EXPERIMENTAL VERTICAL AUGERS FOR A SILO UNLOADER

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THE PRODUCTION OF SILAGE is increasing rapidly in Illinois. Nearly eight times as much grass silage was produced in 1954 as in 1950 (447,000 tons as compared with 56,000 tons), and the production of corn and sorghum silage increased almost 60 percent (1,808,000 tons in 1950; 2,845,000 tons in 1954). More farmers are using silage today, and they are feeding larger amounts per head of livestock.

A mechanical silo unloader will save the farmer many trips up the silo yearly, and will eliminate the hand-lifting of hundreds of tons of silage. In addition, silage that has been unloaded mechanically is well mixed. Livestock find this silage more palatable and waste less of it.

Some farmers are feeding silage from the silo throughout the year with little or no pasturing. A mechanical silo unloader and bunk feeder greatly reduce the daily chore time as compared with daily chopping of the forage and feeding in the dry lot.

Current models of silo unloaders are much more dependable than earlier models, and further improvements in efficiency will lead to even greater use of silo unloaders and a corresponding saving of time and disagreeable labor for Illinois farmers.

The present unloaders that operate on the top surface of the silage perform four functions: (1) loosen the silage on the surface; (2) gather the loosened silage to the center of the top surface; (3) elevate the silage high enough to clear the rotating gathering mechanism; and (4) convey the silage from the center to the silo door.

Present unloaders use a blower or thrower with an estimated power requirement of 2 to 5 horsepower to perform the elevating and conveying function. The loosening and gathering mechanism requires an estimated additional power of 1 horsepower. One unloader employs a horizontal auger to do part of the conveying from the center of the silo to the silo door. This auger operated satisfactorily with a ½-horsepower electric motor.

The greatest opportunity for improving silo unloaders seemed to lie in the development of a more efficient device than the blower-thrower to move silage from the center of the silo to the door. Observations have indicated that an auger will satisfactorily convey the silage horizontally. Therefore, the development of a more efficient device to move the silage vertically to the horizontal auger was needed.

The objective of this research was to point the way to greater capacity and lower power requirements in silo unloaders. Short vertical augers, designed to elevate more silage with less power than a blower or thrower, were tested under laboratory conditions.

Equipment Tested

AUGERS

Four different augers were tested. Each auger was 12 inches in diameter and 2 feet long, with right-hand flighting. Each had two rods mounted horizontally on the top end of the shaft to facilitate discharge of the silage through the side-outlet opening. This opening was 8 inches wide and 6 inches high.

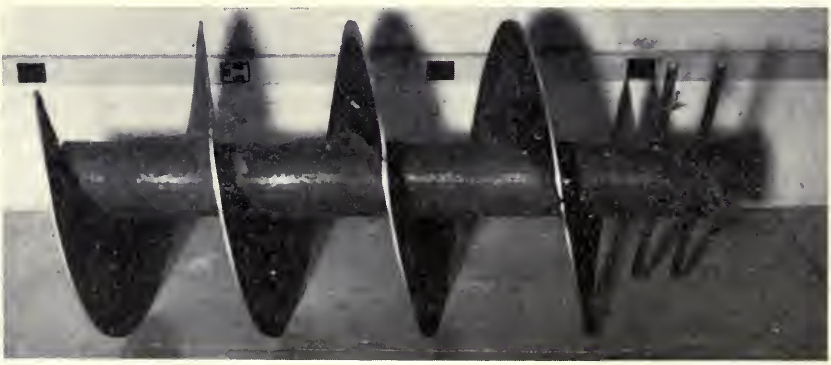
The *standard-pitch auger* (Fig. 1) had a nominal 2-inch pipe shaft with 12-inch-pitch helicoid flighting.

The *half-pitch auger* (Fig. 2) had a 6-inch pitch, and was made of sectional flights butt-welded together on a nominal 2½-inch pipe shaft.

