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# Vertical Elevators on the Farms

H. H. DeLong

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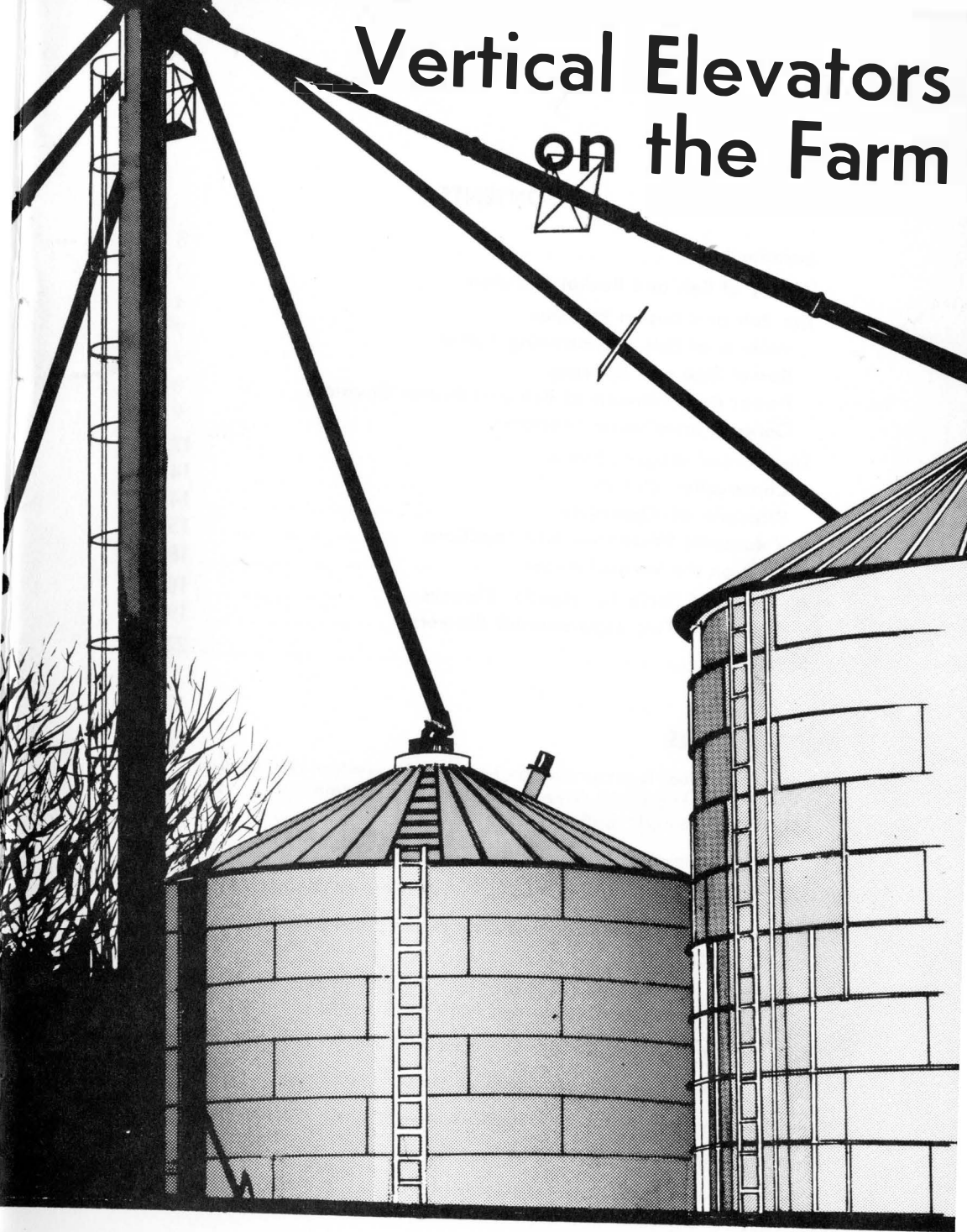
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# Vertical Elevators on the Farm



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**Agricultural Engineering Department**  
**Agricultural Experiment Station**  
**South Dakota State University, Brookings**

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# Vertical Elevators on the Farm

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## INTRODUCTION

Elevators for farm products have had a long history of development, the most rapid development resulting as small gas engine and electric power units became available on the farm. The farm tractor is sometimes used as the source of power.

