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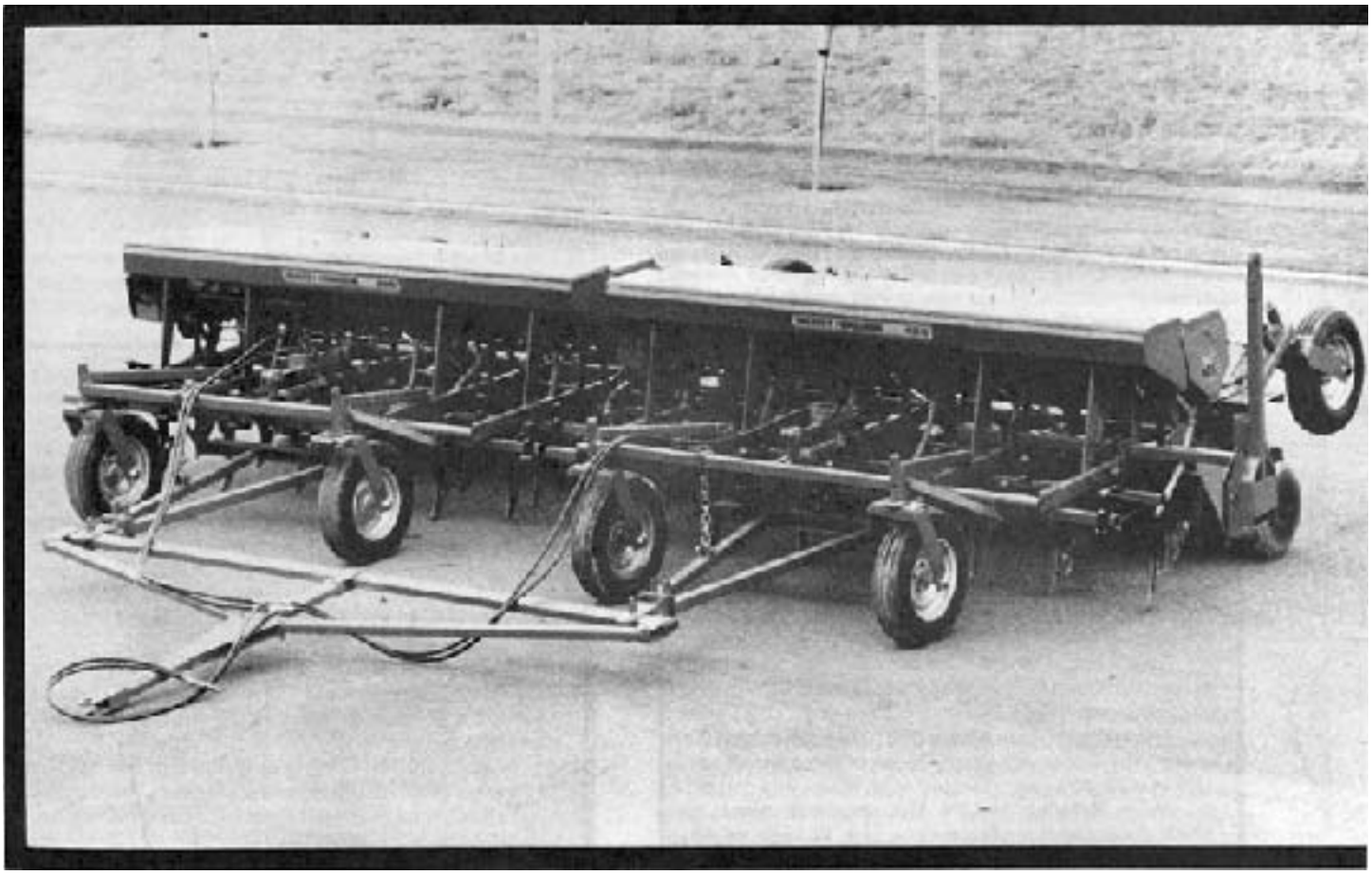

Massey Ferguson 426 Hoe Drill

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

MASSEY FERGUSON 426 HOE DRILL

MANUFACTURER AND DISTRIBUTOR:

Massey Ferguson industries Limited
915 King Street West
Toronto, Canada
M6K 1E3

RETAIL PRICE:

$31,784.00 (August, 1986, f.o.b. Lethbridge, Alberta, for the two unit, 24 ft (7.4 m) wide test machine complete with hitch, hitch winch, Acra-plant openers, acremeter, low rate drive kit, bumper plate kit, hydraulic transport kit and hydraulic system).

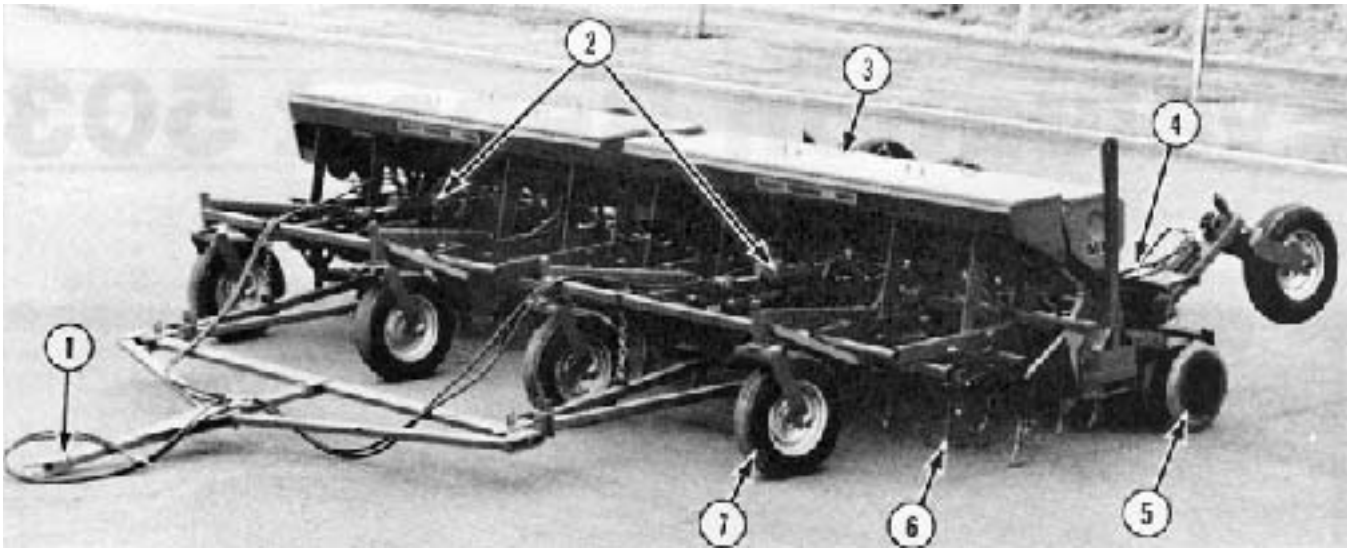

FIGURE 1. Schematic of Massey Ferguson 426 Hoe Drill: (1) Hitch, (2) Hydraulic Lift Cylinder, (3) Grain and Fertilizer Boxes, (4) Rear Walkway, (5) Press Wheels, (6) Hoe Openers, (7) Castor Wheels.

