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Evaluation Report 27

John Deere Sidehill 6600 Self-Propelled Combine

A Co-operative Program Between
ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

John Deere Sidehill 6600 Self-Propelled Combine

Manufacturer:
John Deere Harvester Works
East Moline, Illinois 61244
U.S.A.

Distributor:
John Deere Limited
455 Park Street
Regina, Saskatchewan S4P 3L8

Retail Price:
$49,152.49 (July, 1977, f.o.b. Humboldt, with 3590 mm (11.8 ft) table, 3350 mm (132 ft) belt pickup, straw chopper, electromagnetic header clutch, air restriction indicator, grain tank extensions with extended loading auger, straw walker warning system, low shaft speed monitor, adjustable rear axle, 38 mm (1.5 in) adjustable sieve, signal lights, cab with air conditioning, heater, and rear air intake, hydrostatic pickup drive, hydrostatic ground drive, and automatic levelling system.

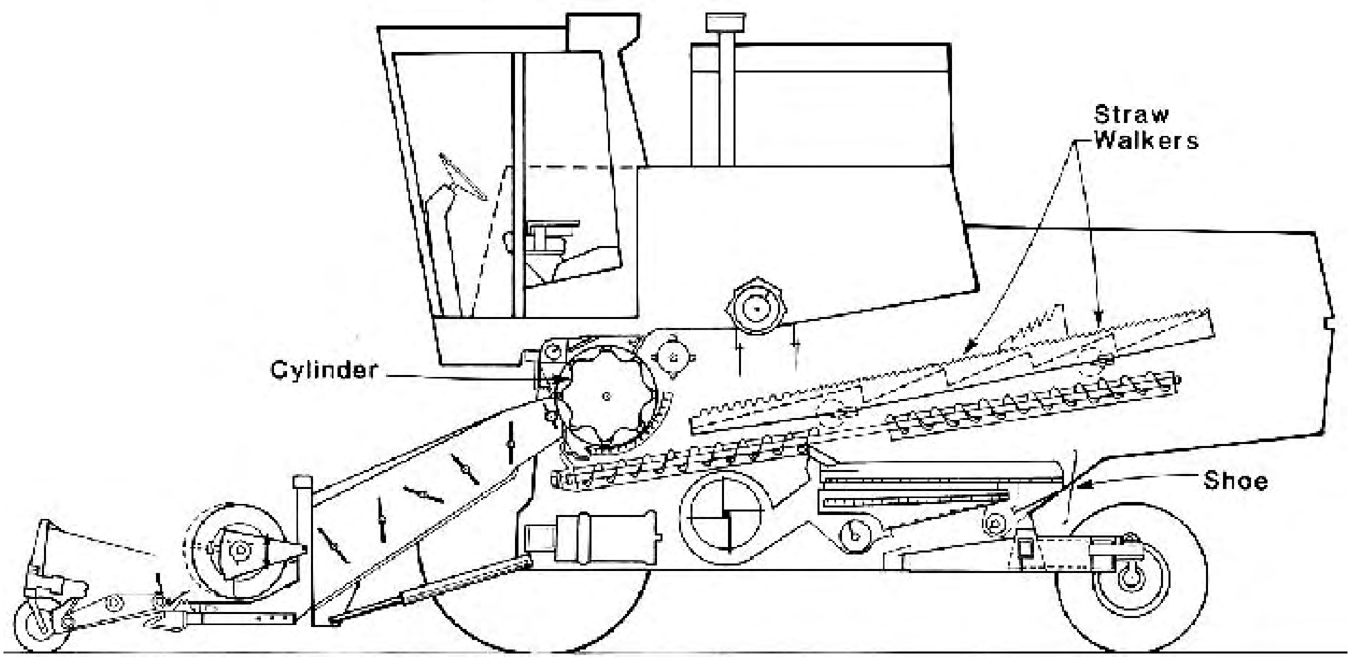

Figure 1. Schematic View of John Deere Sidehill 6600.

Summary and Conclusions

Functional performance of the John Deere Sidehill 6600 self-propelled combine was very good in dry grain and oilseed. Functional performance was good to fair in tough and damp crops.

The MOG feedrate (straw and chaff feedrate) at 3% total grain loss varied from 7.1 t/h (261 lb/min) in 2.78 t/ha (41 bu/ac) Neepawa Wheat to 4.8 t/h (176 lb/min) in 3.18 t/ha (60 bu/ac) Bonanza Barley. Straw walker loss limited the capacity of the John Deere 6600 in nearly all crops. A reduction in grain loss over the straw walkers would have permitted higher combining rates. Cylinder and shoe losses usually were small, in comparison to straw walker loss.

The engine had ample power for all conditions. Fuel consumption varied from 23 to 27 t/h (5 to 6 Imp. gal/h). The rotary radiator air intake screen performed well, preventing radiator plugging even under adverse conditions. The engine started well. The factory installed cold weather starting aid had to be used to start the cold engine at temperatures below +5° C.

Performance of the automatic side levelling system was excellent, permitting level operation on side slopes up to 9°. The levelling system did not in uence combine capacity on side slopes less than 3°. The levelling system increased combine capacity about 1.7 and 3 times on side slopes of 6° and 9°, respectively, by reducing shoe losses.

The steering and braking system were very good and it was possible to pick most sharp corners formed by self-propelled windrowers by using the individual wheel brakes. Instruments and controls were conveniently positioned. All controls were responsive. The cab was adequately pressurized and relatively dust free. The optional heater and air conditioning system performed well. Sound level at the operator's ear was about 88 decibels (A scale).

Header visibility was very good both in the daytime, and at night. Grain level visibility was excellent. Rear visibility was restricted and the rear view mirrors were necessary for road transport. The John Deere 6600 handled welt at maximum transport speed of 30 km/h (18.5 mph).

The John Deere 6600 was easy to adjust for speci c eld conditions. Since both grain and tailings could be inspected from the cab it was easy to check combine performance. The optional shaft speed monitoring system was helpful a number of times by warning the operator of blockages. Ease of servicing was fair. Access to the engine and many lubrication ttings was severely restricted.

The oating table auger and paddle feeder housing both had excellent capacity. Cylinder, table auger or feeder plugging were infrequent, even in damp conditions. Unplugging the cylinder was dif cult due to limited access.

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

The pickup had excellent feeding characteristics in all crops and was easily adjusted for varying straw lengths. Pickup roller plugging was a problem in some damp barley crops.

No serious safety hazards were encountered when operated according to the manufacturer's recommended procedures. Access to the cab was dif cult, especially for older operators.

The operator's manuals were well illustrated and contained much useful information on servicing and adjustments for most crops. They did not contain complete information on the pickup platform.

No major durability problems occurred during the test, although several minor problems occurred with the table auger slip clutch and header. Most of these were due to improper pre-delivery on the header assembly.

Recommendations

It is recommended that the manufacturer consider:

1. Providing a rocking hub for the table auger to facilitate unplugging.
2. Providing inspection holes on both sides of the cylinder for checking concave clearances.
3. Providing a lubrication bank for some hard to reach grease ttings.
4. Providing decals indicating location and frequency of lubrication.
5. Providing information in the operator's manual for adjusting the slip-clutch on the platform auger.
6. Modifying the concave ller plates so they remain in place during operation.
7. Providing padding for the upper frame on the cab door to reduce the possibility of head injuries.
8. Modi cations to the ladder and hand rail assemblies to improve access to the operator's cab.
9. Improving quality control during assembly of the header.

