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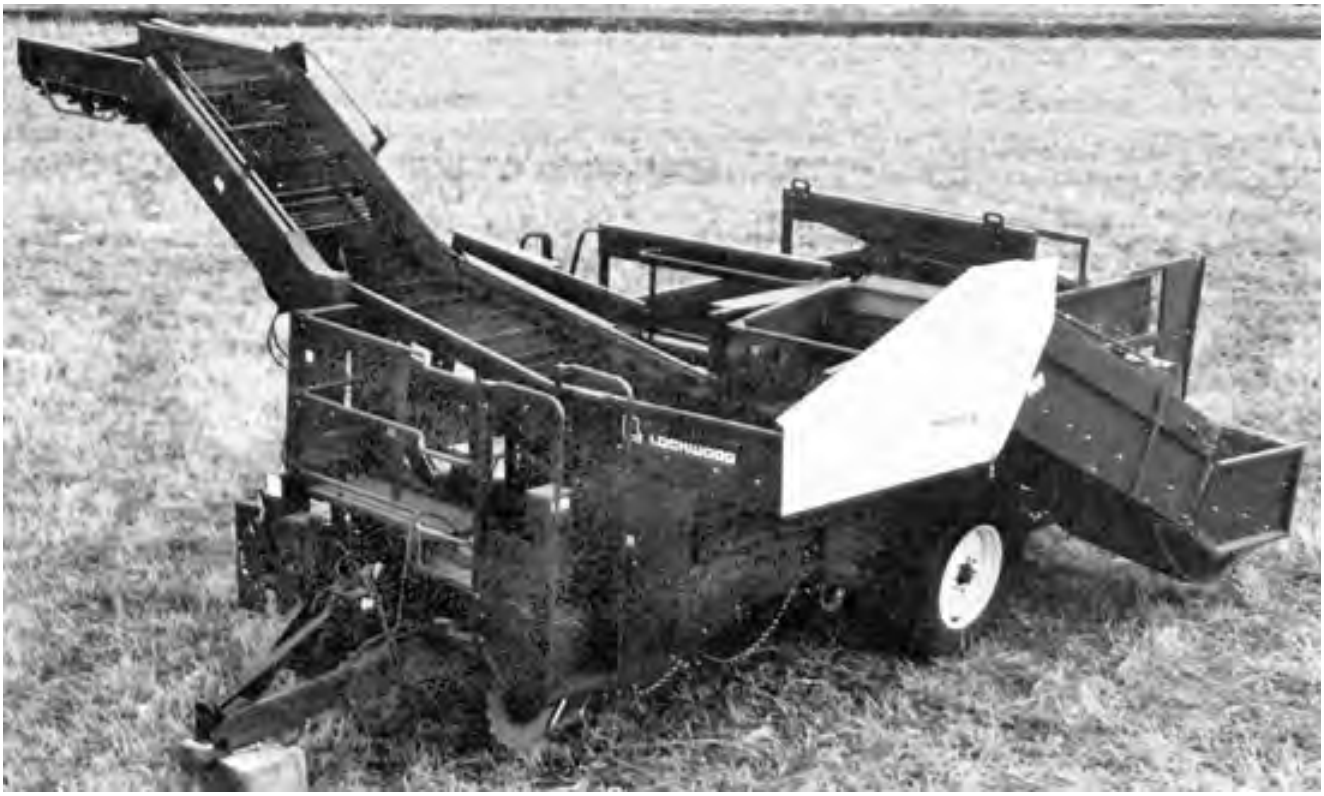

Lockwood Mark XL Potato Harvester

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

LOCKWOOD MARK XL POTATO HARVESTER

RETAIL PRICE: $33,460 (January 1982, f.o.b. Portage la Prairie, MB, with optional steerable axle, hold-down conveyor, delivery boom extension, star table and electro-hydraulic controls.)