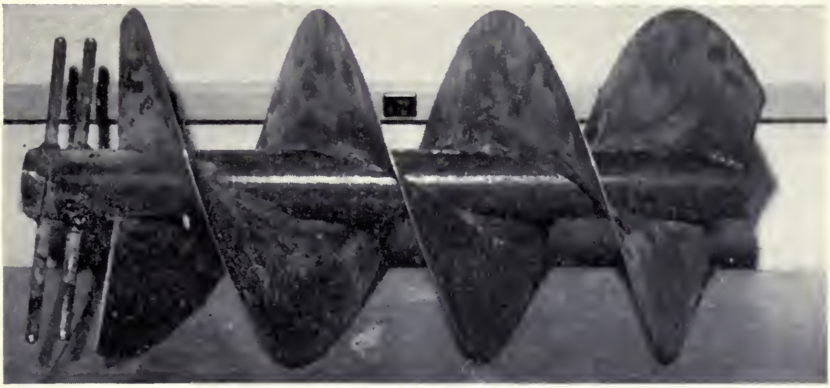
The *double-flight auger* (Fig. 3) consisted of two sections of standard-pitch flighting welded to a nominal 2-inch pipe shaft.

Standard-pitch auger. Right end was at top when installed. (Fig. 1)

Half-pitch auger. Right end was at top when installed (Fig. 2)

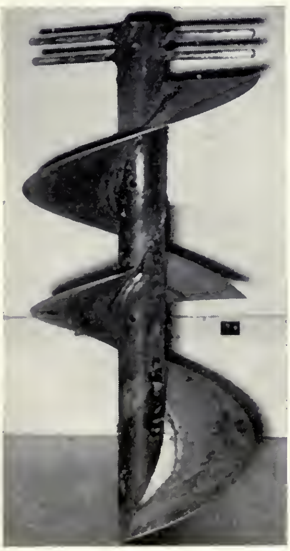


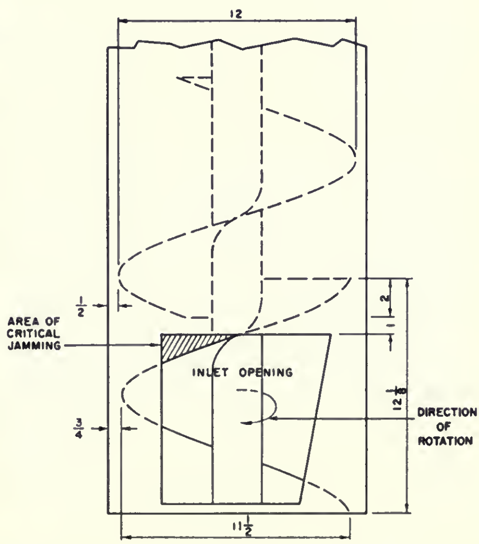
The *modified auger* (Figs. 4 and 5) had two separate sections of flighting (as described by W. R. Peterson in U. S. Patent No. 2,651,438, September 8, 1953). In addition, the lower section of flighting was 11½ inches in diameter and the top section was 12 inches in diameter. This auger was designed in an attempt to reduce the severity of overloading when a wad of silage was forced between the auger and the edge of the opening in the housing. The critical jamming area is shown in Fig. 5.



Double-flight auger. Left end was at top when installed. (Fig. 3)

Modified auger in operating position (left, Fig. 4) and in vertical housing (Fig. 5).





View from top of vertical auger housing with five 5/16-inch rods installed 2 inches apart. Auger rotated clockwise. Inlet opening is on left, outlet on right.
(Fig. 6)

AUGER HOUSING

An adjustable-diameter 16-gage sheet-steel housing was used. After a series of tests, the housing was modified by the addition of spiral ribs on the inside as shown in Fig. 6. These five ribs were made of 5/16-inch copper tubing for ease of fabrication, and were installed 2 inches apart around the circumference, beginning at the corner of the inlet where jamming occurred. The ribs were inclined 17° 40′ from the vertical so that they were perpendicular to the outer edge of the 12-inch-diameter standard-pitch auger. The function of the ribs was to reduce the rotation of silage around the circumference of the housing, thereby shortening the path of the silage between the inlet and the outlet of the housing.

All four augers were tested in the plain housing, and the standard-pitch and the modified augers were tested in the ribbed housing, making a total of six elevating units tested.

