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Evaluation Report 53

Sperry New Holland TR70 Self-Propelled Combine

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

SPERRY NEW HOLLAND TR70 SELF-PROPELLED COMBINE

MANUFACTURER:
Sperry New Holland
Division of Sperry Rand Corporation
New Holland, Pennsylvania 17557

DISTRIBUTORS:
Sperry New Holland
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Box 1907, Regina, Saskatchewan S4N 2S3
Box 1616, Calgary, Alberta T2P 2M7

RETAIL PRICE:
$58,938.00, July, 1978, f.o.b. Humboldt, with 3960 mm (13 ft) table, 3200 mm (126 in) Melroe pickup, straw spreader, shaft speed monitor, grain tank extensions, cab heater and air conditioner, pre-cleaner extension, fixed air stack extension, engine shut-off kit and engine hour meter.

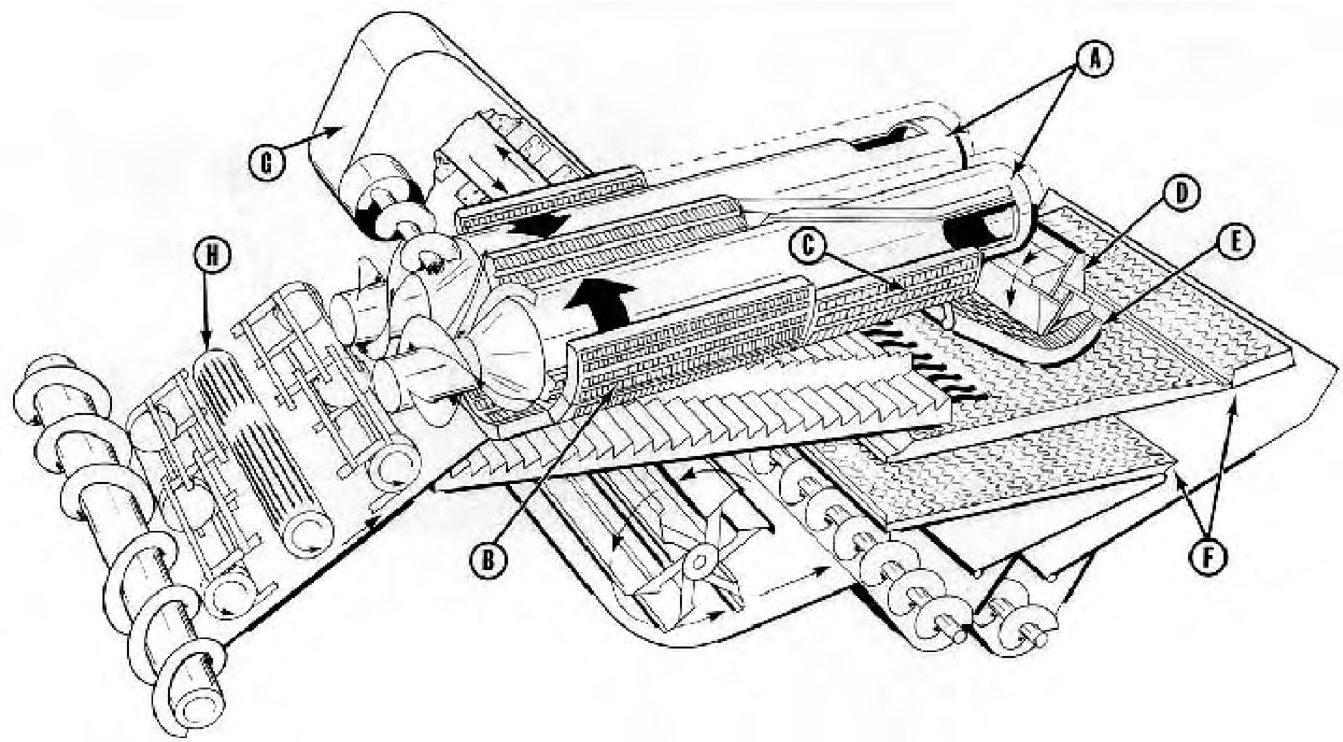

FIGURE 1. Sperry New Holland TR70: (A) rotors, (B) threshing concave, (C) separating concave, (D) back beater, (E) beater grate, (F) shoe, (G) tailings return, (H) stone ejection roller.

SUMMARY AND CONCLUSIONS

Functional performance of the Sperry New Holland TR70 self-propelled combine was excellent in dry grain and oil seed crops. Functional performance was very good in tough crops and fair in damp crops.

The MOG feedrate[1] at 3% total grain loss was 16.4 t/h (603 lb/min) in 3.63 t/ha (67 bu/ac) Bonanza barley. In 3.51 t/ha (52 bu/ac) Neepawa wheat the total grain loss at engine power limit was only 2.5% of yield at a MOG feedrate of 15.5 t/h (570 lb/min). In 3.12 t/ha (58 bu/ac) Betzes barley the total grain loss at engine power limit was only 1.5% of yield at a MOG feedrate of 14.35 t/h (527 lb/min). The capacity of the Sperry New Holland TRT0 was much greater than the capacity of the PAMI reference combine since the TR70 had much lower grain losses when operating at the same feedrate. Rotor, shoe and cylinder losses all were low over the full operating range.

The Sperry New Holland TR70 distributed the incoming crop uniformly to both rotors only if the windrow was parallel and was fed into the centre of the feeder housing. Angled or bunchy windrows fed irregularly with more crop delivered to one rotor than the other. Driving off-centre caused most of the crop to feed to one rotor, leading to occasional rotor plugging and non-uniform shoe loading. Maximum capacity was obtained with parallel windrows centred on the feeder housing. Double-swathing of fields, with consecutive windrows placed side-by-side, is recommended to permit uniform distribution to both rotors and utilization of full combine capacity.

Engine power limited the capacity in most crops. Fuel consumption varied from 32 to 36 L/h (7 to 8 gal/h). The rotary radiator air intake screen permitted chaff and dust entry causing radiator plugging and engine overheating, but replacement with an optional fixed air stack extension remedied the problem. The engine air filter pre-cleaner also plugged until an optional extension was installed. The engine started well, but at temperatures below +5°C, ether was needed to start the cold engine.

The steering and braking systems were very good. By using the individual wheel brakes it was possible to pick most sharp corners formed by the self-propelled windrowers. Instruments and controls were conveniently positioned. Most 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 station was about 85 db(A).

Header visibility was good both in the daytime, and at night, although the steering wheel column restricted windrow visibility. Grain level visibility was excellent. Rear visibility was restricted. The rear view mirrors were needed for road transport. Normal caution was required when operating the Sperry New Holland TR70 at maximum transport speed of 26 km/h (16.1 mph).

The Sperry New Holland TR70 was quite easy to adjust for specific field conditions. Adjustment would have been easier if return tailings could have been inspected. The optional shaft

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

speed monitoring system was helpful by warning the operator of malfunction. Ease of servicing was good.

The rotors, table auger and feeder all were positive and aggressive. Plugging was infrequent, even in tough crops. Unplugging the rotors was inconvenient.

The stone ejection roller and stone trap door ejected all large stones and wads before they entered the rotors, although smaller pebbles caused minor wear on the rotor housing. Upon tripping, the stone trap door had to be manually reset.

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

No serious safety hazards were noticed when operated according to the manufacturers recommended procedures. The operator's manuals were well illustrated and contained useful information on servicing and adjustments for most crops.