This bulletin is confined only to

the study of vertical elevators or conveyors. This group includes the belt and bucket elevator, the vertical auger, and some blower and pneumatic types. Some horizontal conveyor types are not useable in the vertical position.

## History of Belt and Bucket Elevators

The belt and bucket elevator goes back to the invention of belt and pulley systems, and to their use in the earliest water- or steam engine-powered mills. Leather was the original belting material. Metal cups or buckets were fastened to a belt and pulley system placed in an upright position. This was a satisfactory elevator for small grains and small granular materials and is the standard to which other types of elevators are compared.

A certain belt speed is necessary for satisfactory loading and unloading of the buckets.

Large size products, such as chunks of coal or ear corn, can not

be handled at belt speeds as rapid as for small grains, for example. When speeds are lowered, the belt and pulley system, which depends on frictional driving, fails to operate satisfactorily. For the slow moving elevator, the chain and sprocket system was developed. Such a slow-moving elevator could load its buckets easily, but needed additional features at the top to unload. Here was the first major division of elevator design types.

The belt drive type runs fast and unloads by centrifugal force. Friction at belt to pulley can be made to work. Where the elevator linear speed is too slow for frictional drive,

the chain must be used. The bucket will not unload satisfactorily and must have extended time and/or "tipping" action designed into the mechanism. Figure 1 shows some of these details. Figure 1-A shows the typical fast running belt and pulley system. Grain enters through gate "G," which regulates the gravity flow to the working rate of the system, and meets the buckets on their upward travel. There is an acceleration force applied to the grain for its new velocity; but it is not a major force to consider. (The feed chute is sometimes placed across the elevator leg on the descending bucket side where the feed direction and the bucket direction are the same. The buckets must now fill from the bottom of the elevator leg.)

At the top of Figure 1-A, buckets unload by a "throwing" action of circular motion and centrifugal force. In the slower moving chain driven elevator, Figure 1-B, the design at "m" and "n" is such that the bucket can dump by gravity alone without much "throwing" action. The belt and bucket elevator needs a drive at

the top. Due to the weight this is where the belt tension is greatest, therefore the frictional grip is greatest. The bottom pulley has less tension because the weight of the belt and the load lifted all react on the top pulley, not on the bottom one. This is true for a chain and sprocket drive as well. There are cases where the chain elevator is driven from the bottom sprocket, but the chain must be kept snugly tight. Any loosening of the chain accumulates at the lower sprocket and it then begins to "jump cogs," finally resulting in chain breakage.

Pulleys for the belt are slightly "crowned" to keep the belt to the center of the pulley (see Figure 1-C). Spacing, "s," of the buckets along the belt can be set close to increase capacity but is more likely to be  $1\frac{1}{2}$  to 2 times the out-reach dimension of the bucket to facilitate good filling procedure. There are three heights to keep in mind;  $h_1$  in Figure 1 indicates over-all height,  $h_2$  indicates distance between bearings, and  $h_3$  indicates the actual net lifting height of the elevator.

## THE BELT AND BUCKET ELEVATOR

The belt and bucket elevator has become fairly well stabilized in de-

sign. On farms, belt widths vary from 6 to 12 inches, drive pulley

Table 1. Representative data of belt and bucket systems.

