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Group 4c

Evaluation Report 590

Crary Air Reel

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

CRARY AIR REEL

MANUFACTURER:
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DISTRIBUTOR:
Appollo Distributing Corporation
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RETAIL PRICE:
$3,850.00 [March, 1989, f.o.b. Humboldt, Sask., for fan assembly, 24 ft (7.3 m) manifold, mounting hardware, and optional electric nozzle tilt actuator].

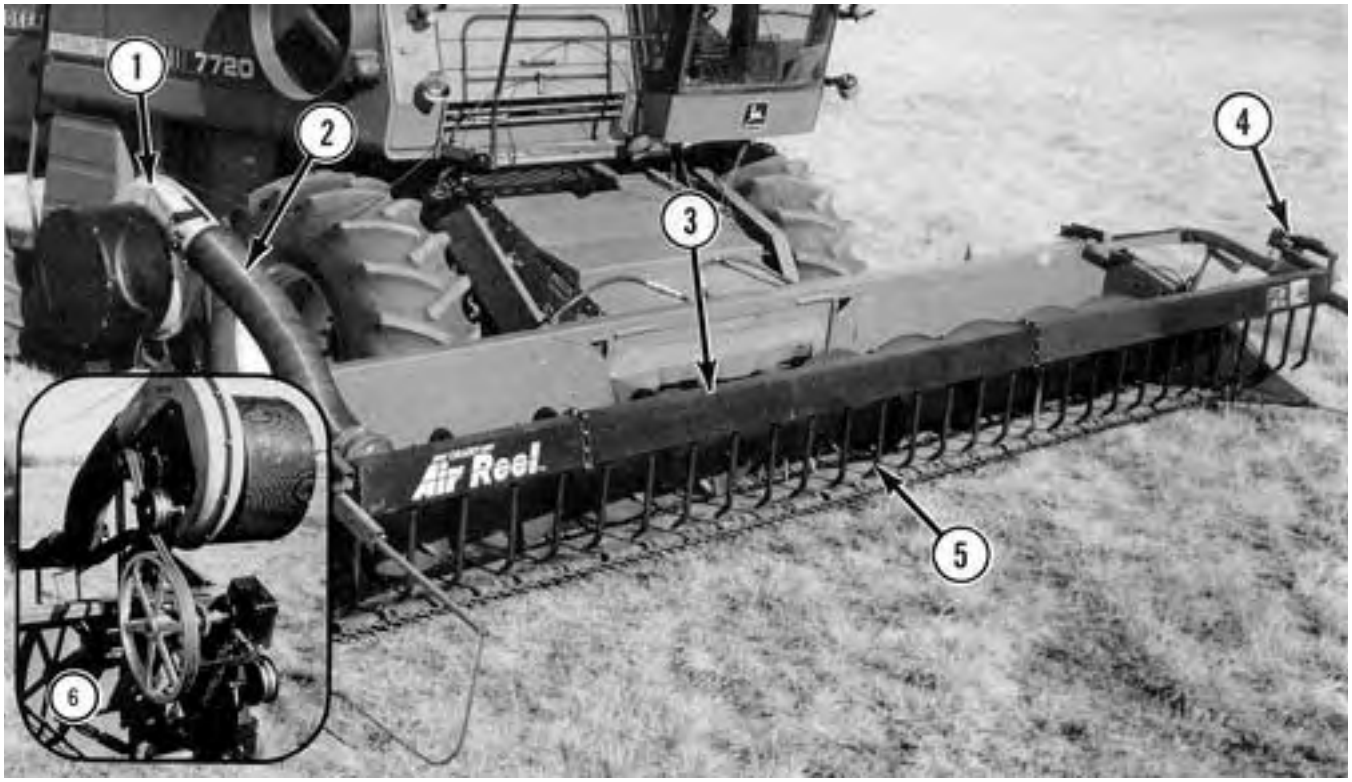

FIGURE 1. Crary Air Reel (1) Fan, (2) Flexible Duct, (3) Manifold, (4) Nozzle Tilt Actuator, (5) Nozzles, (6) Fan Drive.

