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Evaluation Report 55

Western Roto Thresh Self-Propelled Combine

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

WESTERN ROTO THRESH SELF-PROPELLED COMBINE

MANUFACTURER AND DISTRIBUTOR:
Western Roto Thresh Ltd.
1840 Ontario Ave. N.
Saskatoon, Saskatchewan
S7K 1T4

RETAIL PRICE:
$51,900.00, July, 1978, f.o.b. Humboldt, with 4120 mm (13.5 ft) table, 3200 mm (126 in) Melroe pickup, straw chopper, drum filler plates, shaft monitor, cab light, rear view mirrors and spare parts kit.

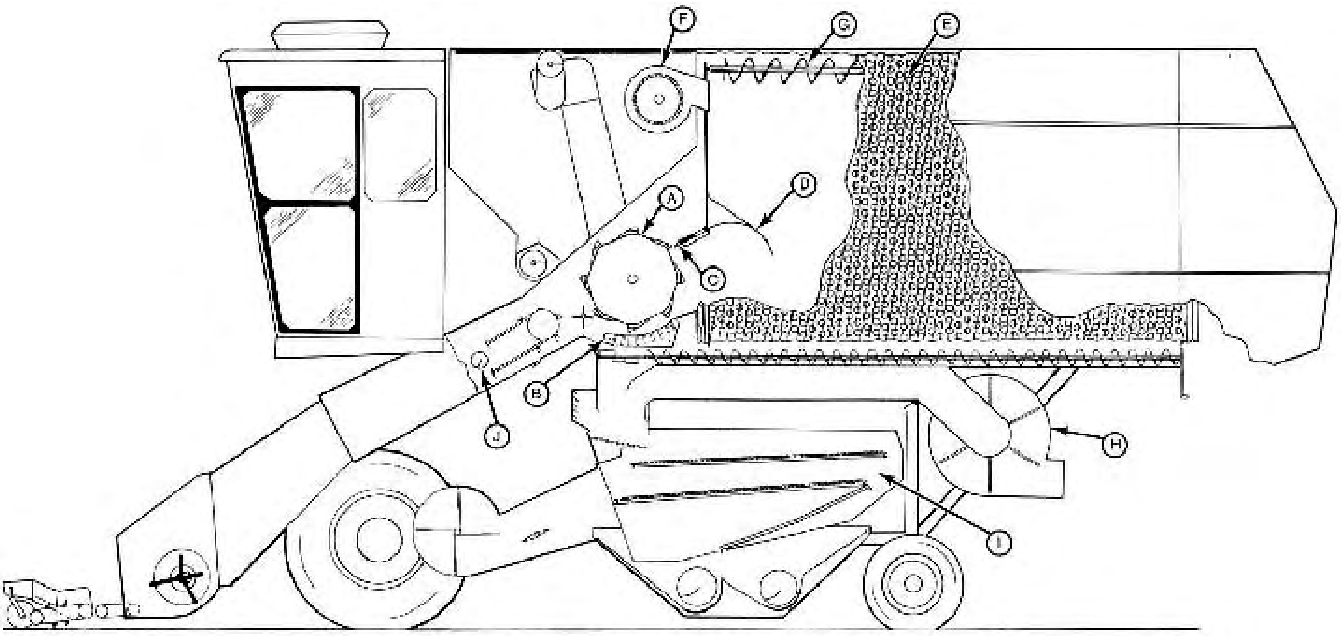

FIGURE 1. Western Roto Thresh: (A) Cylinder (B) Concave (C) Stripper Bar (D) Deflector (E) Separating Drum (F) Separating Drum Fan (G) Stripper Auger (H) Aspirator (I) Shoe (J) Tailings Return.

SUMMARY AND CONCLUSIONS

Functional performance of the Western Roto Thresh self-propelled combine, was good in dry grain and oil seed crops. Functional performance was fair in tough and damp crops.

The MOG Feedrate[1] at 3% total grain loss varied from 11.1 t/hr (408 lb/min) in 3.58 t/ha (53 bu/ac) Neepawa wheat to 7.6 t/hr (279 lb/min) in 2.87 t/ha (53 bu/ac) Betzes barley. The capacity of the Western Roto Thresh was similar to the capacity of the PAMI reference combine for a similar total grain loss. Grain loss from the separating drum limited capacity in most crops. A reduction in grain loss over the separating drum would have permitted higher combining rates. Cylinder loss was usually small and aspirator and shoe losses were insignificant in comparison to the separating drum loss. The aspirator removed from 70 to 90% of the chaff before the shoe, resulting in increased shoe efficiency and reduced grain loss on side slopes.

The engine had ample power for all conditions. Fuel consumption varied from 27 to 32 L/h (6 to 7 gal/h). The rotary radiator air intake screen performed well, preventing radiator plugging even under adverse conditions. The engine started well. At temperatures below +5°C, ether was needed to start the cold engine.

The steering system was excellent for field operation. It was possible to pick most sharp corners formed by self-propelled windrowers. Most controls and instruments were conveniently positioned. All controls were responsive. The cab was adequately pressurized and relatively dust free. The evaporative air conditioning system performed well but needed routine maintenance. Sound level at the operator station was about 94 db(A).

Header visibility was very good both in the daytime and at night. Grain tank visibility was good. Rear visibility was restricted. The rear view mirrors were needed for road travel. Road transport required caution since the short wheelbase created a choppy ride. The maximum road transport speed of 22 km/h (14 mph) was adequate.

The unloading auger was slow, taking over three minutes to unload the 4.6 m^3 (127 bu) grain tank.

The Western Roto Thresh was quite easy to adjust for specific field conditions. Adjustment would have been easier if return tailings could have been inspected. The optional shaft speed monitoring system was helpful by warning the operator of malfunction. Ease of servicing was good.

The cylinder, table auger, and feeder all were positive and aggressive. Plugging was infrequent, even in damp crops. Unplugging the cylinder was inconvenient since access was through the bottom of the grain tank. Unplugging of the separating drum and drum fan also was inconvenient.

The stone trap stopped most stones before they entered the cylinder and was fairly easy to clean.

The Melroe pickup had excellent feeding characteristics, delivering the crop beneath the table auger.

No serious safety hazards were noticed when operated according to the manufacturer's recommended procedures. Access to the cab was hazardous, especially for older operators. The operator's manuals provided adequate information, including a list of standard replacement bearing and drive components.

Durability problems occurred with the crankshaft extension coupling, the cylinder drive and the shoe hangers.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing extensions for some inaccessible grease fittings.
2. Providing a rocking hub on the table auger drive to facilitate unplugging.
3. Providing a safety latch to hold the cab door open, to facilitate safer mounting and dismounting.

[1]MOG Feedrate (Material-Other-than-Grain Feedrate) is the Weight of straw and chaff passing through a combine per unit time.

4. Supplying a header lift safety lock and warning decals for the straw chopper.
5. Providing more convenient access to the separating drum fan to facilitate unplugging, or modifying the fan to eliminate plugging.
6. Eliminating fuel tank contamination during assembly or factory storage.
7. Modifications to increase the grain tank unloading rate.
8. Modifications to the shoe to eliminate spearing.
9. Modifications to the shoe hanger assembly to eliminate bushing loosening.
10. Modifications to the crankshaft extension coupling to eliminate drive line failure.
11. Modifications to eliminate cylinder bar retaining bolt failure.
12. Modifications to the straw chopper to improve ease of installation and to eliminate drive belt slippage and plugging.
13. Revising the operator's manual to improve clarity.