Wheel diameter (inches)	Bucket width (inches)	Bucket projection (inches)	Bucket volume in <sup>3</sup>	Spacing along belt	Volume per linear foot	Capacity bushels/hr.
8	6	4	60	6	120	650
8	8	4	81	6	162	883
8	10	4	102	6	204	1,110
8	12	4	122	6	244	1,350
12	6	5	95	7	163	1,090
12	8	5	127	7	218	1,460
12	10	5	158	7	270	1,810
12	12	5	187	7	320	2,140

Belt Velocity 196 ft/min. for 8-inch wheel, 241 for 12-inch wheel. Belt velocity is related to wheel diameter.

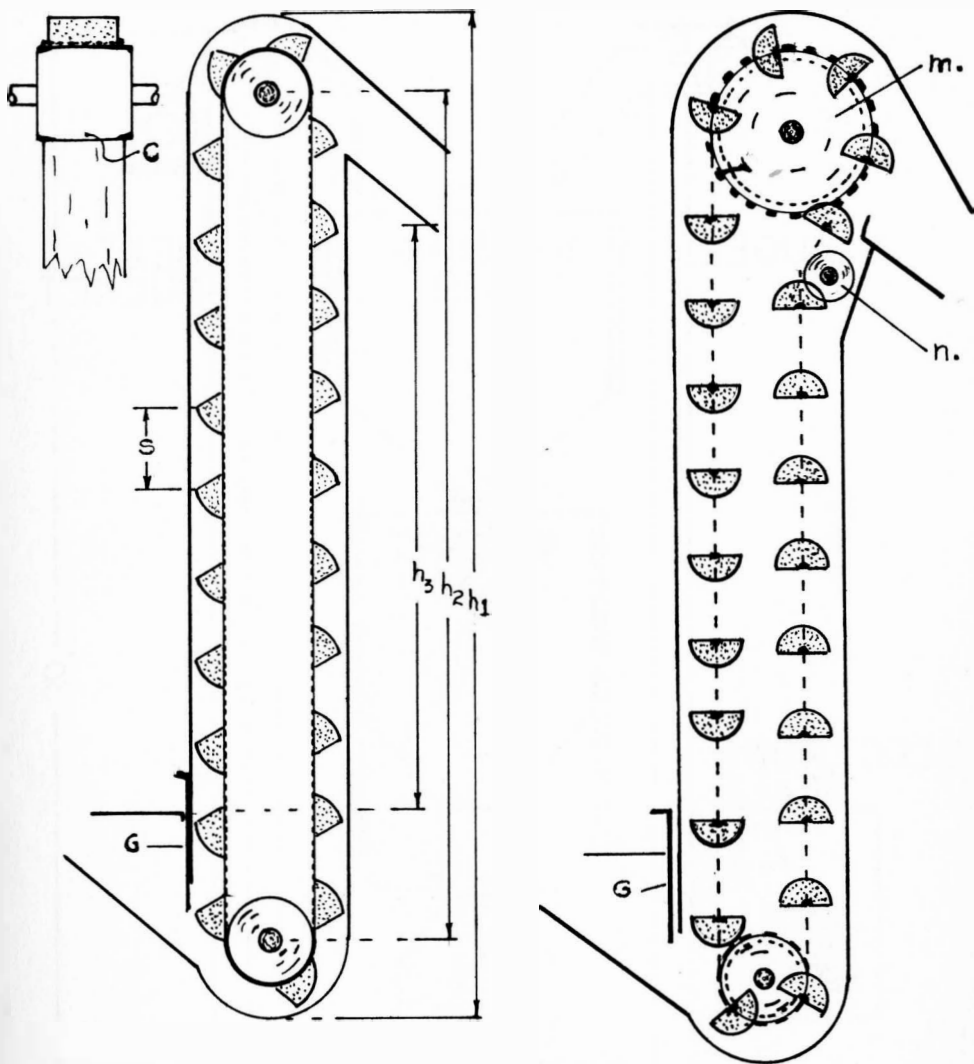


Figure 1. Typical fast running belt and pulley system (A); slower moving chain driven elevator (B); and detail of "crowned" pulley (C).

diameters range from 8, 10, 12, or 16 inches, and bucket spacings vary along the belt. Figure 2 indicates some of the dimensions. Table 1 gives representative statistics of various sizes and how these factors af-

fect the rate of performance of a belt and bucket elevator. There are several patterns of buckets, but the capacity of the bucket is vital in calculating the rate of operation.