SUMMARY AND CONCLUSIONS

Rate of Work: The rate of work for the Crary Air Reel was good. The reel did not limit combine speed in most crop conditions. Occasionally, in very heavy or in lodged, tangled crops, the feedrate had to be reduced to maintain smooth feeding along and under the header table auger.

Quality of Work: The Air Reel provided very good air delivery to the crop. The volume and velocity were adequate and the distribution fairly uniform. “Double drop tubes” were available to provide extra air discharge in critical areas. Crop movement was good in most conditions encountered. Shatter loss and head loss were similar to those of a bat reel in average and taller crops. The Air Reel was much better suited to operation in short crops than a bat reel.

Ease of Operation and Adjustment: The ease of installation of the Craw Air Reel was good. A special split pulley and modified key made it unnecessary to remove the header shaft for installing the fan drive. Ease of adjustment was very good. Reel height, air discharge direction and fan blast were adjustable from in the cab. Ease of setting the reel to suit crop conditions was very good. The manual was helpful and adjustment caused a noticeable change in performance. Appropriate settings were found for all the crop conditions encountered. Visibility was very good in most conditions. Ease of maintenance was very good.

Power Requirements: The fan required up to 24.0 hp (17.9 kW). The extra torque required on start up made it necessary to engage the header before the separator to avoid slipping the clutch on the header shaft driving the fan. Once up to speed, no problems were encountered. The power required by the fan did not noticeably affect the performance of the combine used in these tests.

Operator’s Manual: The operator’s manual was good. It contained most pertinent information but was not well organized which made it inconvenient to use.

Operator Safety: No safety problems were encountered, but normal caution was required.

Mechanical History: A weld on the jackshaft mounting assembly failed.

RECOMMENDATIONS

It is recommended that the manufacturer consider:
1. Modifications to the fan drive tightener to improve ease of belt removal.
2. Improving the organization of the operator’s manual.

Senior Engineer: J. D. Wassermann

Project Manager: L. G. Hill

THE MANUFACTURER STATES THAT

With regard to recommendation number:
1. Crary has redesigned this belt tightener. All units now have the new design.
2. The operator’s manual has been redone and now includes the addition of installation pictures.

GENERAL DESCRIPTION

The Crary Air Reel (FIGURE 1) uses jets of high velocity air to feed crop to a combine direct cut header. The air forces the crop back toward the header, as the cutterbar moves through the crop. Once the stems are cut, the air moves the crop to the combine table auger.

The air is supplied by a centrifugal fan and is ducted into a formed metal manifold, which spans the width of the cutterbar. Vertical "drop tubes" (nozzles) spaced along the manifold direct jets of air at the crop.

The fan is mounted above and slightly behind the end of the header. It is belt driven from an existing header drive shaft and runs at a fixed speed. Air volume is controlled by an adjustable damper in the fan exhaust outlet. The manifold is mounted on the header reel arms. Manifold fore-and-aft positioning is manually set. Vertical reel position is adjusted on-the-go from the cab using the combine's reel height controller. An electric actuator, controlled from the cab, rotates the manifold to change the direction of the air blast from the nozzles.

Detailed specifications are given in Appendix I.

SCOPE OF TEST

The main purpose of the test was to determine the functional performance of the Crary Air Reel. Measurements and observations were made to evaluate the Air Reel for rate of work, quality of work, ease of operation and adjustment, power requirements, operator safety and suitability of the operator's manual. Although extended durability testing was not done, any mechanical failures, which occurred during the test, were recorded.

The reel was mounted on a John Deere 224 direct cut header, which had the cutterbar set in the mid-position. The Air Reel was operated for 19.5 hours during which 300 ac (121 ha) of crop were harvested in various field conditions as shown in TABLE 1.

Gathering loss tests were conducted in both wheat and barley. Shatter loss (threshed kernels) and head loss were collected using "nested" pans placed across the width of cut. Several sets of collections were made at a single ground speed, which was typical for the combine. For comparison, similar collections were made under the same condition at the same speed using a bat reel.

