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Evaluation Report 164

Lockwood Mark 15 Potato Harvester

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

LOCKWOOD MARK 15 POTATO WINDROWER

MANUFACTURER:

Lockwood Corporation
P.O. Box 160
Gering, Nebraska
69341

RETAIL PRICE:

$12,655.00 (June, 1980, f.o.b. Portage la Prairie, with optional vine divider).

DEALERS:

Kroeker Machinery Sales
P.O. Box 1450
Winkler, Manitoba
R0G 2X0

Barrich Farms Ltd.
P.O. Box 610
Outlook, Saskatchewan
S0L 2N0

Mid Plains Implements Ltd.
P.O. Box 610
Carberry, Manitoba
R0K 0H0

O & R Irrigation Ltd.
P.O. Box 10
Taber, Alberta
T0K 2K0

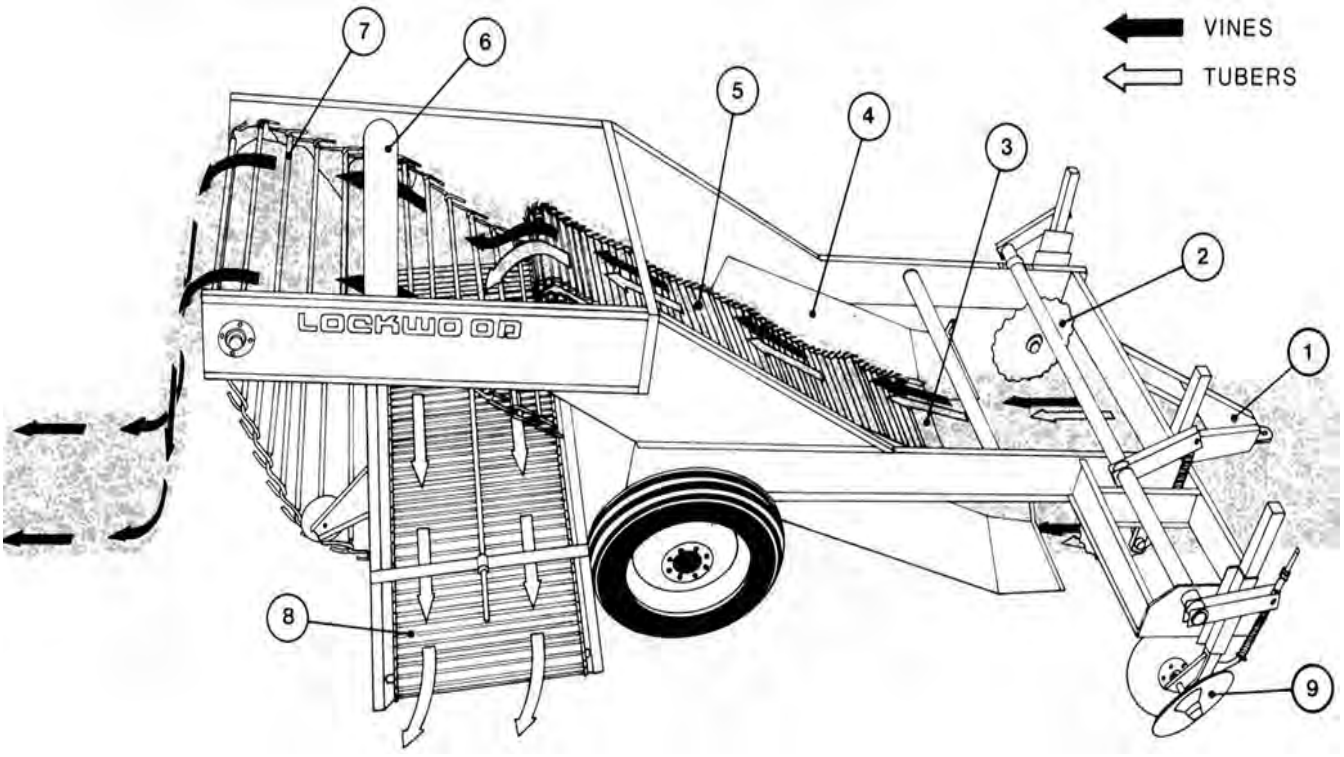

FIGURE 1. Lockwood Mark 15: (1) Drawpole, (2) Coulter, (3) Spade, (4) Dividing Board, (5) Digger Chain, (6) Stripper Roller, (7) Deviner Chain, (8) Cross Conveyor, (9) Vine Divider.