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. A rocking hub is being considered.
2. Inspection holes in the side sheets on both sides of the cylinder have been designed and combines soon will be manufactured this way.
3. Lubrication banks for hard to reach grease ttings were introduced on the 1977 combines.
4. Rather than using decals, the manufacturer is planning to extend greasing intervals and make greasing time more uniform.
5. In future printings of the operator's manual, slip-clutch adjustment instructions will be included.
6. An improved method of ller plate fastening is being considered.
7. This area will be re-evaluated in future designs.
8. An improved ladder and landing has been designed and soon will be in production.
9. Special checks and inspection controls have been added to reduce this kind of problem.

General Description

The John Deere Sidehill 6600 is self-propelled and powered with a 89.5 kW (120 hp) six cylinder diesel engine. Traction drive is through a four speed transmission and an optional hydrostatic drive system. The John Deere Sidehill 6600 is equipped with power steering, hydraulic wheel brakes, a pressurized cab and an automatic system, which levels the combine body on side slopes up to 16% (9°). Optional accessories included on the test machine are listed on page 2.

The JD 6600 has a 3 350 mm (132 in) hydrostatically driven three roller belt pickup mounted on a 3590 mm (11.8 ft) adjustable pickup platform. The header is equipped with a paddle feeder.

The separator drive and unloading auger are controlled through over-centre belt tighteners while the header drive is controlled with an electromagnetic clutch.

Header height, unloading auger swing and pickup speed are hydraulically controlled. Both concave clearance and cylinder speed may be adjusted on-the-go and return tailings can be sampled from the operator's platform. Fan speed is adjusted with a hand wheel controlling a variable speed belt drive, while the chaffer and sieve are adjusted with levers at the rear of the shoe.

Complete speci cations are given in Appendix I.

Scope of Test

The John Deere Sidehill 6600 was operated in a variety of Saskatchewan and Alberta crops (Tables 1 and 2) for 107 hours while harvesting about 186 ha (461 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.

This JD 6600 is also being used as the PAMI reference combine. It will be operated alongside all test combines whenever capacity measurements are made. This will permit capacity comparisons of various combines, independent Of crop conditions in different years. A detailed report on the bene ts of combine levelling, using results from further evaluation of the John Deere Sidehill 6600 will be published at a later date.

Table 1. Operating Conditions

Crop	Variety	Average Yield		Swath Width		Hours	Field Area	
		t/ha	bu/ac	m	ft		ha	ac
Wheat	Neepawa	2.9	43	4.6-5.5	15-18	29.5	55	137
Barley	Betzes	2.1	38	4.6-5.5	15-18	10.5	18	45
Barley	Bonanza	2.8	52	4.6-7.3	15-24	25.5	36	88
Oats	Harmon	3.1	80	6.1	20	5.0	6	15
Flax	Noralta	1.6	25	4.9	16	9.0	19	47
Flax	Linott	1.3	20	4.9	16	6.0	12	30
Rapeseed	Tower	2.0	35	5.5	18	21.0	40	99
Total						107	186	461

Table 2. Operation in Stony Fields

Field Conditions	Hours	Field Area	
		ha	ac
Stone Free	4	10	25
Occasional Stones	59	103	255
Moderately Stony	36	59	146
Very Stony	8	14	35
Total	107	186	461

Results and Discussion

EASE OF OPERATION

Operator Location: The JD 6600 was equipped with the optional operator's cab. 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 manoeuvring in con ned areas. The rear view mirrors improved rear visibility for road transport. Header visibility was good both in the daytime and at night. Grain could be inspected through the hinged window at the rear of the cab while return tailings could be inspected through a door under the seat.

The operator's seat was comfortable and easy to adjust. The steering column was also readily adjustable. 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. The cab pressurization fans effectively ltered the incoming air and reduced dust leaks. The optional heating and air conditioning system provided a suitable cab temperature in all operating conditions.

The total noise at operator ear level was 88 decibels (A scale) with all doors and windows closed while operating at rated capacity in wheat. According to current operator exposure recommendations, this level is not expected to cause any permanent hearing impairment for eight hours of daily operation.

The access ladder to the cab readily folded out of the way for sidehill operation or for straight combining tall crops. Although the folding mechanism worked effectively and was easy to use, access to the cab was dif cult and hazardous, especially for older operators. The rst step was dif cult to negotiate since it was about 740 mm (29 in) off the ground. Lack of suf cient handholds made opening the cab door dif cult especially when carrying something in one hand.

Controls: The control layout for the JD 6600 is shown in Figure 2. All controls were conveniently placed, easy to use and responsive. The optional hydrostatic traction drive, the hydrostatic pickup drive and the responsive header lift gave the operator good control of the combine. Header lift was quick enough to suit all conditions; header drop rate was adjustable.

Automatic Levelling System: The JD 6600 was equipped with an automatic system (Figure 3), which kept the combine body level on side slopes while allowing the header to follow the eld contour. Two controls, an on-off switch and an over-ride switch, controlled the system. The levelling system was precise and responsive, maintaining level operation on slopes up to 9°. As is discussed later, the automatic levelling system substantially reduced shoe losses on sloping fields. As an added benefit, the levelling system could be used to reduce the grain unloading auger discharge height to minimize seed losses when unloading fine seed such as flax or rapeseed on windy days.

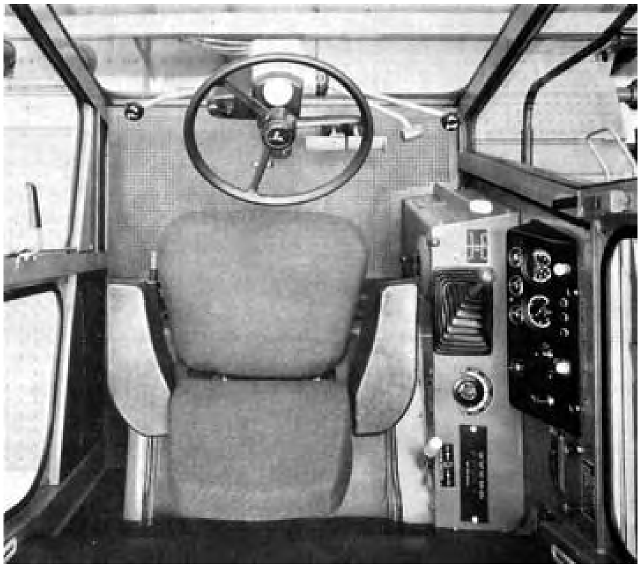

Figure 2. Control Layout on the JD 6600.