MANUFACTURER:

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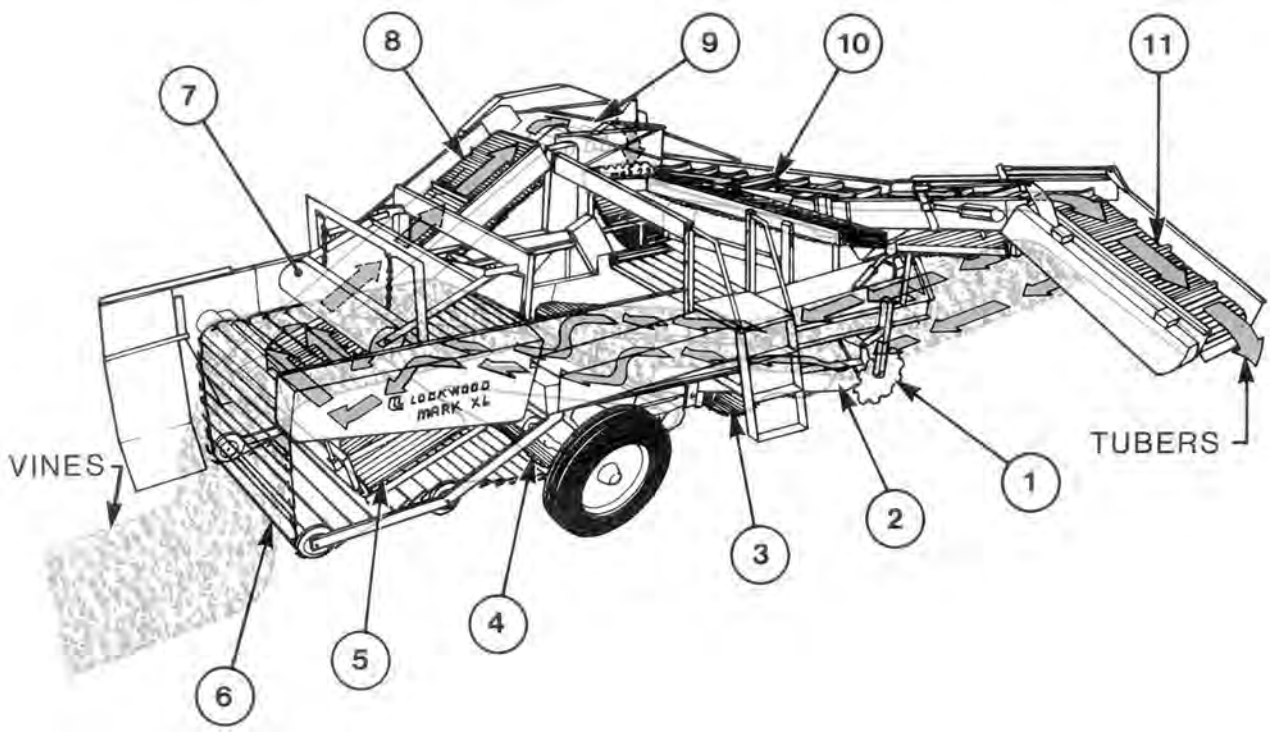

FIGURE 1. Lockwood Mark XL Potato Harvester. (1) Coulters, (2) Spade, (3) Primary digger chain, (4) Secondary digger chain, (5) Cross conveyor, (6) Deviner, (7) Stripper roller, (8) Elevating conveyor, (9) Star clod table, (10) Sorting table, (11) Delivery boom.

SUMMARY AND CONCLUSIONS

Functional performance of the Lockwood Mark XL potato harvester was *good* in dry, sandy loam soil. Performance was *fair* to *good* in severe hard clod conditions.

Clod removal by the conveyor chains was *good* in normal harvesting conditions. Removal of hard clods was difficult due to inadequate clod breakup.

Deviner performance was *very good* in dry, frozen vines and good in tough, green vines. Bunchy trash flow caused some operating problems, with the full width deviner, and some durability problems on the stripper roller. Carryover losses varied from 1% in dry vines to about 5% in bunchy, tough vines.