In the lab, tests were conducted to determine fan performance and also to define the air discharge pattern from the nozzles.

RESULTS AND DISCUSSION

RATE OF WORK

The rate of work for the Crary Air Reel was good. The reel seldom limited harvesting rate in the conditions encountered.

In short low yield crops, ground speeds up to 8 mph (12.9 km/h) were possible. However, at this speed the cut was ragged and the demand on the operator to control the header when cutting so close to the ground made prolonged operation impractical. Speeds of 6 to 7 mph (9.7 to 11.3 km/h) were much more suitable. These speeds were generally 1 to 2 mph (1.6 to 3.2 km/h) faster than practical when using a bat reel. In heavier crops, speed was usually limited by combine capacity and the header's conveying ability. Speeds were similar to those attained when using the bat reel. In some very heavy or tangled crop, speed had to be reduced to permit smooth crop flow along the header.

QUALITY OF WORK

Air Delivery: Air delivery was very good.

Air was supplied by a Crary centrifugal fan. The fan typically delivered about 2000 cfm (940 L/s) of air with the fan damper fully open. The static pressure in the manifold ranged from about 24 to 29 in-wg (5980 to 7220 Pa). The static pressure in the nozzle tubes varied by only about 8% from the average. The small difference in static pressure between the nozzles suggested fairly uniform airflow along the length of the manifold.

The air discharge pattern from the nozzles is shown by the smoke patterns in FIGURES 2 and 3. FIGURE 2 shows that, viewed from above, each nozzle discharged air in a "fan" shaped pattern. The discharge has two distinctly stronger jets of air at the outer edges of the pattern. These jets travel rearward and slightly to the sides meeting jets from adjacent nozzles, approximately 10 to 12 in (254 to 305 mm) behind the nozzle tips. Where the jets met formed a larger uniform jet between the nozzles. This jet travelled straight back. The side view (FIGURE 3) shows that the air blast from the nozzles is not very deep. The air spread to only about 4 in (102 mm) after it had travelled 6 to 8 in (152 to 203 mm). The air blast dispersed rapidly after travelling about 16 in (406 mm), but did maintain a distinct pattern up to about 30 in (762 mm) behind the nozzles.

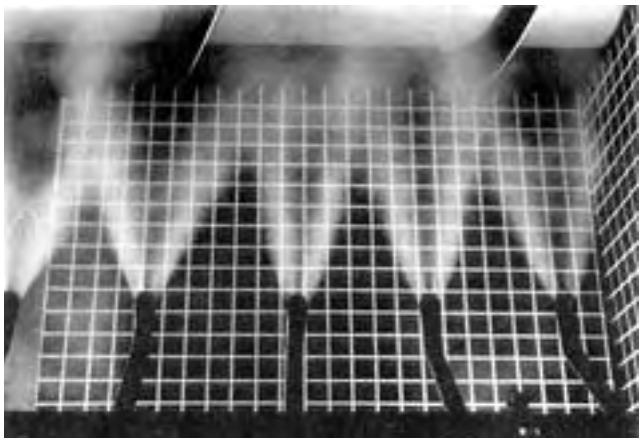

FIGURE 2. Top View of the Nozzle Discharge Pattern.

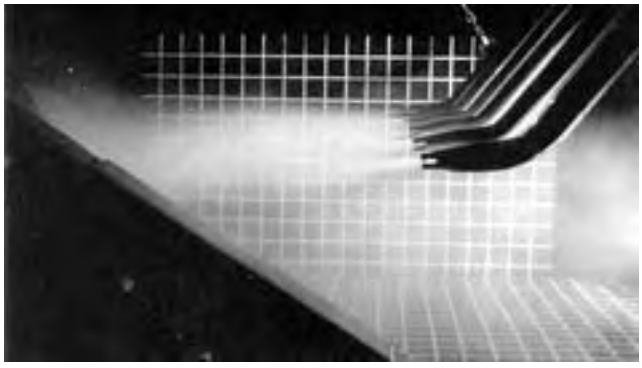

FIGURE 3. Side View of the Nozzle Discharge Pattern.