No major durability problems occurred during the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifications to improve windrow visibility over the steering column.
2. Modifications to eliminate radiator plugging.
3. Providing a rocking hub to facilitate unplugging of the table auger and feeder housing.
4. Modifying the shear pin location in the rotor variable speed adjustment linkage to simplify replacement.
5. Providing padding for the upper frame on the cab door to reduce the possibility of head injuries.
6. Providing suitable clearance gauges to aid in initial concave levelling and adjustment.
7. Revising the operator's manual to improve clarity and to provide explicit adjustment procedures for initial concave settings and rotor variable speed drive settings.

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 new operator station design, incorporating a steering column, which allows improved visibility, is under development.
2. Several changes to reduce radiator plugging are under development and will be incorporated on future production.
3. We will take this recommendation under consideration on updated designs.
4. The shear pin has been eliminated on current production.
5. We will consider this recommendation for improved operator cabs now under development.
6. Gauges to level and adjust concaves can be made from 3/16 inch stock. We do not plan to furnish any special tools.
7. The operator's manual contains information for concave or rotor settings, and adjustments. We will try to clarify or simplify these in the next manual production.

GENERAL DESCRIPTION

The Sperry New Holland TR70 is a self-propelled combine with two longitudinally mounted, axial, threshing and separating rotors. Threshing occurs at the front section of the rotors while separation of grain from straw is accomplished with full length threshing and separation concaves in conjunction with a rear beater and grate. A cleaning shoe is used, with return tailings delivered to the front of the rotors. A stone ejection roller is mounted within the feeder housing.

The test machine was equipped with a 124 kW (166 hp) eight cylinder Caterpillar diesel engine, a 3960 mm (13 ft) header, a 3200 mm (126 in) Melroe 351 pickup and the optional accessories listed on PAGE 2.

The traction drive is through a four speed transmission with a single plate dry clutch and variable speed belt. The Sperry New Holland TR70 is equipped with hydraulic wheel brakes, power steering and a pressurized operator's cab.

The separator drive is lever controlled through a double plate dry clutch, while the header and grain tank unloading drives are lever controlled through over-centre belt tighteners.

Hydraulic levers control the ground speed, header height and unloading auger swing. Pickup speed, Concave clearance and rotor speed can be adjusted on-the-go 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 multi-positional levers at the rear of the shoe. There is no provision to safely and quickly sample the return tailings.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Sperry New Holland TR70 was operated in a variety of Saskatchewan crops (TABLES 1 and 2) for 121 hours while harvesting about 249 ha (616 ac). It was evaluated for ease of operation, ease of adjustment, rate of work, grain loss characteristics, feeding and threshing 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	2.7	40	5.5	18	5.5	14	35
Wheat	Neepawa	3.0	44	4.9-6.1	16-20	19.5	43	106
Barley	Betzes	3.2	59	4.9-7.3	16-24	24.5	62	153
Barley	Bonanza	3.7	68	5.5-7.3	18-24	45.5	66	163
Barley	Conquest	3.5	65	7.3	24	5.0	12	30
Barley	Fergus	2.4	45	5.5	18	1.5	4	10
Barley	Klondike	2.2	40	7.3	24	4.5	15	37
Rapeseed	Tower	1.9	33	4.9-6.1	16-20	14.0	33	82
Total						121.0	249	616

TABLE 2. Operation in Stony Fields

Field Conditions	Hours	Field Area	
		ha	ac
Stone Free	68	147	364
Occasional Stones	45	85	210
Moderately Stony	8	17	42
Total	121	249	616

RESULTS AND DISCUSSION

EASE OF OPERATION

Operator Location: The Sperry New Holland TR70 was equipped with an operator's cab as standard equipment. The cab was positioned ahead of the grain tank centred on the combine body giving good visibility to the left, front and right. Visibility to the rear was completely obstructed necessitating caution when manoeuvring in confined areas. The rear view mirrors improved rear visibility for road transport. Header visibility was good both in the daytime and at night. The grain level could be viewed through a large window but grain and return tailings could not be sampled from the operator's seat.

The steering column obstructed the operator's view of the incoming windrow, resulting in a tendency to feed the windrow to the right of centre (FIGURE 2). Since centering the windrow on the feeder housing is important in obtaining equal flow to both rotors, it is recommended that the manufacturer consider modifications to improve visibility over the steering column.

The operator's seat was comfortable and easy to adjust. The steering column was 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 system effectively filtered the incoming air and reduced dust leaks. The optional heating and air conditioning systems provided suitable cab temperatures in all operating conditions.

Total noise at operator ear level was about 85 db(A) with all doors and windows closed.

Controls: The control arrangement is shown in FIGURE 3. Most controls were conveniently placed, easy to use and responsive. The gear shift lever interfered with the variable speed lever when shifting between third and fourth gear, and with the right armrest when shifting to reverse. Rotor speed adjustment was slow due to the large reduction ratio of the system. The hydraulically controlled pickup drive and the responsive header lift gave the operator good control. Header lift was quick enough to suit all conditions; header drop rate was adjustable.

FIGURE 2. Operator's View of the Windrow, Over the Steering Column and to the Right of the Steering Column.

Steering: Steering and maneuverability were very good. The power steering was smooth and responsive. Although the 7010 mm (24 ft) turning radius was large, 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.

Instruments: The instrument console (FIGURE 4) included gauges for engine oil pressure, coolant temperature, battery charging, fuel level, engine hours, variable speed position and rotor speed. Indicator lights were provided for engine oil pressure, battery charging, transmission oil pressure, parking brake and the unloading auger position. The optional engine shutoff panel contained engine oil pressure and coolant temperature gauges with automatic shutoff, stop and reset buttons.

The optional shaft speed monitors (FIGURE 5) were useful in detecting component stoppage. They monitored the tailings elevator, clean grain elevator, shoe, fan, rotors and straw chopper, signalling the operator if any shafts fell below 80% of normal speed. Also monitored were the air filter, stone trap door and grain bin level.

Lights: The Sperry New Holland TR70 was equipped with four front lights and three rear lights. Header lighting, long range front lighting and lighting for the grain tank, unloading auger and area behind the combine all were very good.

Engine: The engine had ample power for normal combining but operated near its power limit when combining damp crops on soft, hilly fields. Average fuel consumption varied from 32 to 36 L/h (7 to 8 gal/h). The engine was located behind the grain tank and was very accessible.

The rotary radiator air inlet screen was ineffective in preventing radiator plugging. Dust and chaff entered the radiator through the screening or the dust seal. Cleaning was difficult as the chaff lodged within the radiator core. After the rotary radiator air inlet screen was replaced with a fixed air stack, no further problems occurred. Addition of the air stack increased combine height by 760 mm (30 in) necessitating caution when transporting. It is recommended that the manufacturer provide modifications to the rotary inlet screen to eliminate radiator plugging.

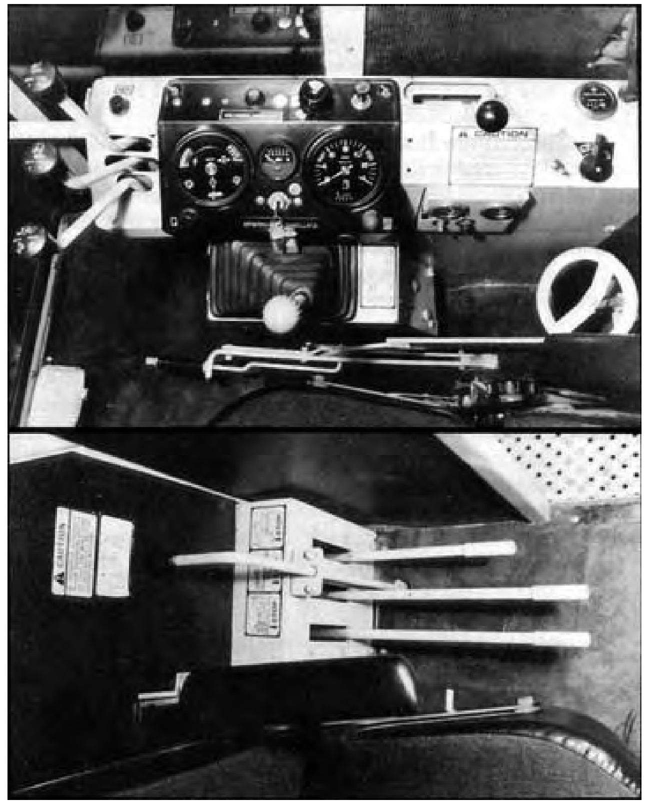

FIGURE 3. Control Layout.