Procedure

The speeds and clearances tested with the six units are shown in Tables 1 and 2 and Fig. 10. With each set of conditions, performance data were recorded at varying outputs. The criteria were (1) effi-

Table 1. — Effect of Speed on Efficiency of Standard-Pitch Auger, Plain Housing; Half-Pitch Auger, Plain Housing; and Double-Flight Auger, Plain Housing, With Grass Silage

Speed (r.p.m.)	Clearance (inches)	Output (pounds per hour)	Performance (pounds per watt-hour)	Efficiency (percent)
		Standard-pitch auger, plain housing		
212	½	13,300	15.2	1.14
300	½	13,200	16.0	1.20
418	½	13,400	15.1	1.14
510	½	13,200	11.6	.87
		Half-pitch auger, plain housing		
300	⅝	9,400	9.7	.73
418	⅝	10,600	10.0	.75
510	⅝	7,800	6.2	.47
510	½	9,500	7.4	.56
418	½	12,700	10.4	.78
		Double-flight auger, plain housing		
510	½	13,100	10.5	.79
418	½	13,700	13.3	1.00
300	½	13,200	14.1	1.06
212	½	13,300	13.2	.99

Table 2. — Frequency of Overloads and Average Motor Current, 300 r.p.m., ½-inch Clearance

Output (pounds per hour)	Average motor current (amperes)	Number motor current peaks over 10 amperes	Computed motor current peaks over 10 amperes per hour	Performance (pounds per watt-hour)	Efficiency (percent)
		Modified auger, plain housing			
Grass silage					
14,300	5.8	0 in 1.8 min.	0	14.7	1.11
16,700	6.2	1 in 1.8 min.	33	15.2	1.14
17,400	6.8	1 in 2.4 min.	25	15.6	1.17
Corn silage					
19,800	5.2	0 in 1.8 min.	0	23.0	1.73
25,700	6.0	0 in 1.8 min.	0	24.0	1.81
		Standard-pitch auger, ribbed housing			
12,100	4.9	1 in 1.8 min.	33	16.0	1.20
15,300	5.2	2 in 1.8 min.	67	17.8	1.34
16,300	5.6	1 in 1.8 min.	33	18.3	1.38
18,600	5.7	4 in 1.8 min.	133	19.5	1.47
		Modified auger, ribbed housing			
14,900	5.7	0 in 1.8 min.	0	15.5	1.17
18,000	6.2	0 in 1.2 min.	0	16.7	1.26
20,900	6.6	1 in 1.2 min.	50	17.0	1.28
24,400	7.0	4 in 0.9 min.	267	18.5	1.39

ciency, expressed in percent;[1] (2) performance, in pounds of silage elevated (2 feet) per watt-hour; and (3) maximum output obtained with a 1-horsepower motor. To determine when maximum output had been reached, an arbitrary limit was set on frequency of instantaneous motor overloads and on average motor current. The maximum frequency of overloads was set at two motor current peaks of over 10 amperes per 0.03 hour (three test runs). A sample recording of these peaks is shown in Fig. 7. The maximum average motor current was set at 6.2 amperes, the rated full-load current of the 1-horsepower, 230-volt motor.

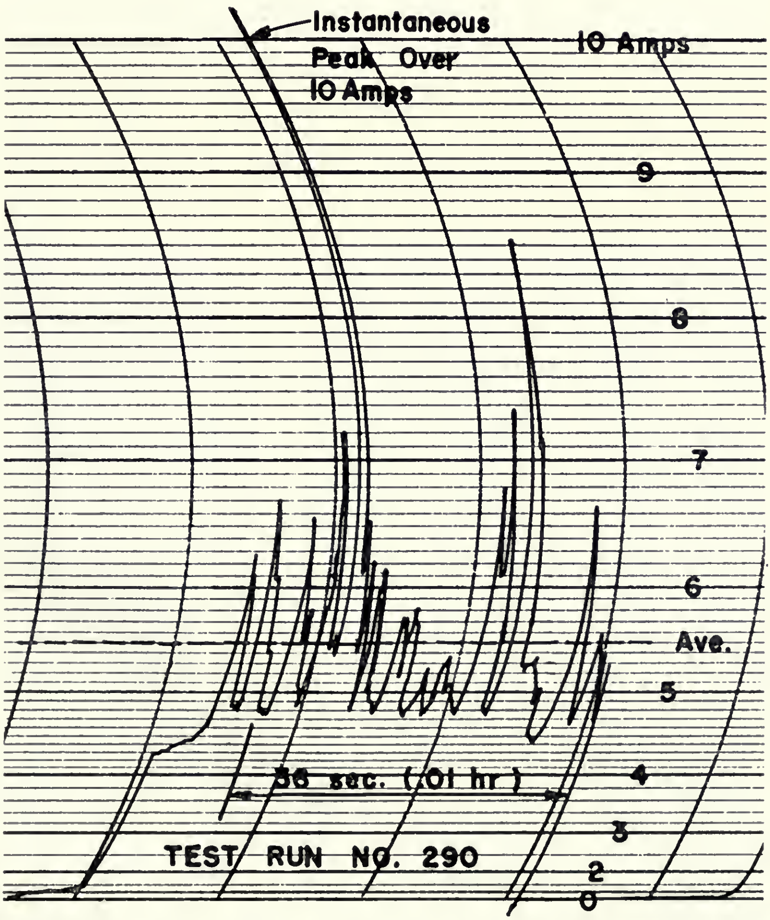
A recirculating system was used to run silage through the vertical auger in the test. An adjustable-speed chain conveyor fed silage into a 6-inch-diameter horizontal auger rotating at 360 r.p.m. The horizontal auger was positioned alongside the housing of the vertical auger. Tines on the end of the horizontal auger discharged the silage at right angles to the horizontal auger and into the inlet opening of the vertical auger (see Figs. 8 and 9). From the vertical auger, the silage