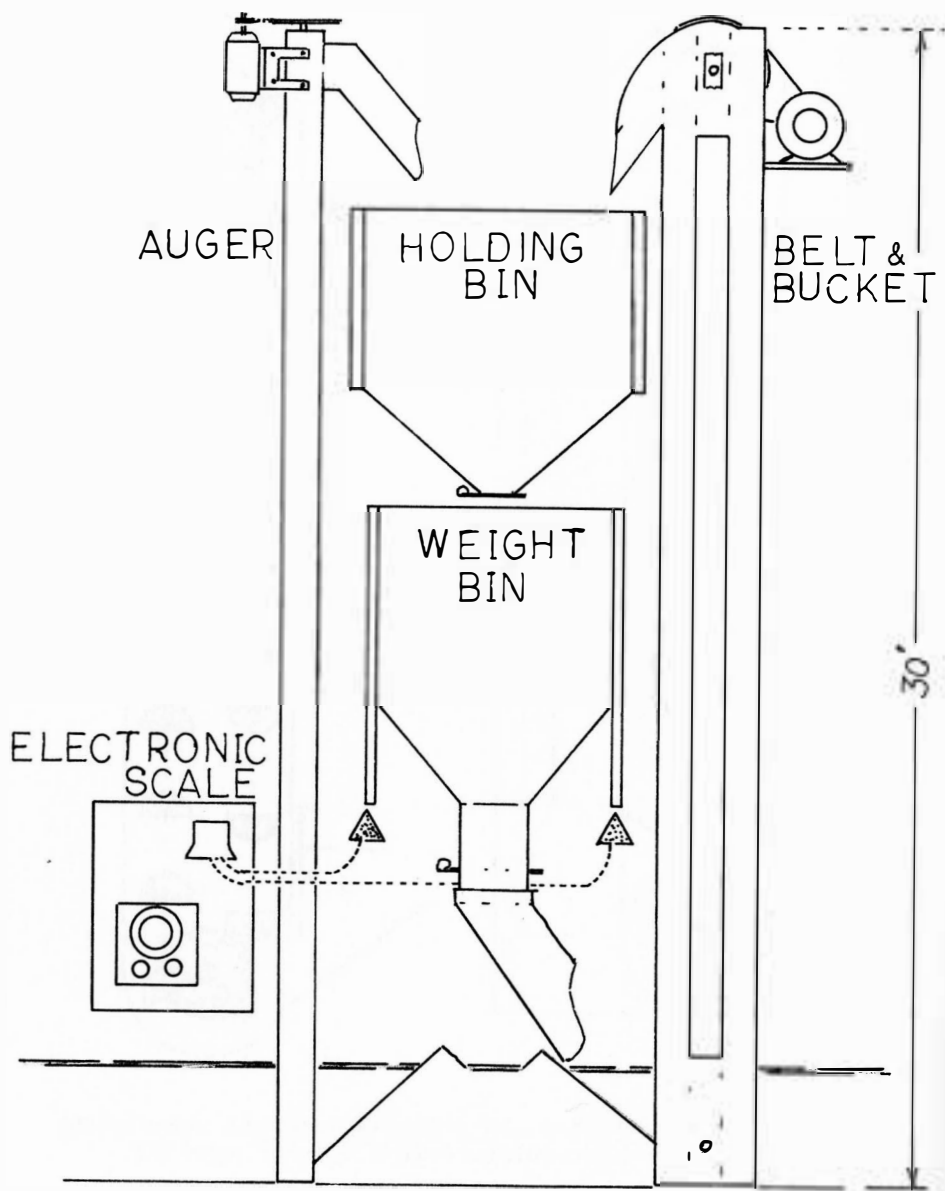


Figure 2. Schematic of apparatus for elevator tests.