SUMMARY AND CONCLUSIONS

Performance of the Lockwood Mark 15 Potato Windrower was *good* in dry loamy sand soils with some clods and relatively dry vines, but was *poor* in severe clod conditions and tough vines. Performance was reduced primarily due to high carry over losses. Conditions during much of the 1979 harvest season were adverse (see Footnote 1) which affected machine performance and durability.

Separation of loose soil was *very good* in dry soil conditions. Performance of the spade and cutting coulters was *very good* in dry conditions. Occasional plugging occurred in tough, green vines.

Friable clod removal, by the digger chains, was *good,* but removal of hard clods *was poor,* since they were not broken by the chains, and were deposited with the tubers.

Deviner performance was *fair* in sparse, dry vines. Performance *was poor* in dense, tough, green and frozen vines. The short separation length of the deviner reduced machine performance, as a vine cushion formed on the deviner, preventing the stripper roller from effectively removing tubers.

The bunchy, intermittent trash flow caused some durability problems for the stripper roller. Tuber carryover losses varied from about 3% in dry vines to more than 8% in bunchy, tough vines.

Performance of the vine divider attachment was *fair.* The vine divider disks had to operate at an excessive depth to properly separate the vine growth, creating deep furrows which trapped some tubers. This resulted in above normal field losses as some tubers could not be recovered by the potato harvester. The depth of the vine divider depended on the cutting coulter depth setting. The optimum depth requirement for the cutting coulters was often different than for the vine divider disks, but an independent setting was not possible.

Maximum work rates were usually the result of a compromise between acceptable deviner carryover losses and forward speed. In fields with average 15 t/ha (7 ton/ac) yields, suitable forward speeds varied from 4 to 8 km/h (2.5 to 5 mph), resulting in workrates from 0.6 to 1.2 ha/h (1.5 to 3 ac/h). Average throughputs were about 10 t/h (11 ton/h).

Typical samples of windrowed potatoes showed 46% undamaged tubers, 36% slightly skinned marketable tubers, 3% moderately bruised and 15% severely damaged unmarketable tubers. The high percentage of damaged tubers was a direct ?esult of poor tuber skin set and severe clod conditions during the test season.

A tractor with a minimum 55 kW (75 hp) power take-off rating had ample power to operate the Lockwood Mark 15 in most soil conditions.

All drives were well shielded, conveyors were well guarded, and warning decals were suitably placed. The right tire was overloaded by 40% at normal transport speeds.

The Lockwood Mark 15 was easy to maneuver, but on very short headlands some backing was needed to align the windrower. Provisions for servicing, lubrication and adjustment were convenient.

Several mechanical problems occurred during the 62 hour test: the cast deviner drive sprockets broke, the hanger bearings on the stripper roller loosened, and the cutting coulters twisted the frame.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Lengthening the deviner to improve separating performance.
2. Providing a better method of securing the stripper roller hanger bearings to prevent them from loosening, and modifying the method of stripper roller adjustment to reduce durability problems.
3. Eliminating the interference b,,etween the return side of the conveyor chain and frame cross members on the drive end of the digger chains.
4. Installing a separate slip clutch on the deviner drive shaft to reduce drive component failures.
5. Modifications, to eliminate frame twisting at the cutting coulter attaching points.
6. Providing a jacking surface on the drawpole to aid in hitching.
7. Providing hydraulic hose brackets on the drawpole.
8. Equipping the windrower with tires of a higher load rating.
9. Providing a lubrication schedule in the operator's manual.
10. Modifications which allow the vine divider attachment depth to be adjusted independently of cutting coulter depth.
11. Modifications to reduce the frequency of digger chain link breakage.