[1] As used in this publication, the term "efficiency" means the efficiency of the entire power unit and the auger (Mechanical Output divided by Electrical Input).

returned on a chain conveyor to the adjustable-speed conveyor or was directed into the weighing cart.

There was no significant difference between the efficiency of elevation of fresh silage and silage that had been rerun through the system about 50 times. Frequency of motor overloads was about double with new silage, however.

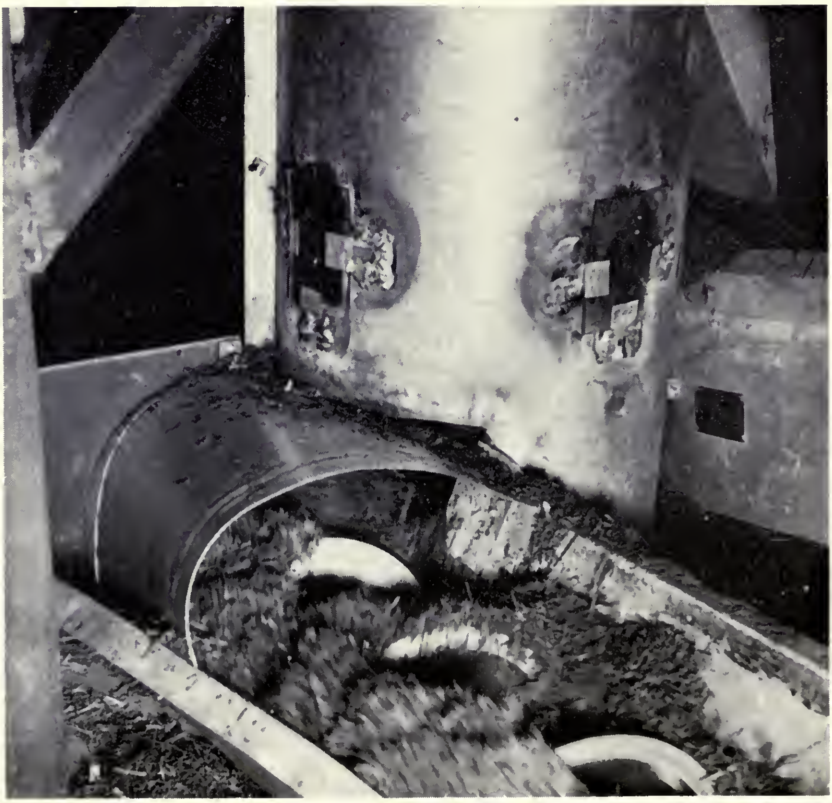
Alfalfa silage ranging in moisture content from 70 percent to 75 percent (wet basis) was used in all the tests except one. The silage had an estimated theoretical cut of 1 to 1½ inches. Since corn silage was handled with much higher efficiency, it was used in only one test.



Sample recording of current for a 1-horsepower, 230-volt motor driving a vertical auger. During the 0.6 minutes of this test run, one current peak of over 10 amps occurred. (Fig. 7)

Charging auger for the vertical auger with hood and vertical auger removed. (Fig. 8)

Grass silage moving from 6-inch charging auger to 12-inch vertical auger. (Fig. 9)