## Velocity of Belt is Controlling Factor

The velocity of the belt is a controlling factor for a belt and bucket elevator that is carrying a granular material such as farm grains and feeds. A satisfactory unloading of the buckets at the top is accomplished by equating the unit weight carried by the bucket to the centrifugal force. The equation used is:

$$S = W V^2 / 3600 \text{ gr}$$

S = centrifugal force (lbs)

W = unit weight carried by the bucket (lbs)

V = feet per minute belt speed [3600 is  $\text{sec}^2 / \text{min}^2$  ( $60/1 \times 60/1$ )], so that  $(\text{ft}/\text{min})^2$  can be used with  $(\text{ft}/\text{sec})^2$

g = 32.2  $\text{ft}/\text{sec}^2$  -

acceleration of gravity  
r = radius of drive pulley in feet

also N = r.p.m. of drive pulley

When S = W then

$$W = W V^2 / 3600 \text{ gr}$$

$$V^2 = 3600 \text{ gr}$$

$$V = 60 \sqrt{\text{gr}}$$

$$N = \frac{V}{2\pi r}$$

Table 2 gives some common drive pulley diameters, their accompanying rated r.p.m.'s and belt velocities. Experience shows some departure

from this "ideal" unloading speed is possible so a 25% lower r.p.m., a 35% higher r.p.m., and respective belt speeds are given.

The "unloading" velocity is the first factor that affects belt and bucket elevator capacity. Too slow speed allows the buckets to dump back down the return leg. Too fast velocity hinders proper loading of buckets and increases the impact and acceleration forces of grain on the buckets.

## Bucket Size and Spacing

The bucket size may be as small as 3 inches wide by 3 inches in projection and up to 20 inches wide and 7 inches in projection. In addition, the cup may be purchased in 4 or 5 patterns, each one having a given depth dimension and its own cup curvature. The cup shape and size in turn determine its capacity or nearly loaded volume. (Any belt and bucket elevator must be throttled at the feed inlet to keep the bucket capacity under the maximum full capacity to prevent clogging at the lower end.) Table 3 gives a few sizes of elevator cups and their carrying capacities (maximum). These figures are quoted for ideal belt speeds; and their rates would go up

Table 2. Statistics for unloading velocities and r.p.m.'s

Wheel diameter (inches)	Ideal belt velocity ft/min	Wheel r.p.m.	25%	Lower velocity	r.p.m.	35/25%	Higher velocity	r.p.m.
8	196	94		147	70.5	35%	254	127
10	220	84		165	63	35%	297	113
12	241	77		180	57.5	35%	325	104
16	278	66.5		208	50	25%	348	83
20	309	59		232	44.3	25%	386	74



Table 3. Bucket size, belt speed, and capacity.

Cup size (inches)	Belt velocity	r.p.m.	Cup capacity (cubic inch)	Spacing on belt (inches)	Bushels /hr. (gross)
(8 inch wheel)					
6x4	196	94	59*	6	645
7x4	196	94	69	6	753
8x4	196	94	78	6	850
10x4	196	94	98	6	1,070
(16-inch wheel)					
8x5	278	66.5	123	7	1,625
10x5	278	66.5	153	7	2,020
12x5	278	66.5	183	7	2,420

\*Cup capacities vary slightly among manufacturers.

or down respectively linearly as the r.p.m. would go up or down.

The capacity is also modified by the number of buckets per foot of the belt. Buckets are usually spaced  $1\frac{1}{2}$  to 2 times the projection distance (generally spaced by the manufacturer who punches the belt and fabricates the cups). As most farm elevators will not be excessively

high, reasonably close spacing will be possible. The closer the spacing, the greater the capacity, and the greater the power required. The operator will soon learn to set the gate on a belt and bucket elevator so it runs 80% to 90% of its gross capacity, which is short of the "running over" or choking stage.