Chief Engineer -- E.O. Nyborg
Senior Engineer -- J. C. Thauberger
Project Engineer -- W.J. Stewart

THE MANUFACTURER STATES THAT:

With regard to recommendation number:

1. Lockwood's extensive Digger windrower experience, particularly on the Mark 15, includes hundreds of units in use worldwide and in a wide variety of harvest conditions. The harvest conditions experienced in Manitoba during the fall of 1979, are extreme and probably will not be encountered for several years. Conclusions drawn from tests must consider the following:
   a. extremely dry, cloddy conditions
   b. frozen, ropey vines
   c. immature skins on potato tubers

   Damage indices will reflect the above and are misleading when compared to tests conducted in other normal years.
2. We will investigate the stripper roll hanger bearing mounting. Subsequent models have been improved.
3. In the adverse test conditions expressed above, an additional roller is often added to the idle end of the cross conveyor to prevent "vine rolling" and buildup. The stripper bar corner can be trimmed to reduce catching.
4. A separate slipclutch for the deviner will be evaluated and can be added. Subsequent models have slipclutches.
5. Additional frame strength will be considered. Generally, this has not been reported except in extremely hard soils or stony conditions.
6. Tractor hydraulics, as mentioned in the text, are most commonly used to raise the hitch.
7. This suggestion will be evaluated. Rubber tie straps are sometimes utilized.
8. Tire capacity has not been reported as a problem on customer's machines.
9. An excellent suggestion; subsequent manuals stress additional maintenance items such as lubrication.
10. This will become an option on subsequent models.
11. Lockwood's digger chain quality is the highest in the industry. Breakage can only be attributed to extreme test conditions especially where frozen vine buildup was incurred.

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

GENERAL DESCRIPTION

The Lockwood Mark 15 (FIGURE 1) is a two row, power take-off driven, pull-type potato windrower with a 1.6 m cutting width. It is designed for use in conjunction with a potato harvester. The windrower is operated ahead of a harvester, placing two rows of dug tubers between the adjacent two rows to be dug by a harvester.

The spade is moved through the soil beneath two rows of potatoes. The mass of soil, tubers, and vines is lifted onto two parallel digger chains where soil separation occurs. Break-up of clods is aided by agitation of the digger chains with both fixed and adjustable shaker sprockets. Tubers are delivered to the adjustable rubber coated cross conveyor, which drops them to the ground between the two adjacent rows. The larger pitch deviner chain separates the vines and trash from the tubers, carrying them out the back of the machine. Tubers attached to the vines are removed with a Stripper roller, located above the cross conveyor.

The windrower may be operated with either a 540 or 1000 rpm tractor power take-off. Dual tractor hydraulic controls provide individual adjustment of the spade depth and the coulter depth.

The test machine was equipped with an optional vine divider. Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Lockwood Mark 15 was operated in the conditions shown in TABLE 1 for 62 hours while windrowing about 70 ha of Netted Gem potatoes[1], yielding from 15 to 28 t/ha. It was evaluated for ease of operation and adjustment, rate of work, quality of work, power requirements, operator safety, and suitability of the operator's manuals.

TABLE 1. Operating Conditions

SOIL TEXTURE	FIELD AREA (ha)	OPERATING HOURS	AVERAGE SOIL MOISTURE CONTENT (%)
Silty Clay Loam	5	12	30
Fine Loamy Sand	65	50	10
TOTAL	70	62	

RESULTS AND DISCUSSION

EASE OF OPERATION AND ADJUSTMENT

Hitching: The hitch weight of 286 kg required that a jack be used to assist in hitching, however it was difficult to find a safe and convenient jacking location on the drawpole. An alternative hitching method was to use the tractor hydraulics and lower the spade onto the ground, thereby raising the drawpole. It is recommended that the manufacturer provide a suitable jacking surface on the drawpole.

Controls: Spade depth and coulter depth were both controlled by the tractor hydraulic system, requiring a tractor with dual hydraulic outlets.

Maneuverability: The Lockwood Mark 15 was easy to maneuver on short headlands, but some backing was often needed to align the windrower with the rows. The drawpole design gave good tire

[1]Harvesting conditions during 1979 were much more extreme than normal. Due to very dry conditions during the test period, severe clodding occurred, especially in the silty clay loam soils. Due to early frost, the frozen vines remained green and tough. In addition, the skin set on the tubers was not mature. These conditions resulted in more clod handling problems and greater tuber damage than should be expected in a normal year.

clearance on short turns. The optional power steering attachment, which was not evaluated, would be useful on short headlands.