FIGURE 4. Instrument Console.

FIGURE 5. Shaft Speed Monitors.

The engine air intake used a screen precleaner, a centrifugal bowl cleaner and two dry filters. The dry filter element required infrequent servicing if the precleaner bowl was emptied before it completely filled. The monitoring system warned the operator if the filter needed servicing. The screen precleaner plugged frequently, especially when operating with a tail wind. Installation of an optional precleaner extension greatly reduced plugging.

The engine started easily. A lockout had to be depressed for five seconds to disengage the automatic shut off switches before the engine could be started. If ambient temperature dropped below +5°C, ether was needed to start the cold engine. Engine oil consumption was insignificant.

The fuel tank inlet was located 2590 mm (8.5 ft) above the ground, causing some problems when the tank was filled from average height gravity fuel tanks.

Stability: The Sperry New Holland TR70 was very stable, even with a full grain tank. The centre of gravity, with a three-quarters full grain tank was about 1930 mm (75 in) above ground, 780 mm (31 in) behind the drive wheels and 130 mm (5 in) left of the combine centre line. Normal care had to be used when turning corners on hillsides.

Grain Tank: The grain tank, when equipped with optional extensions, held 6.35 m^3 (175 bu) of wheat. Unloading a full hopper of dry wheat took 124 seconds. The grain tank filled evenly in all crops. On hillsides, the grain tank occasionally filled without activating the grain bin level monitor.

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

Straw Spreaders: The optional straw spreader attachment performed well in all crops. Maximum spreading width varied from 4.6 to 6.1 (15 to 20 ft), depending on straw and wind conditions. If the straw was to be windrowed, the paddle assemblies were easily removed.

As is common with axial combines, the rotors broke straw into short lengths and a straw chopper was not necessary. As a result, poor pickup performance and reduced bale quality sometimes occurred when baling this straw. An optional windrow shield assembly which funnels the discharged straw into a denser windrow is available but was not evaluated.

Plugging: The table auger was aggressive and when properly adjusted, plugging seldom occurred even in damp crops. Plugging occurred only twice during the test in wet bunchy windrows. Unplugging was difficult because of shielding by the pickup wind guard. A rocking hub on the table auger would have facilitated unplugging. It is recommended that the manufacturer consider providing a rocking hub on the table auger to facilitate unplugging.

The feeder housing had high capacity in all crops and plugged only once during the test on a wad of wet straw. Unplugging was difficult as no device was provided to rotate the feeder housing backwards.

Plugging of the rotors was prevented on many occasions by the stone ejection roller and stone trap door. When a large wad of straw was delivered between the roller and the stone trap door, the stone trap door opened against a spring catch discharging the wad out the bottom of the feeder housing. Several times straw wrapped tightly around the stone roller and had to be cut away with a knife. To reduce this problem the feeder should be disengaged immediately upon warning that the stone trap door is open.

The rotors were very aggressive and positive. Backfeeding never occurred. Rotor plugging occurred infrequently. If the rotors plugged, they could sometimes be unplugged from the operator's seat by lowering the concaves. On three occasions, in which serious plugging occurred, it took about three-quarters of an hour to unplug the rotors. In each case, the right rotor was severely plugged while the left rotor was free. Although the rotor drive jack shaft was equipped with a rocking hub, it usually was ineffective in freeing the plug. It was usually necessary to remove the plug by hand. Rotor access was difficult since both the side panels and the concave extensions had to be removed to free the rotors. Fastest unplugging was accomplished by removing the main concave support J-bolts, and swinging the concave free from the rotor. Driving the combine centred upon the feeder housing to provide even feeding to both rotors and keeping the stone trap door in correct adjustment were very important in reducing rotor plugging.

Stone Ejection Device: The Sperry New Holland TR70 is equipped with a stone ejection roller in the middle of the feeder housing (FIGURE 6). The stone trap door, retained by an adjustable spring loaded latch is located beneath the adjustable ejection roller. When a large straw wad or a foreign object is forced under the roller, the door opens ejecting the object. When the door opens, a monitor is triggered to inform the operator. The operator then has to stop the combine, leave the cab, secure the header and close the door. The ejection roller was very effective, ejecting most roots, stones or wads before they entered the rotors. Examination of the rotor housings after testing showed negligible damage, although there were many small scars, which were probably caused by small stones.

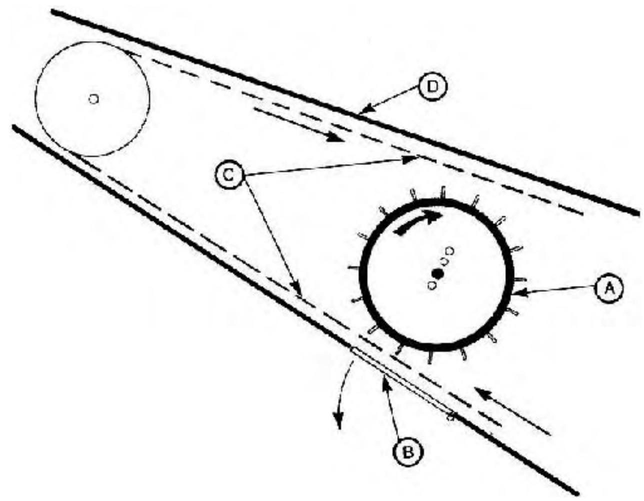

FIGURE 6. Stone Protection. (A) stone ejection roller (B) door, (C) feeder chain, (D) feeder housing.

In bunchy rapeseed windrows, the stone roller had to be raised to its highest position to increase feeder capacity. In this position, only limited stone protection was provided. It was important to operate the stone roller at minimum possible clearance to provide optimum stone protection.

The stone trap door as delivered from the factory could not be. closed due to interference between the catch and the retaining latch necessitating straightening of the latch.

Pickup: The Sperry New Holland TR70 was equipped with a 3200 mm (126 in) Melroe Model 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 with a foot pedal controlling hydraulically actuated variable sheaves, was adequate for all crops.

Machine Cleaning: As with most combines, completely cleaning the Sperry New Holland TR70 for combining seed grain was laborious and time-consuming. The chaffer and sieve were easy to remove and the tailings and clean grain auger troughs could be cleaned by removing the pans beneath the augers. The grain tank was quite easy to clean if the auger discharge covers were raised to their maximum height. Since the combine was quite dusty, chaff accumulated quickly on ledges or obstructions. The tops of the rotor housings beneath the grain tank and engine accumulated a large amount of chaff and were difficult to clean.

Lubrication: The Sperry New Holland TR70 had 50 pressure grease fittings. Seven needed greasing every 10 hours, twenty-seven needed greasing every 50 hours, eight needed greasing every 100 hours, while two had to be greased at 250 hours and six had to be greased at 500 hours. Engine and hydraulic oil levels required daily checking. Forty-three service points required oiling at 50 to 500 hour intervals. Four fittings were difficult to reach; the remainder were quite accessible. Many of the decals indicating lubrication frequency were improperly placed.

