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Evaluation Report 12

Farmhand Model F890-A Tub Grinder

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

FARMHAND MODEL F890-A TUB GRINDER

MANUFACTURER:

Farmhand, Inc.
2401 Second Avenue
Greeley, Colorado 80631
U.S.A.

DISTRIBUTORS:

Renn Sales Ltd.
12555 - 127th Avenue
Edmonton, Alberta
T5L 3E5

3240 - 11th Street S.E.
Calgary, Alberta
T2G 3G8

810A - 48th Street East
Saskatoon, Saskatchewan
S7K 3Y4

Gerry Henchel Implements Ltd.
5540 Portage Avenue
Winnipeg, Manitoba

FIGURE 1. Farmhand Model F890-A Tub Grinder.

SUMMARY AND CONCLUSIONS

Overall functional performance of the Farmhand F890-A was *good* in both stacked hay and straw, but only *fair* with large round bales. Ease of operation was *good.*

Maximum grinding rates with a 51 mm (2 in) screen were about 4.2 t/h (4.6 ton/h) in baled alfalfa, 5.4 t/h (5.9 ton/h) in stacked alfalfa, 3.7 t/h (4.1 ton/h) in stacked barley straw and 2.8 t/h (3.1 ton/h) in baled barley straw. Maximum grinding rates with a 25 mm (1 in) screen were about one-half as large as those with a 51 mm (2 in) screen. Grinding rates were limited by feeding characteristics, particularly in round bales.

As with most tub grinders, specific capacity was low. Specific capacity varied from 0.36 t/kW.h (0.30 ton/hp.h) in stacked alfalfa hay to 0.08 t/kW.h (0.07 ton/hp.h) in round barley straw bales, when using a 51 mm (2 in) screen. Specific capacities were reduced by about 50% when using a 25 mm (1 in) screen.

As with most tub grinders, the method of feeding the hammer mill imposed heavy shock loads on the power train and resulted in wide power fluctuations. For example, at the maximum feedrate of 2.8 t/h (3.1 ton/h), with a 51 mm (2 in) screen in round barley straw bales, the average power input was 33 kW (44 hp), however, a tractor with a maximum power take-off output of at least 63 kW (85 hp) was needed to prevent tractor stalling due to the wide power fluctuations. By adjusting the tub governor, smaller tractors could be used at reduced grinding rates.

The Farmhand F890-A was safe to operate if the manufacturer's recommendations were closely followed. The location of the tub speed control adjacent to the pto shaft required additional caution when adjusting tub speed.

RETAIL PRICE:

$9,714.00 (December, 1975, f.o.b. Humboldt, Saskatchewan with 51 mm (2 in) and 102 mm (4 in) screens).

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing adjustable driving fins on tub sidewalls.
2. Providing positive latching of access platform to reduce possibility of injury.
3. Investigating the possibility of installing a suitable flywheel on the hammer mill to reduce drive train shock loads.

Chief Engineer -- E. O. Nyborg
Senior Engineer -- L. G. Smith

THE MANUFACTURER STATES THAT

With regard to recommendation number:

No reply was received from the manufacturer.

GENERAL DESCRIPTION

The Farmhand Model F890-A Tub Grinder (FIGURE 1) is a portable power take-off driven hammer mill with rotary feed tub, designed to grind loose stacked or baled straw and hay.

The manufacturer recommends use with tractors up to 75 kW (100 hp) at 1000 rpm power take-off speed. An attachment is available to convert the 1000 rpm gearbox for use at 540 rpm.

The Farmhand F890-A is designed to be batch fed with a suitably equipped front end loader. The hydraulically driven, variable speed tub regulates feed to a gear driven hammer mill. A hydraulic governor automatically controls the tub speed and stops tub rotation when the tractor speed drops below a preset level.

Fineness of grind is determined by the size of screen used below the hammer mill. Ground material falls through the screen onto an apron chain conveyor which delivers it to a side mounted, slatted rubber belt elevating conveyor.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Farmhand F890-A was operated for 39 hours while processing about 135 t (149 tons) of hay and straw. It was used to process small square bales, large round bales, and stacked hay.