Performance of the star clod table was *good* in breaking down dry clods. Performance was *fair* in severe, hard clod conditions, since many clods bounced across the short table.

Workrates were governed by soil and clod conditions in high crop yields. Ground speed ranged from 2.5 to 3.5 km/h (1.5 to 2.2 mph). The rated capacity of 55 t/h (60 ton/h) could not be achieved in prairie crops. Typical capacities ranged from 14 to 36 t/h (15 to 40 ton/h) in fields with an average yield of 26 t/ha (11 ton/ac). In loamy sand soils, workrates were limited both by the low yields of 15 t/ha (7 ton/ac) and the ability of the digger chains to separate the dry soil. Workrates were improved by using a potato windrower in conjunction with the harvester.

Typical samples of harvested potatoes showed 78% marketable tubers and 22% damaged tubers. (A good skin set and moist soil conditions predominated during the test season.)

A tractor with a minimum 75 kW power take-off rating had ample power reserve to operate the Lockwood Mark XL in most soil conditions.

Operator visibility of the delivery boom, spade, coulters and primary digger chain was *very good.* The sorting platforms and picking table conveyor restricted the view of the secondary digger chains and deviner. Rear visibility was obstructed by machine frame members. This could be a problem when transporting the machine on public roads.

Overall safety was *very good.* All drives had excellent shielding, conveyors were well guarded, and warning decals were abundant and well placed. However, the sorting platform was not adequately shielded. The right tire of the harvester was overloaded by 7%, while the left tire was overloaded by 18% at normal transport speeds.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing wider corse rollers, for the full width deviner chain, to prevent the chain from dislodging.
2. Providing a better method of securing the stripper roller hanger bearings to the frame to improve durability.
3. Equipping the harvester with tires of a higher load rating.
4. Increasing the size of toggle switches on the control box and repositioning them, to separate group functions from one another.
5. Ensuring better quality control of welded components to improve durability.
6. Providing a safe jacking surface to aid in hitching.
7. Increasing the pitch on the star roller clod table to improve clod separation.

Chief Engineer: E.O Nyborg
Senior Engineer: J.C. Thauberger
Project Engineer: Gregory R. Pool

THE MANUFACTURER STATES THAT:

1. A wider roller for deviner chain was one of the improvements included in the design of our 1981 Harvester, the 4000.
2. The stripper roller hanger bearing mounts have been only a very occasional problem. The item will be investigated.
3. In several years of production of this and similar models, there have been just a few cases of tire failure. A tire with higher load ratings is available for instances of inordinate amount of road travel at high speeds.
4. The control box toggle switches on our 1982 Model 4400 Harvester have been rearranged into groups by function.
5. Quality Control generally in our plant has been emphasized and steadily improved over the last two years.
6. A jacking plate is provided in the hitch area of our 1982, 4400 Harvester.
7. An adjustable pitch star table is another of the improvements made on the 1982, 4400 Harvester.

Note: This report has been prepared using SI units of measurement. A conversion table is given in APPENDIX III.

GENERAL DESCRIPTION

The Lockwood Mark XL is a two row, power take-off driven, pull-type potato harvester with an adjustable spade and a cutting width of 1.6 m (63 in).

The spade is pulled through the soil underneath two rows of potatoes, lifting a mass of soil, tubers and vines onto the primary digger chains. Most soil separation occurs on the primary chains. The tubers, vines and clods are delivered to the dual secondary chains and deviner chain. The secondary chains further separate the soil and tubers before delivering the tubers, trash and clods to the rear cross conveyor.

The large pitch deviner chain separates the vines and trash from the tubers. Vines are carried out the rear of the machine and fall to the ground while any tubers, attached to the vines, are removed by impact with the stripper roller. The rear cross conveyor moves the tubers, trash and clods to the side elevator conveyor. Trash is removed by the powered trash roller. The inclined side elevator carried the tubers and clods to a ievel, rubber-coated star clod table. Undersize tubers and small clods are removed, while the tubers are carried to the picking table. A number of workers perform final hand sorting. The adjustable bulk delivery boom conveys the tubers to a truck for transport to storage.