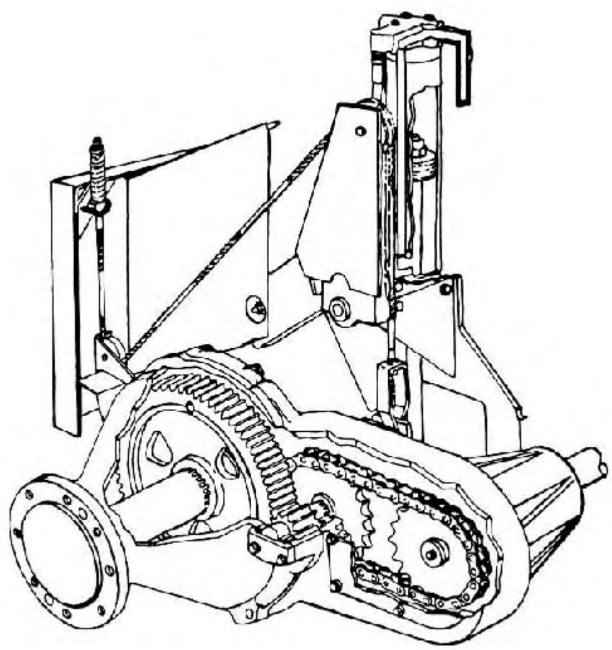

Figure 3. Automatic Levelling System on the JD Sidehill 6600.

Steering: Steering and maneuverability of the JD 6600 were excellent. The power steering was smooth, responsive and effortless. Although the turning radii were large, 9090 mm (30 ft) to the right and 7320 (24 ft) to the left, by using the individual wheel brakes it was possible to pick most corners formed by self-propelled windrowers. The wheel brakes were responsive and effective. The optional 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 4) included gauges for engine oil pressure, coolant temperature, engine speed, cylinder speed, fuel level and an engine hour meter. Indicator lights were provided for transmission oil pressure, battery charging, turn signals and parking brake.

The optional shaft speed monitors were very useful in detecting component blockage. They monitored the tailings elevator, clean grain elevator, grain conveyor augers, straw walkers and straw chopper and indicated, with lights, if any of these systems were operating less than 70% of rated speed. A warning horn also signalled the operator if the straw walkers plugged or if the engine coolant temperature was too high.

Figure 4. Instrument Console on the JD 6600.

Lights: The JD 6600 was equipped with seven front lights and two rear lights. Header lighting and long range front lighting were excellent while lighting for the grain tank, unloading auger and area behind the combine was adequate.

Engine: The engine had ample power, even when using the straw chopper in damp crops in soft hilly fields. Average fuel consumption varied from 23 to 27 L/h (5 to 6 gal/h).

Access to the engine was through a door on the right side of the cab. Although the front and top engine covers swung out of the way, access to many parts of the engine was very difficult. The engine oil filter was located behind the engine and was difficult to change.

The rotary radiator air inlet screen was very effective in eliminating radiator plugging and engine heating. The screen required hand cleaning only once during the test. During late fall combining in below freezing temperatures, the screen sometimes had to be freed by hand before starting the engine to prevent screen drive belt failure.

The engine air intake used a centrifugal bowl pre-cleaner and a dry filter. The dry filter element required infrequent servicing if the pre-cleaner bowl was emptied before it completely filled. The pre-cleaner bowl had to be cleaned several times a day in very dusty conditions.

The engine started easily at all times. If night temperature dropped below + 5°C, the ether starting aid had to be used. Engine oil consumption was insignificant throughout the test.

Stability: The JD 6600 was very stable, even with a full grain tank. The automatic levelling system greatly improved stability on hillsides. The centre of gravity, with a three-quarters full grain tank was 2235 mm (88 in) above ground, 914 mm (36 in) behind the drive wheels and on the combine centre line. Normal care had to be used when turning corners on steep hillsides.

Grain Tank: The grain tank, when equipped with optional extensions and optional extended loading auger, held 3.6 t (134 bu) of wheat. Unloading a full hopper of dry wheat took 96 seconds. The grain tank filled evenly in all crops.

The unloading auger had sufficient clearance and reach for easy unloading on the go. The hydraulically controlled unloading auger tube was easily swung in and out of field position. The tube was easily secured in field position with an over centering lever, accessible from the platform outside the cab.

Straw Chopper: The optional straw chopper attachment performed well in all crops. 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 straw and wind conditions.

The straw chopper had to be removed if the straw was to be windrowed. Removal or replacement took two men about ten minutes.

Plugging: The table auger had high capacity and was very aggressive. It plugged only twice during the test, in wet bunchy windrows. Unplugging was dif cult because of shielding by the pickup wind guard. A rocking hub on the table auger would have facilitated unplugging.

The paddle feeder (Figure 5) had high capacity in all crops and conditions and plugged only once during the test on a wad of wet straw mixed with earth. Unplugging was fairly easy by turning the paddle backward and removing the wad through the two feeder access doors. In one crop of damp Betzes barley, straw wound on the paddle shafts, between the paddles and the feeder side sheets, and had to be cut out by hand. To prevent backfeeding it was essential that the front paddle and stripper were properly adjusted as outlined in the operator's manual.

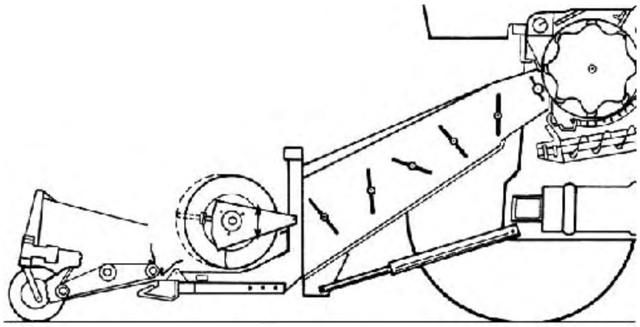

Figure 5. Paddle Feeder on the JD Sidehill 6600.

The cylinder was quite aggressive and positive. Cylinder plugging occurred infrequently. Backfeeding occurred in bunchy rapeseed windrows and when encountering damp wads of wild oat straw. If the cylinder plugged, it could usually be unplugged from the operator's seat by lowering the concave. In one case, however, the concave lowering mechanism jammed and the concave could not be lowered until the cylinder was cleaned. On two occasions, in which serious plugging occurred, it took about one-half hour to unplug the cylinder. Although a rocking hub was supplied on the cylinder shaft, cylinder access was very dif cult due to shielding of the access door by the engine compartment. Keeping cylinder drive belts in proper adjustment was very important when combining damp crops.

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.

The delivery augers beneath the concave and straw walkers plugged twice, stopping the augers, while combining tough Betzes barley. Plugging was caused by tough straw wrapping around the augers. Unplugging was very dif cult as the sieves had to be removed for access. No plugging occurred in dry crops.

Stone Trap: The JD 6600 was equipped with a stone trap in front of the cylinder. The stone trap was quite effective, capturing most roots or stones before they entered the cylinder. One stone bent the front section of the concave, necessitating straightening. As with most combines, if a large stone was inadvertently picked, it could damage the table auger or feeder before being stopped by the stone trap.

Cleaning the stone trap was quite easy. The header had to be raised and secured and an over-centre lever pulled to drop the stone trap door (Figure 6).

Pickup: The JD 6600 was equipped with a 3350 mm (132 in) three-roller belt pickup (Figure 5) with spring steel teeth. The pickup had excellent feeding characteristics, delivering the crop beneath the table auger. Since the pickup could be moved forward for long straw and rearward for short straw, and since the three roller design and wind-guard held the crop horizontally, good feeding could be maintained in all crops encountered. The hydrostatic pickup drive was positive, maintaining the selected pickup speed in all conditions.

In tough and damp Betzes and Bonanza barley, frequent plugging occurred between the rear pickup roller and the stripper bar, causing belt slippage. No adjustments remedied this problem. Plugging never occurred in other crops.