It was evaluated for ease of operation, rate of work, power consumption, quality of work, operator safety, and suitability of the operator's manual.

RESULTS AND DISCUSSION

EASE OF OPERATION

Hitching: The Farmhand F890-A was easily hitched to a tractor. The hitch jack was safe and convenient to use. The 1000 rpm power take-off shaft was attached with a spring loaded locking yoke.

Tub Control: The hydraulic reversible tub drive was equipped with a proportioning valve to control the tub speed and consequently the feedrate. The valve had to be set to obtain steady tub rotation while utilizing the available tractor power. The valve had to be adjusted to suit both the type of material being ground and the tractor size. It was quite easy to determine the proper setting by opening the valve until the tractor was suitably loaded.

The hydraulic governor reduced hammer mill slugging if the proportioning valve was properly set. As engine speed dropped under load, the governor stopped tub rotation if power take-off speed fell below the preset level. As with most tub grinders, slugging and high drive train loads occurred if excessive feedrates were attempted.

A hydraulic motor driven pneumatic tire rotates the tub through contact with the outside of the lower channel ring. Contact is maintained by pressure of the tire and by an adjusting bolt on the pivoted wheel assembly.

Under extremely wet or dry conditions, tire slippage would occur causing a reduction in capacity.

Loading the Tub: The Farmhand F890-A has a tapered tub (FIGURE 1) and a side guide rack. Height to the top of the tub was 2300 mm (7.6 ft). When loading loose hay with grapple forks, large loads tend to wedge as the material drops into the narrower section of the tub. The most effective feeding was obtained by taking small loads which would easily drop to the bottom of the tub.

The inside walls of the tub are equipped with small fixed baffles which at times had difficulty forcing material in the tub to turn. Larger adjustable baffles or fins would be more convenient and effective. The fins on the floor (FIGURE 2) repositioned loose forms of material adequately, but when grinding large round bales the fins do not work satisfactorily. Repositioning the fin (FIGURE 3) improved the performance, as the bale was repositioned with each tub revolution, causing the hammers to cut a new swath from under the bale.

FIGURE 2. Fin on Tub Floor.

FIGURE 3. Fin on Tub Floor Repositioned.

Screen Removal: Thirteen screen sizes from 6.4 to 102 mm (0.25 to 4 in) plus a bar screen were available for the Farmhand F890-A Changing the screen (FIGURE 4) required the removal of four bolts and the use of a bar to pry the screen up and around the mill. Screens could be removed and replaced by one man in about 15 minutes.

FIGURE 4. Hammer Mill.

Hammer Mill: The hammer mill contained four rows of swinging hammers, with six hammers per row. When worn, the hammers could be reversed or rotated end-for-end to present new wear surfaces. This could be accomplished from within the tub by removing each hammer pin shaft. Hammers must be replaced in pairs on opposite sides of rotor to maintain rotor balance.

Discharge Chamber: The hammer mill discharged ground material onto a continuous chain with drag bars below the screen (FIGURE 5). The width of chute and apron conveyor was adequate except when a 76 mm (3 in) or larger screen was used. When the tub was run at full speed with these larger screens the discharge opening would become plugged. The removable back cover provided a suitable clean-out for the mill discharge chamber.

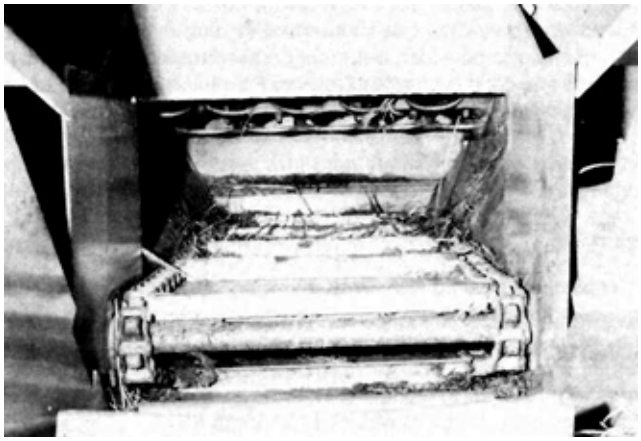

FIGURE 5. Apron Conveyor.