Chief Engineer - E. O. Nyborg
Senior Engineer - L. G. Smith
Project Engineer -P. D. Wrubleski

THE MANUFACTURER STATES THAT:

With regard to recommendation number:

1. Extensions for the left cylinder bearing and right top feeder bearing have been provided on 1978 model combines.
2. A rocking hub is being considered.
3. We will study this.
4. A safety lock is available as a factory option, decals are being supplied on all 1978 model combines.
5. An easily removable access door is provided in the drum fan housing.
6. Improved quality control measures have been instituted.
7. We are currently working to increase the unloading rate.
8. Modifications to eliminate spearing in the shoe are being considered.
9. This problem was caused by the installation of incorrect rubber bushings. All combines in service have been checked and corrected.
10. The assembly procedure for this coupling has been revised to correct the problem.
11. The design of the retainer bars has been modified.
12. Heavy duty drives have been installed. A modification kit to reduce chopper plugging is available.
13. Revisions to the operator's manual will be included in future printings.

GENERAL DESCRIPTION

The Western Roto Thresh is a self-propelled combine with a conventional transverse-mounted tangential threshing cylinder and longitudinally mounted axial separating drum. Threshing and initial separation occur at the cylinder and concave while final separation of grain from straw is accomplished with the separating drum. Two aspirator fans remove chaff from the front of the cleaning shoe. Return tailings are delivered ahead of the cylinder.

The test machine was equipped with a 118 kW (158 hp) eight cylinder Caterpillar diesel engine, a 4120 mm (13.5 ft) header, a 3200 mm (126 in) Melroe 351 pickup and the optional accessories listed on PAGE 2.

The traction drive is totally hydrostatic. The Western Roto Thresh is equipped with power steering and a pressurized operator's cab. A spare parts kit is included.

The separator drive is controlled through an over centre belt tightener while the header drive is controlled with an electro-magnetic clutch. The grain tank unloading auger is hydraulically engaged and powered.

Header height and unloading auger swing are hydraulically controlled while pickup speed is varied electrically. Concave clearance may be adjusted on-the-go from the operator's platform while cylinder speed may be varied by changing sprockets. Fan blast is regulated with crank operated fan doors and directed with an adjustable windboard. The chaffer and sieve are adjusted with push-pull rods while the aspirator suction is controlled by varying a door opening. There is no provision to safely and quickly sample the return tailings.

Detailed specifications are given in APPENDIX 1.

SCOPE OF TEST

The Western Roto Thresh was operated in a variety of Saskatchewan crops (TABLES 1 and 2) for 51 hours while harvesting about 90 ha (222 ac). It was evaluated for ease of operation, ease of adjustment, rate of work, grain loss characteristics, operator safety and suitability of the operator's manual. Throughout the test, comparisons were made to the PAMI reference combine.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield		Swath Width		Hours	Field Area	
		t/ha	bu/ac	m	ft		ha	ac
Wheat	Glenlea	3.0	45	5.5	18	7	11	27
Wheat	Neepawa	2.8	42	5.5-6.1	18-20	12	22	54
Barley	Betzes	3.5	65	5.5	18	7	12	30
Barley	Bonanza	3.3	62	5.5-7.3	18-24	11	20	49
Barley	Fergus	2.9	54	5.5	18	3	5	12
Barley	Klondike	2.2	40	7.3	24	4	8	20
Rapeseed	Tower	2.0	35	4.9-5.5	16-18	7	12	30
Total						51	90	222

TABLE 2. Operation in Stony Fields

Field Conditions	Hours	Field Area	
		ha	ac
Stone Free	29	49	212
Occasional Stones	22	41	101
Total	51	90	222

RESULTS AND DISCUSSION

EASE OF OPERATION

Operator Location: The Western Roto Thresh was equipped with an operator's cab as standard equipment. The cab was positioned ahead of the grain tank to the left of the engine, giving good visibility to the left, front and right. Visibility to the rear was completely obstructed necessitating caution when maneuvering in confined areas. The rear view mirrors improved rear visibility for road transport. Header visibility was very good both in the daytime and at night. The grain level could be viewed through a small window but grain and return tailings could not be sampled from the operator's seat.

The operator's seat was comfortable and easy to adjust. The steering column was readily adjustable, but the range of wheel positions was not suitable for all operators. The cab was not high enough to permit standing operation, however seat position and control location made standing unnecessary.

The cab was relatively dust free when the cab pressurization fans were used. Access to the filter was inconvenient. The evaporative cooling system maintained an acceptable cab temperature in hot weather, but had to be filled with water regularly.

The total noise at operator ear level was about 94 db(A) with all doors and windows closed. It is advised that the operator wear suitable ear protection especially on long working days.

Access to the cab was hazardous, as the right railing was attached to the door, which swung freely. It is recommended that a safety latch be installed to hold the door firmly in open position, thereby providing a rigid railing for mounting and dismounting.

Controls: The control arrangement is shown in FIGURE 2. Most controls were conveniently placed, easy to use, and responsive. The hydrostatic traction drive, the electrically controlled pickup drive, and the responsive header lift gave the operator good control. The engine speed control was inconvenient to use. The separator drive was very difficult to engage due to location and the arc of the control lever travel.

Steering: Steering and maneuverability were excellent, though the short wheelbase produced a choppy ride at road speeds. The power steering was responsive. The turning radius was about 5490 mm (18 ft). Although the Western Roto Thresh was not equipped with wheel brakes, it was possible to pick most corners formed by self-propelled windrowers. The hydrostatic drive also made it easy to turn corners, by stopping and backing up, since no clutching or gear shifting was needed.

Instruments: The instrument console (FIGURE 3) included gauges for engine oil pressure, coolant temperature, battery charging, hydraulic oil temperature, hydrostatic oil temperature, engine speed, fuel level and engine hours.

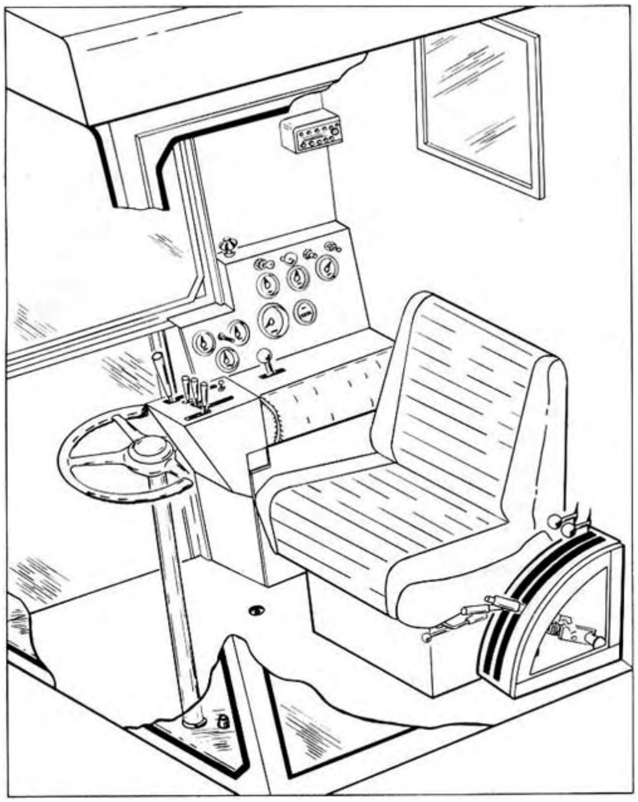

FIGURE 2. Control Layout.

FIGURE 3. Instrument Console.

The shaft speed monitors were very useful in detecting component stoppage. They monitored the tailings elevator, clean grain elevator, cleaning fan, stripper auger, straw chopper and grain bin level.

Lights: The Western Roto Thresh was equipped with four front lights, a grain tank light and an unloading auger light. Header lighting, long range front lighting, lighting for the grain tank and lighting for the unloading auger all were adequate.

Engine: The engine had ample power, even when using the straw chopper in soft hilly fields. Average fuel consumption varied from 27 to 32 L/hr (6 to 7 gal/hr). The engine was fairly accessible.