The harvester drives are driven by the tractor power take-off. Primary, secondary and deviner chain speeds Can be adjusted through a 3-speed gear transmission on the harvester. All other conveyor speeds are dependent on the power take-off speed. Hydraulic controls adjust the depth of the spade, coulters, inner and outer delivery booms and the steerable axle.

A minimum 75 kW (100 hp) tractor (with a suitable drawbar to support the hitch weight) equipped with 540 or 1000 rpm power take-off, hydraulic outlets and a 12 volt electrical system, is required to operate the Lockwood.

The test machine was equipped with heavy duty contour spade, notched trash coulters, full width deviner, adjustable stripper roller and rear mounted trash conveyor. Optional equipment included steerable rear axle, a hold-down conveyor on the flightless side elevator, a long extension on the delivery boom, a star roller clod table and electro-hydraulic controls.

Detailed specifications are given in Appendix I.

SCOPE OF TEST

The Lockwood Mark XL potato harvester was operated in the soil conditions shown in TABLE 1 for about 155 hours on stone free, level fields, while harvesting about 100 ha (250 ac) of Netted Gem potatoes. Row spacings were 915 to 965 mm (36 to 38 in), with yields averaging 25 t/ha (11 ton/ac).

The harvester was evaluated for quality of work, ease of operation and adjustment, rate of work, power requirements, operator safety and suitability of the operator manuals.

TABLE 1 . Operating Conditions

SOIL TEXTURE	Hours	Field Area (ha)
Clay Loam	68	33
Silty Clay Loam	33	23
Fine Sandy Loam	54	44
Total	155	100

RESULTS AND DISCUSSION

QUALITY OF WORK

Spade and Coulters: The spade penetrated the soil to the selected digging depth quickly and cleanly in clay loam and loamy sand soils. In dry soil, the spade scoured clean and the soil mass flowed freely. Digging depth was even, which allowed the spade to lift a uniform bed of soil.

The cutting coulters remained clean in all soil and vine conditions. They did an excellent job of cutting the vines, leaving a clear path for the edge of the spade, thus reducing plugging problems.

Soil Separation: Most of the loose soil was separated from the tubers on the primary chains. Further separation occurred on the secondary chains, while the smaller, loose clods were broken down on the star clod roller table.

Devining: The full width deviner chain was very effective in removing vines and tall weeds. In frozen dry vines, performance was very good. In tough and green vines trash flow was bunchy and intermittent, however, vines were effectively removed.

If agitation of the deviner was not sufficient to separate tubers from vines, contact with the stripper roller effectively removed the tubers. Carryover losses were less than 1% in frozen, dry vines. In tough, clumpyvines, carryover losses increased to about 5% of total yield.

Trash Removal: Trash falling through the deviner in light weed conditions was effectively removed by the powered trash roller at the end of the rear cross conveyor. The tubers on the picking table, under these conditions, were usually free of trash. In heavy weed conditions, the trash load was too heavy for effective removal by the powered roller (FIGURE 2).

FIGURE 2. Weed clogging near powered roller .

Clod Separation: Clod removal at the star clod roller table was good. In loosely packed, moist soils, most small clods were effectively broken down and removed from the tuber sample. During a very dry harvest season, large hard clods, which were predominant in the clay loam soils, were not effectively removed by the star clod table. Capacity of the harvester was then usually influenced by the rate of clod removal possible by hand sorting.