Elevating Conveyor: The slatted rubber belt conveyor had ample conveying capacity at lift angles up to 25°. In most materials, at lift angles greater than 25°, the material slipped and tumbled on the belt. At a 25° angle, the conveyor had a discharge height of 2591 mm (8.5 ft) and a corresponding reach of 4420 mm (14.5 ft).

The conveyor was equipped with self cleaning pulleys which

effectively reduced the buildup of fines between the conveyor belt and the belt trough. The sides of the conveyor trough prevented the blowing of fines in moderate winds.

The side mounted conveyor folds for reduced height in transport (FIGURE 6). The friction drag cable winch is used to set the desired height and in folding the conveyor for transport.

The side mounted conveyor was somewhat inconvenient to maneuver in narrow passages and was too low for loading into a high truck or wagon. It was convenient for mobile grinding directly into a feed bunk or trough.

FIGURE 6. Elevating Conveyor in Transport Position.

Winter Operation: All evaluation was conducted in winter conditions, typical of most tub grinder use in the prairie provinces. All components, including the hydraulic tub control, worked well, even at temperatures of -30° C.

During winter operation, accumulated snow should be removed from the tub and rotating parts checked for ice accumulation before starting. It is also recommended to start the grinder with the tub control in neutral position.

As is common with all tub grinders, excessive snow mixed with ground hay can result in heating problems. If ground hay is to be stockpiled, the moisture content must be low enough to ensure that the stockpile will not heat and spoil.

Transporting: The Farmhand F890-A had a fixed single axle with no spring suspension. As a result, it was not suited for high speed transport. The side mounted elevating conveyor caused the machine to be wider, but the increased tread width provided a stable stance. It is unsafe to tow the Farmhand F890-A behind a light truck; a tractor or large truck is needed.

The conveyor was safely held in position by a support strap during transport.

RATE OF WORK

Maximum Grinding Rate: The maximum grinding rate for a tub grinder depends on the type of hay being ground, whether the hay is baled or loose, its moisture content and temperature, the screen size used, and the available tractor power. In general, grinding rates are higher at very low temperatures as hay becomes more brittle at reduced temperatures.

Maximum grinding rates obtained with the Farmhand F890-A when equipped with a 51 mm (2 in) screen were 4.2 t/h (4.6 ton/h) in baled alfalfa, 5.4 t/h (5.9 ton/h) in stacked alfalfa, 3.7 t/h (4.1 ton/h) in stacked barley straw and 2.8 t/h (3.1 ton/h) in baled barley straw. In general, the capacity was directly related to the screen size used and reducing the screen size by 50% also reduced the capacity by about 50%. For example, the maximum capacities to be expected when using a 25 mm (1 in) screen would be about from 2.1 to 2.7 t/h (2.3 to 3 ton/h) in alfalfa and from 1.4 to 1.9 t/h (1.6 to 2.1 ton/h) in barley straw.

POWER CONSUMPTION

Power Take-off Requirements: FIGURE 7 shows the average power take-off input for the Farmhand F890-A in alfalfa and barley straw. The power input is plotted against grinding rate up to the maximum rate reached for each test. The average power input, at maximum grinding rate, with a 51 mm (2 in) screen varied from 15 kW (20 hp) in stacked alfalfa hay to 33 kW (44 hp) in round barley straw bales.

The power consumption at reduced grinding rates, corresponding to smaller tractors, may be read from FIGURE 7. As mentioned previously, the capacity was directly related to screen size for a certain power input. For example, a power input of 33 kW (44 hp) in round barley straw bales corresponds to a maximum capacity of 2.8 t/h (3.1 ton/h) with a 51 mm (2 in) screen and a maximum capacity of only 1.4 t/h (1.5 ton/h) with a 25 mm (1 in) screen.