A service bulletin circulated during the test advised that the 100 hour lubrication interval be changed to a 10 hour interval for the main shaft bearings. All future operator's manuals should indicate the 10 hour lubrication interval.

EASE OF ADJUSTMENT

Field Adjustments: The Sperry New Holland 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: Each rotor was equipped with a set of concaves (FIGURE 7), consisting of an adjustable threshing portion and a stationary separating portion. Access to the threshing concaves was through doors on both sides of the combine.

Levelling and adjustment of initial concave clearance was very difficult, and was possible only after fabricating a suitable clearance gauge for use on the leading concave bars. It is recommended that the manufacturer supply suitable gauges and a more explicit concave levelling and initial adjustment procedure in the operator's manual. Suitable initial concave settings (FIGURE 8), with the operator station control lever in its first notch, were 6 mm (0.22 in) at the leading bars and 1 mm (0.04 in) at the trailing bars.

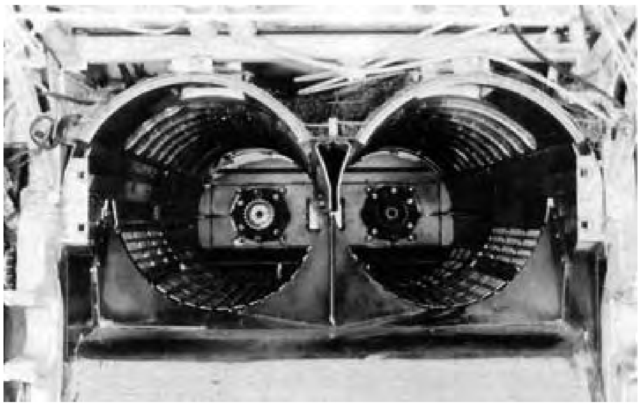

FIGURE 7. Threshing and Separating Concaves.

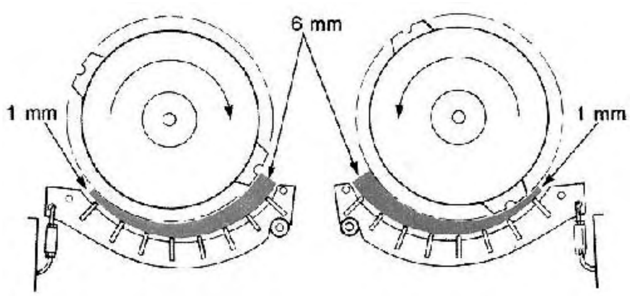

FIGURE 8. Initial Concave Settings used in Grain and Oilseeds.

Once the concaves had been initially set, clearance was easily adjusted with a lever in the operator's cab. The control linkage held the leading and trailing concave bars parallel to the rotor axis, however the leading bars opened faster than the trailing bars. Leading bar clearances could be varied from 6 to 36 mm (0.24 to 1.42 in), while trailing bar clearances could be varied from 1 to 20 mm (0.04 to 0.79 in).

Concave adjustments were not needed as frequently as on conventional combines with tangential threshing cylinders. Suitable concave control lever settings were notches number 2 in tough wheat, number 4 in dry wheat, number 3 in tough barley, number 5 in dry barley, number 4 in tough rapeseed and number 6 in dry rapeseed. Greater differences in threshing were obtained with rotor speed adjustment than with concave clearance adjustment.

The concave extensions are attached to the adjustable main concaves and their clearances are controlled by the main concaves and the combine side sheets. The concave extensions provide additional threshing and separating area.

Rotor Adjustment: The rotors (FIGURE 9) were powered through two gearboxes and a variable speed drive, adjustable from the operator's seat.

During run in, the rotor variable speed adjustment assembly became inoperative when a protective shear pin failed. Pin replacement was very difficult and it is recommended that the manufacturer consider modifying the shear pin location to simplify replacement.

The variable drive provided a rotor speed range from 525 to 1140 rpm, when initial settings were in accordance with the operator's manual. This range was inadequate for most prairie crops. Initial settings were changed to provide a range from 700 to 1325 rpm, which was satisfactory for all crops, it is recommended that the manufacturer supply explicit instructions in the operator's manual for initial rotor variable speed drive settings.

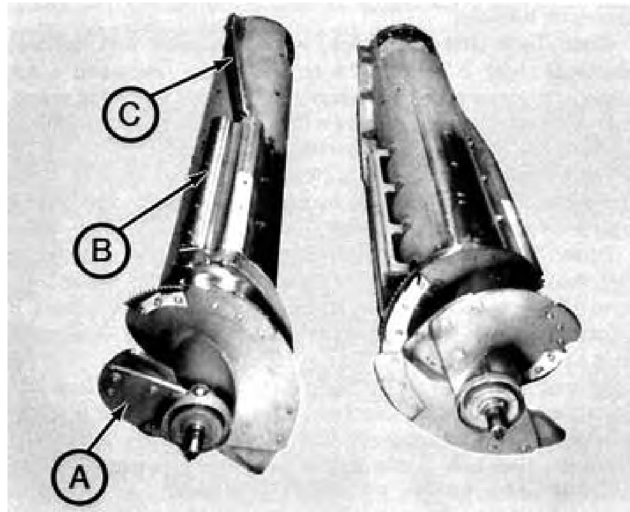

FIGURE 9. Rotors (A) Feed Augers (B) Rasp Bars (C) Separation Fins.

Higher rotor speeds than indicated in the operator's manual could be used. Suitable rotor speeds were 1100 rpm in dry wheat, from 1200 to 1300 rpm in tough wheat, 1200 rpm in both tough and dry barley, 1000 rpm in dry rapeseed and 1100 rpm in tough rapeseed. Grain crackage varied from 0.3 to 1.5% in Betzes and Bonanza barley and from 0.8 to 4.7% in Neepawa wheat (FIGURE 10). In Tower rapeseed crackage was about 0.3%.

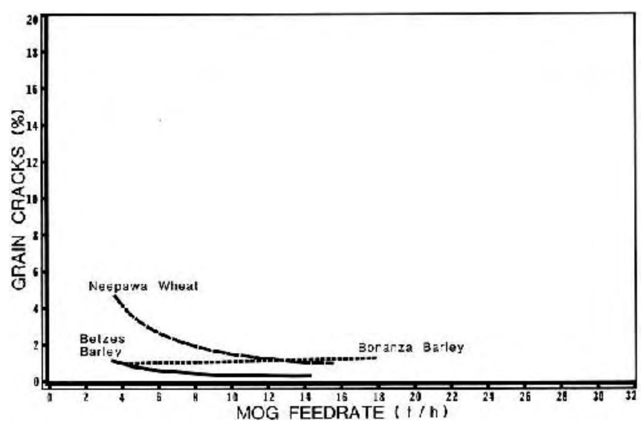

FIGURE 10. Grain Damage in Barley and Wheat.

The rotor rasp bars were in good condition at the end of the test. Wear was greater than on conventional combines with tangential threshing cylinders.

Back Beater Adjustment: The back beater and grate provide additional separation of grain and straw after leaving the rotors. The beater grate should be set in the lowest position which provides a positive straw discharge. Mid-position setting was satisfactory for most crops.

Optional beater grate end cover plates were not evaluated. Operating without the plates resulted in some spearing of straw through the bottom of the beater grate, although spearing never was serious enough to cause plugging.