The rotary radiator air inlet screen was very effective in preventing radiator plugging. The oil cooler swung away from the face of the radiator, simplifying maintenance.

The engine air intake used a centrifugal bowl precleaner and a dry filter. The dry filter element required infrequent servicing if the precleaner bowl was emptied before it completely filled.

The engine started easily. If ambient temperature dropped below +5°C, ether was needed to start the cold engine. As the engine was not equipped with an automatic ether starting aid, ether had to be hand fed through the engine air intake.

Throughout the test, problems were experienced with blockage in the primary fuel filter. The problem was traced to contamination in the fuel tank, which had been present on delivery. Flushing the tank several times did not completely correct the problem. It is recommended that the manufacturer institute measures to prevent fuel tank contamination during assembly or factory storage.

Engine oil consumption was insignificant.

Stability: The Western Roto Thresh was very stable, even with a full grain tank. The centre of gravity with a three-quarters full grain tank was about 1930 mm (76 in) above ground, 990 mm (39 in) behind the drive wheels and on the combine centre line. Normal care had to be used when turning corners on hillsides.

Grain Tank: The grain tank held 4.6 m^3 (127 bu) of wheat. The grain tank filled evenly in all crops. Unloading a full hopper of dry wheat took 185 seconds. It is recommended that the manufacturer consider increasing the grain tank unloading rate.

The unloading auger had adequate clearance and reach for unloading on-the-go. The hydraulically controlled unloading auger tube was easily positioned.

Straw Chopper: The optional straw chopper attachment performed satisfactorily in grain crops after drive modifications. Length of cut could be adjusted by varying the clearance between the rotor hammers and the concave. Although the straw deflectors were adjustable to control spreading width, maximum width varied from 4.6 to 6.1 m (15 to 20 ft), depending on the straw and wind conditions.

The straw chopper initially caused drive belt slippage between the main jackshaft and the aspirator fan drives resulting in a reduction of straw chopper, separating drum, stripper auger, grain delivery auger and aspirator fan speeds. An additional drive belt was added between the main jackshaft and the aspirator fan drives to correct this problem. It recommended that the manufacturer supply this modification if the combine is equipped with a straw chopper.

In rapeseed, plugging occurred since the straw fed to the rear of the straw chopper rotor and had to be redirected to the front of the rotor against the flow. This resulted in bridging above the rotor, and plugging of the separating drum. It is recommended that the straw chopper be relocated to eliminate this problem.

Removal and installation of the straw chopper was a very difficult three-man job and took about 20 minutes. It is recommended that the ease of installation be improved.

Plugging: The table auger was quite aggressive in dry grain crops and plugging was infrequent when operating at normal feedrates. In heavy, bunchy rapeseed and damp grain crops, choking and plugging of the table auger occurred more frequently. Unplugging was difficult because of shielding by the pickup windguard. It is recommended that the manufacturer provide a rocking hub on the table auger drive to facilitate unplugging.

The two stage feeder conveyor (FIGURE 4) had high capacity in all crops and plugged only once during the test on a very large wad of damp straw. Since only the first stage plugged, unplugging was accomplished by rotating the feeder backward and removing the wad from the entrance. If severe plugging of the second stage should occur, unplugging could be accomplished by removing a door in the bottom of the housing.

The cylinder was very aggressive and plugging seldom occurred. If the cylinder plugged, it could usually be unplugged from the operator's seat by lowering the concave. Cylinder access was through a door in the bottom of the grain tank and was convenient once the grain tank had been emptied. It was very important to keep the stripper bar in correct adjustment to prevent backfeeding as the combine was not equipped with a back beater. With the stripper bar in correct adjustment no back feeding problems occurred until the separating drum became overloaded or plugged.

As with most combines, dust and chaff collected inside the cylinder rasp bars, causing cylinder imbalance. The inside of the rasp bars occasionally had to be cleaned to prevent cylinder vibration.

Plugging of the separating drum fan occurred occasionally in barley. This restricted airflow resulted in plugging of the separating drum. It is recommended that the manufacturer provide more convenient access to the separating drum fan to facilitate unplugging or modify the fan to eliminate plugging.

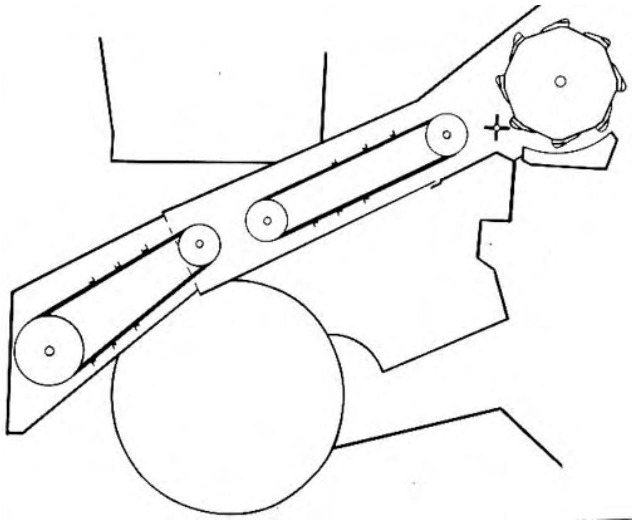

FIGURE 4. Two Stage Feeder Conveyor.

The separating drum occasionally had to be cleaned to remove straw, which had speared through the grate holes. In one field of tough Betzes barley the stripper auger wound with straw and plugged. No plugging occurred in dry crops. Since entering the separating drum was difficult with the straw chopper in place, it is recommended that the manufacturer provide alternate access to the separating drum or improve the ease of installation of the straw chopper.

Spearing of straw in the shoe occurred in Neepawa wheat and Bonanza barley. It is recommended that the manufacturer consider modifications to the shoe to eliminate spearing.

Stone Trap: The Western Roto Thresh was equipped with a stone trap (FIGURE 5) in front of the cylinder. The stone trap was quite effective, capturing most roots or stones before they entered the cylinder, and was emptied onto the front of the shoe.

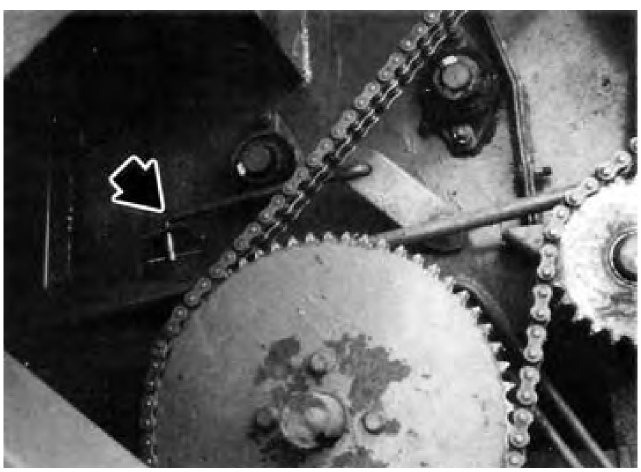

FIGURE 5. Stone Trap Release.

Pickup: The Western Roto Thresh was equipped with a 3200 mm (126 in) Melroe 351 pickup. The pickup had excellent feeding characteristics delivering the crop beneath the table auger in all conditions. In bunchy Tower rapeseed, the wind guard had to be removed to prevent plugging between the wind guard and pickup draper. Pickup speed, which could be varied electrically from the operator's seat, was adequate for all crops.

Machine Cleaning: As with most combines, completely cleaning the Western Roto Thresh for combining seed grain was laborious and time consuming. Cleaning of the delivery augers beneath the separating drum was very difficult. The chaffer and sieve were difficult to remove and even after removal, cleaning of the tailings auger trough was very difficult. The grain tank was fairly easy to clean if the discharge auger covers were raised to their maximum height. Entering and working in the grain tank was hazardous.