Machine Cleaning: As with most combines, completely cleaning the JD 6600 for combining seed grain was laborious and time consuming. The delivery augers beneath the concave could be cleaned by pivoting the clean-out door upward and blowing compressed air through the exposed slots. Clearing the rear delivery augers under the straw walkers necessitated removal of four cap screws to drop the auger troughs. The chaffer and sieve were easy to remove for cleaning of the tailings and clean grain augers. The grain tank was fairly easy to clean if the front discharge auger cover was raised to its maximum height.

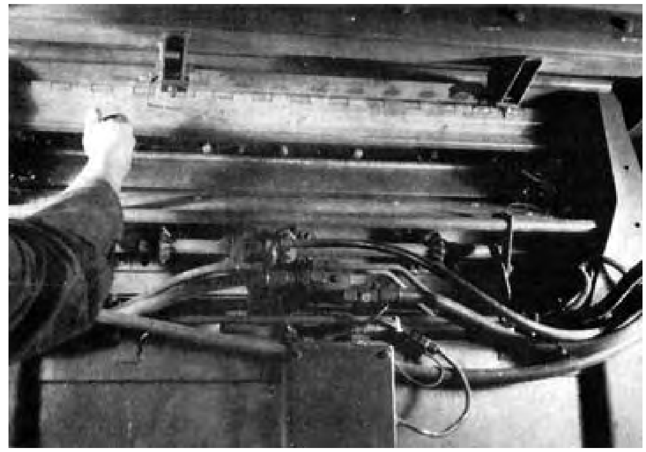

Figure 6. Stone Trap Access on the JD 6600.

Lubrication: The JD 6600 had 77 pressure grease ttings. Twenty needed greasing every 10 hours, 37 needed greasing every 50 hours, 17 needed greasing every 100 hours, while two had to be greased at 250 hours and one had to be greased at 500 hours. Four 50-hour ttings on the left side of the combine were dif cult to reach. The fan shroud had to be removed to reach the primary countershaft bearing, while the seat and an inspection cover had to be removed to reach three lever-pivot ttings under the operator's platform. A lubrication bank for these ttings is recommended. On the right side of the combine, the rotary de ector drive tightener (10 hour), the tailings drive tightener arm (50 hour), the primary counter shaft bearing (50 hour), the header drive shaft slide (50 hour), and the second lower feeder paddle bearing (100 hour) all were very dif cult to lubricate.

Engine and hydraulic oil levels required daily checking. The oil lter, which required replacement at every 100 hour oil change, was very dif cult to change as it was located behind the engine. The main hydraulic oil reservoir was easy to ll while the hydrostatic drive oil reservoir was dif cult to ll.

EASE OF ADJUSTMENT

Field Adjustments: The JD 6600 was easy to adjust, and could usually be set for a crop by one person. Since the return tailings and grain could be inspected, while cylinder speed and concave clearance could be varied from the 6 operator's seat, it was easy to monitor combine performance and change settings as required during the day.

Concave Adjustment: The JD 6600 had a single segment concave. The concave could be levelled with two draw bolts at the rear and a single levelling bolt at the front. Front concave clearance could be gauged through the stone trap door while the rear was gauged by entering the straw walker compartment since no inspection holes were provided on the side of the combine. Concave clearance was easily adjusted with a hand crank in the operator's cab. The control linkage was designed so that the front concave opening always was twice as large as the rear opening. Front opening could be adjusted from 5 mm (0.20 in) to 38 mm (1.5 in). Each turn of the adjusting crank changed the front opening by 3.2 mm (0.13 in). Although a clearance indicator was attached to the concave pivot shaft on the side of the combine, this gauge was not visible from the operator's cab and concave clearance could be determined only by counting the number of turns of the adjusting crank from closed position.

It was critical to keep a proper balance between concave clearance and cylinder speed. Hard-to-thresh bottom kernels, especially in Neepawa wheat, were dif cult to remove and critical adjustments were necessary to avoid excessive cylinder loss without undue crackage. Suitable front concave clearances were from 10 to 13 mm (0.4 to 0.5 in) for dry wheat. In rapeseed a suitable front clearance was 32 mm (1.25 in). In ax, a front clearance of

5 mm (0.20 in), together with two ller plates in the front two concave intervals, was required. The ller plates enabled the cylinder speed to be reduced to eliminate cracking with an acceptable cylinder loss level. After 16 hours of operation, both ller plates had been threshed as the spring clips did not hold the ller plates securely.

Cylinder Adjustment: The cylinder was equipped with a tachometer and a variable speed drive, adjustable from the operator's seat with a reversible hand ratchet assembly (Figure 2). Cylinder speed could be varied from 450 to 1220 rpm, a suitable range for all crops encountered. An optional cylinder drive sheave is available to provide a speed range from 280 to 845 rpm. Suitable cylinder speeds were about 900 rpm in ax, from 800 to 950 rpm in dry wheat, 600 rpm in rapeseed and from 650 to 800 rpm in dry barley. Typical grain crackage varied from 0.5 to 2.0% when properly adjusted.

The cylinder rasp bars were in good condition at the end of the test, showing negligible wear.

Shoe Adjustments: The shoe was convenient to adjust. Fan speed was varied with a calibrated hand wheel (Figure 7) while the chaffer and chaffer extension were adjusted with levers at the rear of the shoe. Access to the clean grain adjusting lever was through a door at the rear of the shoe. Return tailings could conveniently be inspected at the top of the return elevator under the operator's seat. The fan speed reference decal was incorrectly af xed to the combine and could be used as a reference only, as it did not indicate correct fan speed.

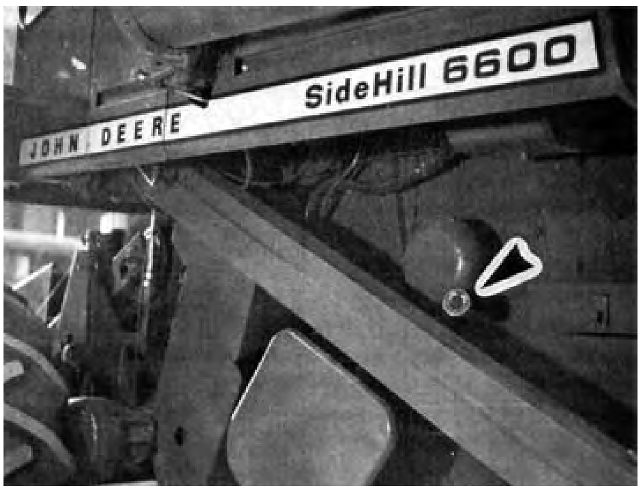

Figure 7. Fan Adjustments on the JD 6600.

The shoe was easily adjusted and performed well in most crops encountered. Since the JD 6600 Sidehill maintained a level shoe on side slopes up to 9°, grain loss over the shoe usually was insigni cant. Total dockage in the grain tank, including cracks, whitecaps and chaff usually varied from 1 to 3% when properly adjusted.

As is common with most combines, the shoe was dif cult to set in non-uniform crops of some varieties of rapeseed due to the large variation in seed size and amount of shoe load between heavy and light windrows. It was found best to set the shoe for optimum performance in the heavy windrow sections and to increase feed rate in light windrow sections to maintain a fairly uniform shoe load. In normal conditions, shoe plugging never occurred. In late fall combining in extremely wet conditions, the chaffer and sieve plugged with wet material and combining could not take place unless the temperature was well below freezing.