Operator Visibility: Visibility of all working areas was very good. Monitoring of the coulters, vine divider, spade, digger chains and tuber discharge was easy. Observation of the trash flow out the back was adequate for determining carry-over losses. Visibility of the deviner Chain was restricted, especially in heavy, green vines.

The spade depth indicator on the front of the windrower, was adequate but was difficult to monitor, since it lacked markings and was poorly contrasted against the windrower background color.

Cleaning: Periodic cleaning of trash from catch points was important especially in grass infested fields. Accessibility for cleaning was good, except for trash removal from the central, upper digger chain idlers (FIGURE 2). Cleaning these idlers was difficult. Permitting trash to accumulate on the idlers caused the return side of the digger chain to raise and jam on a cross member, breaking the chain (see Mechanical History).

Night Operation: No lighting system was provided for night operation, however, standard tractor lighting was adequate.

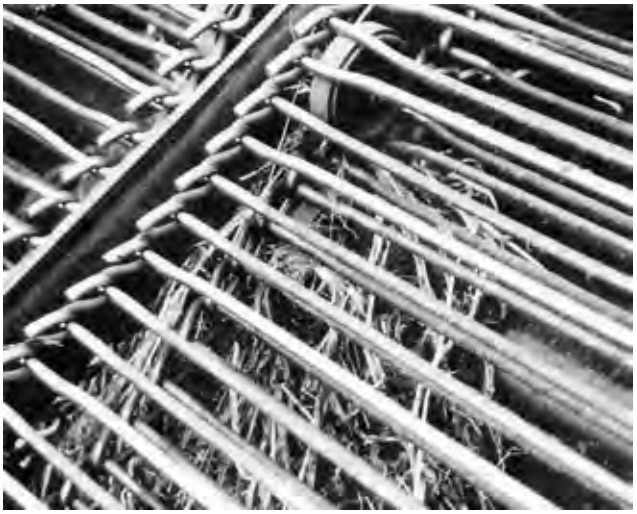

FIGURE 2. Accumulation on Central Upper Digger Chain Idlers.

Lubrication: The Lockwood Mark 15 had four roller chains and 14 pressure grease fittings that required periodic lubrication. Daily lubrication time was minimal. Access to most lubrication points was good, however several small shields had to be removed for drive lubrication. A lubrication schedule was not provided. It is recommended that the manufacturer supply an appropriate lubrication schedule.

Transport: The Lockwood Mark 15 towed well at speeds up to 20 km/h, on smooth gravel and paved roads. Operator visibility to the rear was good. A slow moving vehicle sign was provided for road transport.

Coulter's Spade and Vine Divider: Provision for control of the coulter working depth, independent from the spade, was an excellent feature. Adjusting coulter position with respect to the dividing boards, and adjusting the coulter spring force, were both simple and convenient. Similarly, spade angle and maximum digging depth were easy to adjust. Sideways adjustment of vine divider position was inconvenient.

Conveyors: All conveyor speeds depended on the tractor power take-off speed, which permitted easy adjustment for changing conditions. The digger chains had to operate above a minimum speed to prevent tuber carry-over and loss at the discharge end of the digger chains. If digger chain speed was too slow, tubers could lodge between chain links and be carried around the discharge end, dropping on the ground beneath the windrower. Cross conveyor slope and tuber drop height were relatively easy to adjust.

Stripper Roller: Although the stripper roller height was relatively easy to adjust, the stripper roller bearing supports and adjusting mechanism were not sufficiently rigid to permit full use of the adjusting range. If the stripper roller was set too high, the constant jarring caused by passing vine clumps, loosened and deformed the bearing mounts during operation. In addition, one support strap eventually broke. It is recommended that the manufacturer provide a better method of securing the hanger bearings to prevent them from loosening during operation, and modify the method of stripper roller adjustment to reduce durability problems.