Lubrication: The Western Roto Thresh had 27 pressure grease fittings. Eight needed greasing every 10 hours while nineteen needed greasing every 50 hours. Lubrication of the crank shaft extension shaft bearings and other fittings located above shoulder height required caution as there was no suitable place to stand. It is recommended that extensions be provided for the left cylinder bearing and the right top feeder bearing as both fittings are obstructed by drive sprockets.

Engine and hydraulic oil levels required daily checking. The engine oil filters, located on the front of the engine, were easy to change. The hydraulic and hydrostatic systems used a common reservoir.

EASE OF ADJUSTMENT

Field Adjustments: The Western Roto Thresh was easy to adjust, and could usually be set by one person. Since return tailings could not be inspected, the operator did not have a complete feel of the effect of settings on performance.

Concave Adjustment: The Western Roto Thresh had a single segment concave. The concave has to be initially levelled and adjusted with four turnbuckles. Front and rear concave clearances may be gauged through side inspection holes. Suitable initial concave settings, with the operator station control lever in the first notch, were 6 mm (0.24 in) at the leading bar and 2 mm (0.1 in) at the trailing bar.

Once the concave had been initially set, clearance could be adjusted with a lever in the operator's cab. The control linkage was designed so that the leading concave bar opened faster than the trailing bar. Leading bar clearances could be varied from 6 to 40 mm (0.24 to 1.6 in) while trailing bar clearances could be varied from 2 to 10 mm (0.1 to 0.4 in).

Suitable concave control lever quadrant settings were at notches 4 and 5 in wheat, 5 and 6 in barley and from 9 to 12 in rapeseed. Concave filler bars were not needed in any crop.

Cylinder Adjustment: Cylinder speed could be varied by changing the cylinder and beater sprockets (FIGURE 6). Each sprocket was attached to its hub with four set screws. With the standard sprockets, fourteen speeds ranging from 400 to 1200 rpm were available.

Suitable cylinder speeds were 966 and 1062 rpm in wheat, 876 rpm in barley, 613 rpm in dry rapeseed and 876 rpm in tough rapeseed. Grain crackage varied from 0.5 to 2% in Betzes and Bonanza barley and from 2.5 to 5% in Neepawa wheat (FIGURE 7). In Tower rapeseed, crackage was about 0.5%.

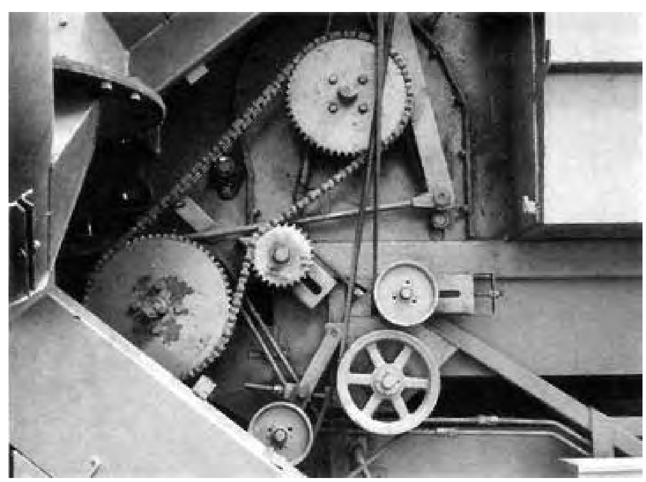

FIGURE 6. Cylinder Speed Adjustments.

Aspirator Adjustment: The aspirator was easy to adjust. Suction was controlled by varying a door in the suction throat opening (FIGURE 8). Best results were obtained with the door fully closed in wheat, from fully closed to 25 mm (1 in) open in barley and from 60 to 100 mm (2.4 to 3.9 in) open in rapeseed.

Aspirator performance was excellent in all crops. Any grain or seed removed by the aspirator was low density. The combine had to be allowed to clean out before shut down to prevent aspirator throat blockage.

Shoe Adjustments: The shoe was convenient to adjust.

Fan blast was varied with adjustable fan doors and directed with a windboard (FIGURE 9) while the chaffer and clean grain sieves were adjusted with push-pull rods. There was no provision to safely and easily inspect return railings.

The shoe was easy to set and performed well in most crops. Spearing occurred in barley and wheat and removal of the straw was time consuming. It is recommended that the manufacturer modify the shoe to eliminate spearing.

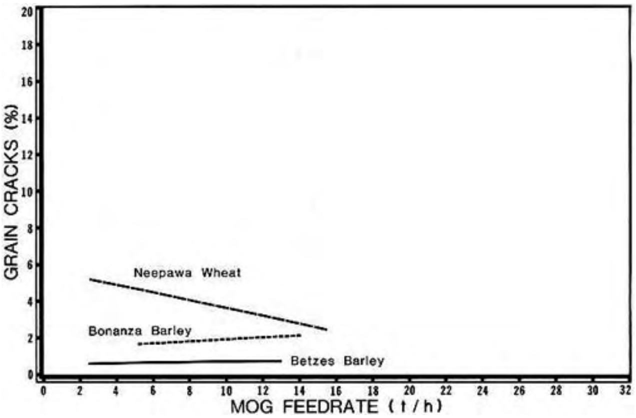

FIGURE 7. Grain Damage in Barley and Wheat.

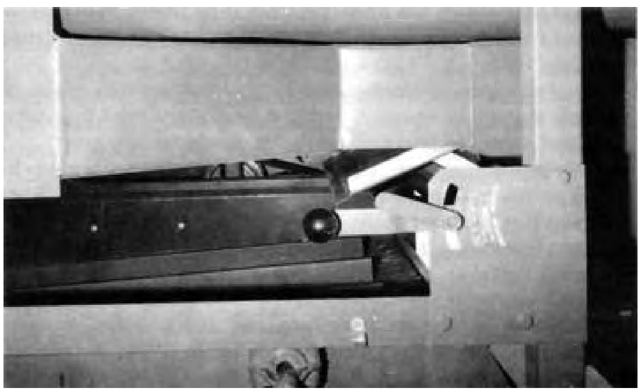

FIGURE 8. Suction Throat Adjustment.

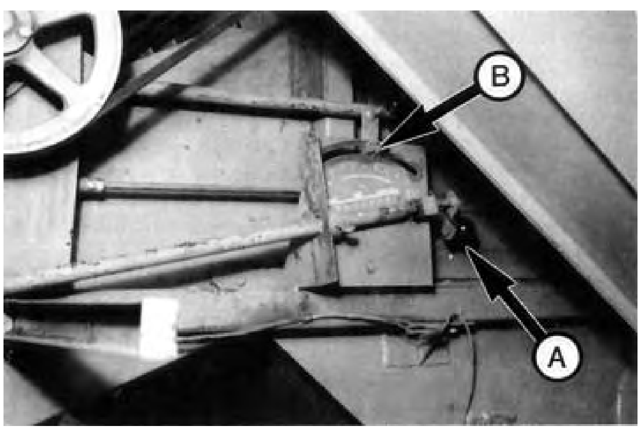

FIGURE 9. Shoe Adjustments (A) Fan (B) Windboard.

Total dockage in the grain tank including cracks, white caps, and chaff usually varied from 0.5 to 2% when properly adjusted. Shoe adjustment was not critical since most chaff was removed with the aspirator. Shoe performance was not signi cantly affected by side slopes of up to 7°, due to chaff removal by the aspirator.

Stripper Bar Adjustments: It was important to keep the cylinder stripper bar in proper adjustment to prevent backfeeding and to provide proper straw discharge into the separating drum. Stripper bar clearance should be set at 1.6 mm (0.06 in) and checked periodically. Adjustment was dif cult due to stripper location.

