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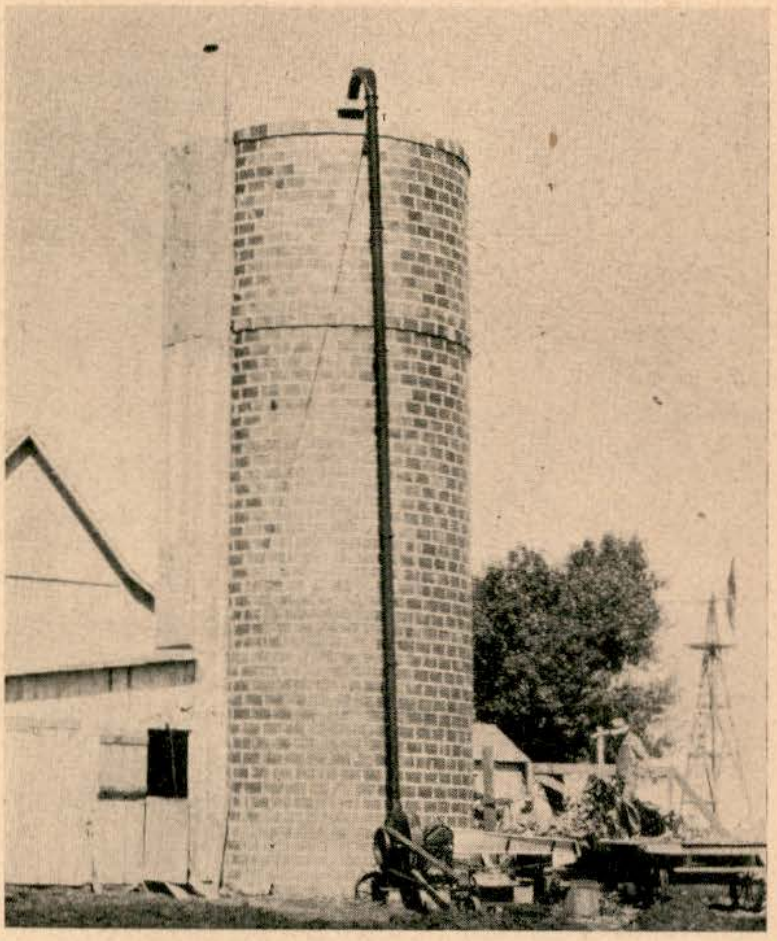

Filling the silo with a small motor operating the cutter—on the Geo. K. Welsh farm near Seward.

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Filling a silo 30 feet or more in height with a motor as small as five horsepower has been looked upon in general by Nebraska farmers as an impractical, if not impossible, procedure. The practice is not unheard of in other states, and certainly the possibility of avoiding the large tractor-driven cutters and the large crews will be welcomed by those who have available service from power lines.

Only a few Nebraska farmers have electrical service of sufficient capacity for motors of ten horsepower or more. Even those who consume the largest amounts of electricity, such as pump irrigators, dairymen, and cattle feeders, have little use for large motors or large capacity in the transformers except for short periods. Consequently most transformers in use are small, usually 5 kva. (kilovolt-amperes) or less in capacity.

In order to gather data on the use of the five horsepower motor in filling silos, three set-ups were made on farms in Seward county. The first was on the farm of George K. Welsh. There was nothing about Mr. Welsh's electrical connections which might not be duplicated on any farm where power-line service is available. In fact, practically all the farmsteads that have been connected with electric service in the last three years in Nebraska have better installations than Mr. Welsh. His transformer is small (2½ kva.), his switches are light (30-ampere size), none of his wire is larger than No. 6, and his silo is 300 feet from the transformer. None of these conditions is conducive to good performance in a 5-horsepower motor.

The silo on this farm is 14 feet in diameter and 43½ feet high, with 37½ feet above ground and 6 below. The equipment consisted of a motor and a fly-wheel type ensilage cutter. The motor had been used for many experimental jobs but the cutter was new. Nothing was specially built for this experiment nor was there anything that could not be easily duplicated or used in other ways. The cutter had a throat 12¾ by 5½ inches. The blower drum was 6½ inches wide and 40 inches in diameter, and the pipe was 6 inches in diameter. The same cutter was used later when a 15-30 tractor supplied the power. The silo and equipment data for this and the two other set-ups are found in Table 1.