The Crary Air Reel also had double "drop" tubes (double nozzles), which provided two jets from one position on the manifold. These second nozzles discharged above the regular nozzle to provide two levels of air blast (FIGURE 4). The second nozzle could also be rotated to give an angled discharge to aid crop movement and/or give a more dense pattern by overlapping the jets (FIGURE 5).

Although the lab test showed a variation in the airflow across each discharge pattern, in the field there were no definite signs, which indicated that a more uniform pattern was needed.

Only a very small amount of chaff ever collected on the inlet screen and at no time did it cause any noticeable effect on the airflow.

Crop Movement: Crop movement was good.

When straight combining, a reel performs several functions critical to proper crop movement into the combine. First, it must hold the crop so that the cutterbar can move through the crop and cut the

TABLE 1. Operating Conditions

Crop	Variety	Yield Range		Crop Height		Field Area		Crop Harvested		Hours
		bu/ac	t/ha	in	mm	ac	ha	bu	t	
Barley	Harrington	50-60	2.7-3.2	12-24	305-610	15	6.2	850	18.5	2
Wheat	Katepwa	5-35	0.3-2.4	10-40	254-1016	285	115.3	2785	76.0	17.5
Total						300	121.5	3635	94.5	19.5

stalks. Next, it must ensure that the crop is moved back to the table auger correctly for proper conveying and feeding. In taller crops, the material should be transported vertically along the front of the table auger. The reel must prevent plants from falling forward which is especially important at the center where the crop accumulates before being fed under the auger. In shorter crops, material is normally conveyed under the auger rather than in front of the auger. The reel must direct the plants to fall head first into the auger. This is required to ensure headfirst conveying to the feeder. However, once under the auger, there is a natural tendency for the crop to spiral with the auger. To prevent this, most headers are equipped with “auger strippers”. This is an adjustable metal strip, located on the header panel behind the auger. It is set at a minimal clearance to the auger flighting. This strips the crop away from the auger, forcing the auger to convey the material to the center.

FIGURE 4. Deeper Air Blast with “Double Drop Tubes”.

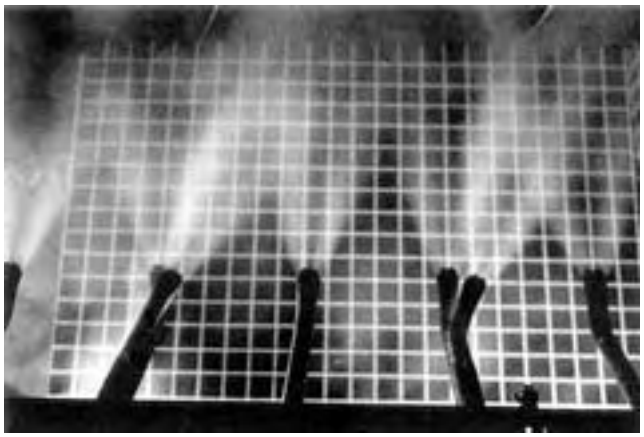

FIGURE 5. Wider “Fan” Pattern with “Double Drop Tubes”.

The Crary Air Reel, when properly adjusted, provided suitable crop movement in the crop conditions encountered. In typical crop stands, 20 to 30 in (510 to 760 mm) tall, the air blast held the crop for effective cutting and kept the crop travelling smoothly along the front of the auger (FIGURE 6). At the center, the crop was pulled under the auger and fed headfirst into the feeder. In taller crops, the crop conveyed smoothly without any problems. However, the reel was operated for a only a short time and it is possible that in some conditions it may be necessary to add the “double drop tubes” to maintain smooth feeding. In shorter crops, 10 to 15 in (250 to 380 mm) tall, the air blast worked well for holding the crop while being cut, and it moved the crop smoothly over the cutterbar. However, since the crop was very short, it was conveyed under the table auger. Once under the table auger, the typical tendency of an auger to carry material around with it resulted in most of the crop being conveyed behind the auger against the “auger stripper”. On this header the “auger stripper” often did not hold the crop. Towards the center of the header, where more material was being conveyed, crop was carried around the auger, and often thrown forward onto the ground. The air blast had little to do with the carry over and it is possible that this behavior was unique to this one header. To keep the crop contained, a second “auger stripper” was added. A small angle was bolted to the auger trough floor just slightly behind the auger’s vertical center line. The “floor stripper” greatly improved this header’s crop conveying in the short crops encountered.