SUMMARY

Quality of Work: Penetration was good in a wide variety of field conditions provided adequate pre-seeding tillage had been performed. Seeding directly into stubble was possible with adequate soil moisture.

Seed and fertilizer were normally placed in a 1.7 in (43 mm) wide band with most seeds within 0.5 in (13 mm) of the average seed depth in uniform soil conditions. Each press wheel exerted a packing force of at least 142 lb (632 N), which effectively packed the soil around the seed and fertilizer.

Trash clearance was adequate in all test conditions except wet wheat stubble in which case occasional plugging occurred.

The spring cushion trip provided adequate protection in stony conditions. Maximum lift height of the shank was 18.5 in (470 mm).

Grain Metering System: Metering calibrations in wheat, barley and canola were accurate. Differences between the manufacturer's and PAMI's metering calibrations were attributed to the difference in seed size and density.

Variation in seeding rates among seed runs across the width of the machine was within the acceptable range when seeding wheat, barley and canola. The rates in all crops were unaffected by level of seed in the box, variations in ground speed and field roughness. Travelling up a 15° slope caused a 10% decrease, while travelling down a 15° slope caused a 5% increase in seeding rate. Seeding on a side slope caused a 5% decrease in seeding rate.

Fertilizer Metering System: The fertilizer metering calibration was accurate when density and particle size differences were considered. Variation in application rate among runs across the width of the machine was very low. The application rate was unaffected by level of fertilizer in the box, ground speed or by field vibrations. The application rate was affected by field slope. When applying 11-51-00 fertilizer at a gear setting of A1 using the 42 tooth feed gear, travelling up a 15° slope caused a 14% increase while travelling down a 15° slope caused a 56% decrease in application rate. Seeding on a side slope had no affect on application rate.

Ease of Operation and Adjustment: One-man hitching was difficult in both transport and field positions since the hitches were not supported. The optional drill transport package did not perform adequately throughout the test. When the transport wheels were locked, excessive tire wear resulted.

The grain and fertilizer box lids and the 11 in (279 mm) wide metal walkway made filling and cleaning difficult and unsafe. Dropout bottoms on the fertilizer box made thorough cleaning easy.

Seeding and fertilizing rates were easily adjusted by changing a gearbox setting and a gear set arrangement. Feed wheels were changed by moving a cover over whichever wheel was not in use.

Seeding depth was adjusted with the hydraulic lift cylinders. The depth of each opener was controlled by a two-position adjustment for the pressure rod.

The area counter was accurate. Lubrication was easy with good access to all grease fittings.

Power Requirements: Tractor size depended on field conditions, soil type, seeding depth, ground speed and drill width. In silt loam soil, seeding at a normal seeding depth at 5 mph (8 km/h), a 55 PTO hp (41 kW) tractor was needed to operate one 12 ft (3.7 m) section of the Massey Ferguson 426.

Operator Safety: The Massey Ferguson 426 seed drill was fairly safe to operate if normal safety precautions were observed. The narrow metal walkway and the transport system hydraulic hoses were safety hazards. No slow moving vehicle sign was supplied.

Operator's Manual: The operator's manual contained some useful information on adjustments, maintenance, operation and assembly but requires updating.

Mechanical History: The packer rock guards shifted and rubbed on the packers throughout the test. The packer gang shaft nuts had to be tightened throughout the test. Several rear seed tubes bent and separated. Several connectors between the front seed tubes and the shanks failed. The hoe points were still useable after seeding 28 ac (11 ha) per point.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Supplying supports or jacks for the drawbar and transport hitches.
2. Modifying the metal walkway and box lids to make filling safer and more convenient.
3. Modifying the transport system to provide adequate performance during road transport.

4. Providing more depth adjustment for each opener.
5. Modifying the hoe bed lock-ups to provide a secure lock-up.
6. Improving the layout of the transport system hydraulic hoses for operator safety reasons.
7. Supplying a slow moving vehicle sign.
8. Updating the operator's manual.
9. Modifying the packer rock guard supports to prevent them from shifting and rubbing on the packers.
10. Modifying the packer gang shaft nuts to prevent loosening of the packers.
11. Providing more flexible seed delivery tubes and improving the attachment of the seed tubes to the shanks.

Project Manager: R. P. Atkins

Project Engineer: L. W. Papworth

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. The provision of supports for drawbar and end transport hitch will be considered for future production MF426 drills.
2. The perforated, skid-proof steel footboards supplied with the MF426 Drill have been well accepted in the marketplace to date. We will, however, consider increasing the size of the footboards and improving the design of the grain and fertilizer hopper lids for future production.
3. Improvements to the end transport system, particularly the method of locking the castering wheels to eliminate excessive tire wear, will be incorporated into future production.
4. The recommendation to provide more depth adjustment of the openers will be investigated.
5. Improvements to the hoe bed lockups will be considered for future production units.
6. The routing/layout of the hydraulic hoses for the end transport system will be considered for future production units.
7. Provision for mounting a slow moving vehicle warning sign will be incorporated in future production units.
8. Revisions and updates of the Operator's Manual for all Massey-Ferguson products are issued as errors, omissions and new technical information pertinent to the product warrant. We will consider updating the manual for the MF426 Hoe Drill at next printing.
9. A more reliable method of attaching the rock guards will be investigated prior to next production of the MF426.
10. Improvements in the gang axle design, to prevent loosening of the retaining nuts, will be considered for future productions.
11. Improvement in the performance and attachment of the seed tubes will be investigated for future production.

GENERAL DESCRIPTION

The Massey Ferguson 426 is a basic three-row hoe drill with either 7, 9, 10 or 12 in (178, 228, 254 or 305 mm) spacing in seeding widths of 8, 10, 12 or 14 ft (2.4, 3.1, 3.6 or 4.3 m). Hitches are available for hitching up to four basic drill units together, depending on the unit width. Seeding depth is controlled with an adjustable spring rod and a hydraulic cylinder equipped with an adjustable stop. The separate grain and fertilizer boxes are capable of holding 18 bu (655 L) of grain and 840 lb (381 kg) of fertilizer.