TABLE 1.—*Silo and equipment data*

Number	Silo		Motor size	Cutter throat	Length of cut	Empty cutter
	Height	Diameter				
	Feet	*Feet*	*H. P.*	*Sq. in.*	*Inch*	*R. P. M.*
1	37.5	14	5	70	½	460
2	30.0	12	5	70	½	460
3	Pit	16	5	70	½	460

Silo No. 1 is Mr. Welsh's, No. 2 is the above ground silo on Mr. Rolfsmeier's farm, and No. 3 s the pit silo on the farm of the latter.

The corn with which Mr. Welsh filled his silo was taken from three different fields and was fairly representative of the corn usually raised in most parts of the eastern half of the state. First there was a small amount of mature sweet corn. The bundles from the field contained foxtail and other weeds. Then from a field of new ground where the corn stood ten to twelve feet high, the ears were big, the foliage was dense, and the yield would have been at least 45 bushels to the acre. The last field would have averaged about 25 bushels to the acre of mature corn. The stalks were small and the bundles averaged about 6 feet in length.

At first no attempt was made to make small bundles. However, it was found that about half a bundle was all that could be put thru the cutter at one time because of excessive overloading of the circuit to the motor. Bundle weights in the big fodder varied from 14 to 48 pounds and the average length was over 8 feet. The 14-pound bundles required no feeding or band cutting, but with a 48-pound bundle, containing a big ear to every stalk, the load on the motor was so heavy as to cause burning out of fuses. For this reason one man was placed at the feed table. When fodder was hauled from the field yielding about 25 bushels and the stalks were small, the bundles averaged about 20 pounds, were about 6 feet long, and required very little hand feeding.

This equipment cut and elevated into the silo slightly more than 120 tons, by weight, in 31¼ hours of actual running time and used 140 kilowatt-hours of electrical energy, which at 5 cents per kilowatt-hour cost Mr. Welsh $7.00, as compared to an average of $22.00 that he had paid for the use of a tractor or thresher engine in former years.

The crew of five men started on the silo filling each morning after the dairy work was done and stopped promptly at five o'clock to start caring for the cows and milking. The

filling was scattered over six days from start to finish. A rainy day or two, one Sunday, and some time taken up in trying out different arrangements for motor and cutter and for trying various speeds on the cutter accounted for the time. This time permitted the ensilage to settle and more feed was stored than if all had been accomplished in one day. However, this long period might easily have been the cause of loss if frost, drying winds, or a storm had been encountered. Silo filling in this manner caused the least disturbance and inconvenience and the lowest expense Mr. Welsh has experienced in the nine years he has used the silo.

After filling the silo on the Welsh farm, the cutter and motor were moved to the farm of Herman Rolfsmeier. On this farm 50 tons was cut, weighed, and elevated into a silo 12 feet in diameter by 34 feet high, and 28 feet above ground, in 15 hours of running time. This was done with a maximum crew of five men including the man on the corn binder. Sixty-eight kilowatt-hours were required to process this 50 tons, and Mr. Rolfmeier's power cost was $2.85. In addition about 60 tons was cut and run into a pit silo.