Header Adjustments: The Western Roto Thresh was evaluated only with a pickup attachment for windrowed crops. Straight combining attachments were not tested. The table could be removed from the feeder by one man in about 10 minutes. The complete header and lower stage feeder assembly could also be removed from the combine, but this was a more dif cult job.

The table auger was easy to adjust both vertically and horizontally. Adjustment was seldom required.

Slip Clutches: Individual slip clutches protected the table auger, feeder conveyor and tailings elevator.

RATE OF WORK

Average Workrates: TABLE 3 presents average workrates for the Western Roto Thresh, at acceptable loss levels, in all crops harvested during the test. Average work rates are affected by crop conditions in a speci c year and should not be used for comparing combines tested in different years. In some crops, workrates were reduced by bunchy and sunken windrows, rough ground, irregular shaped elds and driving the combine empty to unload grain at a central location. During the 1977 harvest, average workrates varied from 6.0 t/h (276 bu/hr) in 3.5 t/ha (65 bu/ac) Betzes barley to 3.4 t/h (150 bu/hr) in 2.0 t/ha (35 bu/ac) Tower rapeseed.

TABLE 3. Average Workrates

		Average Yield		Average Speed		Average Workrate			
Crop	Variety	t/ha	bu/ac	km/h	mph	ha/h	ac/h	t/h	bu/h
Wheat	Glenlea	3.0	45	4.8	3.0	1.6	3.9	4.8	176
Wheat	Neepawa	2.8	42	4.6	2.9	1.8	4.5	5.0	186
Barley	Betzes	3.5	65	4.3	2.7	1.7	4.3	6.0	276
Barley	Bonanza	3.3	62	3.0	1.9	1.8	4.5	5.9	271
Barley	Fergus	2.9	54	4.4	2.8	1.7	4.2	4.9	226
Barley	Klondike	2.2	40	3.4	2.1	2.0	5.0	4.4	202
Rapeseed	Tower	2.0	35	5.7	3.6	1.7	3.4	3.4	150

Maximum Feedrate: The workrates given in TABLE 3 represent average workrates at acceptable loss levels. The engine had ample power to achieve higher workrates in nearly all crops. In most crops, the maximum acceptable feedrate was limited by grain loss and the maximum feedrate was limited by cylinder plugging and backfeeding. In light crops, the maximum feedrate was limited by pickup performance.

Capacity: Combine capacity is the maximum rate at which a combine can harvest a certain crop, at a speci ed total loss level, when adjusted for optimum performance. Many crop variables affect combine capacity. Crop type and variety, grain and straw moisture content, grain and straw yield and local climatic conditions during the growing season all affect the threshing and separating ability of a combine.

MOG Feedrate, MOG/G Ratio and Percent Loss: When determining combine capacity, combine performance and crop conditions must be expressed in a meaningful way. The loss characteristics of a combine in a certain crop depend mainly on two factors, the quantity of straw and chaff being processed and the quantity of grain being processed.

The weight of straw and chaff passing through a combine per unit time is called the MOG Feedrate. MOG is an abbreviation for "Material-Other-than-Grain" and represents the weight of all plant material passing through the combine except for the grain or seed.

The weight of grain or seed passing through a combine per unit time is called the Grain Feedrate. The ratio of MOG Feedrate to Grain Feedrate, which is abbreviated as MOG/G gives an indication of how dif cult a certain crop is to separate. For example, if a certain combine is used in two wheat elds of identical grain yield but one with long straw and one with short straw, the combine will have better separation ability in the short crop and will be able to operate faster. This crop variable is expressed with the MOG/G ratio when determining combine capacity. MOG/G ratios for prairie wheat crops vary from about 0.5 to 2.25.

Grain losses from a combine are of two main types, unthreshed grain still in the head and threshed grain or seed, which is discharged with the straw and chaff. Unthreshed grain is called cylinder loss. Free grain in the straw and chaff is called separator loss and consists of shoe loss and separating drum loss. Losses are expressed as a percent of total grain passing through the combine. Combine capacity is expressed as the maximum MOG Feedrate at which total grain loss (cylinder loss plus separator loss) is 3% of the total grain yield.

Capacity of the Western Roto Thresh: TABLE 4 presents capacity results for the Western Roto Thresh in three different crops. MOG Feedrates for a 3% total grain loss varied from 11.1 t/h (408 lb/min) in a eld of 3.58 t/ha (53 bu/ac) Neepawa wheat to 7.6 t/h (279 lb/min) in a eld of 2.87 t/ha (53 bu/ac) Betzes barley.

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics for the Western Roto Thresh, in the three crops described in TABLE 4, are presented in FIGURES 10 to 12.

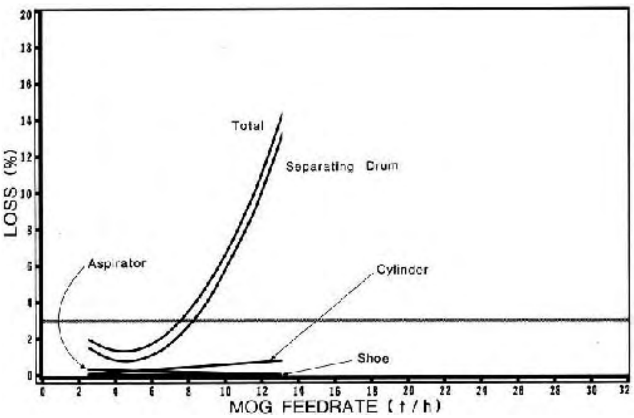

FIGURE 10. Grain Loss in Betzes Barley.

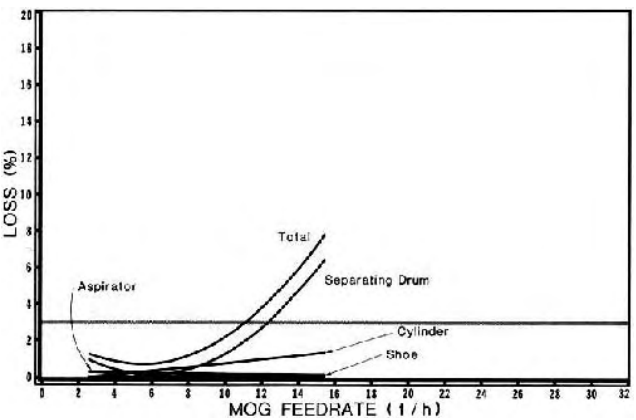

FIGURE 11. Grain Loss in Neepawa Wheat.

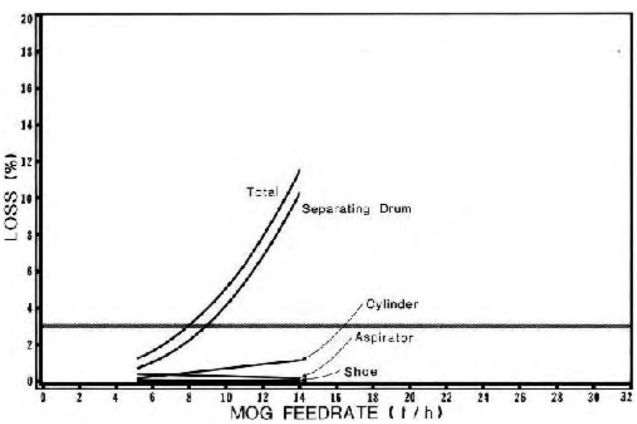

FIGURE 12. Grain Loss in Bonanza Barley.

Separating Drum Loss: Separating drum loss was the most significant factor limiting capacity in all grain crops. The performance was similar to conventional combines, where straw walker loss is usually the most significant factor. A reduction in free grain loss over the separating drum would have enabled much higher combining rates especially in difficult to separate crops such as barley.