As is common with most combines, the windrow should be fed centred on the feeder housing. In rapeseed and ax, shoe loss became significant if the windrow was fed on one side of the feeder housing. One side of the shoe became underloaded while the other side was overloaded, causing seed to be blown over on one side and mechanically transported over on the other side.

Header Adjustments: The JD Sidehill 6600 was evaluated with a pickup header for windrowed crops. A straight combining header was not evaluated. The pickup header could be removed from the feeder, or installed, by one man in about ten minutes. The complete header and feeder assembly could also be removed from the combine. Removal or installation took two men about one hour.

The table auger was easy to adjust both vertically and horizontally while the front feeder paddle height and paddle stripper location could also be varied. Adjustment of either was seldom needed.

Slip Clutches: Individual slip clutches protected the table auger, straw walkers, shoe grain supply augers and tailings elevator. In addition, the paddle feeder drive was protected with a shear pin.

RATE OF WORK

Average Workrates: Table 3 presents the average work-rates for the JD 6600, at acceptable loss levels, in all crops harvested during the test. Average workrates are affected by crop conditions in a specific year and should not be used for comparing combines tested in different years. In some crops, workrates were reduced by bunchy and sunken windrows, muddy or rough ground, irregular shaped fields with many corners and driving the combine empty to unload grain at a central location. During the 1976 harvest, average workrates varied from 5.4 t/h (199 bu/h) in 2.9 t/ha (43 bu/ac) Neepawa wheat to 2.6 t/h (100 bu/h) in 1.3 t/ha (20 bu/ac) Linott flax.

Table 3. Average Workrates for the JD 6600

		Average Yield		Average Speed		Average Workrate			
Crop	Variety	t/ha	bu/ac	km/h	mph	ha/h	ac/h	t/h	bu/h
Wheat	Neepawa	2.9	43	4.3	2.7	1.9	4.7	5.4	199
Barley	Betzes	3.1	38	4.3	2.7	1.8	4.4	3.7	168
Barley	Bonanza	2.8	52	3.4	2.1	1.4	3.5	4.0	177
Oats	Harmon	3.1	80	2.5	1.6	1.2	3.0	3.7	240
Flax	Noralta	1.6	25	5.0	3.1	2.1	5.2	3.3	1.29
Flax	Linott	1.3	20	6.4	4.0	2.0	5.0	2.6	100
Rapeseed	Tower	2.0	35	4.8	3.0	2.2	5.3	4.3	186

Maximum Feedrate: The workrates given in Table 3 represent average workrates at acceptable loss levels. The engine had ample power to achieve much higher workrates in nearly all crops. In most crops the maximum acceptable feedrate was limited by grain loss, while 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 specified 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.

Table 4. Capacity of the JD 6600 at a Total Grain Loss of 3% of Yield*

Crop Conditions									Capacity Results						
		Width of Cut		Crop Yield		Straw Condition	Grain Moist.ure	MOG	MOG Feedrate		Grain Feedrate		Ground Speed		Loss Curve
Crop	Variety	m	ft	t/ha	bu/ac		%	G	t/h	lb/min	t/h	bu/h	km/h	mph	
Wheat	Neepawa	5.5	18	3.36	50	dry to tough	14.7	1.13	8.30	305	7.35	270	4.0	2.25	Fig. 10 & 14
Wheat	Neepawa	5.5	18	3.69	55	dry	12.0	1.23	8.30	305	6.75	248	3.4	2.1	Fig. 11 & 15
Barley	Bonanza	7.3	24	3.56	66	dry to tough	14.6	0.81	5.65	208	6.98	321	2.7	1.7	Fig. 12 & 16
Flax	Linott	4.6	15	1.82	29	very dry	8.7	0.92	5.90	216	6.40	252	8.4	5.2	Fig. 13 & 17

*In flax, maximum total loss was only 1% of yield.

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 difficult a certain crop is to separate. For example, if a certain combine is used in two wheat fields 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, un-threshed grain still in the head and threshed grain or seed, which is discharged with the straw or chaff. Unthreshed grain is called cylinder loss. Free grain in the straw and chaff is called separator losses and consists of shoe loss and straw walker loss. Shoe and straw walker losses are very dependent upon MOG Feedrate and MOG/G ratio. 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 JD 6600: Table 4 presents capacity results for the JD 6600 in four different crops. MOG Feedrates for a 3% total grain loss varied from 7.1 t/h (261 lb/min) in a field of Neepawa wheat to 4.8 t/h (176 lb/min) in a field of Bonanza barley. In flax, the total loss level was only 1% at a maximum feedrate of 4.7 t/h (173 lb/min). In this crop, capacity was limited by pickup performance at higher speeds.

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics for the JD 6600, while operating on level ground, in the four crops described in Table 4, are presented in Figures 8 to 11.

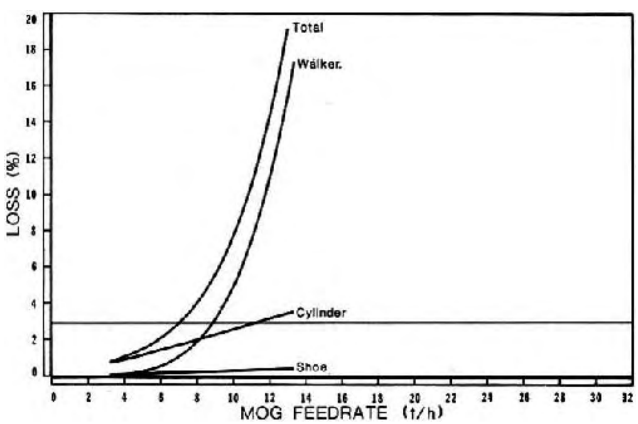

Figure 8. Grain Loss for the JD 6600 in Neepawa Wheat at 14.7% Grain Moisture Content.

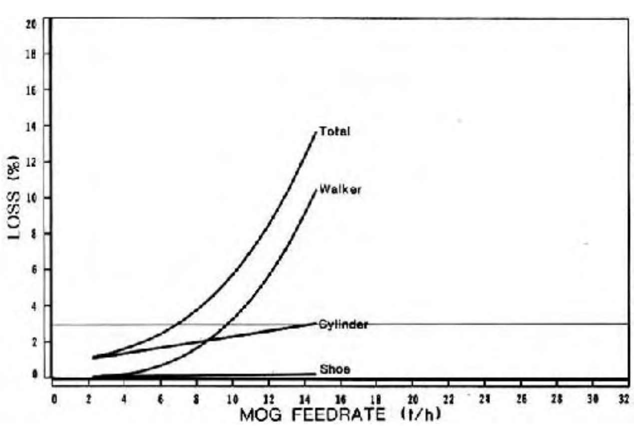

Figure 9. Grain Loss for the JD 6600 in Neepawa Wheat at 12% Grain Moisture Content.

Walker Loss: As is common with most combines, walker loss was the most significant factor limiting capacity in all grain crops. Cylinder loss and shoe loss usually were insignificant in comparison to walker loss. A reduction in free grain loss over the straw walkers would have enabled much higher combining rates especially in difficult-to-separate crops such as barley.