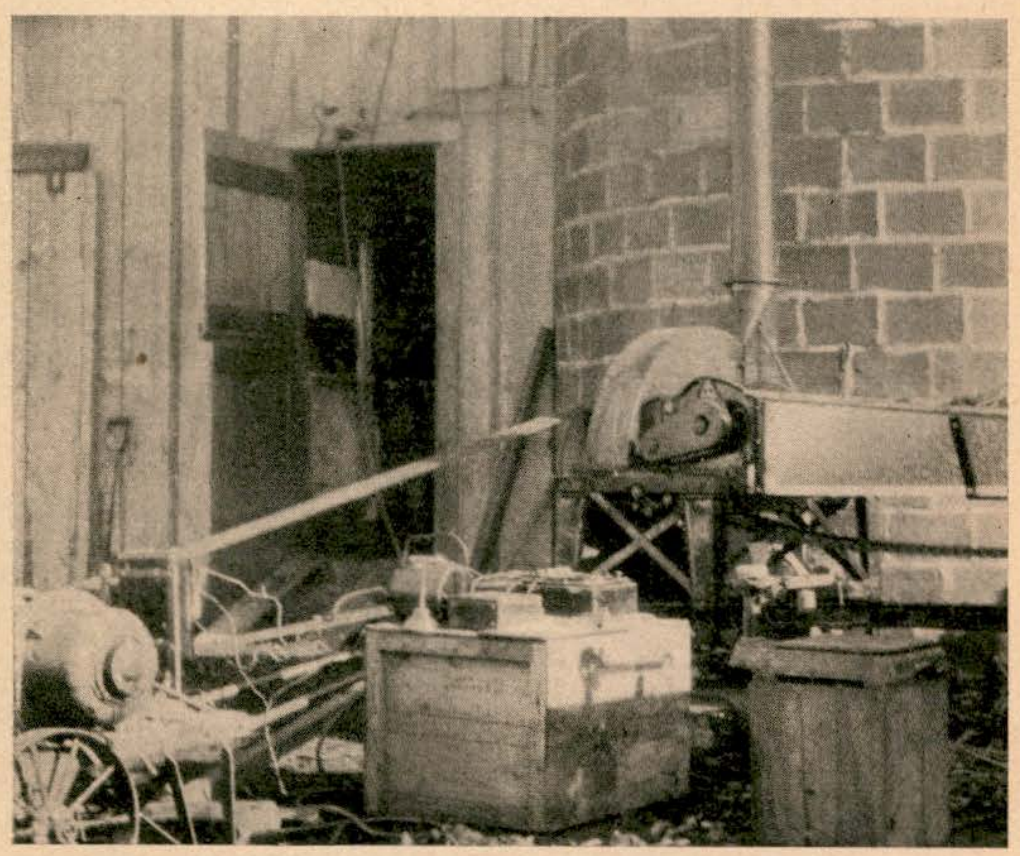

FIG. 1.—Some of the instruments for measuring power to the motor. A watt hour meter is installed just inside the open door.

At this last place a 5-kva. transformer was installed. This is of sufficient capacity for a five-horsepower motor, but the transformer was over 400 feet from the silo; the wires were No. 6; there were several pieces of dairy equipment (a mechanical refrigerator unit, motor-driven bottle washer, motor-driven bottler) drawing current from the same transformer and wires a part of the time. All of this equipment was 300 feet or more from the transformer. When too many operations came on while the silage cutter was operating, the voltage at the motor would drop so low that often two or three horsepower was all that was available. The power factor, as it is called, was very low on Rolfsmeier's farm most of the time. Even with these poor conditions, during the running time the outfit averaged between three and four tons per hour for both silos.

On this farm precedence was given to the dairy work. Cows were milked at noons and early evenings and during these periods the three-horse motor on the milking machine and the motors on the compressor and brine pump were given preference. During these periods the motor on the cutter was not operated. Short runs were made Saturday, Monday, Tuesday, and Wednesday. Most of the time three men and three racks kept up with the binder. The fodder in this field had large stalks with little foliage and well-dented ears. Most of the time the green corn did not have time to dry out after it was cut with the corn binder. The fodder put in the silo on Monday was an exception as it had been subjected to a very drying wind all day Sunday. Some water was added to this. When the water was added, extra care in regulating the amount of water and in feeding the cutter was necessary. Apparently the slow speed at which the cutter was operated did not supply the force necessary either to throw or blow large quantities of water into the silo.

TABLE 2.—*Filling data—summary*

Silo number	Silage cut	Running time	Energy required	Tons per hour	Average energy per ton	Power to motor		Av. cutter speed
	Tons	*Hours*	*Kw. hr.*	*Tons*	*Kw. hr.*	*Kw.*	*H. P.*	*R. P. M.*
1	120	31¼	140	3.84	1.17	4.48	6.0	449
2	50	15¾	68	3.17	1.36	4.32	5.8	448
3	54 7/10	16¼	75	3.37	1.38	4.61	6.1	446

In Table 2 the weight of silage was found by counting all bundles and weighing several out of each load. The average weight of bundles multiplied by the number of bundles gave the weights shown in the table. The running time was found by adding the number of minutes the motor operated in cutting and elevating the different loads. The loads varied from 1,900 to 3,100 pounds and the time required to run the loads thru the cutter varied from 8 to 24 minutes.

Special attention should be given to the column headed "Power to the motor." It will be noted that the horsepower values are all above the five-horse rating of the motor used. These values denote power *to the motor* and include power used in the motor to overcome friction, etc. This motor had an efficiency of slightly more than 80 per cent under test at the loads encountered in silo filling. The power developed *by the motor* is about 80 per cent of the power to the motor and when the input is 6.0, 5.8, and 7.3 horsepower, the output of the motor is about 4.8, 4.6, and 5.8 horsepower respectively. Since motors, gas engines, tractors, etc., are rated on output horsepower, this motor was not overloaded.

Many times during the filling of each of the three silos the voltage drop was excessive. This was due to too much iron wire in the primary circuit, excessive distances of

FIG. 2.—Filling the pit silo on the Rolfsmeier farm. The man at the feed table watches so that no large bundle can overload the electric circuit too heavily.

equipment from transformers, too small wire in secondary cicuit, and other causes.