Shoe Adjustments: The shoe was convenient to adjust. Fan speed was varied with a hand wheel (FIGURE 11) while the chaffer, chaffer extension and clean grain sieves were adjusted with levers at the rear of the shoe. Access to the adjusting levers was through a door at the rear of the shoe. There was no provision to safely and conveniently sample tailings to aid in machine adjustment. Fan blast could also be directed with wind boards. Windboard position was not adjusted throughout the test as shoe performance was always satisfactory without changing their position.

FIGURE 11. Fan Adjustments.

The shoe performed well in most crops. Total dockage including cracks, whitecaps and chaff usually varied from 0.5 to 2% when properly adjusted. It was best to set the shoe for optimum performance in the heavy windrow sections and to increase feedrate in light windrow sections to maintain uniform shoe load.

It was very important to feed the windrow centred on the feeder housing. Feeding off-centre delivered more crop to one rotor, overloading that side of the shoe. In rapeseed and barley, shoe loss became significant if the windrow was fed on one side of the feeder housing. One side of the shoe was insufficiently loaded while the other side was overloaded causing seed to be blown over on one side and mechanically transported over on the other. As with most combines, shoe loss increased noticeably when combining on side slopes greater than 5°, due to non-uniform shoe loading.

Header Adjustments: The Sperry New Holland TR70 was tested only with a pickup attachment for windrowed crops. Straight combining attachments were not evaluated. The table could be removed from the feeder by one man in about 10 minutes. The complete header and feeder assembly could also be removed from the combine, taking two men about 20 minutes.

The table auger was easy to adjust both vertically and horizontally and only routine adjustment was needed when moving between grain and oilseed crops.

Slip Clutches: Individual slip clutches protected the table auger, feeder conveyor and tailings elevator. In addition, the grain unloading auger was protected with a shear pin.

RATE OF WORK

Average Workrates: TABLE 3 presents the average workrates for the Sperry New Holland TR70, 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 and driving the combine empty to unload grain at a central location. During the 1977 harvest, average workrates varied from 8.3 t/h (383 bu/h) in 3.5 t/ha (65 bu/ac) Conquest barley to 4.4 t/h (194 bu/h) in 1.9 t/ha (33 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	Neepawa	3.0	44	5.0	3.1	2.1	5.3	6.1	225
Wheat	Glenlea	2.7	40	5.1	3.2	2.5	6.4	6.6	243
Barley	Betzes	3.2	59	4.8	3.0	2.5	6.2	8.0	369
Barley	Bonanza	3.7	68	3.8	2.4	1.4	3.5	5.2	237
Barley	Conquest	3.5	65	4.8	3.0	2.4	5.9	8.3	383
Barley	Fergus	2.4	45	5.3	3.3	2.7	6.6	6.5	297
Barley	Klondike	2.2	40	6.4	4.0	3.3	8.1	7.1	325
Rapeseed	Tower	1.9	33	4.8	3.0	2.4	5.9	4.4	194

Maximum Feedrate: The workrates given in TABLE 3 represent average workrates at acceptable loss levels. In most fields, grain losses were still acceptable when the engine was operated near its power limit. In most heavy crops the maximum acceptable feedrate was limited by engine power, 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 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 the 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 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, unthreshed 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 loss and consists of shoe loss and rotor 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. Combine capacity may also be expressed as the MOG Feedrate at which the engine reaches its power limit if this occurs before the total grain loss reaches 3% of yield.

Capacity of the Sperry New Holland TR70: TABLE 4 presents capacity results for the Sperry New Holland TR70 in three different field crops and in one laboratory run.

The MOG Feedrate at 3% total grain loss was 16.4 t/h (603 lb/min) in 3.63 t/ha (67 bu/ac) Bonanza barley. In 3.51 t/ha (52 bu/ac) Neepawa wheat the total grain loss at engine power limit reached only 2.5% of yield at a MOG Feedrate of 15.5 t/h (570 lb/min). In 3.12 t/ha (58 bu/ac) Betzes barley the total grain loss at engine power limit reached only 1.5% of yield at a MOG Feedrate of 14.35 t/h (527 lb/min).

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics for the Sperry New Holland TR70 in the four crops described in TABLE 4 are presented in FIGURES 12 to 15.

Rotor Loss: Rotor losses were very low throughout the full operating range. With most other combines, straw walker loss is the most significant factor limiting capacity in all grain crops.

The good separating performance of the axial threshing and separating system was attributed to the large threshing and separating concave areas and the number of times the straw passed by the concaves. The exponential increase in grain loss with increased MOG Feedrate, which is common with conventional combining was not present at available power levels.

Shoe Loss: Shoe loss rarely limited combine capacity although adjustment was critical in rapeseed and high losses could occur with improper settings.

Cylinder Loss: Cylinder loss was low in all dry and well matured crops. Although loss increased slightly in tough and damp crops, it was always acceptable. The good threshing performance of the rotors in all crops and conditions was attributed to the large number of times that the straw passed by the concaves.

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[1]	Neepawa	4.9	16	3.12	58	21.0	17.3	1.09	14.35	527	13.20	606	8.6	5.4	Fig. 12 & 16
Wheat[1]	Neepawa	6.1	20	3.51	62	11.3	14.2	0.96	15.50	570	16.15	594	7.5	4.7	Fig. 13 & 17
Barley	Bonanza	7.3	24	3.63	67	26.5	14.0	1.32	16.40	603	12.40	571	4.7	2.9	Fig. 14 & 18
Wheat (Laboratory run)	Linott	7.3	24	4.34	65	15.5	15.8	1.35	22.75	835	16.85	620	5.3	3.3	Fig. 15

[1]Capacity limited by engine power at total loss less than 3% of yield.

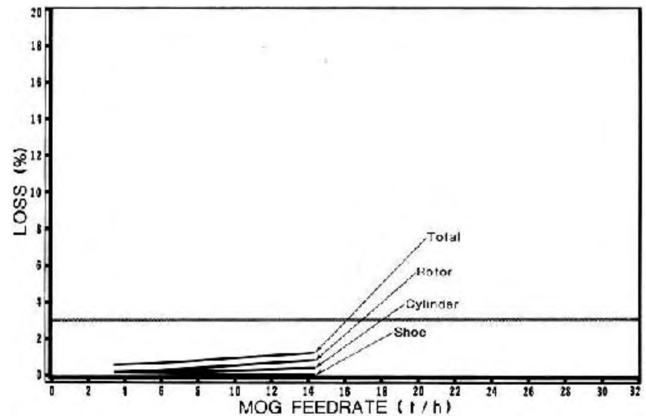

FIGURE 12. Grain Loss in Betzes Barley.

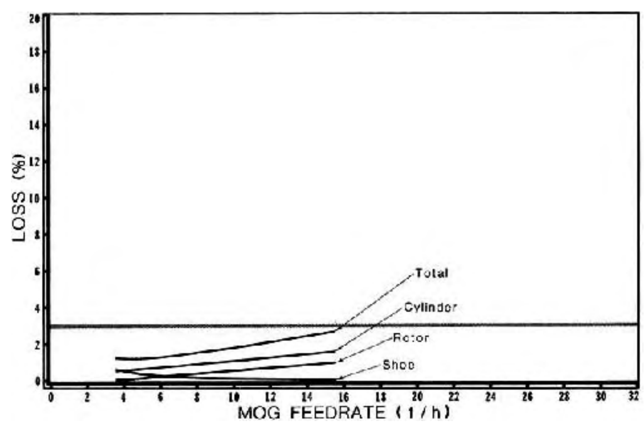

FIGURE 13. Grain Loss in Neepawa Wheat.