RATE OF WORK

Workrates were influenced both by crop yield and deviner chain separating ability. A compromise had to be maintained between forward speed and tuber carryover on the deviner chain. Suitable forward speeds usually ranged from 4 to 8 km/h, resulting in workrates from 0.6 to 1.2 ha/h. In fields yielding 15 t/ha, average throughputs were about 10 t/h. The ability of the digger chain to separate the soil did not reduce workrates in sandy soils, except in heavy weed conditions.

QUALITY OF WORK

Spade and Coulters: The spade penetrated well in all soil conditions and maintained a uniform depth as long as spade angle was properly adjusted. The spade scoured well in all conditions.

The cutting coulters did an excellent job of cutting the vines, leaving a clean path for the dividing board. No plugging problems occurred in any conditions except in very tough vines. In tough vines, occasional hairpinning on the dividing board edge caused some plugging. The springs provided adequate downward pressure to cut vines and penetrate adequately. The coulters helped to prevent the soil from being pushed outward by the spade. In situations where soil tended to push out past the coulters, the round, formed rod on the dividing board edge caught the trash and directed it back towards the spade bed opening.

Soil Separation: The full length digger chains did a good job of removing loose soil from the tubers before dropping them on the cross conveyor. The separating ability of the digger chains was reduced in heavy weeds, particularly couch grass. Due to dry soil conditions during the test, soil build-up on the chain links was no problem.

Devining: Performance of the large pitch (152 mm) deviner chain was good in removing vines and long stemmed weeds. The short overall length of the deviner, however, resulted in poor tuber separation from the vines, even with a properly adjusted stripper roller. This tuber separation problem was compounded in tough, green and frozen vines.

The short separation length of the deviner chain caused the formation of a bunchy vine cushion on the deviner which trapped and carried over a significant number of tubers. In ideal conditions, carry-over losses were usually less than 3%, while in tough vines, carry-over losses were more than 8%. It is recommended that the manufacturer consider lengthening the deviner to improve operating performance and reduce carry-over losses.

Clod Separation: Clod removal was good in fire sandy loam soil. The action of the digger chain broke down the friable clods to a size which fell through the chain.

Clod removal was poor in dry, silty clay loam soil. This was largely due to extremely dry soil conditions during the test period, resulting in an inordinate quantity of clods. Digger chain action and shaker agitation were not sufficient to break up the hard irregular clods.

Vine Dividers: Performance of the double disk vine divider attachment was fair. The disks had to operate deep in the soil to properly separate and spread the vines. A furrow resulted into which tubers collected when dumped from the cross conveyor. The potato harvester did not always operate deep enough to collect all the tubers in the furrow, resulting in high field losses.

Depth of the vine divider attachment was dependent on the cutting coulter depth. Its performance suffered because of the required performance of the cutting coulters to handle changing field conditions. It is recommended that the manufacturer consider modifications permitting the vine divider'depth to be adjusted independently of cutting coulter depth.

Tuber Damage:[2] Approximately 18% of the tubers harvested with the Lockwood Mark 15 sustained sufficient damage to be considered unmarketable. Typical samples of windrowed tubers showed 46% undamaged, 36% slightly skinned, 3% moderately bruised and 15% severely bruised.

[2] *PAMI T7719-R79, Detailed Test Procedures for Potato Harvesters.*

The latter two categories were unmarketable and would probably spoil in storage. The parameters used to determine damage were bruising, (including black spot) and shatter bruise.

To reduce tuber damage to a minimum it was important to have the digger chains well loaded with soil to act as a cushion to the tubers.

POWER REQUIREMENTS

Tractor Size: Average power take-off input varied from 8 to 10 kW. Average draft requirements ranged from 6 kW at 2 km/h to 18 kW at 3 km/h. A tractor with a minimum 55 kW power take-off rating should have am pie power reserve to operate the Lockwood Mark 15 in most conditions.

OPERATOR SAFETY

All drives were well shielded. All exposed areas of the conveyor chains not close to normal worker activity had bumper guards. Adjustments, servicing, and lubrication were safe to perform with the power take-off disengaged.

When cleaning out vines or making adjustments to the stripper roller, care had to be taken to avoid being pinched between the roller frame and the inside of the windrower frame.