TABLE 3.—*Performance as affected by conditions*

No load voltage	Av. full load voltage	Cutter speed	Power to motor		Silage cut per hour	Average energy per ton	Remarks
Volts	*Volts*	*R. P. M.*	*Kw.*	*H. P.*	*Tons*	*Kw. hr.*	
228	207	455	5.5	7.3	6.7	.82	Voltage steady, bundles even size, fodder green, knives sharp.
224	180	430	4.6	6.1	2.8	1.64	Voltage drop excessive, mature fodder, knives dull.

In Table 3 the fact that conditions influence the net results is brought out very clearly. With good voltage, fodder in ideal condition for cutting, and knives sharp and set close to the shear plate, the speed of the cutter was very good, the rate of cutting was high, and the cost of power low per ton. With the voltage lowered, the fodder mean to handle, and the knives dull and set with too much clearance between them and the shear plate, the rate of cutting dropped to about one-third the rate under ideal conditions and the cost of power was twice that when everything was in good condition.

TABLE 4.—*Effect of empty cutter speed*

Cutter speed	Power to motor		No load voltage	Operating voltage	Remarks
R. P. M.	*Kw.*	*H. P.*	*Volts*	*Volts*	
460	1.5	2.0	224	210	Cutter fully equipped. Top of blower pipe 40 feet above ground.
650	4.2	5.6	224	200	

In Table 4 is shown the effect of too high a speed on an ensilage cutter. Special attention is called to this table. The empty cutter speed of 460 revolutions per minute which was chosen by test as that best for the machine required but 2 horsepower to the motor or, at 80 per cent efficiency, a 1.6 horsepower output. When the pulleys were changed to give a cutter speed of 650 revolutions per minute the power to the motor increased to 5.6 horsepower or, at 80 per cent efficiency in the motor, to 4.5 horsepower output. This higher speed and empty cutter required about the same power as that required when cutting an average of nearly 4 tons of fodder per hour at the speed of 460 revolutions per minute. This power required for excessive speed was further empha-

sized when the men using the five-horsepower motor and 13-inch cutter visited a farm on which a 15-horsepower motor and an 11-inch cutter were being tried. On this latter farm no thought was given to the cutter, which was running at 1,100 revolutions per minute and the power required was so excessive that the 15-horsepower motor was burning fuses about as fast as they could be replaced.

Mr. Welsh and Mr. Rolfsmeier were surprised and pleased with the low cost of power when the small equipment was used. The rate of energy for Mr. Welsh's silo was 5 cents per kilowatt-hour. From Table 2 it is found that 1.17 kilowatt-hours were used per ton. This multiplied by 5 is 5.85 cents per ton. The energy for Mr. Rolfsmeier's two silos averaged about 4.2 cents per kilowatt-hour, or 5.7 and 5.8 cents per ton.

The crews for filling these silos had a maximum of five men, including the man on the binder. No one did any tramping in the silo. When the silage was fed it was found that some spots near the walls were spoiled badly where some of the fodder was too dry or where there was a large percentage of grain as compared to stalk. However, most of the silage was in good condition.

Many near-by farmers visited the two farms while the filling was in progress. Several men thought the cutter must have been idle when they drove into the farmyard because they heard no hum of the blower. The idea that a man had to feed the cutter did not fit in with plans or ideas of many who watched the operation nor was the slow speed at which the cutter ran in accord with previous experience. But when the men who watched the operation a while found that the motor was not developing even five horsepower most of the time and that the crew of three to five men were putting three to five tons per hour into the silo, they were more interested and willing to agree that the method and equipment might be practical. This method compared favorably with 15- to 30-horsepower tractors and crews of 12 to 20 filling at the rate of 6 to 15 tons an hour.

To sum up these experiences briefly it is felt that if the farmer has a good installation so that his transformer is not too far from his silo, with wires and switches of ample size, and has a five-horsepower motor for other purposes, he can get on well if he wishes to use it for silo filling. But he must have an ensilage cutter with a drum of large diameter and a fan that revolves in such a manner that the edges and sides of the blade clear the drum by a very small allowance. In addition the blower pipe should not be over 6 or 7 inches in diameter. Not over 30 tons of ensilage should be cut before

sharpening and readjusting the knives. The knives must be set up as close to the shear plate as possible without striking and last but not least, the speed of the cutter must be as low as possible to elevate to the necessary height. The data in Table 4, which show the added horsepower required for a speed of 650 as compared to 460 revolutions per minute on this particular cutter, should not be forgotten.

[5M]