Grain is metered by externally ribbed fine or medium feed wheels through plastic feed cups. Fertilizer is metered by externally ribbed traction wheels. The metering wheels are chain driven from the press wheels through a variable speed gearbox. The metering drive clutch system is protected with a shear pin.

Coiled steel tubes deliver the seed and fertilizer to the openers. Three gangs of 20 in (508 mm) diameter press wheels pack the soil directly behind each opener. Available opener shovels are the 1.5 in (38 mm) spearpoint, 3 in (76 mm) shovel, 5 in (127 mm) shovel and the Acra-plant point assembly.

Semi-pneumatic rubber and fully pneumatic rubber packer wheels are available but the test unit was equipped with standard steel V-shaped packer wheels.

The test machine consisted of two basic 12 ft (3.6 m) drill units with 7 in (178 mm) spacing, equipped with duplex hitch and Acra-plant opener shovels. Optional equipment included a fertilizer attachment with drive, digital acremeter, low-rate seed drive kit and a hydraulic transport kit. An optional grass seed attachment is available, but was not evaluated.

FIGURE 1 shows the location of major components while detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Massey Ferguson 426 was operated in the conditions shown in TABLE 1 for 95 hours while seeding about 1105 ac (442 ha). It was evaluated for quality of work, ease of operation, ease of adjustment, power requirements, operator safety and suitability of the operator's manual. In addition, the seed and fertilizer metering systems were calibrated in the laboratory.

RESULTS AND DISCUSSION

QUALITY OF WORK

Penetration: Penetration was good in a wide variety of field conditions provided adequate pre-seeding tillage had been performed. Seeding directly into stubble fields was possible provided the soil contained adequate moisture.

The hoe assemblies (FIGURE 2) were equipped with a spring cushioned trip. Opener depth was controlled by the setting of the hydraulic cylinder and a two position adjustment for the pressure rod. This adjustment was used mainly to lower openers in tractor wheel tracks. The spring cushion trip provided adequate protection in stony conditions.

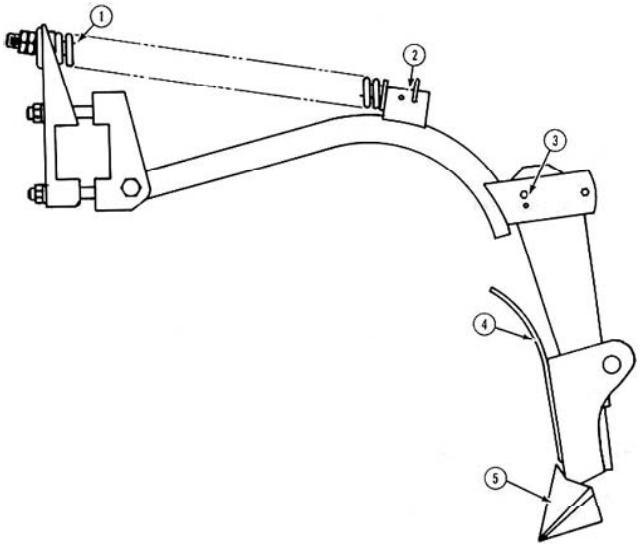

FIGURE 2. Hoe Assembly: (1) Compression Spring and Rod, (2) Depth Adjustment, (3) Shank Angle Adjustment, (4) Trash Deflector, (5) Acra-Plant Opener.

The shank angle could be adjusted to either of two positions. During testing the shank was left in the vertical position so the Acra-plant point was operated at a shallow pitch angle. The operator's manual did not specify what angle the shank should be operated at for the various types of openers available.

TABLE 1. Operating Conditions

Crop	Soil	Stone Conditions	Field Area		Hours
			ac	ha	
Barley on tilled barley stubble	Silty loam	Occasional stones	160	64	13
Durum wheat on summerfallow	Sandy loam	Stone free	250	100	22
Barley on summerfallow	Sandy loam	Stone free	40	16	3
Oats on summerfallow	Silty loam	Moderately stony	50	20	5
Wheat on tilled stubble	Silty loam	Occasional stones	70	28	5
Barley on tilled barley stubble	Silty loam	Occasional stones	180	72	15
Durum wheat on summerfallow	Silty loam	Occasional stones	100	40	9
Spring Wheat on summerfallow	Silty loam	Occasional stones	110	44	9
Durum wheat on tilled wheat stubble	Silty loam	Occasional stones	110	44	9
Rye on summerfallow	Fine sand	Occasional stones	15	6	2
Winter wheat on summerfallow	Sandy loam	Occasional stones	10	4	1.5
Winter wheat on wheat stubble	Sandy loam	Occasional stones	10	4	1.5
Total			1105	442	95

Seed Placement: In normal prairie conditions, the grain is ideally placed when it is in moist soil on a firm seedbed from 1 to 2 in (25 to 50 mm) deep with soil packed tightly around the seed for

optimum moisture contact and minimum soil drying.

The Massey Ferguson 426 normally placed seed and fertilizer within a 1.7 (43 mm) wide band. When seeding in pre-tilled uniform soil conditions, variation in seed depth was uniform. For example, at an average seeding depth of 2 in (51 mm), although seeding depth across the width of the machine varied from 1.2 to 2.8 in (30 to 71 mm), most of the seeds were placed within 0.5 in (13 mm) of the average seed depth.

Soil Compaction: The V-shaped press wheels followed directly behind the openers, effectively pressing the soil about the seeds. Average packing force exerted by each press wheel ranged from 142 lb (632 N) with empty seed and fertilizer boxes to 204 lb (908 N) with full boxes. Press wheel furrow depth ranged from 0.8 to 2.0 in (20 to 50 mm) depending on soil conditions. FIGURE 3 shows the soil surface after seeding into a tilled stubble field. The 1.8 in (46 mm) wide openers provided minimum soil disturbance, therefore giving the seed good soil coverage.

FIGURE 3. Soil Surface after Seeding into a Tilled Stubble Field.

Trash Clearance: Trash clearance is dependent on field conditions and a number of drill design characteristics. Field conditions that affect trash clearance are soil type, soil and straw moisture content, straw length and type, how the soil was tilled last and how the trash was managed. The drill design characteristics that affect trash clearance are shank type, number of hoe rows, run spacing, distance between rows and the ground to frame clearance.

The Massey Ferguson 426 was operated in four different types of trash conditions- summerfallow with long wheat straw, pre-tilled heavy barley stubble, wet wheat stubble and dry wheat stubble.

The Massey Ferguson 426 cleared trash adequately in all conditions but performance was reduced occasionally in wet wheat stubble. The ground to frame clearance of 19 in (483 mm) did not provide enough clearance in wet wheat stubble as shown by the plugged unit in FIGURE 4. The trash deflector mounted on each hoe boot effectively broke up trash in tilled stubble and summerfallow conditions.