Specific Capacity: Specific capacity is a measure of how efficiently a machine performs a task. A high specific capacity indicates efficient energy use while a low specific capacity indicates inefficient operation. Tub grinders, in general, are inefficient machines.

The specific capacity of the Farmhand F890-A, with a 51 mm (2 in) screen, varied from 0.36 t/kW.h (0.30 ton/hp.h) in stacked alfalfa hay to 0.08 t/kW.h (0.07 ton/hp.h) in round barley straw bales. These values represent average operating values and not peak outputs. These values would be reduced to about 0.18 t/kW.h (0.15 ton/hp.h) in alfalfa and 0.04 t/kW.h (0.03 ton/hp.h) in straw, when equipped with a 25 mm (1 in) screen.

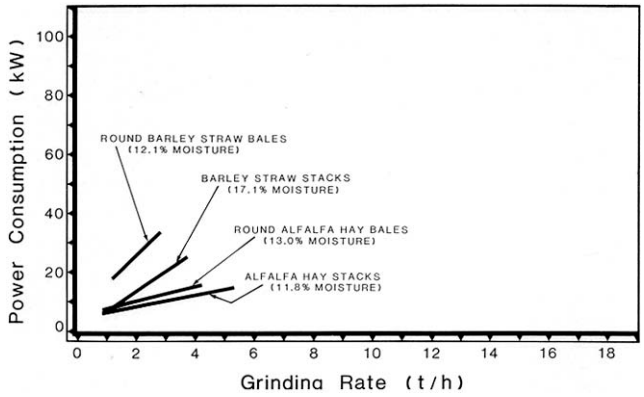

FIGURE 7. Power Consumption of the Farmhand F890-A, at Various Grinding Rates, when Equipped with a 51 mm (2 in) Screen.

Instantaneous Power Requirements: FIGURE 7 shows the average power consumption at various feedrates. Instantaneous power input fluctuates rapidly due to non-uniform feeding to the hammer mill and governor sensitivity. Peak power requirements are much greater than those shown in FIGURE 7. A typical one-minute long instantaneous record of power input while grinding baled alfalfa hay is shown in FIGURE 8. As can be seen, input power fluctuated rapidly during one minute of operation at a fixed governor setting. These wide power fluctuations represent shock loads to the tractor and grinder drive train and indicate the amount of reserve power needed to prevent tractor stalling.

The coefficient of variation[1] (TABLE 1) may be used to compare the power train shock loads and to show the possibility of tractor stalling when grinding various materials. The larger the coefficient of variation, the higher the shock loads and the greater the possibility of tractor stalling. Large variations in power requirements may be partially controlled with the tub governor. Most of the variation, which is beyond operator control, is due to the erratic nature of feeding in most tub grinders. In

[1]The coefficient of variation is the standard deviation of the power fluctuation expressed as a percent of the mean power at one feedrate setting. The coefficients of variation given in TABLE 1 are the average of the coefficient of variation for at least five different feedrates in each material.

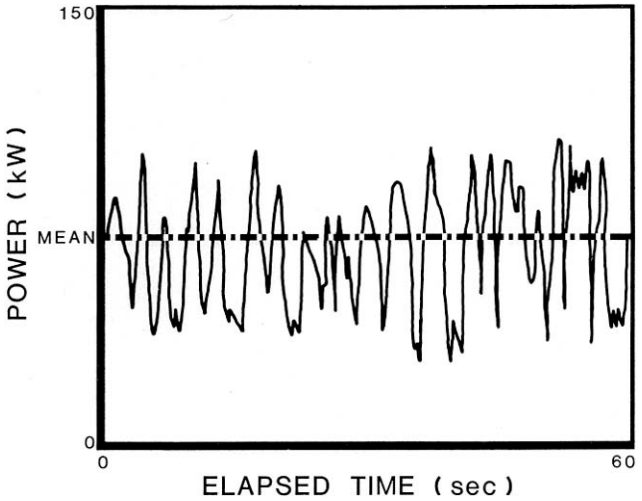

FIGURE 8. Typical Instantaneous Power Requirements for a Tub Grinder.

general, smaller variations in power requirements occurred with loose hay or straw than with bales, due to more uniform feeding. It is recommended that the manufacturer investigate the possibility of installing a suitable flywheel on the hammer mill to reduce drive train shock loads.