Shoe Loss: Shoe loss was low in all crops and never limited combine capacity.

Aspirator Loss: Aspirator loss was negligible in all crops. The aspirator removed from 70 to 90% of the chaff before the shoe (FIGURE 13), resulting in increased shoe efficiency. The aspirator was especially effective in barley and rapeseed.

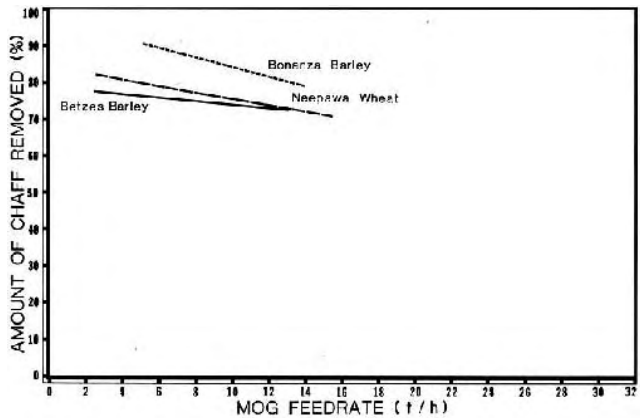

FIGURE 13. Amount of Chaff Removed by the Aspirator.

Cylinder Loss: Cylinder loss was low in most dry and well matured crops. In difficult to thresh crops, cylinder and concave adjustments were important and cylinder loss could make a significant contribution to total loss. In most hard to thresh grains, such as Neepawa wheat, accepting a cylinder loss of 1 to 2% was necessary to avoid higher losses through cracking.

Body Loss: Slight grain leakage occurred from the junction between the first and second stage feeder housings and from the elevator doors, but was insignificant.

Comparison to Reference Combine: Comparing combine capacities is complex because crop and growing conditions influence combine performance with the result that slightly different capacity characteristics can be expected every year. As an aid in determining relative combine capacities, PAMI uses a reference combine. This combine is operated alongside test combines whenever capacity measurements are made. This permits the comparison of loss characteristics of every test combine to those of the reference combine, independent of crop conditions. The reference combine used by PAMI is commonly accepted in the prairie provinces and is described in PAMI evaluation report E0576C. See APPENDIX III for the PAMI reference combine capacity results.

FIGURES 14 to 16 compare the total grain losses of the Western Roto Thresh and the PAMI reference combine in the three crops described in TABLE 4. The shaded areas on the figures are the 95% confidence belts. If the shaded areas overlap, the loss characteristics of the two combines are not significantly different whereas if the shaded areas do not overlap, the losses are significantly different. The capacity of the Western Roto Thresh was similar to the capacity of the reference combine and both usually had similar grain losses when operating at the same feedrate.

OPERATOR SAFETY

The operator's manual contained appropriate safety suggestions.

The Western Roto Thresh was equipped with slow-moving-

TABLE 4. Capacity at a Total Loss of 3% of Yield

Crop Conditions									Capacity Results							
		Width of Cut		Crop Yield		Grain Moist.ure			MOG Feedrate		Grain Feedrate		Ground Speed		
Crop	Variety	m	ft	t/ha	bu/ac	Straw %	Grain %	MOG/G	t/h	lb/min	t/h	bu/h	km/h	mph	Loss Curve
Barley	Betzes	4.9	16	2.87	53	17.4	16.6	0.97	7.6	279	7.85	360	5.6	3.5	Fig. 10 & 14
Wheat	Neepawa	6.1	20	3.58	53	13.6	14.7	0.91	11.1	408	12.20	448	5.6	3.5	Fig 11 & 15
Barley	Bonanza	7.3	24	4.21	78	27.3	13.7	1.06	8.0	294	7.60	350	2.5	1.5	Fig 12 & 16

vehicle sign, warning lights and some warning decals. It is recommended that the manufacturer supply suitable warning decals for the straw chopper.

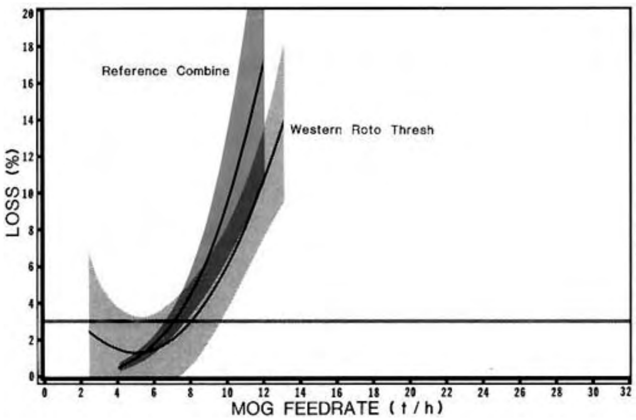

FIGURE 14. Total Grain Losses in Betzes Barley.

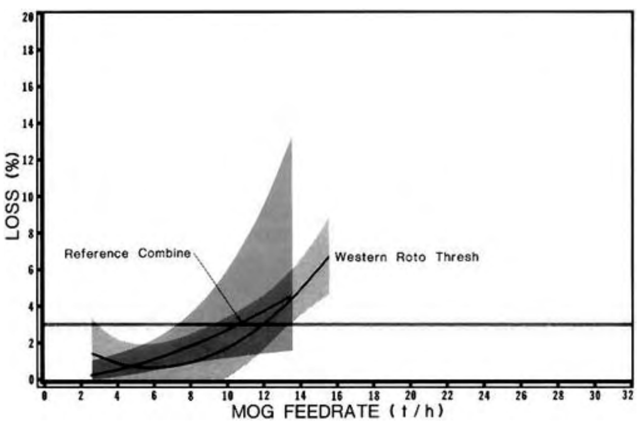

FIGURE 15. Total Grain Losses in Neepawa Wheat.

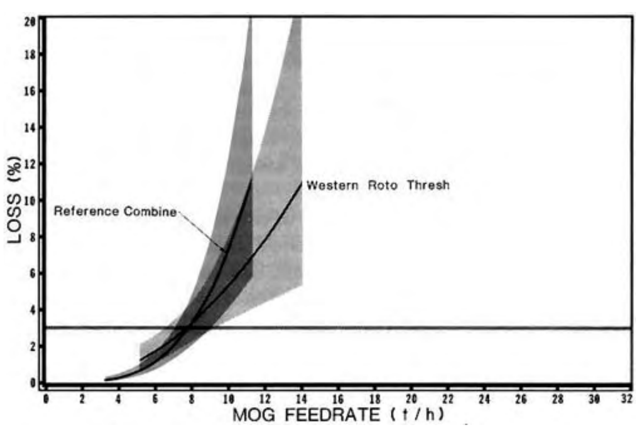

FIGURE 16. Total Grain Losses in Bonanza Barley.

The short wheelbase created a choppy ride and caution was needed when transporting. The combine should not be reversed in high range.

Shielding was excellent and gave good protection from all moving parts. Most shields were hinged and easily opened for servicing, thereby discouraging the practice of permanent shield removal.

The Western Roto Thresh was not equipped with a header lock. It is recommended that the manufacturer supply a header lock and emphasize its proper use in the operator's manual.

Cab entry was hazardous and it is recommended that a safety latch be attached between the cab and the door to provide a rigid railing for mounting and dismounting.

The grain tank must not be entered with the engine running. Entering the grain tank for cleaning or cylinder access was both difficult and hazardous due to its shape and location.

Care is required when servicing the engine and when lubricating several grease fittings above shoulder level to avoid slipping and falling from the combine as there is no appropriate place to stand.

A fire extinguisher should be carried on the combine at all times.

OPERATOR'S MANUAL

Operator's manuals were supplied for the combine, engine, shaft speed monitor and evaporative air conditioner.