FIGURE 4. Plugging in Wet Wheat Stubble.

Operation in Stony Fields: The spring cushion trip provided adequate protection in stony conditions. Maximum lift height of the opener ranged from 16.3 in (414 mm) to 18.5 in (470 mm) depending on the position of the pressure rod adjustment and the shank angle.

Plant Emergence: As with most drills, plant emergence depended primarily upon seedbed preparation and soil moisture.

FIGURE 5 illustrates good emergence in a pre-tilled stubble field seeded to wheat.

FIGURE 5. Wheat Emergence on Summerfallow Field.

Metering Accuracy: The grain and fertilizer metering systems (FIGURE 6) were calibrated in the laboratory and compared with the manufacturer's calibrations. Since the actual application for certain settings depends on factors such as size, density and moisture content of seeds and fertilizer particles, it is not possible for a manufacturer to present charts to include all the variations of seed and fertilizer used. Field calibrations may be necessary for seed and fertilizer with properties differing from those indicated in the manufacturer's table. Research has shown, however, that small variations in seed or fertilizer application rates will not significantly affect grain crop yields.

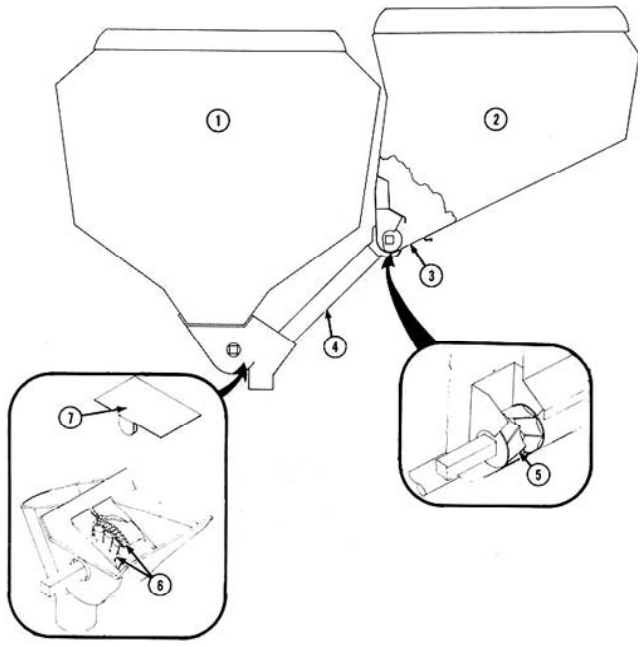

FIGURE 6. Grain and Fertilizer Metering Systems: (1) Grain Box, (2) Fertilizer Box, (3) Fertilizer Hopper Drop Bottom, (4) Fertilizer Spout, (5) Fertilizer Metering Wheel, (6) Fine and Coarse Metering Wheels, (7) Feed Cup Cover.

Grain Metering System: FIGURES 7 to 9 show the calibration curves obtained by PAMI and the manufacturer for the Massey Ferguson 426 in wheat, barley and canola. The wheat and barley calibration curves were accurate. The canola calibration curve was accurate in the common seeding range using the optional 14 and 70 tooth low-rate seed drive kit. The curve obtained by PAMI using the 18 and 42 tooth gears was approximately 13% higher than the manufacturer's curve. Therefore, the low-rate seed drive kit should be used when seeding canola and other small seeds. The difference between calibration curves obtained by PAMI and those given by

the manufacturer are probably due to different seed size, density and moisture content. The seed densities (bushel weights) used by PAMI are indicated on the graphs.

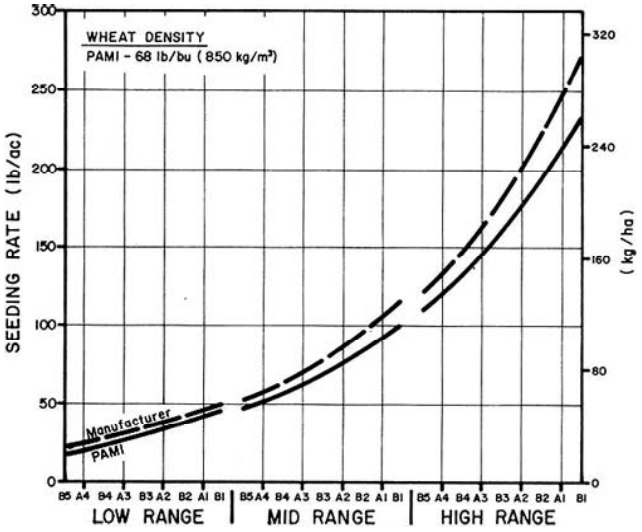

FIGURE 7. Metering Accuracy in Wheat with Medium Feed Wheel.

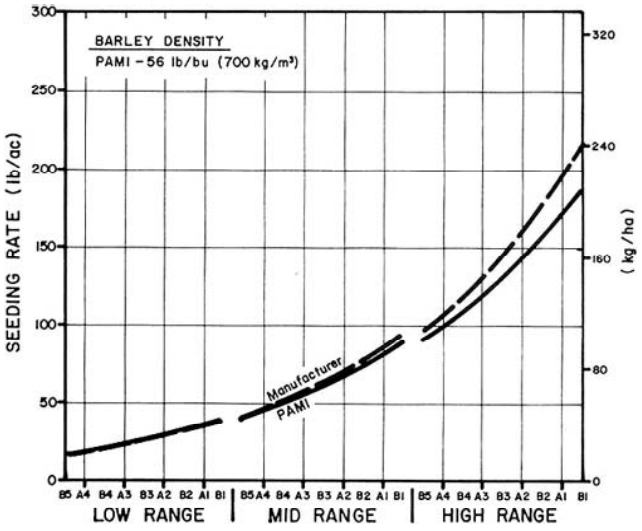

FIGURE 8. Metering Accuracy in Barley with Medium Feed Wheel.

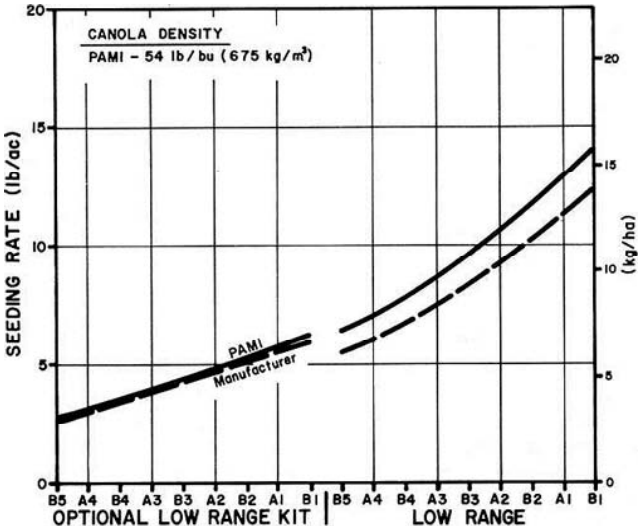

FIGURE 9. Metering Accuracy in Canola with Fine Feed Wheel.