TABLE 1. Coefficients of Variation of Input Power for the Farmhand F890-A with 51 mm (2 in) Screen.

STRAW BALES	STRAW STACKS	ALFALFA BALES	ALFALFA STACKS
44.7%	18.1%	37.3%	21.3%

Determining Expected Grinding Rate for Certain Tractor Size: FIGURE 9[2] may be used to estimate the average grinding rate which may be expected for a certain tractor size in a certain type of material when using a 51 mm (2 in) screen. FIGURE 9 represents the same data as given in FIGURE 7, but has been corrected to include the peak power fluctuations shown in TABLE 1. For example, a tractor with maximum power take-off output of 20 kW (27 hp) at 1000 rpm, expected maximum grinding rates without tractor stalling are 5.1 t/h (5.6 ton/h) in stacked alfalfa hay, 2.6 t/h (2.9 ton/h) in round alfalfa hay bales, and 2.1 (2.3 ton/h) in stacked straw. As previously discussed, changing to 25 mm (1 in) screen would reduce the expected grinding rates to about one-half of those shown in FIGURE 9, for the same power input.

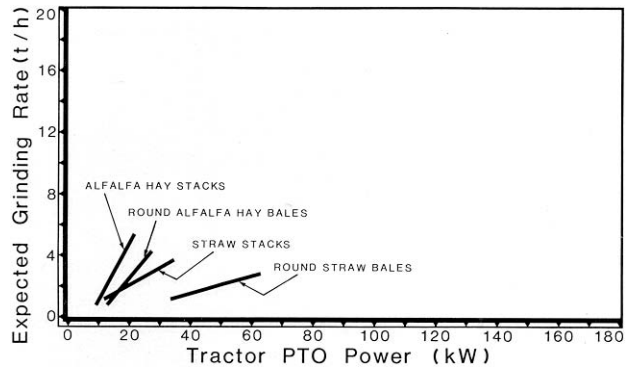

FIGURE 9. Determining Expected Average Grinding Rates With the Farmhand F890-A for Various Tractor Sizes when Using a 51 mm (2 in) Screen.

[2]FIGURE 9 is a plot of the mean power requirements plus twice the standard deviation of the power fluctuations. Instantaneous power requirements should fall below the line 98% of the time.

QUALITY OF WORK

Length of Cut: For a certain screen size, tub grinders produce chopped hay of varying particle lengths. FIGURE 10 shows a typical particle size distribution for the Farmhand F890-A when grinding stacked alfalfa hay with a 51 mm (2 in) screen. TABLE 2 shows the percent by weight of each of the particle sizes given in FIGURE 10, when grinding various materials with a 51 mm (2 in) screen.

TABLE 2. Size Distribution of Ground Material When Using a 51 mm (2 in) Screen.

	PERCENT OF TOTAL SAMPLE WEIGHT				
LENGTH OF PARTICLE	STACKED BARLEY	ROUND BARLEY	STACKED ALFALFA	ROUND ALFALFA	STACKED SWEET CLOVER
Less than 3 mm long (FIG. 10a)	8.5	11.4	23.1	20.1	17.9
3 to 10 mm (FIG. 10b)	32.0	34.7	37.1	40.9	29.6
10 to 18 mm (FIG. 10c)	21.8	17.9	11.4	12.1	15.8
18 to 25 mm (FIG. 10d)	12.4	13.4	12.0	14.1	15.3
25 to 38 mm (FIG. 10e)	19.9	17.9	13.5	11.3	16.0
Greater than 38 mm (FIG. 10f)	5.4	4.7	2.9	1.5	5.4

OPERATOR SAFETY

The Farmhand F890-A was generally safe to operate and service as long as common sense was used and the manufacturer's safety recommendations were followed. Rotating parts were well shielded, the unloading conveyor could be fixed in position for transport and the cable winch had a friction drag for safety in lowering the elevating conveyor.