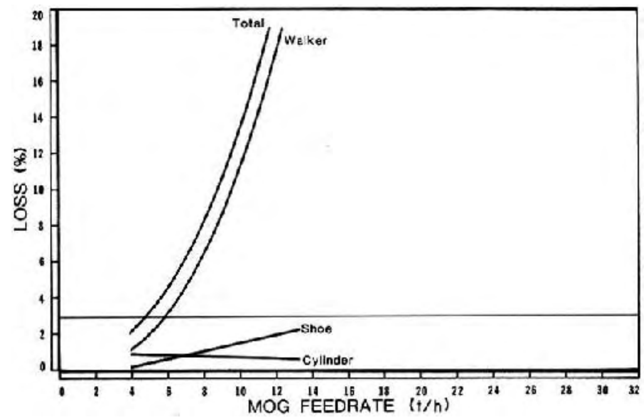

Figure I0. Grain Loss for the JD 6600 in Bonanza Barley.

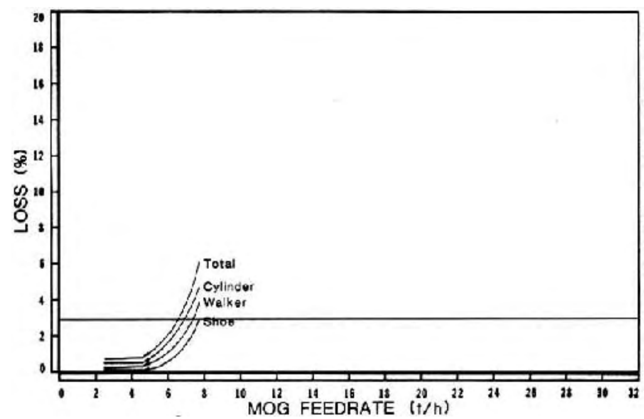

Figure 11. Grain Loss for the JD 6600 in Linott Flax.

The JD 6600 was equipped with straw walker risers, mounted ahead of the fourth step on each walker. It was also equipped with adjustable extension pans at the rear of each walker. All capacity measurements were conducted with the risers in place and with the walker pans extended halfway to their mid-position. The effect of riser or extension pan position was not evaluated.

Shoe Loss: Shoe loss rarely limited combine capacity on level ground although adjustment was critical in rapeseed and flax and high losses could occur with improper settings. (The effect of automatic sideways levelling on shoe performance is discussed on page 9).

Cylinder Loss: Cylinder loss was low in most dry and well matured crops. In more difficult-to-thresh crops, such as Neepawa wheat, cylinder and concave adjustments were critical and cylinder loss could make a significant contribution to total loss. In tough to damp Neepawa wheat it was very difficult to remove the bottom kernels in the head, even with the cylinder closed tight. In Neepawa wheat with a grain moisture content of 14.7% (Figure 8) cylinder loss varied from 1 to 3.8% while in Neepawa wheat with a grain moisture content of 12% (Figure 9) cylinder loss varied from 1 to 3%.

Body Loss: Slight seed leakage occurred from the two doors on top of the feeder house, from the top inspection door of the clean grain elevator and from several other locations, but was insignificant. Total grain leakage from the combine body measured in a 1.3 t/ha (20 bu/ac) crop of Linott flax, was only 0.05% of yield.

LOSS CHARACTERISTICS ON SIDEHILLS

Table 5 gives comparisons of the capacity of the JD 6600 at a 3% loss level, with and without automatic side levelling. These results, as well as those in Figures 12 to 15, were collected in a crop of damp Betzes barley averaging 1.97 t/ha (37 bu/ac). Width of cut was 5.5 m (18 ft) while grain moisture content was 18.6%. Average MOG/G Ratio was 1.28.

Automatic side levelling did not appreciably influence combine capacity on side slopes less than 3°. However, in this crop, automatic levelling increased combine capacity about 1.7 times on a 6° side slope and about 3 times on a 9° side slope.

Table 5. Capacity of the JD 6600 at Various Side Slopes, with and without Automatic Levelling.

	Capacity with Automatic Levelling						Capacity with Side Levelling					
	MOG Feedrate		Grain Feedrate		Ground Speed		MOG Feedrate		Grain Feedrate		Ground Speed	
Side Slope	t/h	lb/min	t/h	bu/h	km/h	mph	t/h	lb/min	t/h	bu/h	km/h	mph
0° - 3°	6.3	232	4.9	226	4.8	3.0	6.3	232	4.9	226	4.8	3.0
6°	6.3	232	4.9	226	4.8	3.0	3.7	136	3.2	147	2.9	1.8
9°	6.3	232	4.9	226	4.8	3.0	2.1	77	1.5	70	1.3	0.8

Figures 12 to 15 show cylinder, shoe, straw walker and total losses at various side slopes, with and without side levelling. Side slopes, up to 9° did not appreciably affect straw walker or cylinder performance. Shoe losses, without automatic levelling, increased rapidly on side slopes greater than 3°. Automatic side levelling, by reducing shoe losses on side slopes, permitted the JD 6600 Sidehill to be operated at the same feedrates on side slopes, up to 9°, as on level fields.

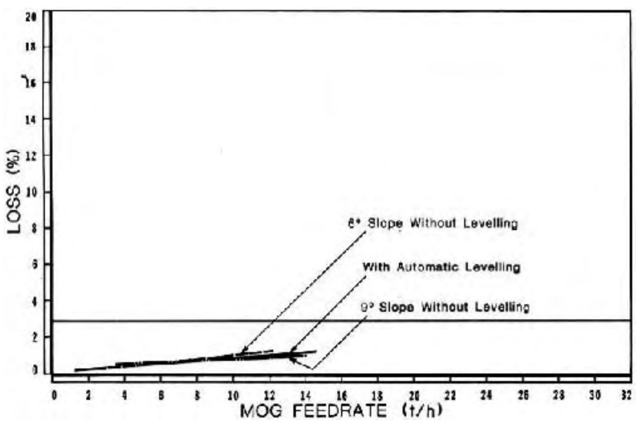

Figure 12. Cylinder Losses for the JD Sidehill 6600 with and without Automatic Side Levelling.

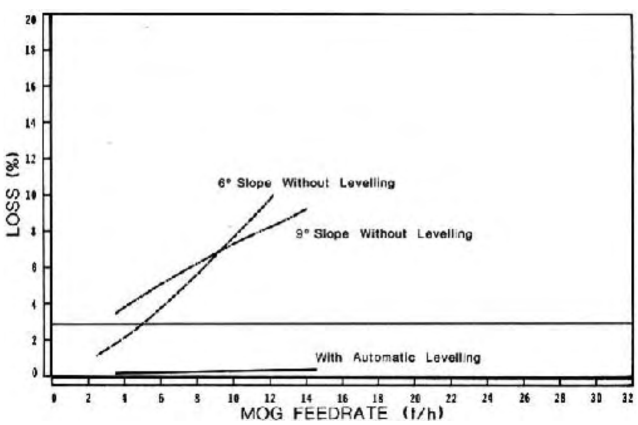

Figure 13. Shoe Losses for the JD Sidehill 6600 with and without Automatic Side Levelling.