Bruise Damage: When using the Lockwood Mark XL in standard two-row harvesting, for the field conditions stated in the report, an average damage index1 of 145 was established. An average 22% of the tubers sustained sufficient damage to be considered unmarketable. Typical samples of harvested tubers showed 65% undamaged, 13% slightly skinned, 9% moderately bruised and 13% severely bruised (FIGURE 3). The latter two categories were considered unmarketable. The parameters used to determine mechanical damage were blackspot and shatter bruising. Bruise damage was influenced by forward speed and chain speeds. The soil flow rate onto the primary chain ensured that the soil was adequate to provide a cushion for the tubers until they dropped onto the rubber coated secondary chain. If the combination of forward speed and chain speeds was not closely matched, this cushion effect was lost. Mechanical damage was also noted as some tubers were pinched by the chain links against the edge of the side elevators.

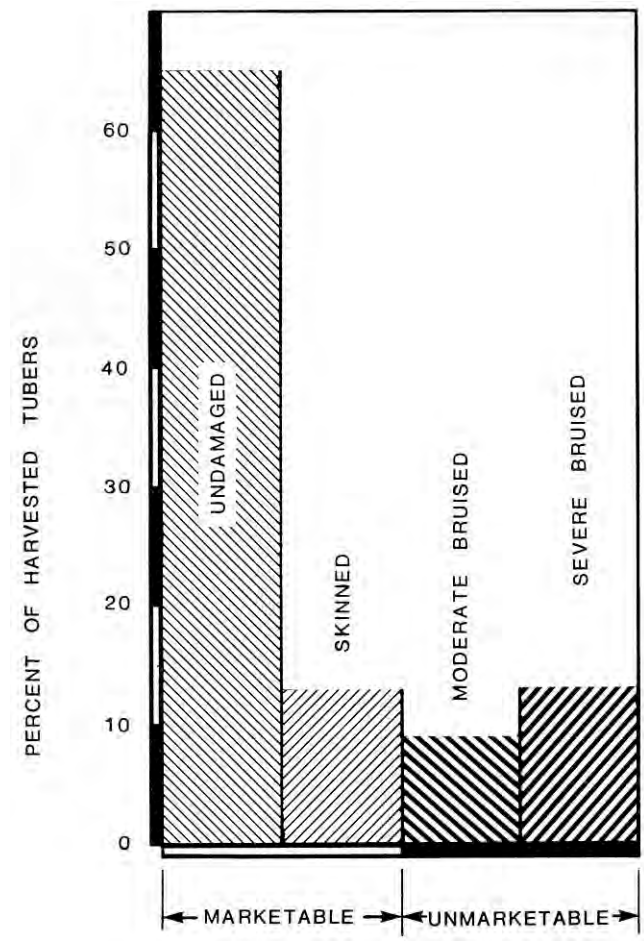

FIGURE 3. Typical Bruise Damage.

[1]*PAMI-T7719-R79 Detailed Test Procedures for Potato Harvesters*

EASE OF OPERATION

Hitching: The harvester was difficult to hitch to a tractor, due to the heavy hitch weight of 1210 kg (2665 lb). The hitch could not be safely lifted with a jack (FIGURE 4) due to the slope of the hitch frame. It is recommended that the manufacturer consider providing a more convenient jacking location for lifting the hitch.

FIGURE 4. Hitch frame.

An alternative hitching method was to lift the hitch to the appropriate height by lowering the spade to the ground. This required connection, first, of the hydraulic hoses and electric control box.

Maneuverability: The hitch allowed good tractor tire clearance on short turns. The harvester could turn satisfactorily on 10 to 15 m (35 to 50 ft) headlands without backing. On extremely short headlands, the optional steerable axle increased maneuverability by permitting quick row alignment.

Electric Controls: The electro-hyd raulic controls permitted control of the machine Without the inconvenience of hydraulic oil lines in the tractor cab. The control box was compact and lightweight. It was easily positioned on the tractor in a convenient location. The switches were logically grouped (FIGURE 5), however, larger toggle switches and a distinct space between groupings would have been more convenient. It is recommended that the manufacturer provide larger toggle switches and make the groupings more definitive.

FIGURE 5. Control Box.

Operator Visibility: The delivery boom was visible at all times. Monitoring the performance of the spade, coulters and primary chains from the tractor was easy. The operator had a clear view of the workers at the picking table. Visibility of the secondary and deviner chains was obscured by the picking table, platforms and workers.