The hinged inspection platform was held in place by an elastic strap (FIGURE 11) and failure to secure the latch would result in the platform tipping up, when the operator climbed onto it from the right hand side. A positive latch is recommended.

The location of the tub speed control (FIGURE 11) adjacent to the pto shaft required caution when making adjustments to the tub speed.

GENERAL SAFETY COMMENTS

The operator is cautioned that a tub grinder is potentially very dangerous. The following precautions should be observed when operating any tub grinder.

Never stand on the inspection platform or look into the tub while the grinder is in operation as dangerous objects may be thrown out of the tub by the hammer mill.

Never grasp loose baler twine that is hanging over the tub wall as it may be instantaneously reeled into the hammer mill causing injury.

Periodically remove twine buildup from the hammer mill rotor to reduce fire hazard and carry a fire extinguisher on the grinder at all times.

Tow the grinder behind a tractor or suitably sized truck at low speed. A light pickup truck is not suitable. Be especially careful of conveyor height and overhang when turning corners or passing under power lines.

Disengage the power take-off and stop the tractor to clear blockages or to make adjustments. The manufacturer can only go to certain limits in providing shielding and safety devices and must rely on the operator's common sense in following established safety procedures.

As is common with all tub grinders, great care must be taken to ensure that hay is free of foreign material such as barbed wire or baling wire. This is especially true when processing large round bales. Although wire presents no problem to the tub grinder, the short pieces formed after grinding are a potential source of "hardware disease" in cattle.

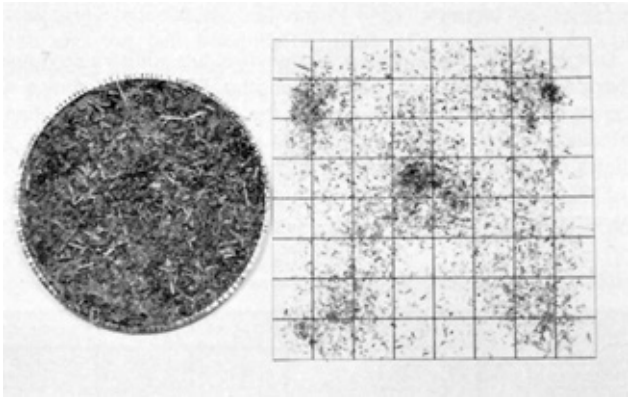

FIGURE 10a. Less than 3 mm long.

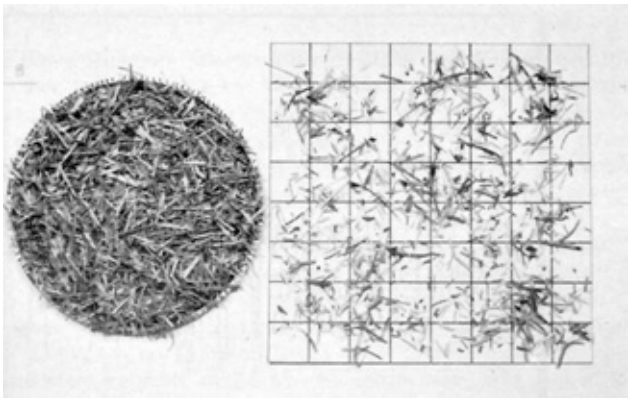

FIGURE 10b. 3 to 10 mm.

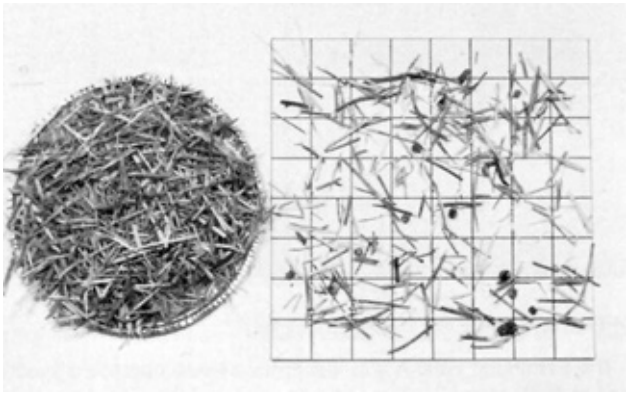

FIGURE 10c. 10 to 18 mm.