Level of seed in the grain box, variation in ground speed, and field roughness did not affect the seeding rate of either large or small seeds. FIGURE 10 shows the variation in seed application rates as affected by field slope. Travelling up a 15° slope caused an 10% decrease in seeding rate and travelling down a 15° slope caused a 5% increase. Seeding on a side slope caused a 5% decrease in seeding rate.

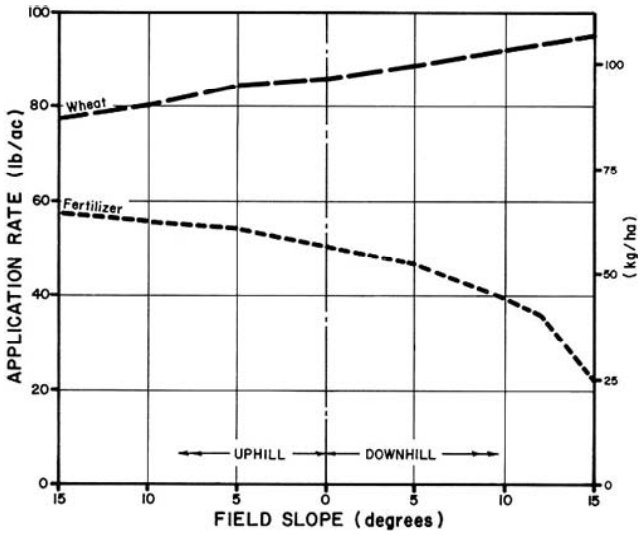

FIGURE 10. Variation in Seed and Fertilizer Application Rate with Change in Field Slope.

The coefficient of variation (CV)[1] is commonly used to describe the variation of application rate among individual seed cups across the width of the machine. An accepted variation for grain or fertilizer is a CV value not greater than 15%. If the CV is less than 15%, seeding is acceptable, whereas if the CV is much greater than 15%, the variation among individual seed cups is excessive.

The seeding rate, across the width of the machine for wheat, barley and canola, was very uniform with CV's of 3 to 9%. Grain crackage through the grain metering system was negligible for both small and large seeds.

Fertilizer Metering System: FIGURE 11 shows the calibration curve for fertilizer obtained by PAMI and the manufacturer while metering 11-51-00 fertilizer and the fertilizer calibration curve given by the manufacturer. The curves are identical. The maximum fertilizer rate attainable was 280 lb/ac (315 kg/ha) at a gear setting of B1 using the 18-tooth feed shaft gear.

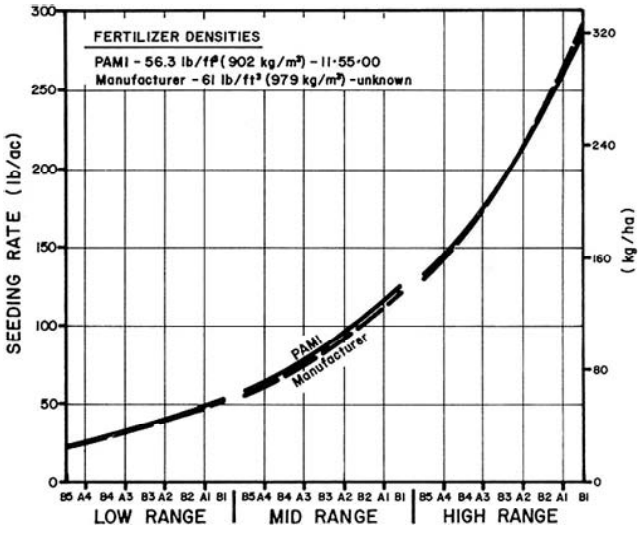

FIGURE 11. Metering Accuracy in Fertilizer.

Fertilizer distribution across the width of the drill was quite uniform. CV's ranged from 2 to 4%.

Level of fertilizer in the box, ground speed and field vibrations did not significantly affect the application rate of fertilizer. The rate was, however, affected by field slope. FIGURE 10 shows the variation in fertilizer application rates obtained when fertilizing uphill, downhill and on level ground at a gear setting of A1 using the 42-tooth feed shaft gear while applying 11-51-00 fertilizer. For example, travelling up a 15° slope increased the fertilizing rate by about 14%.

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[1]*The coefficient of variation is the standard deviation of application rates from individual seed cups, expressed as a percent of the mean application rate.*

Travelling down a 15° slope decreased the fertilizing rate by about 56%. At the 15° downhill slope a large variation of application rate across the width of the machine resulted in CV's as high as 48%. Seeding on a side slope had no effect on application rate.

EASE OF OPERATION

Hitching: Hitching in transport position was difficult in both transport and field positions by one man because both hitches were not supported. It is recommended that the manufacturer consider supplying supports or jacks for the drawbar and transport hitches.

Filling: The 11 in (279 mm) wide metal walkway made filling with grain and fertilizer unsafe and difficult. The 13 in (330 mm) wide lids on the grain and fertilizer boxes did not open to a vertical position, making filling difficult. It is recommended that the manufacturer consider modifying the metal walkway and box lids to make filling safer and more convenient.

Moisture: The grain and fertilizer boxes were adequately sealed to prevent leakage into the boxes in light rains.

Cleaning: The narrow openings on the boxes made cleaning inconvenient. The grain box contained optional baffles, which partly covered the feed wheels. To clean the grain box, the baffles (FIGURE 12) had to be removed and then replaced. A vacuum cleaner or compressed air was needed for thorough cleaning of the grain box.

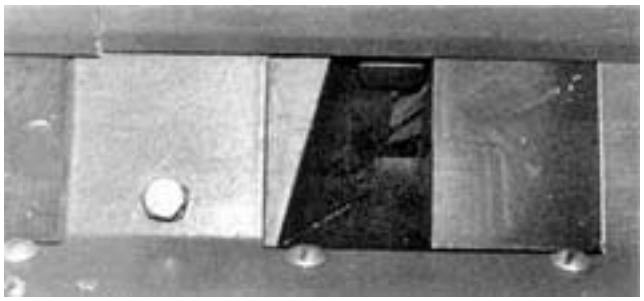

FIGURE 12. Baffles and Seed Cup.