The orientation of the tires was not visible during turns on short headlands, however an indicator on the front of the harvester showed the orientation of the steerable axle. Assistance was usually required when backing the machine, due to poor visibility.

Delivery Boom: The 890 mm (35 in) optional boom extension gave the harvester excellent reach to the truck. The outer boom height adjustment was very responsive for changing tuber drop heights in the truck. The inner boom was equally effective in adjusting to changing conditions, although its response time was slower.

Cleaning: Periodic cleaning was required to prevent trash buildup from affecting performance. In heavy weeds, frequent cleaning was required. Accessibility for cleaning was usually very good. Plugging occurred occasionally at the digger apron, which was less accessible for hand cleaning.

The deviner chain frequently plugged in heavy vine conditions, forcing the chain to ride below the cone rollers. It is recommended that the manufacturer consider providing wider cone rollers for the fall width deviner chain. Although access to the plugged area was good, the vines were difficult to remove. The weight of the stripper roller frame made it awkward and inconvenient to lift out of the way.

Manual Sorting: The workers had good access to the full width of the picking table from both sides. The table was at a reasonable working height, which eased back strain and worker fatigue. Proper shielding was not provided on the front platform under the picking table. One worker's loose clothing became caught between the conveyor chain and an idler roller.

Night Operation: No lighting system was provided, or available as an option, for night operation. Tractor lights provided only limited illumination for night operation. Lights were installed for the workers, on the picking table platform, and for tractor operator visibility of the bulk delivery boom.

Lubrication: The Lockwood Mark XL had 10 pressure grease fittings, as well as 15 roller chains that required periodic lubrication. A lubrication chart was provided in the operator manual. Daily lubrication took from 30 to 45 minutes. Most roller chain drive shields were easily removed for lubrication.

Transport: The heavy hitch weight permitted towing the harvester safely at speeds up to 20 km/h (12 mph) on gravel roads. However caution had to be exercised during transport, due to limited rear visibility and the wide machine width.

EASE OF ADJUSTMENT

Digger Spade and Coulters: Digging depth of the spade was easy to adjust with the hydraulic controls. The coulters were adjustable independently from the spade, which provided excellent control of cutting depth in variable field conditions.

Conveyor Speeds: Most conveyor speeds were controlled by the engine speed through the power take-off, to suit changing harvest conditions. The speed ratio of the primary digger chain to the forward speed could also be set, through a 3 speed transmission.

Stripper Roller: The clearance between the deviner and the roller was easily adjustable with a threaded eyebolt. Adjustment was adequate to effectively strip the tubers from the vines, as field conditions changed.

Conveyor Tilt Angle: Adjusting the tilt angle of the rear cross conveyor and the side elevator was time consuming; it required proper tools and a certain amount of care. Once set, the adjustment was usually not changed for the remainder of the season.

Indicators: Indicators for spade working depth, orientation of the steerable axle, and harvester transmission gear were closely grouped on one side ofthe machine. Monitoring all functions was easy; markings were clear.

WORK RATE

Typical workrates in three soil-types are shown in TABLE 2. In two-row harvesting, the conveyors were not fully loaded due to field conditions and yields. The harvester was only loaded from 25% to 65% of the manufacturer's suggested capacity of 54 t/h (60 ton/h). In sandy soils with lighter yields, a potato windrower was used in conjunction with the harvester, to permit the harvesting of four rows and greatly increasing the workrate. The conveyors were kept more fully loaded, which reduced the tendency of tubers to roll and bounce, thus reducing bruise damage.

TABLE 2. Rates of Work

SOIL	Number of Rows Harvested	Yield (t/ha)	Workrate (t/h)
Silty clay loam	2	28	36-23
Clay loam	2	26	17-14
Fine sandy loam	4	15	23-13

POWER REQUIREMENTS

Average power take-off input was from 6 to 18 kW (8 to 24 hp). Average d raft requirements were from 12 to 15 kW (16 to 20 hp) at speeds from 2.4 to 3.5 km/h (1.5 to 2.2 mph). A tractor with a minimum 75 kW (100 hp) power take-off rating should have ample power reserve for most conditions. Tire floatation must be taken into consideration when selecting a tractor, due to the heavy hitch weight of the harvester.