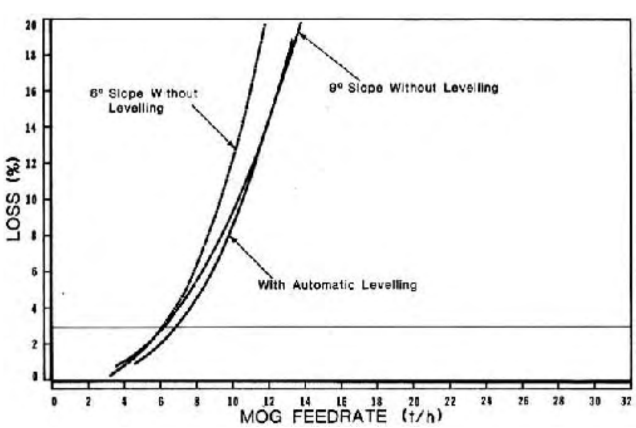

Figure 14. Walker Losses for the JD Sidehill 6600 with and without Automatic Side Levelling.

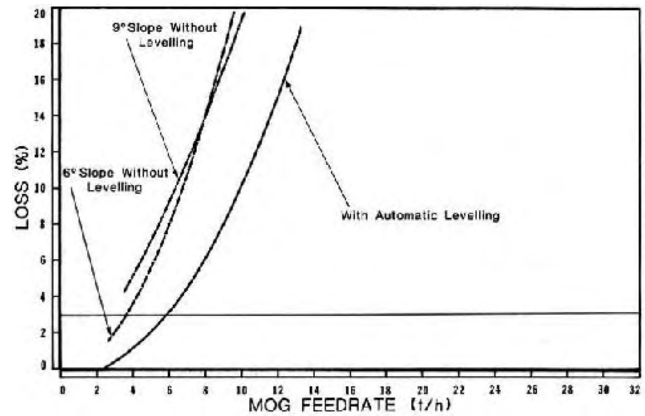

Figure 15. Total Losses for the JD Sidehill 6600 with and without Automatic Side Levelling.

OPERATOR SAFETY

The operator's manuals for both the combine and the pickup attachment emphasized operator safety precautions.

The JD 6600 had adequate warning decals. It was also equipped with a slow-moving-vehicle sign, warning lights and rear view mirrors for safe road transport.

The JD 6600 was well shielded, giving good protection from moving parts. Most shields were easy to remove and install without tools. The hydrostatic pump drive shields were difficult to remove and install as they were bolted in place. Although the main body shrouding was aesthetically pleasing, it made servicing difficult and increased repair time and difficulty.

The combine was equipped with a header lock and its proper use was emphasized in the operator's manual. The header lock must be used when working beneath the cylinder, such as when cleaning the stone trap or unplugging a choked cylinder.

No rocking wrench or rocking hub was provided for unplugging the feeder auger. This necessitated entry into the header, if plugging should occur. Entry into the header was difficult and hazardous due to sharp pickup teeth and the pickup windguard. An auger rocking wrench and hub would improve operator safety.

The operator must be cautioned about the many loaded springs used for tensioning drive tighteners.

The ladder for cab access was inconvenient to use and could be hazardous for older operators due to lack of adequate hand holds when scaling the ladder or when opening the cab door. Padding should be installed on the upper frame of the cab door to reduce the possibility of head injury when entering or leaving the cab.

If recommended safety procedures were followed, all adjustments could be safely made. Lubricating the grease fittings under the operator's platform required raising a door to which the seat was attached. A hard hat is recommended when working in this area to avoid head injury.

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

OPERATOR'S MANUAL

Operator's manuals were provided for both the combine and the windrow pickup. Since the combine operator's manual contained information for three models of combines with various attachments it was lengthy and contained much information, which did not pertain to the model 6600. The index was incorrect on many references, making it difficult to find some specific items. The manual was, however, clearly written, well illustrated and contained much useful information on servicing, adjustments and suggested settings in various crops. The manual did not include complete information on the pickup platform.

DURABILITY RESULTS

Table 6 outlines the mechanical history of the John Deere 6600 Sidehill combine during 107 hours of operation while combining about 186 ha (461 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 6. Mechanical History

Item	Operating Hours	Field Area ha	Field Area (ac)
Header Assembly			
-The table auger slip clutch stub shaft broke and was replaced at	33	63	(156)
-Many bolts on the header had loosened and were tightened at	33	63	(156)
-An auger finger, bushing and retainer were lost and replaced at	53	100	(247)
-The spring retaining bolts on the table auger slip clutch loosened and were re-secured at	78	144	(356)
Drives			
-The table auger drive chain stretched and was replaced at	33	63	(156)
-The rotary cooling screen drive belt broke when the engine was started without first freeing the screen. The belt was replaced at	79	146	(361)
-The lower left tailings elevator bearing failed and was replaced at	82	148	(366)
-The timing chain between the cylinder variable speed sheaves came off. The chain was remounted and the Sheaves retimed at	88	157	(388)
This recurred at	103	183	(452)
-The main separator drive belt jumped out of the guides, and was badly damaged by the hydro-static drive belts. The belt was replaced and the guides positioned at	97	172	(425)
Cylinder and concave			
-The front concave bar was bent, requiring straightening when a stone entered the cylinder at	End of Test		
Miscellaneous			
-The combine drifted to the right and counter clockwise steering wheel rotation was constantly required. The steering valve was replaced at	7	15	(37)
-Two headlights and a warning light had burned out and were replaced by	End of Test		

Discussion of Mechanical Problems

TABLE AUGER SLIP CLUTCH

The table auger slip clutch broke at the weld attaching the jaw plate to the stub shaft. Failure appeared to be caused by poor weld penetration, and may have been initiated by over tightening of the slip clutch in a crop of heavy rapeseed. The operators' manual contained no information on correct slip clutch adjustment.

MAIN SEPARATOR DRIVE BELT

The main separator drive belt, a banded triple V-belt, jumped over one groove on the separator drive pulley; and was badly damaged by the hydrostatic drive belts. It could not be determined if the belt had forced the guides away during operation or if the guides had been improperly set during pre-delivery. Replacing the belt was a major repair operation, taking one man six hours.