Dropout bottoms on the fertilizer box (FIGURE 13) could be conveniently removed and replaced, making cleaning easy. The fertilizer box also contained baffles, which had to be removed to thoroughly clean the box.

FIGURE 13. Dropout Bottom of Fertilizer Box.

EASE OF OPERATION

Hitching: Hitching in transport position was difficult in both transport and field positions by one man because both hitches

Area Counter: The optional acre counter (FIGURE 14) read approximately 5% high. It recorded to the nearest tenth acre up to one million acres.

Transporting: The optional drill transport package (FIGURE 15) did not perform adequately throughout the test. To prevent the unit from swaying during transport, at least three of the rear transport wheels had to be locked. This caused tire skidding in cornering and also severe tire wear because the transport wheels were not aligned. Wheel stops were provided for the front castor wheels but they did not adequately stabilize the unit during road transport. It is recommended that the manufacturer consider modifying the transport system to provide adequate performance during road transport.

It took 5 to 10 minutes to place the drill in transport position. Speeds were limited to 10 mph (16 km/h) because of wheel oscillation. The unit should not be transported with grain and fertilizer tanks full due to the excessive weight placed on the transport wheels. When backing up in transport position all of the rear transport wheels had to be locked to prevent interference with the packers. Lift chains were provided to stabilize the packers during transport. No explanation of the operation of the lift chains was given in the operator's manual.

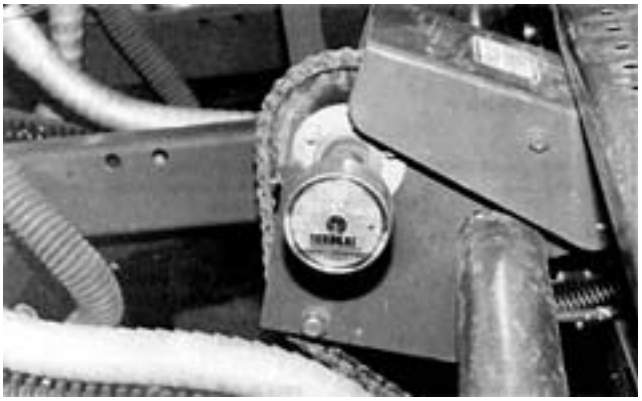

FIGURE 14. Acremeter.

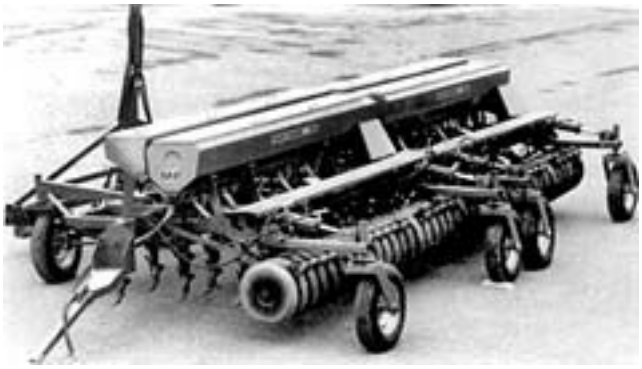

FIGURE 15. Transport Position.

EASE OF ADJUSTMENT

Lubrication: Lubrication was easy with good access to all grease fittings. Eight grease fittings required weekly greasing. The wheel bearings required packing with grease each season.

Seeding and Fertilizing Rates: Seeding and fertilizing rates were easily adjusted by changing the gearbox setting (FIGURE 16) and the gear set arrangement located at the end of the feed shafts (FIGURE 17).

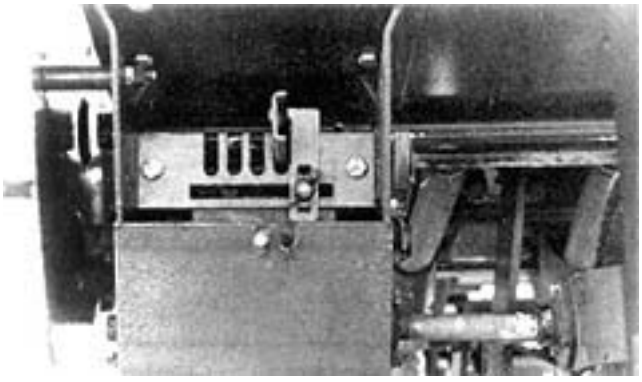

FIGURE 16. Gearbox.

To change feed wheels the baffles had to be removed and the seed cup covers (FIGURE 12) switched to cover the type of feed wheel not in use. The baffles (FIGURE 12) also had two different positions corresponding to whichever type of feed wheel was in use. The optional baffles were included with the drill and were recommended for use with the fine and medium feed wheels.

Depth of Tillage: Seeding depth was adjusted by positioning the hydraulic lift cylinder. Seeding depth of each row was adjusted by turnbuckles between the rows of hoe openers. The depth of each opener was controlled by a two-position adjustment for the pressure rod and the spring tension of each opener. A two-position adjustment to change the angle of the shank was also provided.

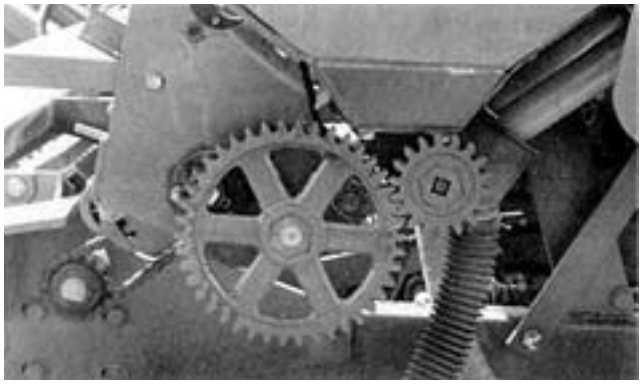

FIGURE 17. Gear Set Arrangement.

During testing it was found that the two-position adjustment of the pressure rod did not provide enough movement to lower the opener in some tire tracks. It is recommended that the manufacturer consider providing more depth adjustment for each opener.

POWER REQUIREMENTS

Draft: Draft (drawbar pull) requirements depended on field preparation, soil type and moisture content, ground speed and level of fertilizer and grain in the boxes.

Average draft at a normal seeding depth and at 5 mph (8 km/h), with fully loaded seed boxes, ranged from 2150 lb (9570 N) to 2375 lb (10,570 N) in silt loam soil for one 12 ft (3.7 m) drill unit.

Tractor Size: The power take-off horsepower requirements per foot of drill width for varying seed depths are given in FIGURE 18. Requirements varied from 2.2 hp/ft (5.4 kW/m) at 0.5 in (13 mm) seed depth to 6 hp/ft (14.7 kW/m) at a 3.0 in (75 mm) seed depth.