OPERATOR SAFETY

All moving parts in the vicinity of the sorting platform were shielded, however shielding was not adequate on the front platform under the picking table. Visibility to the sides of the machine was fair, while visibility directly behind was obscured. Workers on the sorting platforms were in clear view of the operator. Safety decals clearly warned workers of hazardous areas. Display and placement of decals was excellent. A slow moving vehicle sign was supplied on the rear of the harvester.

The maximum load ratings[2] for the 11.25 x 24, 9 ply implement tires, was exceeded. The right and left tires were overloaded by 7% and 18% respectively, at normal road transport speeds. It is recommended that the manufacturer equip the harvester with tires of a higher load rating.

OPERATOR MANUALS

The Lockwood Mark XL was supplied with a very good set of manuals. The operator manual supplied general information on operation, maintenance and adjustment. A lubrication chart, a brief list of safety points, and machine specifications were included. The parts manual which detailed information on major components was easy to understand and well organized.

DURABILITY RESULTS

The intent of the test was evaluation of functional performance. The failures listed in TABLE 3 represent those which occurred during functional testing. An extended durability evaluation was not conducted.

TABLE 3. Mechanical History

ITEM	Operating Hours	Equivalent Field Area (ha)
Brackets on the left steerable axle broke and were rewetded at	12	8
Bolts holding the stripper roller hanger bearings loosened and were replaced at	33, 126	21, 82
The star roller clod table shaft bent and was repaired at	83	54
The hand adjusting lever for the shakers broke and was rewelded at	96	62
Several deviner chain links broke and were removed at	98, 124	64, 80

[2] *The Tire and Rim Association, Inc. 1980 Year Book*

TABLE 3. Mechanical History - continued

ITEM	Operating Hours	Equivalent Field Area (ha)
The chain tightener for the rear cross conveyor drive loosened, causing the roller chain to jump off the sprockets	101, 140, 147	66, 90, 95
The steel cable on the spade depth indicator broke and was replaced at	103	67
The delivery boom drive chain broke and was repaired at	108	70
A primary digger chain link broke and was removed at	114	74
The left coulter broke and was repaired at	120	77
The'deviner chain slipped below the cone rollers on both sides of the apron frame and was repositioned at	21, 126, 153	14, 82, 99
The delivery boom jackshaft twisted and was replaced at	128	83
Several welds on the delivery boom conveyor cracked and were rewelded at	128	83
Flighting on the hold-down conveyor loosened, breaking the drive chain	several times	
Shear bolts on the rear cross conveyor drive universal joints broke and were replaced at	145	94
The roller chain drive for the secondary chains broke and was repaired at	150	97

DISCUSSION OF MECHANICAL PROBLEMS

Deviner Chain: The deviner chain falling below the cone rollers was predominant in heavy, green vine conditions.

Stripper Roller: The roller mounting bolts frequently loosened. due to constant jarring of the roller by clumps of vines.

Delivery Boom: Several drive failures on the delivery boom conveyor were caused by chain tighteners loosening, allowing the drive chains to jump off the sprockets. Numerous weld failures on the boom were noticed during the test. It is recommended that the manufacturer institute better quality control of welded components.

Hold Down Conveyor: After repeated failures of the flighting chain on the hold down conveyor on the side elevator, the entire assembly was removed, to prevent further down time. Although roll back of tubers was more noticeable on the flightless side elevator, bruising of tubers was not significantly increased.