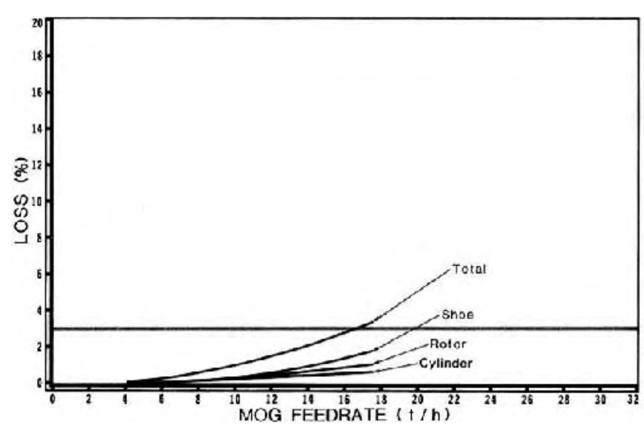

FIGURE 14. Grain Loss in Bonanza Barley.

Body Loss: Slight grain leakage occurred from the junction between the feeder housing and the stone trap door, and from other locations, 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 PAMI reference combine capacity results.

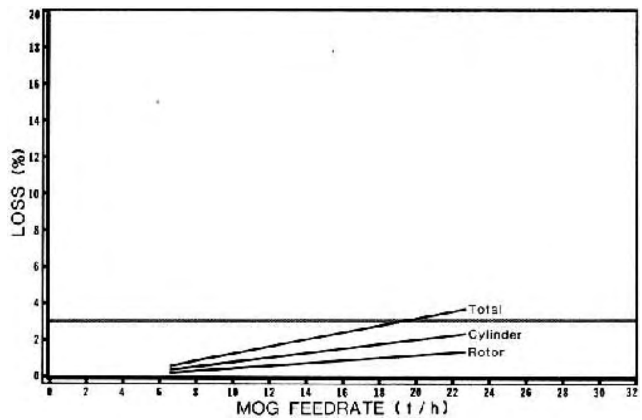

FIGURE 15. Grain Loss in Neepawa Wheat (Laboratory Run).

FIGURES 16 to 18 compare the total grain losses of the Sperry New Holland TR70 and the PAMI reference combine in three of the 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 Sperry New Holland TR70 was much greater than the capacity of the reference combine and the Sperry New Holland TR70 had much lower grain losses than the reference combine when operating at the same feedrate.

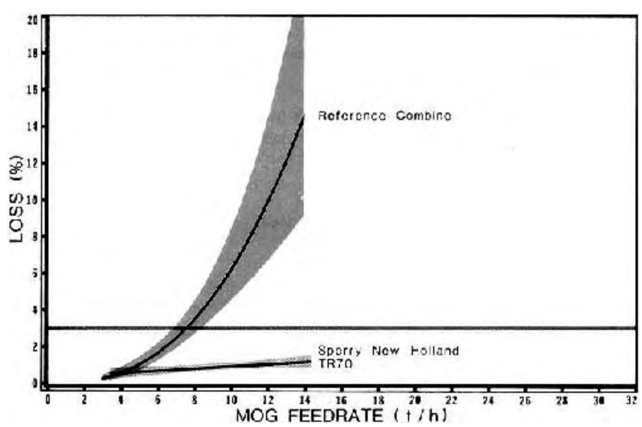

FIGURE 16. Total Grain Losses in Betzes Barley.

FEEDING AND THRESHING CHARACTERISTICS

Feeding Characteristics: Throughout the test, it was apparent that the rotors were not receiving equal crop flow. For example, after quick shutdowns in barley, heavier loading was usually noted on either the left or right side of the shoe. In addition, whenever rotor blockage occurred, usually only one rotor was plugged.

Laboratory studies were conducted to determine if equal crop division was occurring. Results are summarized in FIGURE 19. When parallel windrows were fed, centred on the feeder housing, nearly equal amounts of crop were fed to each rotor. When angled windrows were fed, centred on the feeder housing, or when parallel windrows were fed to one side of the feeder housing, one rotor had to process considerably more crop than the other. As can be seen, driving only 230 mm (9 in) off the centre of the windrow forced one rotor to process two-thirds of the incoming crop.

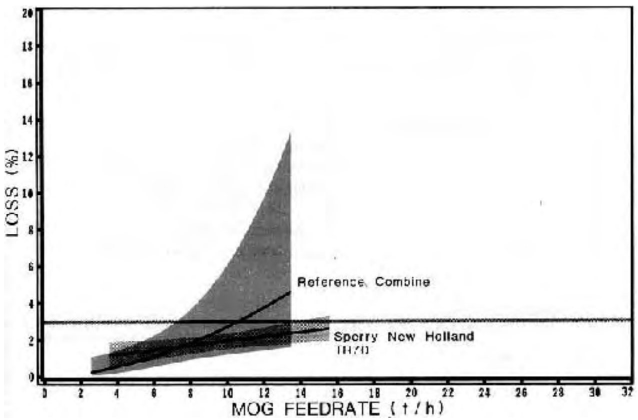

FIGURE 17. Total Grain Losses in Neepawa Wheat.

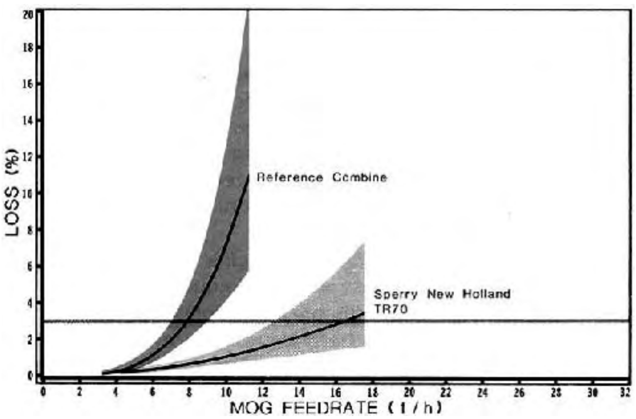

FIGURE 18. Total Grain Losses in Bonanza Barley.

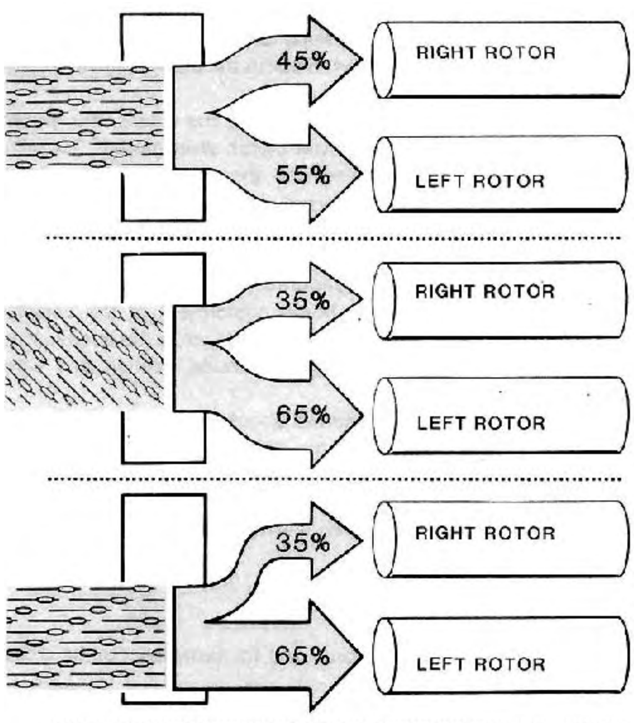

FIGURE 19. Crop Division to the Rotors with a Parallel Windrow Fed into the Centre of the Feeder (top), with an Angled Windrow Fed into the Centre of the Feeder (centre), and with a Parallel Windrow Fed 230 mm (9 in) to Left of Centre (bottom).