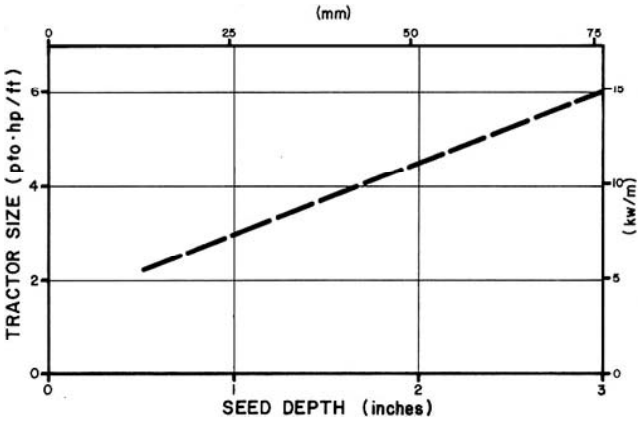

FIGURE 18. Average Horsepower Requirements at 5 mph (8 km/h).

Therefore, overall tractor size needed to pull 12 ft (3.7 m) of Massey Ferguson 426 drill varied from 52 hp (39 kW) to 57 hp (43 kW) in silt loam soil. These tractor sizes have been adjusted to include tractive efficiency and represent a tractor operating at 80% of maximum power take-off ratings as determined by Nebraska tests or as presented by the tractor manufacturer. The tractor sizes given will have ample power reserve to operate in the stated conditions.

OPERATOR SAFETY

The Massey Ferguson 426 was fairly safe to operate if normal safety precautions were observed. Lock-up pins were provided for the hoe bed, the transport system, the drawbar hitch and the transport hitch. The hoe bed lock-ups were mounted on a round shaft (FIGURE 19) and were difficult to secure. It is recommended that the manufacturer consider modifying the hoe bed lock-ups to provide a secure lock-up. As mentioned before, the narrow metal walkway was unsafe and difficult to move around on. The routing of the transport system hydraulic hoses between the two drills (FIGURE 20) presented a hazard to the operator on the walkway. It is recommended that the manufacturer consider improving the layout of the transport system hydraulic hoses for operator safety reasons.

No slow moving vehicle sign was supplied with the Massey Ferguson 426. It is recommended that the manufacturer consider supplying a slow moving vehicle sign.

Tire loads did not exceed the Tire and Rim Association maximum load ratings.

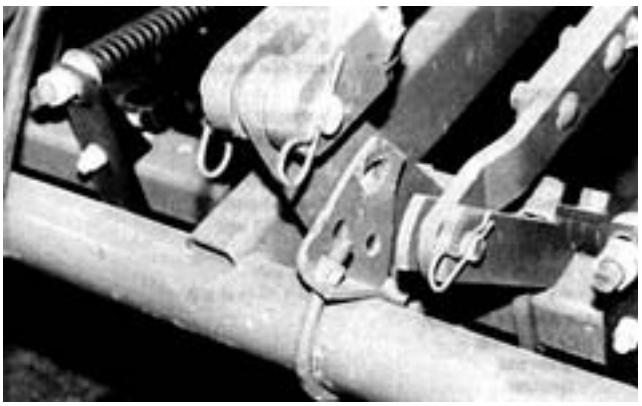

FIGURE 19. Hoe Bed Lock-up.

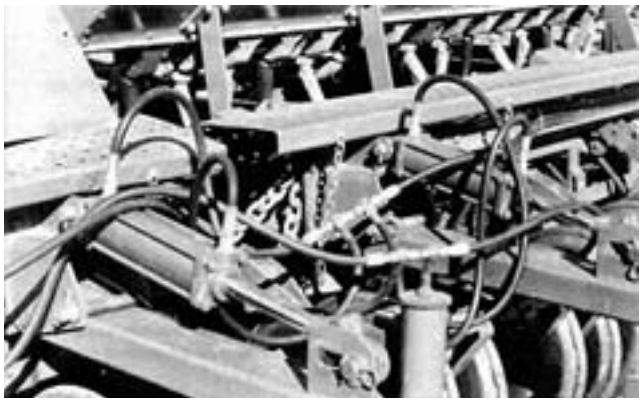

FIGURE 20. Unsafe Layout of the Transport System Hydraulic Hoses.

OPERATOR'S MANUAL

The operator's manual contained useful information on adjustments, maintenance, operation and assembly. No parts list was provided. Calibration charts were provided in the operator's manual and on the drill box. Rates were expressed in Imperial units (lb/ac) and in metric (SI) units (kg/ha). The fertilizer application rates expressed in the charts were incorrect. The values for lb/ac and kg/ha should be reversed. The operator's manual lacked information on the adjustment of the shank angle for the various shovel and points available and of the function of the packer lift chains. The operator's manual also contained several typographical errors making the instructions hard to understand. It is recommended that the manufacturer consider updating the operator's manual.

MECHANICAL PROBLEMS

The Massey Ferguson 426 was operated for 95 hours while seeding about 1105 ac (442 ha). The intent of the test was evaluation of functional performance and an extended durability evaluation was not conducted. TABLE 2 outlines the mechanical problems that did occur during the functional testing.

DISCUSSION OF MECHANICAL PROBLEMS

Rock Guards: The packer rock guards were held to each support by a single bolt. Throughout the field testing, the bolts would loosen and the guards would shift and rub on the packers as shown in FIGURE 21. It is recommended that the manufacturer consider modifying the packer rock guard supports to prevent them from shifting and rubbing on the packers.

Packer Wheels: The packer gang shaft nuts had to be tightened throughout the test. Occasionally spacers had to be added to the shaft ends because of lack of threads. It is recommended that the manufacturer consider modifying the gang shaft nut to prevent loosening of the packers.

Seed Tubes: The rear seed tubes would not flex so when the shanks were raised in and out of the ground the tubes would eventually bend and separate as shown in FIGURE 22. All of the

rear tubes were replaced with new ones that were more flexible. Several connectors (FIGURE 23) between the front seed tubes and the shanks failed, causing the tubes to plug with seed. It is recommended that the manufacturer consider providing more flexible seed delivery tubes and improving the attachment of the seed tubes to the shanks.

FIGURE 21. Rock Guards Rubbing on Packers.

FIGURE 22. Seed Tube Failure.

FIGURE 23. Seed Tube Connection Failure.

Hoe Point Wear: FIGURE 24 shows the wear on a typical hoe point after seeding 28 acres (11 ha) of the conditions listed in TABLE 1. It should be noted that the point in FIGURE 24 provided adequate performance when removed from the drill.