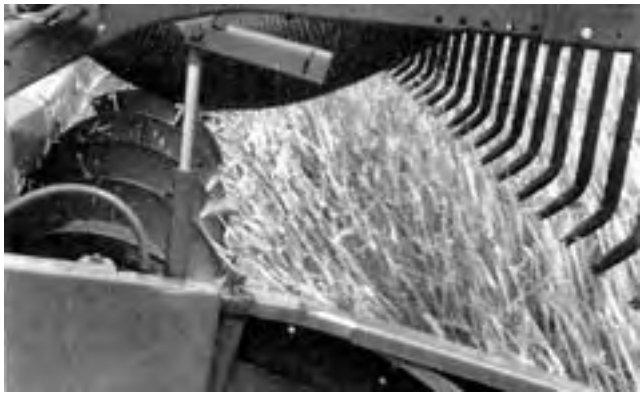

FIGURE 6. Typical Crop Movement.

Gathering Loss: Gathering loss is made up of loose kernels and heads, which are lost during the gathering process. The loose grain is called shatter loss and is grain threshed by contact with the reel, table auger or auger fingers and/or by the vibration created by cutting and crop movement. Head loss consists of whole or part heads which fall to the ground. These heads may be lost because the heads have dropped into the crop due to weakened straw and the cutterbar cuts above them. Alternatively, the heads may be just above the cutterbar and fall off the cutterbar as soon as they are cut. As well, some heads may be thrown forward by the auger or auger fingers.

When comparing two different reels it would be beneficial to be able to compare the loss from each reel. However, it is nearly impossible to collect only the loss that each reel caused. A more practical method is to compare the gathering loss from the same header alternately equipped with each reel and tested under similar conditions. Since the other components are the same, any differences in gathering loss can be attributed to the reels.

The wheat and barley crops used for the loss tests were mature, dry and of an average stand. The combine was operated at about 3 mph (4.8 km/h) in barley and at about 3.5 mph (5.6 km/h) in wheat. Shatterloss when using the Air Reel was low. In barley, the shatter loss was less than 0.5% and in wheat was about 0.3%. These losses were nearly identical to those of a bat reel. Harvesting at slightly higher moisture content would have likely even further reduced the shatter loss. Head loss was about 2 to 2.5% of the yield in both wheat and barley, which was nearly identical to the head loss for the bat reel. Again, harvesting at higher moisture before the heads had settled into the crop would most likely have greatly reduced head loss.

Although gathering loss for the Crary Air Reel was not significantly different than the bat reel in average crop conditions, different results could occur in other crop conditions. However, there are simply too many combinations of speeds, equipment selection and crop conditions to provide a complete comparison, Nevertheless general observations were used to qualitatively assess losses in more extreme conditions. In short crop, the constant air blast continually moved heads and short crop over the cutterbar and into the auger. On some headers, a reel bat may not have been able to clean the cutterbar. In such a case, the cut crop would have dropped onto the cutterbar, with a large percentage falling to the ground. Whereas with the Air Reel, very little crop fell off the cutterbar.

EASE OF OPERATION AND ADJUSTMENT

Installation: Ease of installation was good.

It took two people about five hours to mount the Air Reel on a John Deere 224 direct cut header. The fan assembly was mounted on the right end of the header (FIGURE 1). The main bracket was welded to the top beam on the header. The support tensioning brackets were bolted to the back header panel. The manufacturer supplied a special pulley and key so that the header shaft did not have to be removed. A key way was ground in the shaft with a hand grinder and the two halves of the pulley slipped over the shaft and bolted together. Care was required to ensure belt alignment.