Crop flow could quickly switch between rotors during operation. Feeding was more uniform with parallel windrows than in angled windrows. Feeding and shoe loading were most uniform when wide, uniform, parallel windrows were fed into the centre of the feeder. Performance was reduced in angled, irregular windrows or when feeding off-centre. Double-swathing of fields, with consecutive windrows placed side-by-side, is recommended to permit uniform feeding to both rotors and utilization of full combine capacity.

Vibration: When operating near engine power limit at high feedrates, a shuddering noise and low frequency vibration were apparent. This behavior was intermittent, originating from the rotor assembly, and could have been caused by rotor vibration or vibration of the concave extensions against the side plates of the combine. No cause was determined, and it was avoided by operating at a feedrate just below its occurrence.

OPERATOR SAFETY

The operator's manuals for both the combine and the header emphasized operator safety.

The Sperry New Holland TR70 had adequate warning decals. It was also equipped with a slow moving vehicle sign, warning lights and rear view mirrors for road transport. It was well shielded, giving good protection from moving parts. Most shields were easy to remove and install without tools. Although the upper body shrouding was aesthetically pleasing, it made repair and servicing difficult.

The combine was equipped with a header lock and its proper use was emphasized in the combine and header manuals. The header lock must be used when working beneath or around the header.

No rocking wrench or hub was provided for unplugging the feeder auger. This necessitated entry into the header, which was difficult and hazardous due to the windrow pickup. An auger rocking wrench and hub would improve operator safety.

The elevator doors were awkward to open and care had to be taken to avoid skinning knuckles.

The unloading auger should be swung back against the side of the combine after unloading or when transporting. Care should be taken when extending the hydraulic unloading auger as it swings outward and upward during positioning. When working on the left side of the combine with unloading auger extended, the safety lock should be installed on the hydraulic ram to prevent the auger tube from swinging downward if hydraulic failure should occur.

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

When using the slug wrench to unplug the rotors, the engine should be shut off and the separator clutch disengaged. The rotor slug wrench should be removed and the side inspection doors replaced before the engine is started and the separator engaged. Never attempt to unplug the stone roller before shutting off the engine and securing the header lock.

If recommended safety procedures were followed, all adjustments could be safely made. Some adjustment of the variable speed drive belts and sheaves must be made while the sheaves are rotating. In these instances observe extreme caution and wear tight clothing.

The operator must be cautioned about the possibility of head injury when entering or leaving the cab. It is recommended that padding be installed on the upper frame of the cab door to reduce the possibility of head injuries.

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 header.

The manuals were well illustrated and contained detailed information on servicing, adjustments and combine settings. Organization was poor and adjustment procedures were not explicit. It is recommended that the operator's manual be revised to improve clarity.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the Sperry New Holland TR70 during 121 hours of operation while combining about 249 ha (616 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)
Drives			
-A pin in the rotor variable speed adjusting drive sheared and was replaced at	Beginning of test		
-The spring tensioned arm for the main drive belt idler had seized in its carrier and was freed at	32	80	(198)
The unloading auger drive shear pin failed when unloading tough wheat and was replaced at	119	244	(603)
Miscellaneous			
-The bearings on the air conditioning unit failed and the unit was replaced at	33	82	(203)
-A pin in the mechanical linkage actuating the unloading auger swing hydraulic spool failed and was replaced at	36	89	(220)
Front and rear wheel bolts were retorqued at	44	108	(267)
-The power steering cylinder ball joint had become loose in its retainer and was secured at	47	115	(284)
-The gearshift portion of the shifting cables loosened from their retainers, resulting in a toss of transmission shifting. No further problems occurred after the cables were resecured at	114	231	(571)

APPENDIX I
SPECIFICATIONS

MAKE: Sperry New Holland Self-Propelled Combine

MODEL: TR70

SERIAL NUMBER: Header 283269, Combine Body 202317, Engine 90N22804

MANUFACTURER: Sperry New Holland, Division of Sperry Rand Corporation, New Holland, Pennsylvania 17557

WINDROW PICKUP:
- -- make and model: Melroe 361 - 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 hydraulically controlled
- -- apron speed range: 0.6 to 1.6 m/s (118 to 315 ft/min)

HEADER:
- -- type: centre feed
- -- width: 3960 mm (13 ft)
- -- auger diameter: 520 mm (20.5 in)
- -- feeder conveyor: 3 roller chains, undershot slatted conveyors
- -- conveyor speed: 2.64 m/s (520 ft/min)
- -- range of picking height: -290 to 1200 mm (-11.4 to 48 in)
- -- number of lift cylinders: 2
- -- raising time: 4 s
- -- lowering time (adjustable): 4 s
- -- options: header cutting equipment, floating cutting bar, header height control, header auger slow down kit, auger sweep kit, auger flight extensions, header support stands, protection plates, false floor, galvanized feeder floor.

STONE PROTECTION:
- -- type: 4 position stone roller in feeder housing
- -- ejection: door with adjustable spring loaded catch; door manually reset upon tripping.

ROTORS:
- -- crop flow: axial
- -- number of rotors: 2
- -- type: 4 parallel rasp bars front portion; 2 angled smooth bars rear portion
- -- diameter
  - - tube: 308 mm (12.13 in)
  - - feeding portion: 455 mm (17.91 in)
  - - threshing portion: 430 mm (16.93 in)
  - - separating portion: 425 mm (16.73 in)
- -- length
  - - feeding portion: 420 mm (16.54 in)
  - - threshing portion: 710 mm (27.95 in)
  - - separating portion: 1060 mm (41.73 in)
- -- total: 2190 mm (86.22 in)
- -- drive: wheel controlled variable pitch belt through two 90° gearboxes
- -- speeds: 500 to 1325 rpm (with changes in initial variable speed settings)

CONCAVES (THRESHING):
- -- number
  - - concaves: 2
  - - concave extensions: 2
- -- type: bar and wire grate
- -- number of bars
  - - concave: 11
  - - concave extension: 5
- -- configuration
  - - concave: 10 intervals with 3.6 mm (0.14 in) wires and 6.4 mm (0.25 in) spaces
  - - concave extension: 4 intervals with 3.6 mm (0.14 in) wires and 6.4 mm (0.25 in) spaces
- -- area
  - - concave: 0.272 m² (422 in²)
  - - concave extension: 0.149 m² (231 in²)
- -- wrap
  - - concave: 100°
  - - concave plus extension: 150°
- -- grain: delivery to shoe grain pan
- -- options: grain distribution kit, hillside kit, concave spacer kit

CONCAVES (SEPARATING):
- -- number: 2
- -- type: bar and wire grate
- -- number of bars: 11
- -- configuration: 12 intervals with 6.4 mm (0.25 in) wires and 51.6 mm (2.0 in) spaces
- -- area: 0.449 m² (696 in²)
- -- wrap: 150°
- -- grain: delivery to shoe grain pan

BACK BEATER:
- -- type: 4 wing box
- -- speed: 790 rpm

BACK BEATER GRATE:
- -- type: bar and wire grate
- -- number of bars: 6
- -- configuration: 5 intervals with 6.4 mm (0.25 in) wires at 19 mm (0.75 in) spaces
- -- area: 0.360 m² (558 in²)
- -- grain: delivery to shoe gravity
- -- options: beater grate covers

SHOE:
- -- type: opposed action
- -- speed: 325 rpm
- -- chaffer sieve: adjustable lip, 1.07 m² (1658 in²) with 43 m (1.69 in) throw
- -- chaffer extension: adjustable lip, 0.32 m² (494 in²)
- -- rake extension: wire rake, 0.13 m² (195 in²)
- -- cleaning grain sieve: adjustable lip, 1.07 m² (1658 in²) with 32 mm (1.25 in) throw
- -- options: perforated auger and elevator cover, wide lip chaffer, small seed kit