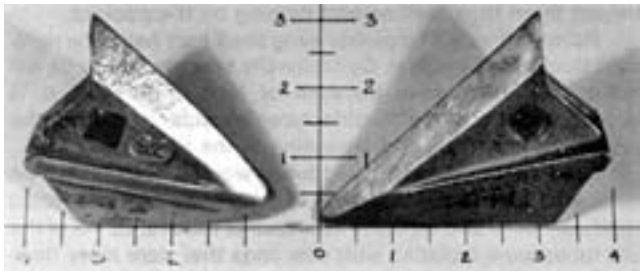

FIGURE 24. Hoe Point Wear at End of Test.

TABLE 2. Mechanical History

Item	Operating Hours	Equivalent Field Area ac	(ha)
-during transport the pin in the spreader bar broke. Replaced with a new one at		beginning of test	
-two transport wheel lock pins broke. Replaced at		beginning of test	
-rock guard brackets loosened and guards rubbed on packers. Moved and retightened brackets		throughout the test	
-rear seed tubes bent and spread. Replaced with new tubes as needed		throughout the test	
-connector holding seed tube to shank failed. Connector then blocked seed tube		throughout the test	
-the packer wheels needed tightening		throughout the test	
-pin holding a packer arm dropped out at	58, 90	690, 1070	(276, 428)
-bracket holding packer arm broke at	63	750	(300)
-shaft in transport wheel hub bent due to oscillation during transport at	63	750	(300)
-replaced a transport wheel tire which wore out at	81	960	(384)
-set screws on spreader bar loosened at	90	1070	(428)
-replaced hoe openers at	90	1070	(428)

APPENDIX I
SPECIFICATIONS

MAKE:	Massey Ferguson Hoe Drill
MODEL:	426
SERIAL NUMBER:	00101, 00102
MANUFACTURER:	Massey Ferguson Industries Ltd. 915 King Street West Toronto, Canada M6K 1E3

DIMENSIONS OF TWO UNITS:	**Field Position**	**Transport Position**
-- height	7.5 ft (2.3 m)	6.3 ft (1.9 m)
-- length	23.0 ft (7.0 m)	29.0 ft (8.8 m)
-- width	24.8 ft (7.6 m)	14.0 ft (4.3 m)
-- effective seeding width	23.5 ft (7.2 m)	
-- transport ground clearance		4.0 in (102 m)

SEED METERING SYSTEM:	
-- type	double feed cup with choice of two externally ribbed traction feed wheels
-- drive	chain driven from press wheels
-- adjustment	two feed wheels, 9 position gear box, 4 gear set arrangements
-- transfer to openers	coiled steel tubes or rubber hoses
-- feed wheels	fine and medium on test unit, intermediate and coarse available
FERTILIZER METERING SYSTEM:	
-- type	externally ribbed traction feed wheels
-- drive	chain driven from press wheels
-- adjustment	9 position gear box, 4 gear set arrangements
-- transfer to openers	short plastic hose to seed cup, then to coiled steel tubes or rubber hoses
OPENERS:	
-- type	hoe
-- point	Acra-plant
-- number	20 per drill unit
-- spacing	7 in (178 mm)
-- number of rows	3
-- distance between rows	17 in (432 mm)
-- options	3 in (76.2 mm) shovel, 5 in (127 mm) shovel 1.5 in (38.1 mm) spear point 9, 10 and 12 in (228, 254 and 305 mm) hoe spacing
PRESS WHEELS	
-- type	V-shaped steel
-- diameter	20 in (508 mm)
-- width	3 in (76 mm)
-- number	20 per drill unit
-- spacing	7 in (178 mm)
-- number of gangs	3 per drill unit
CASTOR WHEELS:	
-- number	2 per unit
-- tire size	6.70 x 15 in, 4-ply
GRAIN AND FERTILIZER BOX CAPACITIES:	
-- grain box	36 bu (1310 L)
-- fertilizer	1680 lb (763 kg)

WEIGHTS: (FIELD POSITION)	**Boxes Empty**	**Boxes Full**
-- weight on press wheels	5670 lb (2580 kg)	8170 lb (3710 kg)
-- weight on castor wheels	2780 lb (1260 kg)	4410 lb (2000 kg)
Total	8450 lb (3840 kg)	12580 lb (5710 kg)

WEIGHTS: (TRANSPORT POSITION)	**Boxes Empty**	**Boxes Full**
-- weight on front castor wheels	4360 lb.(1980 kg)	6415 lb (2910 kg)
-- weight on transport wheels	4090 lb (1860 kg)	6165 lb (2800 kg)
Total	8450 lb (3840 kg)	12580 lb (5710 kg)

NUMBER OF CHAIN DRIVES:	2 per drill unit
NUMBER OF LUBRICATION POINTS:	4 per drill unit
NUMBER OF HYDRAULIC LIFTS:	3 per drill unit
NUMBER OF SEALED BEARINGS:	24

OPTIONS INCLUDED ON TEST MACHINE:	fertilizer attachment with drive, digital acremeter, low-rate seed drive kit, hydraulic transport kit
OTHER AVAILABLE OPTIONS:	grass seeding attachment, bumper plates, single or double markers, semi-pneumatic or fully pneumatic packers 1.5 in (38 mm) spearpoint, 3 in (76 mm) shovel, 5 in (127 mm) shovel openers 9, 10 or 12 in (228, 254 or 305 mm) run spacing 8, 10 or 14 ft (2.4, 3.05 or 4.3 m) seeding widths

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Very Good
Good	Fair
Poor	Unsatisfactory

SUMMARY CHART
MASSEY FERGUSON 426 HOE DRILL

RETAIL PRICE:	$31,784.00 (August, 1986, f.o.b. Lethbridge)
QUALITY OF WORK:	
Penetration	- good - moist stubble fields
Trash Clearance	- plugged occasionally in wet wheat stubble; cleared in all other conditions
Stony Conditions	- adequate protection
Metering	- accurate in wheat, barley, canola and fertilizer
EASE OF OPERATION:	
Hitching	- no support for hitches
Filling and Cleaning	- narrow walkway made access difficult; dropout bottom on fertilizer box
Transportability	- inadequate
EASE OF ADJUSTMENT:	
Seeding and Fertilizer Rates	- easy to set
Depth	- simple; each opener needs more adjustment for tire tracks
POWER REQUIREMENTS:	-55 PTO hp (41 kW) tractor per 12 ft (3.7 m) drill was sufficient for all conditions
OPERATOR SAFETY:	- fairly safe - narrow walkway and no slow moving vehicle sign supplied
OPERATOR'S MANUAL:	- requires updating
MECHANICAL HISTORY:	- rock guards shifted; packer nuts loosened; seed tubes bent and disconnected from shanks. - hoe points were still useable after 28 ac (11 ha) per point.

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