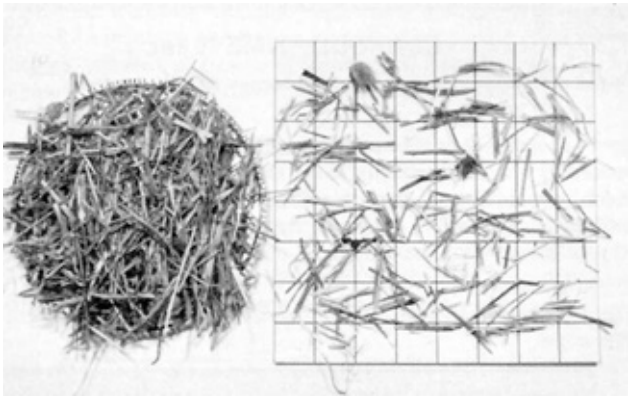

FIGURE 10d. 18 to 25 mm.

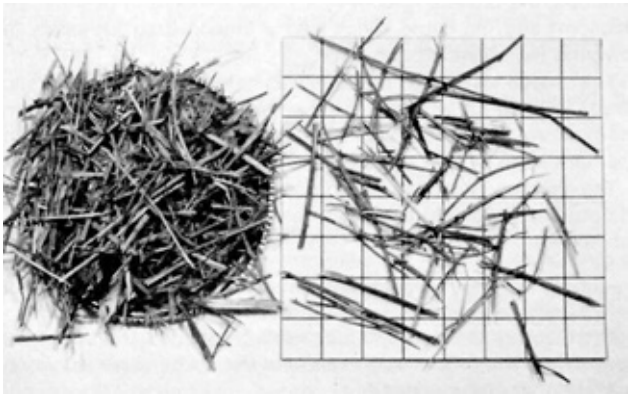

FIGURE 10e. 25 to 38 mm.

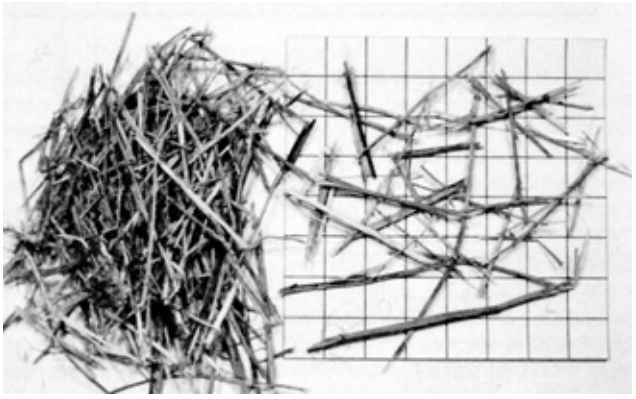

FIGURE 10f. Greater than 38 mm.

FIGURE 10. Distribution of Particle Lengths when Grinding Stacked Alfalfa Hay with a 51 mm (2 in) Screen. Pictures were taken on a 2 cm grid.)

OPERATOR'S MANUAL

The operator's manual was clear, well written and contained much useful information on operation, servicing adjustments and safety precautions.

DURABILITY RESULTS

The Farmhand F890-A was operated for 39 hours while processing about 135 t (149 tons) of hay and straw. The intent of the test was to evaluate functional performance and an extended durability evaluation was not conducted. No significant mechanical problems occurred during functional testing.