Hazardous areas were clearly marked by color contrast warning decals. A slow moving vehicle sign was supplied. When transporting, the deviner chain should be checked to see that residual trash is not obscuring the sign.

OPERATOR'S AND PARTS MANUAL

Both the operator's manual and parts book were good. They contained suitable information for satisfactory windrower operation. The manuals did not provide information on the current design of the cutting coulter and the vine divider. The parts book lacked detail on the cross conveyor, dividing boards and spade. A lubrication schedule was not included.

DURABILITY RESULTS

TABLE 2 outlines the mechanical history of the Lockwood Mark 15 during 62 hours of operation while windrowing about 70 ha. The intent of the test was evaluation of functional performance. The following failures represent those which occurred during functional testing. An extended durability evaluation was not conducted.

TABLE 2. Mechanical History

ITEM	OPERATING HOURS	EQUIVALENT FIELD AREA (ha)
The right cast deviner chain drive sprocket broke and was replaced at	2, 12	2, 13
The deviner roller chain drive sprocket loosened. The keystock and set-screws were replaced at	46	52
Frame members twisted at the spade mouth due to the action of the cutting coulters and were modified at	53	58
The cross conveyor drive chain jumped off its sprockets and was repaired	many times during the test	
Primary digger chain links broke and were replaced	many times during the test	
The stripper roller hanger bearing points loosened and were tightened	many times during the test	
The right stripper roller support strap broke and was replaced at	end of test	

DISCUSSION OF MECHANICAL PROBLEMS

Machine Frame: The front left frame member (FIGURE 3) twisted during operation because it was not sufficiently stiff to overcome the soil reaction force on the coulter. Twisting caused the coulter blade angle to change. It is recommended that the manufacturer consider modifications to overcome this problem.

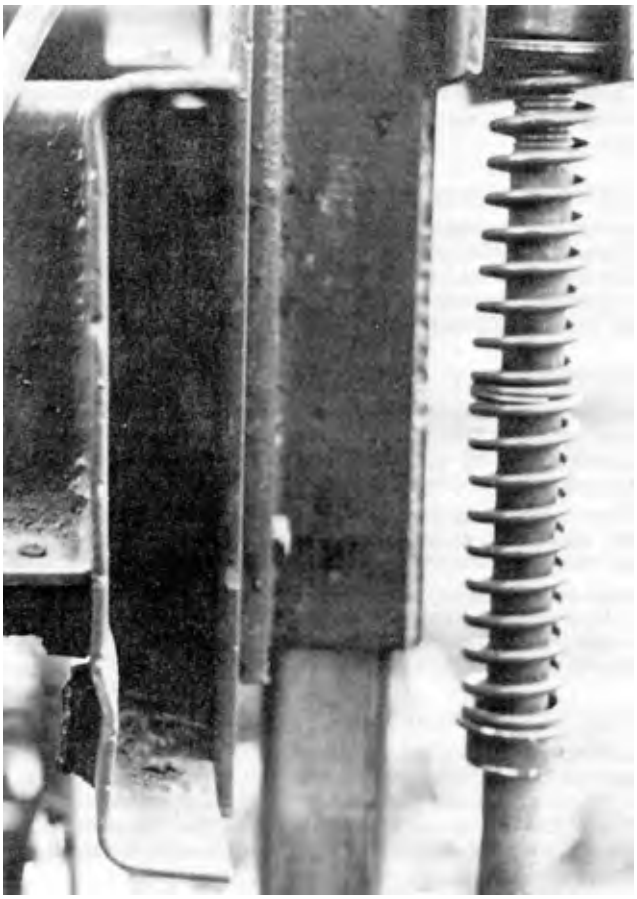

FIGURE 3. Twisting of left, front Frame Member.