The manifold was supplied with the nozzles installed. Mounting

the manifold on the reel arms was easy although it was heavy to handle. The flexible duct was fairly easy to install although it was hard to get over the pipe insert, which joined it to the reducer. The manufacturer's nozzle angle controller would have been easy to install. However, to accommodate PAMI's need to switch reels often, a modified actuator mount was used. The fan damper control was easy to install.

Adjustment: Ease of adjustment was very good. Moving the reel fore-and-aft was easy except for the repositioning of the tilt control arm length.

Nozzle angle adjustment was very easy using the electric actuator to rotate the manifold. The actuator was controlled by a switch in cab and could be adjusted on-the-go.

The push-pull control located in the cab permitted adjusting the fan damper on-the-go, which was very convenient. However, it was fairly stiff to operate when the fan was running. Reel height adjustment was easy using the combine's reel height controls.

Field Setting: Ease of setting for crop conditions was very good.

The operator's manual provided basic information and change in settings provided very noticeable differences in performance. The clear feedback enabled quick easy establishment of appropriate settings for particular crop conditions. Once an appropriate setting was found for a particular crop condition, the Air Reel was able to handle considerable variation in plant population, forward speed, and differences in crop height across the header without additional adjustment.

In average crops, where 16 to 24 in (410 to 610 mm) was cut, the nozzles were typically set at head level, 10 to 16 in (250 to 410 mm) ahead of the cutterbar and pointed at the cutterbar (FIGURE 6). The fan damper was usually set from half to fully open.

In taller crops, the nozzles were often lowered slightly into the crop with air blast directed more toward the top of the plants. This also worked well in crops, which leaned away from direction of travel although the air blast was usually directed more towards the cutterbar (FIGURE 7).

FIGURE 7. Setting for Taller and Leaning Crops.

In lodged, tangled crop, the nozzles were lowered into the crop and the air blast directed towards the cutterbar (FIGURE 8).
In short thin crops, the nozzles were run close to the ground with the air blast nearly parallel to the ground and pointed at the cutterbar (FIGURE 9).

FIGURE 8. Settings for Lodged Crop.

FIGURE 9. Settings for Short Crop.

Visibility: The Crary Air Reel enabled very good visibility of the crop, cutterbar and header in most crop conditions.

In short sparse crops, the constant airflow kept the cutterbar clean, while in all crops the manifold and nozzles obstructed the operator's view very little. The Air Reel stirred up more chaff and dust than a bat reel. This was not a problem except in the dim light between sunset and dark. At this time of day the chaff and dust became more noticeable. The decreased visibility was especially noticeable when operating in short crops where header height control was critical. During this hour or two, the natural light wasn't adequate to be able to see the ground and cutterbar, and the combine lights didn't make an appreciable difference. It was helpful to reduce airflow to as low as practical. Once dark, the combine lights were much more effective. The light penetrated the dust and chaff and visibility was greatly improved and normal airflow settings could be used.

The Air Reel was less tiring to operate especially at night due to the absence of intermittent light reflection typically experienced with a bat reel.

Maintenance: Ease of routine maintenance was very good.

Very little maintenance was required. The drive belts used spring loaded tensioners and the jack shaft bearings required infrequent lubrication. Fan belt removal was inconvenient due to the tensioning idler pivot being located such that the idler could not be pulled away from the belt. It is recommended that the manufacturer consider modifications to the fan drive tightener to permit more convenient belt removal.

POWER REQUIREMENTS

Power requirements for the Crary fan ranged from about 17.5 hp (13 kW) with the damper closed to 24.0 hp (17.9 kW) with the damper open.

The fan drive handled the load without any problems. However, on start-up, the power demand of the fan caused the clutch, on the header drive shaft, to slip. This was overcome by engaging the header before engaging the main combine drive. Once up to operating speed, no adverse effects on the combine's performance were noticed.

The power required was much higher than the power required for the bat reel. On combines, which operate near their power limit, the extra power required to run the fan may cause a noticeable reduction in the feedrates normally attained.

OPERATOR'S MANUAL

The operator's manual was good.