APPENDIX I
SPECIFICATIONS

Make:	John Deere Self-Propelled Combine
Model:	Sidehill 6600
Serial Number:	Combine Body 209553H, Engine 514505 RG
Manufacturer:	John Deere Harvester Works East Moline, Illinois 61244 U.S.A.
Windrow Pickup:	
-- type	belt
-- pickup width	3350 mm (132 in)
-- number of belts	6
-- teeth per belt	70
-- type of teeth	spring steel
-- number of rollers	3
-- height control	castor wheels
-- speed control	hydrostatic
-- speed range	50 to 400 rpm
Header:	
-- type	centre feed, follows ground contour when combine levels
-- width	3590 mm (11.8 ft)
-- auger diameter	610 mm (24 in)
-- feeder	6 fabric belted paddles
-- paddle speed	265 to 435 rpm
-- range, of picking height	-390 to 1030 mm (-15.4 to 40.6 in)
-- number of lift cylinders	2
-- raising time	5 s
-- lowering time	adjustable
-- options	straight combining headers, corn headers, automatic header height control, header float springs, feeder house closure strips, perforated elevator and feeder house parts, electromagnetic header clutch.
Cylinder:	
-- type	rasp bar
-- number of bars	8
-- diameter	559 mm (22 in)
-- width	1096 mm (43.15 in)
-- drive	crank controlled Variable pitch belt
-- speeds (standard)	450 to 1220 rpm
-- speeds (optional)	280 to 845 rpm
-- stripper bar	10 mm (3/8 in) fabric belting
Cylinder beater:	
-- type	drum with 4 triangular bats
-- diameter	330 mm (13 in)
-- speed	varies with cylinder speed
Concave:	
-- type	bar and wire grate
-- number of bars	13
-- configuration	12 intervals with 6.2 mm (0.25 in) wires and 17 mm (0.69 in) spaces
-- area	0.57 m² (885 in²)
-- transition grate area	0.29 m² (455 in²)
-- wrap	105 degrees
-- grain delivery to shoe	5 auger conveyors
-- options	concave filler bars, stone trap cover
Straw walkers:	
-- type	rotary, formed metal
-- number	4
-- length	3302 mm (130 in)
-- width of body	1118 mm (44 in)
-- separating area	3.69 m² (5 720 in²)
-- crank throw	152 mm (6 in)
-- speed	157 rpm
-- grain delivery to shoe	5 auger conveyors
-- options	risers, plugging sensor
Shoe:	
-- type	opposed action
-- speed	275 rpm
-- chaffer sieve	adjustable lip, 1.65m² (2550 in²) with 47 mm (1.88 in) throw
-- clean grain sieve	adjustable lip, 1.24 m² (1928 in²) with 39 mm (1.50 in) throw
Cleaning fan:	
-- type	4 blade undershot
-- diameter	510 mm (20 in)
-- width	1080 mm (42.5 in)
-- drive	crank controlled variable pitch belt
-- speed range	280 to 970 rpm
Elevators:	
-- type	roller chain with rubber flights and top delivery
-- clean grain (top drive)	162 mm x 241 mm (6.38 in x 9.5 in)
-- tailings (bottom drive)	130 x 203 mm (5 in x 8 in)

Grain tank:	
-- capacity (with optional	4.9 m³ (134 bu) extensions)
-- unloading time	96 s
-- options	grain tank extensions, extended tank loading auger
Straw chopper:	
-- type	rotor with 24 freely swinging hammer
-- speed	2350 rpm
-- options	straw spreader
Engine:	
-- make and model	John Deere 404DH - 05
-- type	4 stroke naturally aspirated diesel
-- number of cylinders	6
-- displacement	6.62 L (404 in³)
-- governed speed (full throttle)	2650 rpm
-- manufacturer's rating at	89.5 kW (120 hp) 2650 rpm
-- fuel tank capacity	216 L (47.5 Imp. gal)
-- options	air restriction indicator
Clutches:	
-- header	electromagnetic
-- separator	V-belt
-- unloading auger	V-belt
Number of chain drives:	14
Number of belt drives:	22
Number of pre-lubricated bearings:	92
Lubrication points:	
-- 10 h lubrication	20
-- 50 h lubrication	37
-- 100 h lubrication	17
-- 250 h lubrication	2
-- 500 h lubrication	1
Tires:	
-- front	2, 23.1 x 26, 8-ply
-- rear	2, 11.0 x 16, 6-ply
Traction drive:	
-- type	hydrostatic (optional)
-- speed ranges with 23.1 x 26 tires	
-- forward -- 1st gear	0 to 3.0 km/h (0 to 1.8 mph)
-- 2nd gear	0 to 6.6 km/h (0 to 4.1 mph)
-- 3rd gear	0 to 12.4 km/h (0 to 7.7 mph)
-- 4th gear	0 to 29.7 km/h (0 to 18.5 mph)
- reverse -- 1st gear	0 to 1.8 km/h (0 to 1.1 mph)
-- 2nd gear	0 to 4.1 km/h (0 to 2.5 mph)
-- 3rd gear	0 to 7.4 km/h (0 to 4.6 mph)
-- 4th gear	0 to 10.1 km/h (0 to 6.3 mph)
Overall dimensions:	
-- wheel tread (front)	3050 mm (120 in)
-- wheel tread (rear)	1626 to 2210 mm (66 to 87 in)
-- wheel base	3780 mm (149 in)
-- transport height	3810 mm (150 in)
-- transport length	8860 mm (349 in)
-- transport width	4480 mm (176 in)
-- field height	3990 mm (157 in)
-- field length	8560 mm (337 in)
-- field width	6930 mm (273 in)
-- unloader discharge height	3350 mm (132 in)
-- unloader clearance height	3300 mm (130 in)
-- unloader reach	2450 mm (96 in)
-- turning radius -- left	7320 mm (288 in)
-- right	9090 mm (358 in)
-- clearance radius -- left	7870 mm (3l0 in)
-- right	12,040 mm (474 in)
Weight: (with empty grain tank)	
-- right front wheel	3560 kg (7850 lb)
-- left front wheel	3505 kg (7730 lb)
-- right rear wheel	755 kg (1660 lb)
-- left rear wheel	765 kg (l690 lb)
Total	8585 kg (18,930 lb)

APPENDIX ii

STATISTICAL SIGNIFICANCE OF CAPACITY RESULTS

The following data are presented to illustrate the statistical significance of the capacity results shown in Figures 8 to 11. This information is intended for use by those who may wish to check results in greater detail. Sufficient information is presented to permit calculation of confidence belts.

In the following table for the John Deere 6600 Sidehill combine, C = cylinder loss in percent of yield, S = shoe loss in percent of yield, W = straw walker 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 loss collections. Limits of the regressions may be obtained from Figures 8 to 11 while crop conditions are presented in Table 4.

Crop Variety	Fig. No.	Regression Equation	Simple Correlation Coefficient	Standard Error of Slope	Residual Mean Square	Mean Feed-rate	Sample Size
Wheat — Neepawa	8	$\ln C = -1.66 + 1.13 \ln F$	0.95	0.16	0.05	8.05	7
		$\ln S = -4.80 + 1.48 \ln F$	0.80	0.50	0.46		
		$\ln W = -8.44 + 4.36 \ln F$	0.95	0.64	0.74		
Wheat — Neepawa	9	$C = 0.71 + 0.16 F$	0.84	0.04	0.20	8.96	8
		$S = 0.06 + 0.01 F$	0.39	0.01	0.01		
		$\ln W = -5.84 + 3.05 \ln F$	0.96	0.35	0.30		
Barley — Bonanza	10	$C = 0.99 - 0.03 F$	0.32	0.04	0.10	9.23	8
		$S = -0.73 + 0.22 F$	0.81	0.06	0.28		
		$\ln W = -3.27 + 2.47 \ln F$	0.97	0.27	0.08		
Flax — Linott	11	$C = 0.50 - 0.01 F$	0.08	0.08	0.02	3.79	5
		$S = -0.01 + 0.01 F$	0.58	0.01	0.0002		
		$\ln W = -2.01 + 0.57 \ln F$	0.34	0.91	0.19		

APPENDIX III

MACHINE RATINGS

The following rating scale is used in P.A.M.I. Evaluation Reports:

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

APPENDIX IV

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)	= 2 204.6 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 meter (m)	= 39.37 inches (in)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 litre/hour (L/h)	= 0.22 Imperial gallons/hours (gal/h)

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