APPENDIX I

SPECIFICATIONS

Make:	Lockwood
Model:	Mark XL L06030-00278
Serial Number:	9767 RY
Overal Dimensions:	
-- wheel tread	2080 mm
-- transport height	4050 mm
-- transport length	7500 mm
-- transport width	4890 mm
-- maximum boom reach	2700 mm
-- ground clearance	255 mm
Weight: (unloaded)	
-- right wheel	2200 kg
-- left wheel	2400 kg
-- hitch	1200 kg
Total	5800 kg
Tires:	two, 11.25 x 24, 8 ply
Turning Radius:	
-- without steering axle	5000 mm
-- with steering axle	4500 mm
Spade:	
-- type	heavy duty contour blade
-- width	760 mm (two)
-- depth control	hydraulic cylinder
Coulters:	
-- type	notched trash blade
-- diameter	610 mm
-- depth control	hydraulic cylinder
Primary Digger Chains:	
-- type	offset links
-- number of links	214
-- pitch	45 mm
-- total bed length	2100 mm
-- size (diameter)	13mm
-- maximum slope	25°
-- tuber drop height	295 mm
Secondary Digger Chains:	
-- type	(featheredge) rubber covering
-- number of links	210
-- pitch	45 mm
-- total bed length	2100 mm
-- size (diameter)	11 mm
-- flights	
-- number	30
-- type	rubber upright
-- maximum slope	25°
-- tuber drop height	290 mm
Deviner Chain:	
-- type	(pillow cushion) rubber covering
-- number of links	66
-- pitch	129 mm
-- total bed length	3400 mm
-- size (diameter)	16 mm
-- width	1590 mm
-- maximum slope	30°
Rear Cross Conveyor:	
-- type	(featheredge) rubber covering
-- number of links	110
-- pitch	40 mm
-- total bed length	1900 mm
-- size (diameter)	11 mm
-- width	890 mm
-- tilt	12°
-- tuber drop height	330 mm
Side Elevator:	
-- type	(featheredge) rubber covering
-- number of links	215 mm
-- pitch	40 mm
-- total bed length	3900 mm
-- size (diameter)	11 mm
-- width	890 mm
-- tilt	12°
-- maximum slope	25°
-- tuber drop height	360 mm
-- flights	
-- number	9
-- type	overhead rubberized flaps
Clod Table:	
-- type	star roller
-- material	soft rubber
-- pitch	130 mm
-- width	900 mm
-- length	780 mm
Picking Table/Delivery Boom:	
-- type	(featheredge) rubber covering
-- number of links	336
-- pitch	40 mm
-- total bed length	6400 mm
-- size (diameter)	11 mm
-- width	890 mm
-- flights	
-- number	48
-- type	rubber uprights
Powered Trash Roller:	
-- length	810 mm
-- diameter	90 mm
Stripper Roller.	
-- length	1480 mm
-- diameter	170 mm
Drives:	two. #50 roller chain eleven, #60 roller chain two, #80 roller chain one, 3/c multiple banded V-belt
Gear Boxes:	two, fixed rate one, 3 speed adjustable
Safety Clutches:	
-- number	5
-- type	slip clutch
Number of Sealed Bearings:	55
Number of Pressure Grease Fittings:	23

Optional Equipment:
- -- electro-hydraulic controls
- -- star roller clod table
- -- non-adjustable, steerable axle
- -- hold-down conveyor on side elevator
- -- long boom extension
  belted conveyor and digger chain

APPENDIX II

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation reports:

(a) excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory

APPENDIX III

CONVERSION TABLE

1 hectare (ha)	=	2.5 acres (ac)
1 kilometre/hour (km/h)	=	0.6 miles/hour (mph)
1 metre (m)	=	3.3 feet (ft)
1 millimetre (mm)	=	0.04 inches (in)
8 kilowatt (kW)	=	1.3 horsepower (hp)
1 kilogram (kg)	=	2.2 pounds mass (lb)
1 tonne (t)	=	2200 pounds mass (lb)
1 tonne/hour (t/h)	=	1.1 ton/hour (ton/h)
1 tonne/hectare (t/ha)	=	0.5 ton/acre (ton/ac)

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