The manual contained most pertinent information on installation, operation, maintenance and parts. However, it was not well organized which made it inconvenient to use. It is recommended that the manufacturer consider improving the organization of the operator's manual.

OPERATOR SAFETY

The Crary Air Reel did not present any safety problems. The fan was well shielded and there was a decal under the shield, which warned not to operate without the shield in place. The operator's manual also made specific notes for safe operating procedures.

Any time when working near the header, it is vitally important to disengage all drives and shut off the engine. The header should be lowered to the ground or securely blocked.

MECHANICAL HISTORY

The intent of the test was evaluation of functional performance. Extended durability testing was not conducted. However, TABLE 2 outlines the mechanical history of the Crary Air Reel during the test.

TABLE 2. Mechanical History

Item	Operating Hours
-a weld on the fan mounting assembly failed due to poor weld penetration and was rewelded	end of test

Weld Failure: The weld failure was due to poor weld penetration (FIGURE 10). Proper welding procedure and quality control would prevent similar failures. It should be noted that the same fan was also used in the Crary Finger Air Reel test as reported on in PAMI Report #591. This is the same failure which was described in that report; not another similar failure.

FIGURE 10. Weld Failure on Fan Mounting Bracket.

APPENDIX I
SPECIFICATIONS

MAKE:	Crary
MODEL:	Air Reel - 24 ft (7.4 m)
FAN:	
-- type	Centrifugal - “squirrel cage”
-- number of blades	48
-- outside diameter	16.4 (416 mm)
-- inlet diameter	14.3 in (362 mm)
-- outlet diameter	7.4 in (188 mm)
-- operating speeds	run at 4200 rpm (maximum 4600 rpm)
-- damper control	lockable control cable from cab
-- drive	2 stage V-belt 3 “b” belts from header shaft to jackshaft 2 “b” belts from jackshaft to fan
MANIFOLD:	
-- material	steel
-- thickness	0.08 in (2 mm)
-- cross section shape	trapezoid - Top 3.5 in (89 mm) - Bottom 5.5 in (14 mm) - Sides 6.5 in (16.5 mm)
-- length	23.6 ft (7.2 m) - 3 bolted sections
-- inlet diameter	6 in (152 mm)
-- angle adjust	manual adjust linkage
NOZZLES:	
-- type	single, curved steel tube with crimped outlet
-- number	29
-- length	20 in (508 mm)
-- diameter	1.25 in (32 mm)
COUPLER:	
-- type	flexible vinyl tube with spiral steel reinforcing wire
-- diameter	8 in (203 mm)
-- length	4.3 ft (1.3 m)
-- adapter to manifold	molded rubber reducer
-- retainers	hose clamps
WEIGHTS:	
-- fan assembly	180 lb (81.6 kg)
-- manifold and nozzles	260 lb (118.2 kg)

OPTIONS:
-- electric fan damper control
-- electric actuator for nozzle angle adjustment
-- double “drop” tubes

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Fair
Very Good	Poor
Good	Unsatisfactory

SUMMARY CHART
CRARY AIR REEL

RETAIL PRICE	$3,850.00 (March, 1989, f.o.b. Humboldt Sask.)
RATE OF WORK	**Good;** seldom limited combine speed
QUALITY OF WORK	
Air Delivery	**Very Good;** uniform over length of manifold, pattern from each nozzle uniform
Crop Movement	**Good;** proper crop movement in most crops
Gathering Loss	similar to bat reel in average crops, lower head loss in very short crop
EASE OF OPERATION AND ADJUSTMENT	
Installation	**Good;** header shaft didn't have to be removed
Adjustment	**Very Good;** controlled most functions from cab
Field Setting	**Very Good;** appropriate settings were easily determined
Visibility	**Very Good;** little obstruction, no intermittent reflected light at night
Maintenance	**Very Good;** very little service required
POWER REQUIREMENTS	up to 24.0 hp (17.9 kW)
OPERATOR'S MANUAL	**Good;** contained useful information but not well organized
SAFETY	normal caution required
MECHANICAL HISTORY	a minor weld failure on jackshaft bracket

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