The combine operator's manual was well illustrated. It contained information on servicing, adjustments, suggested settings and a list of standard replacement bearing and drive components. Organization was poor and wording unclear. It is recommended that the operator's manual be revised to improve clarity. Other manuals were clearly written and helpful.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the Western Roto Thresh combine during 51 hours of operation while combining about 90 ha (222 ac). 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 5. Mechanical History

Item	Operating Hours	Field Area ha	(ac)
Hydraulic System			
-A park brake hydraulic line burst and was replaced at	35	61	(151)
Drives			
-The cylinder chain idler sprocket bearings failed and were replaced at	Beginning of test		
-The main hydraulic pump sheave loosened on its shaft. The pump was aligned and a new hub installed at	10	17	(42)
-The right header jackshaft drive bearing was replaced at	11	19	(47)
-The radiator fan drive idler arm failed and was rewelded at	17	31	(77)
-The crankshaft extension coupling loosened causing loss of power to the separator and was repaired at	20	37	(91)
-An idler mount on the clean grain elevator drive failed and was repaired at	40	70	(173)
-The stripper auger drive chain failed and was replaced at	50	89	(220)
Cylinder and Concave			
-The cylinder shaft bent and a new cylinder and shaft were installed at	7	11	(27)
-A cylinder bar retaining bolt failed and was replaced at	21	38	(94)
Miscellaneous			
-A faulty latch on the feeder inspection door was replaced at	11	19	(47)
-Three left wheel bolt studs failed and were replaced. All wheel bolts were retorqued at	13	22	(54)
-The rear left shoe hanger loosened on its bushing and was reinstalled at	23	42	(104)
This recurred and other hangers had loosened on their bushings by	49	86	(213)

DISCUSSION OF MECHANICAL PROBLEMS

Crankshaft Extension: Power is supplied to the combine separator and main hydraulic pump from a jackshaft coupled to the front of the engine with a tapered lock collar. The locking screws loosened and power transmission ceased. Reconnecting the drive was a major repair operation, taking two men five hours.

It is recommended that the manufacturer modify the coupling to eliminate driveline failure.

Cylinder: The cylinder shaft bent between the left bearing and the drive sprocket. No cause was determined for the failure and a new cylinder and shaft were installed.

Fatigue failure of a bolt caused the retaining bar and corresponding rasp bar to move away from the cylinder and strike the stripper bar. A new retaining bar, hardware and stripper bar were installed and no further problems occurred. It is recommended that the manufacturer consider modifications to the cylinder retaining bar fasteners to prevent failure.

Shoe Hangers: The rear left shoe hanger pulled free of its rubber bushing causing the rear of the shoe to drop and strike the frame. This later occurred on all hangers. It is recommended that the shoe hanger assembly be modified to prevent loosening of the rubber bushings.

APPENDIX I
SPECIFICATIONS

MAKE:	Western Roto Thresh Self-Propelled Combine
SERIAL NUMBER:	Header 1859-38743, Combine body 3977
MANUFACTURER:	Western Roto Thresh Ltd. 1840 Ontario Ave. N. Saskatoon, Sask. S7K 1T4
WINDROW PICKUP:	
--make and model	Melroe 351-12
--type	aluminum apron with rubber draper
--pickup width	3200 mm (126 in)
--number of belts	7
--teeth per belt	40
--type of teeth	spring steel
--number of rollers	
-- apron	2
--draper	2
--height control	castor wheels and support chains
--speed control (combine)	variable pitch sheaves electrically controlled
--apron speed range	0.6 to 1.4 m/s (118 to 276 ft/min)
HEADER:	
--type	centre feed
--width	4120 mm (13.5 ft)
--auger diameter	508 mm (20 in)
--feeder conveyor (two stages)	3 roller chains, undershot slatted conveyors
--conveyor speeds	3.38 m/s (665 ft/min)
--range of picking height	-60 to 1220 mm (-2.4 to 48 in)
--number of lift cylinders	2 double acting
--raising time	4 s
--lowering time	3 s
--options	straight cut header
FEEDER BEATER:	
--type	four wing box
--diameter	130 mm (5.12 in)
--speed	920 rpm
CYLINDER:	
--type	rasp bar
--number of bars	8
--diameter	565 mm (22.25 in)
--width	1232 mm (48.50 in)
--drive	chain
--speeds	399, 460, 570, 598, 613, 644, 707, 743, 797, 876, 966, 1062, 1139 and 1196 rpm
--stripper bar	13 mm (0.5 in) bevelled steel flat
--crop entry into drum	steel deflector shroud
CONCAVE:	
--type	bar and wire grate
--number of bars	11
--configuration	9 intervals with 8 mm (0.31 in) wires and 7 mm (0.28 in) spaces; 1 interval blocked
--area	0.607 m² (941 in²)
--wrap	106 degrees
--grain delivery to shoe	gravity
SEPARATING DRUM:	
--type	rotating perforated metal drum with corrugated spirals and 13 mm (0.5 in) holes
--diameter	1660 mm (65.35 in)
--length	2640 mm (104 in)
--separating area	13.77 m² (21,350 in²)
--speed and direction	34 rpm clockwise
--grain delivery to shoe	5 auger conveyors
--options	drum filler plates
SEPARATING DRUM FAN:	
--type	squirrel cage
--diameter	381 mm (15 in)
--width	241 mm (9.5 in)
--speed	675 rpm
STRIPPER AUGER:	
--diameter	203 mm (8 in)
--effective length	1930 mm (76 in)
--speed and direction	310 rpm counter-clockwise
ASPIRATOR:	
--type	two fans with common suction
--diameter of each fan	530 mm (20.88 in)
--width	241 mm (9.5 in)
--speed	975 rpm
--suction control	adjustable door in throat
SHOE:	
--type	single action
--speed	330 rpm
--chaffer sieve	adjustable lip, 1.58 m² (2450 in²) with 38 mm (1.50 in) throw
--clean grain sieve	adjustable lip, 1.47 m² (2280 in²) with 38 mm (1.50 in) throw
CLEANING FAN:	
--type	4 blade undershot
--diameter	590 mm (23.23 in)
--width	1180 mm (46.46 in)
--wind control	variable inlet
ELEVATORS:	
--type	roller chain with rubber flights and top delivery
--clean grain (top drive)	207 x 290 mm (8.15 x 11.42 in)
--tailings (top drive)	160 x 290 mm (6.30 x 11.42 in)
GRAIN TANK:	
--capacity	4.8 m³ (127 bu)
--unloading time	185 s
--options	4570 mm (180 in) unloading auger
STRAW CHOPPERS:	
--type	rotor with 27 feely swinging hammers
--speed	2590 rpm
--option	straw spreader
ENGINE:	
--make and model	Caterpillar 3208
--type	4 stroke naturally aspirated diesel
--number of cylinders	8
--displacement	10.42 L (636 in³)
--governed speed (full throttle)	2450 rpm
--manufacture's rating at 2450 rpm	118 kW (158 hp)
--fuel tank capacity	227 L (50 gal)
CLUTCHES:	
--header	electromagnetic
--separator	V-belt
NUMBER OF CHAIN DRIVES:	16
NUMBER OF BELT DRIVES:	14
NUMBER OF PRELUBRICATED BEARINGS:	96
LUBRICATION POINTS:	
--10 h lubrication	8
--50 h lubrication	19
TIRES:	
--front	2, 23.1 x 26, 10-ply
--rear	2, 12.5L x 16, 12-ply
TRACTION DRIVE:	
--type	fully hydrostatic
--speed ranges with 23.1 x 26 tires forward and reverse	
- low range	0 to 11.2 km/h (0 to 7 mph)
- high range	0 to 22.4 km/h (0 to 14 mph)
OVERALL DIMENSIONS:	
--wheel tread (front)	2790 mm (110 in)
--wheel tread (rear)	2420 mm (95 in)
--wheel base	3170 mm (125 in)
--transport height	4070 mm (160 in)
--transport length	9020 mm (355 in)
--transport width	4220 mm (166 in)
--field height	4070 mm (160 in)
--field length	9090 mm (358 in)
--field width	5840 mm (230 in)
--unloader discharge height	3350 mm (132 in)
--unloader clearance height	2890 mm (114 in)
--unloader reach	1650 mm (65 in)
--turning radius	
- left	5610 mm (221 in)
- right	5490 mm (216 in)
--clearance radius	
-left	7340 mm (289 in)
-right	7320 mm (288 in)
WEIGHT(with empty grain tank):	
--right front wheel	3110 kg (6860 lb)
--left front wheel	3110 kg (6860 lb)
--right rear wheel	1440 kg (3170 lb)
--left rear wheel	1460 kg (3220 lb)
TOTAL	9120 kg (20,110 lb)