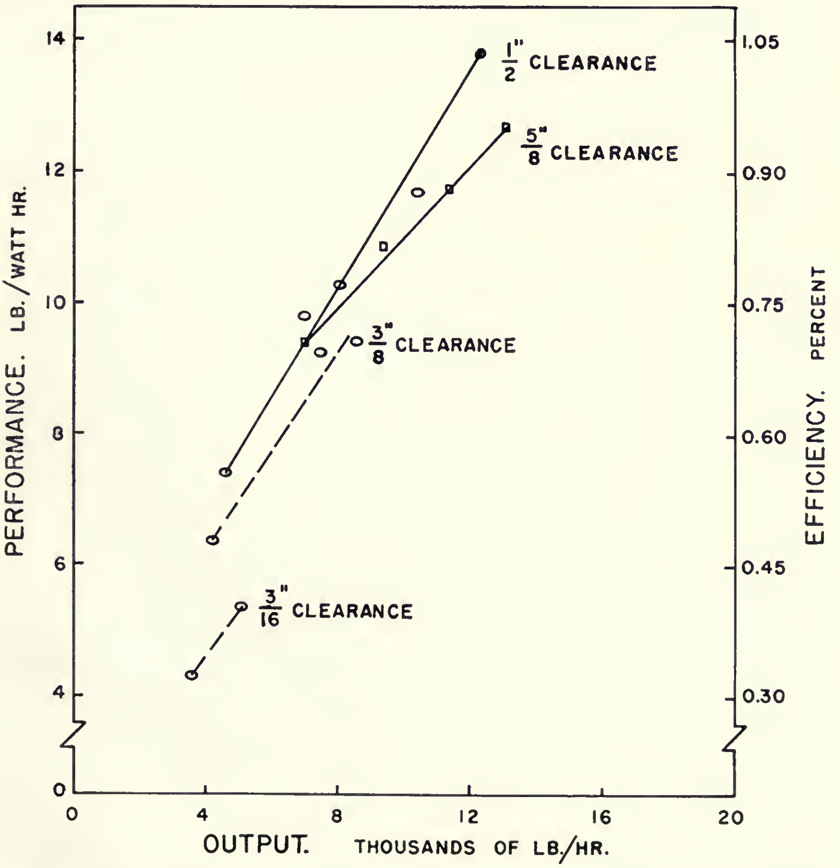
Results

EFFECT OF OUTPUT ON EFFICIENCY

Increased output generally resulted in increased elevating efficiency. Fig. 10 shows this tendency for the standard-pitch auger. The other units tested showed a similar relationship. So that efficiencies could be compared, the average outputs shown in Table 1 (page 7) were chosen as nearly equal for each speed as possible.

STANDARD-PITCH AUGER, PLAIN HOUSING

As shown in Fig. 10, a clearance of ½ inch between auger and housing was more efficient than 3/16 inch, ⅜ inch, or ⅝ inch. The larger clearances reduced jamming at the auger inlet, but caused more



Output and efficiencies with various clearances between auger and housing. Standard-pitch auger, 300 r.p.m. (Fig. 10) wedging between the auger and the inside of the housing. Smaller clearances caused less wedging in the housing and more jamming at the inlet. The standard-pitch auger elevated silage more efficiently at a speed of 300 r.p.m. than at 212 r.p.m., 418 r.p.m., or 510 r.p.m (Table 1, page 7).

HALF-PITCH AUGER, PLAIN HOUSING

A speed of 418 r.p.m. and a clearance of ½ inch were the most efficient for this auger (Table 1). The half-pitch auger did not compare favorably with the other augers tested in either efficiency or output. All tests with it caused too many motor overloads.

DOUBLE-FLIGHT AUGER, PLAIN HOUSING

One-half-inch clearance was assumed best for this auger on the basis of tests with the standard-pitch auger. The most efficient speed for the double-flight auger was 300 r.p.m. (Table 1). The efficiency of this auger was not as high as that of the standard auger.

MODIFIED AUGER, PLAIN HOUSING

This was the only auger that used an average motor current higher than the rated current without producing too many momentary overloads (Table 2, page 8). The smaller diameter of its lower section afforded more clearance at the critical jamming area and reduced the severity of the jamming. The ½-inch clearance was between the upper flighting and the housing. Clearance between the lower flighting and the housing was ¾ inch. Comparative figures for grass and corn silage are also shown in Table 2. The output of the modified auger was higher than that of any other auger in the plain housing (Table 3).

STANDARD-PITCH AUGER, RIBBED HOUSING

The ½-inch clearance with the ribbed housing refers to the clearance between the auger flight and the sheet-steel housing itself. The ribbed housing raised the efficiency of the standard auger from 1.20 to 1.38 percent and increased the maximum output from 13,200 to 16,300 pounds per hour (Table 3). The increase in output would probably not be as high in new silage. Motor overloads limited the output in the laboratory tests with rerun silage and would probably limit the output with new silage still further (see Table 2).