CLEANING FAN:
- -- type: 6 blade undershot
- -- diameter: 560 mm (22 in)
- -- width: 940 mm (37 in)
- -- drive: wheel controlled variable pitch belt
- -- speed range: 500 to 1000 rpm
- -- options: shield group

ELEVATORS:
- -- type: roller chain with rubber flights and top delivery clean grain (top drive) 126 x 270 mm (4.96 x 10.63 in) tailings (bottom drive) 126 x 270 mm (4.96 x 10.63 in)

GRAIN TANK:
- -- capacity (with optional extensions): 6.35 m³ (175 bu)
- -- unloading time: 123 s options grain tank extensions

STRAW SPREADER:
- -- number of paddles: 2
- -- type: steel hub with 3 rubber bats speed of paddles 230 rpm
- -- options: straw chopper, windrow rear hood

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): 2730 rpm
- -- manufacturer's intermittent rating at 2600 rpm: 124 kW (166 hp)
- -- fuel tank capacity: 305 L (67 gal)
- -- options: engine shut-off kit, diesel cold start kit, engine hour meter, pre-cleaner extension, radiator air intake fixed extension

CLUTCHES:
- -- header: V-belt
- -- separator: dry friction disk
- -- unloading auger: V-belt
- -- traction: drive dry friction disk

NUMBER OF CHAIN DRIVES: 11

NUMBER OF BELT DRIVES: 17

NUMBER OF GEAR BOXES:	5
NUMBER OF PRELUBRICATED BEARINGS:	54
LUBRICATION POINTS:	
-- 10 h lubrication	7
-- 50 h lubrication	27
-- 100 h lubrication	8
-- 250 h lubrication	2
-- 500 h lubrication	6
TIRES:	
-- front	2, 23.1 x 26, 10-ply
-- rear	2, 11 L x 16, 6-ply
TRACTION DRIVE:	
-- type	hydraulically controlled variable pitch belt
-- speed ranges with 23.1 x 26 tires	
- 1st gear	1.1 to 2.7 km/h (0.7 to 1.7 mph)
- 2nd gear	2.4 to 6.1 km/h (1.5 to 3.8 mph)
- 3rd gear	4.3 to 11.2 km/h (2.7 to 7.0 mph)
- 4th gear	10.0 to 25.8 km/h (6.3 to 16.1 mph)
- reverse	1.9 to 5.1 km/h (1.2 to 3.2 mph)
OVERALL DIMENSIONS:	
-- wheel tread (front)	2400 mm (94 in)
-- wheel tread (rear)	2030 mm (80 in)
-- wheel base	3230 mm (127 in)
-- transport height	4390 mm (173 in)
-- transport length	8810 mm (347 in)
-- transport width	4270 mm (268 in)
-- field height	4390 mm (173 in)
-- field length	8250 mm (325 in)
-- field width	7000 mm (276 in)
-- unloader discharge height	3330 mm (131 in)
-- unloader clearance height	2860 mm (113 in)
-- unloader reach	2300 mm (91 in)
-- turning radius	
- left	7210 mm (284 in)
- right	6960 mm (274 in)
-- clearance radius	
- left	8260 mm (325 in)
- right	10,110 mm (398 in)
WEIGHT: (with empty grain tank)	
-- right front wheel	3030 kg (6680 lb)
-- left front wheel	3480 kg (7670 lb)
-- right rear wheel	920 kg (2030 lb)
-- left rear wheel	980 kg (2160 lb)
TOTAL	8410 kg (18,540 lb)

ADDITIONAL OPTIONS:

-- Front wheel spacers, rear wheel weights, shaft speed monitor, heater, air conditioner, radio, lighter and ash tray.

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations, for the capacity results shown in FIGURES 12 to 15 are presented in TABLE 6. In the regressions, C = cylinder loss in percent of yield, S = shoe loss in percent of yield, R = rotor 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 12 to 15 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	12	$C = 0.12 + 0.02F$ $\ln S = 0.24 - 1.27 \ln F$ $R = -0.03 + 0.06F$	0.89 0.91 0.82	8
WHEAT — Neepawa	13	$C = 0.24 + 0.09F$ $\ln S = 1.43 - 1.48 \ln F$ $R = -0.22 + 0.08F$	0.87 0.84 0.82	9
BARLEY — Bonanza	14	$C = -0.20 + 0.05F$ $\ln S = -6.98 + 2.65 \ln F$ $\ln R = -5.02 + 1.79 \ln F$	0.95 0.91 0.97	7
WHEAT — Neepawa	15	$C = -0.38 + 0.12F$ $R = -0.24 + 0.07F$	0.86 0.96	10

APPENDIX III
PAMI REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 20 and 21 present capacity results for the PAMI reference combine in wheat and barley crops harvested in 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 20 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 thresh-ability of the 1977 Neepawa wheat crop, and lower straw walker losses resulted from the lower MOG/G ratio.

FIGURE 21 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 break-up than is common for barley at low straw moisture contents which, in combination with the 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.

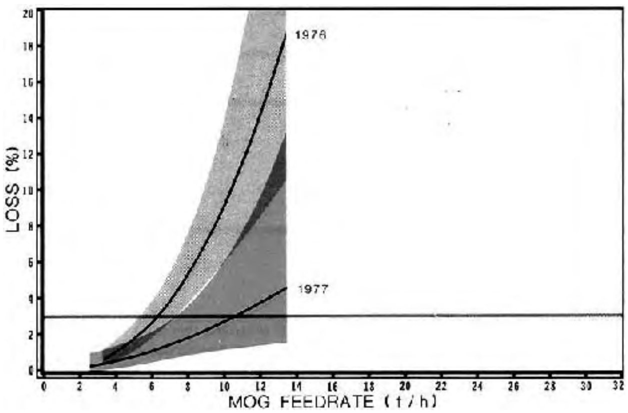

FIGURE 20. Total Grain Losses for the PAMI Reference Combine in Neepawa Wheat.

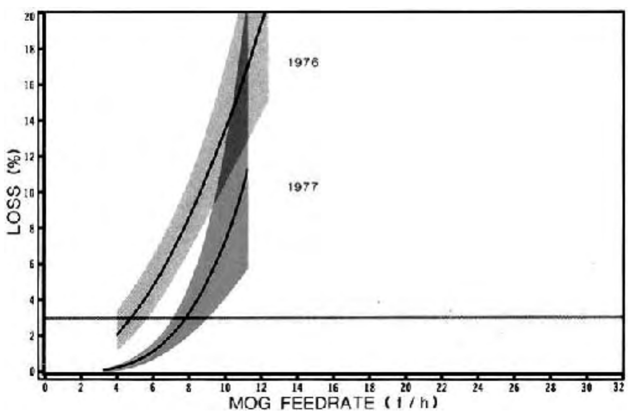

FIGURE 21. Total Grain Losses for the PAMI Reference Combine in Bonanza Barley.

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		MOISTURE CONTENT			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/ac)	km/h	(mph)	LOSS CURVE
1977	Barley	Betzes	4.9	(16)	3.38	(63)	19.6	18.1	1.03	7.80	(287)	7.60	(349)	4.6	(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. 20
	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. 21
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. 20
	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. 21

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

(a) excellent
(b) very good
(c) good
(d) fair
(e) poor
(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 meter (m)	= 39.37 inches (in)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 litre/hour (L/h)	= 0.22 Imperial gallons/hour (gal/h)

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