OPTIONAL EQUIPMENT:
--shaft monitor, grain monitor, cab heater, cab light and rear view mirrors

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations, for capacity results shown in FIGURES 10 to 12, are presented in TABLE 6. In the regressions, C = cylinder loss in percent of yield, S = shoe loss in percent of yield, A = aspirator loss in percent of yield, D = separating drum loss in percent of yield, F = the MOG feedrate in t/h, while $\ln$ is the natural logarithm. Sample size refers to the number of toss collections.

Limits of the regressions may be obtained from FIGURES 10 to 12 while crop conditions are presented in TABLE 4.

TABLE 6. Regression Equations

Crop - Variety	Fig. No.	Regression Equations	Simple Correlation Coefficient	Sample Size
Barley - Betzes	10	C = -0.04 + 0.07F S = 0.04 + 0.002F A = 0.34 - 0.03F D = 4.34 - 1.55F + 0.17F	0.70 0.52 0.73 0.92	9
Wheat - Neeawa	11	C = -0.22 + 0.10F S = 0.03 + 0.001F A = 0.30 - 0.02F D = 2.70 - 0.84F + 0.07F	0.97 0.48 0.59 .093	8
Barley - Bonanza	12	C = -0.30 + 0.10F S = 0.02 + 0.0001F A = 0.52 - 0.03F $\ln$D = -4.72 + 2.67 $\ln$F	0.95 0.05 0.71 0.91	8

APPENDIX III
PAMI REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 17 and 18 present capacity results for the PAMI reference combine in wheat and barley crops harvested m 1976 and 1977.

In 1976, after a warm and dry growing season, capacity tests were conducted in crops harvested soon after windrowing, with the windrows receiving little or no rain. In 1977, after a cool and moist growing season, tests were conducted in crops harvested long after windrowing and subjected to many wetting and drying cycles.

FIGURE 17 shows large capacity differences in Neepawa wheat for the two years. Although straw and grain moisture contents were similar the MOG/G ratios, growing conditions and windrow maturities were quite different. Much lower cylinder losses resulted from the easier threshability of the 1977 Neepawa wheat crops and lower straw walker losses resulted from the lower MOG/G ratio.

TABLE 7. Capacity of the PAMI reference combine at a Total Grain Loss of 3% of Yield.

	Crop Conditions									Capacity Results						
			Width of Cut		Crop Yield		Grain Moist.ure			MOG Feedrate		Grain Feedrate		Ground Speed		
	Crop	Variety	m	ft	t/ha	bu/ac	Straw %	Grain %	MOG/G	t/h	lb/min	t/h	bu/h	km/h	mph	Loss Curve
1977	Barley	Betzes	4.9	16	3.35	62	17.2	15.9	0.92	7.10	261	7.70	354	4.7	2.9	
	Wheat	Neepawa	6.1	20	3.97	59	13.4	14.6	0.79	11.10	408	14.05	516	5.8	3.6	Fig. 17
	Barley	Bonanza	7.3	24	4.74	88	25.7	14.6	0.84	7.90	290	9.40	432	2.7	1.7	Fig. 18
1976	Wheat	Neepawa	5.5	18	2.78	41	dry to tough	14.7	1.29	7.1	261	5.5	202	3.6	2.3	Fig. 17
	Barley	Bonanza	7.3	24	3.18	60	dry to tough	14.6	0.96	4.8	176	5.0	230	2.2	1.4	Fig 18

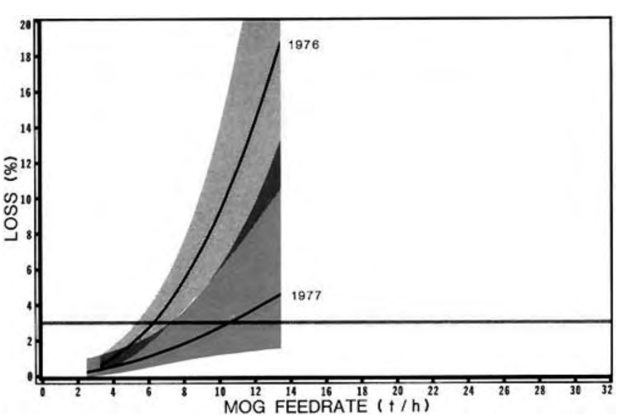

FIGURE 17. Total Grain Losses for the PAMI Reference Combine in Neepawa Wheat.

FIGURE 18 also shows differences in capacities in Bonanza barley Grain moisture contents were similar but MOG/G ratios were different. Growing conditions and windrow maturities also were quite different in the two years. The high straw moisture content of the 1977 Bonanza barley crop was not indicative of the physical properties of the straw, which was green but not damp. This resulted in less straw breakup that is common for barley at low straw moisture contents which, in combination with lower MOG/G ratio, resulted in lower straw walker losses.

These results show that a reference combine is important in determining the effects of crop variables and in comparing capacity results of combines evaluated in different growing seasons.

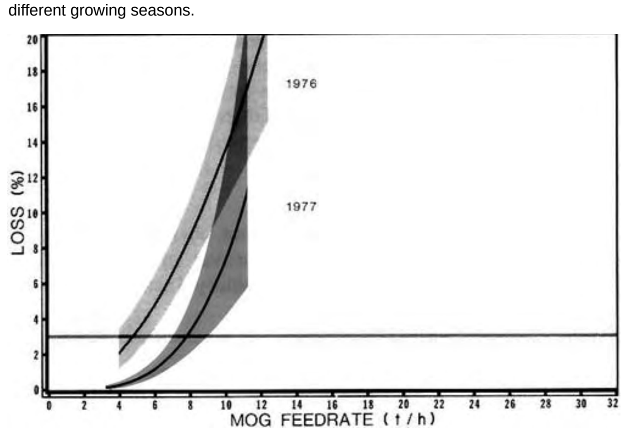

FIGURE 18. Total Grain Losses for the PAMI Reference Combine in Bonanza Barley.

APPENDIX IV
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 V
METRIC UNITS

In keeping with the Canadian metric conversion program, this report has been prepared in SI units. For comparative purposes, the following conversions may be used:

1 kilometre/hour (km/h)	= 0.62 miles/hour (mph)
1 hectare (ha)	= 2.47 acres (ac)
1 kilogram (kg)	= 2.2 pounds (lb)
1 tonne (t)	= 2204.6 pounds (lb)
1 tonne/hectare (t/ha)	= 0.45 ton/acre (ton/ac)
1 tonne/hour (t/h)	= 36.75 pounds/minute (lb/min)
1000 millimetres (mm) = 1 metre (m)	= 39.37 inches (in)
1kilowatt (kW)	= 1.34 horsepower (hp)
1 litre/hour (L/h)	= 0.22 Imperial gallons/hour (gal/hr)

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