Digger Chains: Digger chain links broke or bent frequently due to contact with the two flat iron cross members at the drive end of the conveyor (FIGURE 4). This problem was caused by a trash

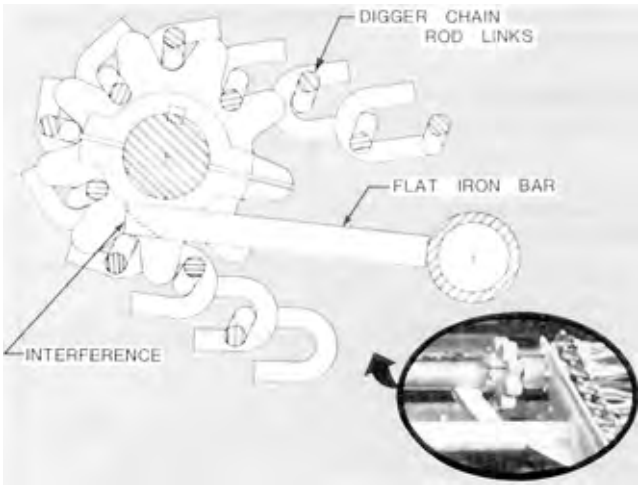

FIGURE 4. Digger Chain Interference.

build-up on the rear conveyor idler (FIGURE 2), raising the return side of the conveyor chain. This reduced the clearance until a link caught on the bars and the chain was forced apart. It is recommended that the manufacturer consider modifications to reduce this problem.

Deviner: The cast iron sprockets on the deviner drive (FIGURE 5) broke twice despite a properly adjusted slip clutch. One failure was caused by large vine clumps, carried between the stripper roller and deviner chain, forcing the deviner chain below the cone rollers at the sides.

The second failure was caused by a link being caught in a groove worn in the lower stripper bar. It is recommended that the manufacturer consider placing a separate slip clutch on the de-

FIGURE 5. Deviner Chain Cast Iron Drive Sprocket.

FIGURE 6. Failure of Support Strap on Stripper Roller: (A) Adjustment Bolt, (B) Support Strap, (C) Hanger Bearing.

viner drive shaft, since the existing one also protects the digger chain.

Stripper Roller: The carriage bolts securing the stripper roller hanger bearings would not remain tight. Continuous jarring of the roller due to vine clumps caused the bolts to loosen, and caused the right support strap to break (FIGURE 6).

APPENDIX I

SPECIFICATIONS

Make:	Lockwood
Model:	Mark 15 L06130 - 00215
Serial Number:	G2777A
Coulters:	
-- type	notched blade
-- diameter	610 mm
-- depth control	hydraulic
Digger Spade:	
-- type	contour clod blade
-- width	794 mm
-- depth control	hydraulic
Digger Chains:	
-- type	offset links, alternate up & down
-- number of links	125
-- length	2550 mm
-- bar size	13 mm
-- pitch	45 mm
Deviner Chain:	
-- type	air cushion rubber coating
-- number of links	34
-- length	1920 mm
-- bar size	16 mm
-- pitch	152
Delivery Boom Conveyor Chain:	
-- type	Feather edge rubber coating
-- number of links	139
-- length	2820 mm
-- bar size	11 mm
-- pitch	45 mm
Stripper Roller:	
-- length	1480 mm
-- diameter	168 mm
Belt Drives:	1
Chain Drives:	4
Gear Boxes:	1
Sealed Bearings:	15
Pressure Grease Fittings:	14
Clutches:	
-- slip clutches	2
-- torque limiters	0
Tires:	two, 7.50 x 24, 4-ply
Overall Dimensions:	
-- wheel tread	1816 mm
-- length	6096 mm
-- width	3098 mm
-- height	1664 mm
-- ground clearance	189 mm
Weight: (unloaded)	
-- right wheel	1394 kg
-- left wheel	912 kg
-- hitch	286 kg
TOTAL	2592 kg

Optional Equipment:
- -- vine divider
- -- steerable axle
- -- digger chain
- -- rear cross chain
- -- double disk coulter assembly
- -- spades

APPENDIX II

MACHINE RATINGS

The following rating scale is used in PAMt Evaluation Reports:

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

APPENDIX tit

CONVERSION TABLE

1 kilometer/hour (km/h)	= 0.6 mile/hour (mph)
1 metre (m)	= 3.3 feet (ft)
1 millimetre	= 0.04 inches (in)
1 kilogram (kg)	= 2.2 pounds mass (lb)
1 kilopascal (kPa)	= 0.15 pounds per square inch (psi)

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