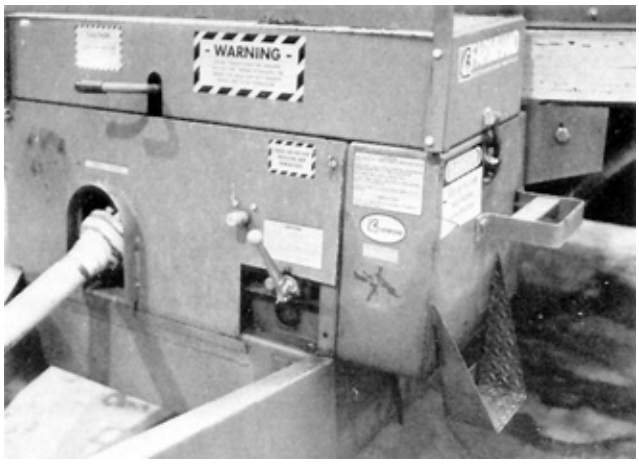

FIGURE 11. Front of Farmhand F890-A.

APPENDIX I

SPECIFICATIONS

MAKE:	Farmhand
MODEL:	F890-A
SERIAL NUMBER:	203
MANUFACTURER:	Farmhand Inc. 2401 Second Avenue Greeley, Colorado 80631 US.A.

OVERALL DIMENSIONS:

-- width	6300 mm (248 in)
-- height (with conveyor at 25°)	3100 mm (122.0 in)
-- length	4800 mm (189.0 in)
-- ground clearance	300 mm (11.8 in)

WEIGHT:

-- hitch	536 kg (1181.7 lbs)
-- left wheel	410 kg (903.9 lbs)
-- right wheel	1330 kg (2932.1 lbs)
(TOTAL)	2266 kg (4995.6 lbs)

SUSPENSION:	Solid

TIRES:

-- size	2 -- 9.00 x 16, 10 ply

TUB:

-- top diameter	2630 mm (103.5 in)
-- bottom diameter	2225 mm (87.6 in)
-- total depth	1215 mm (47.8 in)
-- loading height	2330 mm (91.7 in)
-- type of governor	Hydraulic
-- tub speed range	Min. 0 Max. 11 rpm
-- drive	16 x 6.50, 4 ply tire chain driven from hydraulic motor

HAMMER MILL:

-- length	559 mm (22.0 in)
-- diameter	520 mm (20.5 in)
-- shaft diameter	61.9 mm (2.4 in)
-- hammers	
-- length	165 mm (6.5 in)
-- thickness	9.5 mm (0.375 in)
-- type	Reversible & sharp 4 sides
-- number of rows	4
-- hammers per row	6
-- total number of hammers	24
-- pin size	25.4 mm (1.0 in)
-- drive train	Direct from gearbox off pro shaft
-- speed at 1000 rpm power take-off	1981 rpm
-- speed when governor engages tub	1910 rpm
-- speed when governor disengages tub	1750 rpm

HAMMER MILL CONVEYOR:

-- type	continuous chain with drag bars
-- length	1054 mm (41.5 in)
-- width	483 mm (19 in)
-- minimum clearance to screen	216 mm (8.5 in)
-- drive	chain driven off gearbox
-- conveying speed	1.1 m/s (219 f/m)

ELEVATING CONVEYOR:

-- type	rubber slatted belt
-- length	4877 mm (192 in)
-- height at 25 incline	2591 mm (102 in)
-- width	464 mm (18.3 in)
-- depth	254 mm (10 in)
-- drive train	chain driven from gearbox
-- speed	2 m/s (400 f/m)

SCREENS:

-- type	one piece
-- length	650 mm (25.6 in)
-- circumferential length	1110 mm (43.7 in)
-- thickness	6.350 mm (0.25 in)
-- h01e size	50.8 mm (2.0 in)
-- screened area	0.72m^2 (1118 in^2)

MANUFACTURER'S MAXIMUM RECOMMENDED TRACTOR SIZE AT 1000 RPM:	75 kW (100 hp)

APPENDIX II

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

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

APPENDIX III

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 kilogram (kg)	= 2.2 pounds (lb)
1 tonne (t)	= 2204.6 pounds (lb)
1 tonne/hour (t/h)	= 1.10 ton/hour (ton/h)
1000 millimetres (mm) = 1 metre (m)	= 39.37 inches (in)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 tonne/kilowatt.hour (t/kW.h)	= 0.82 ton/horsepower hour (ton/hp.h)

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