and the return side of the chain and discharged to the ground.

The trash eliminator roll could be added to existing harvesters only if the anti-roll belt is used. When the drop from the side elevator to the roll table is reduced to the minimum, some means must be provided to keep the potatoes from being pulled onto the ground by the chain. The trash roll will stop potatoes from being pulled from the roll table and is worthwhile for trash removal.

Variable speed drives on all chains

Keeping chains loaded to capacity will reduce bruise damage to potatoes. Variable speed drives make it possible to vary the speeds of all chains on the harvester to match the type of soil, soil moisture and yield. This helps keep the maximum load on all chains in all conditions.

Major modification in the drive line would be required to provide variable speed drives to existing harvesters. The modifications would not be difficult to make but the hydraulic pumps and motors that replace the existing gear boxes, drive lines and chains would involve considerable expense. If variable speed drives are used, provide a way to control the primary and secondary chain speeds from the tractor while digging. Proper design of the hydraulic circuits is necessary.

Fig. 10. Sensor used in the automatic boom height control.

Automatic boom height control

Operators of present harvesters spend from 50 to 75% of their time monitoring the boom while digging. This often leaves too little time to attend to the operation of the rest of the machine. As a result, more potatoes are bruised than necessary because of improper machine operation. The boom is often set high above the potatoes in the truck so less operator time is required to monitor the boom. Then the extensive drop often damages potatoes.

An automatic boom height controller was designed to answer this problem. The controller or sensor uses high frequency sound to sense the distance between the boom and potatoes in the truck. When this distance is greater or less than desired, the sensor generates an electrical signal which is fed to a solenoid of the hydraulic valve. The valve is activated until the boom returns to the proper height.

When it becomes available commercially, this automatic controller could easily be added to any harvester.

Modifications of Handling Equipment

Many of these harvester modifications could be used on pilers and other handling equipment, although most adaptations would require extensive modifications of the equipment or a new design.

The automatic boom height controller could be used on a piler to control the boom while piling or loading trucks from storage. Variable speed drives could be used on conveyors where a variable delivery is desired or where varying conditions exist.

In most fresh packing sheds, the elevator that lifts the potatoes to the eliminator usually is steep with high flights. The high flights and steep angle require an excessive drop—as much as 3 feet—onto the eliminator. The anti-roll belt and trash roll could be used here to reduce the drop and also help remove sprouts and other trash.

We can envision new piling and handling systems that would use most of these modifications to reduce potato injury. Any reduction in injury would mean additional returns to the potato industry and help get highest quality potatoes to the customer.

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