Table 3. — Maximum Efficiency and Output of Vertical Augers at Optimum Speed and Clearance Elevating Grass Silage, ½-inch Clearance, 1-Horsepower Electric Motor

Type of auger	r.p.m.	Maximum output (pounds per hour)	Performance (pounds per watt-hour)	Efficiency (percent)
Standard auger, plain housing	300	13,200	16.0	1.20
Half-pitch auger, plain housing	418	12,700	10.4	.78
Double-flight auger, plain housing	300	13,200	14.1	1.06
Modified auger, plain housing	300	16,700	15.2	1.14
Standard auger, ribbed housing	300	16,300	18.3	1.38
Modified auger, ribbed housing	300	18,000	16.7	1.26

MODIFIED AUGER, RIBBED HOUSING

The clearance between the upper flighting and the sheet-steel housing was ½ inch. The ribbed housing increased both the efficiency and the maximum output of the modified auger. The output was limited by average motor current rather than by motor overloads (see Table 2). This fact gives promise of an output in new silage equal to that obtained with rerun silage in the laboratory.

Conclusion

The modified auger in the ribbed housing was the best silage-elevating device of the six tested. Although less efficient than the standard-pitch auger in the ribbed housing (Tables 2 and 3), it had a higher output and caused fewer motor overloads. It is expected to perform as well in new silage as in the rerun silage used in these tests. This unit shows a great deal of promise as an elevating device in a silo unloader.

Plans for Future Work

A silo unloader with a modified-auger elevator in a ribbed housing will be built and tested extensively in a silo. This work will be performed in cooperation with silo unloader manufacturers for the best integration of the vertical auger into a current model unloader and for quicker translation of any favorable results into equipment commercially available to Illinois farmers.

List of Recent Silo Unloader Patents

Patent No.	*Date*	*Inventor*	*Assignee*
2,445,056	July 13, 1948	Cordis, Nat	....
2,500,043	March 7, 1950	Radtke, A. C.	International Harvester Co.
2,518,601	August 15, 1950	Cordis, Nat	....
2,615,594	October 28, 1952	Clapp, George D.	Leach Company
2,701,652	February 8, 1955	Patz, Paul Graetz, Edward A.	....
2,580,306	December 25, 1951	Leach, E. C. Manthie, Otto F. Clapp, George D.	Leach Company
2,595,333	May 6, 1952	Clapp, George D.	Leach Company
2,649,215	August 18, 1953	Dickson, John	....
2,651,438	September 8, 1953	Peterson, W. R.	International Harvester Co.
2,677,474	May 4, 1954	Long, Robert J. Van Nest, Robert A.	....
2,671,696	March 9, 1954	McClean, William W.	....
2,678,241	May 11, 1954	Miller, Wilbur A.	....
2,717,812	September 13, 1955	Eglitis, Victors	....
2,718,970	September 27, 1955	Dueringer, E. G.	A. O. Smith Corporation
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2,794,560	June 4, 1957	Buschbom, Floyd E.	....

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2. Asmus, R. W., Silo unloaders on Ohio farms. Ohio Agr. Col. Ext. Bul. 360. 8p. 1957.

3. Larson, L. W. Mechanical silo unloaders. N. Y. Agr. Col. (Cornell), Dept. Agr. Engin. Mimeo. 1955.

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6. Van Arsdall, R. N., and Cleaver, Thayer. Handling silage and concentrates for beef cattle in drylot. Ill. Agr. Ext. Ser. Cir. 714. 16p. 1954.

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John M. McCann, VanDale Farm Machines, Inc., Wayzata, Minnesota

W. R. Peterson, Peterson-Brethauer Company, Plainfield, Illinois

F. O. Rowell, Rowell, Inc., St. Paul, Minnesota

Lester Seversike, Van Dusen and Company, Inc., Wayzata, Minnesota

Lynn L. Seymour, James Manufacturing Company, Ft. Atkinson, Wisconsin

F. E. Van Dusen, Van Dusen and Company, Inc., Wayzata, Minnesota

This publication is another research report on materials handling by the Department of Agricultural Engineering, University of Illinois. Other phases of this research have been reported in the following bulletins of the Illinois Agricultural Experiment Station.

Electrical Control System for Automatic Feed Grinding. B555. 1952.

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