### Power Requirements of Belt and Bucket Elevators

The power requirements for the vertical belt and bucket elevator depend on two things: friction of the machine, and weight of material being moved. The first is hard to get in any other way than by test of a given installation. There will be bearing friction, belt-bending friction, and friction of belt against guides. Some horsepower (hp) is consumed in running the elevator empty. The second part of the power comes largely from the weight of grain lifted a given number of feet in the elevator. This is "lift" horsepower and is always increased slightly by acceleration of the grain in loading the cups, acceleration of grain in unloading (change of direction) and perhaps some scraping of cups on grain in the lower boot.

Some faster running belt and bucket elevators are built to load from the back, thus reducing the acceleration, and probably increasing the "scooping" friction.

The test elevator used to find the horsepower for a belt and bucket elevator was specifically constructed for this work and installed in a 3-story feed handling test-building. The elevator legs were of wood and overall height of the elevator was 29 feet, distance between pulley shafts 27 feet, and net delivery left was 25 feet. Pulley diameter was 8 inches, belt width 8 inches and buckets 4x7 inches with capacity of 70 cubic inches. Bucket spacing along the belt was 7 inches.

Power was provided for the top pulley by a  $1\frac{1}{2}$  horsepower electric

motor which drove through a double V-belt reduction. The electric motor was equipped with several diameters of pulleys for speed changes. It was also cradle-mounted for use as a reaction dynamometer. During a test run, readings were made of voltage, amperage, and a recording watt meter was used. The force of the reaction on a known lever arm was also recorded. From this and from the r.p.m. of the motor the horsepower could be calculated by the following equation:

$$\text{hp} = F \times 2\pi r \times \text{r.p.m.} / 33,000$$

where  $F$  = force on scale in lbs

$r$  = lever arm of motor in feet

r.p.m. = revolutions per minute of electric motor

For repeated test work this elevator was placed adjacent to a receiving bin on the third story. This bin was directly over a weight bin on the second story, from which a gravity or mechanical feed was used to feed the elevator inlet at the first story. Figure 2 illustrates the arrangement which also accommodated the auger

elevator and the blower elevator equipment. The electronic scale was used to weigh out a given amount, usually a 1,000 pound test batch. Shelled corn and grain sorghum were the two grains tested. Each test was repeated three to five times or until a series of duplicate tests proved reliable.

The test data are shown in a series of curves in Figures 3 and 4. Three belt speeds were chosen by using such V-pulley combinations available. Belt speeds and r.p.m. data are stated on the charts. The horsepower required to run the empty elevator is substantial, being nearly a third to a half of the total power of a full load test. The same general relation holds for cost of electric power as shown by the recording watt meter and then for electric energy when translated into Kw/hrs.

An increase in feeding rate gives a straight line increase in power required, and this is expected from the "weight times height lifted" relation. The right hand test point on each line is near the full bucket-carrying capacity of the elevator at that speed of operation.

### General Installation Problems

The belt and bucket elevator is best suited to the task of vertical movement of grain and has become the standard of comparison. It requires the least power for delivering a given quantity. It does have some features that may at times be troublesome. The elevator housing must be complete all of the way or grain will be scattered. At the open ends for feeding, emptying, or inspection, there is some air turbulence and spreading of dust. The ele-

vator needs the feed gate closed after each run to prevent plugging at the next start. Pulleys must be kept in alignment so the belt will follow the center of the crowned pulleys, thus minimizing friction.

The belt and bucket elevator is designed for the vertical position. In some locations the grain needs to be moved horizontally at bottom or top or perhaps both locations. When this is necessary angled spouts or bin walls are needed or horizontal con-

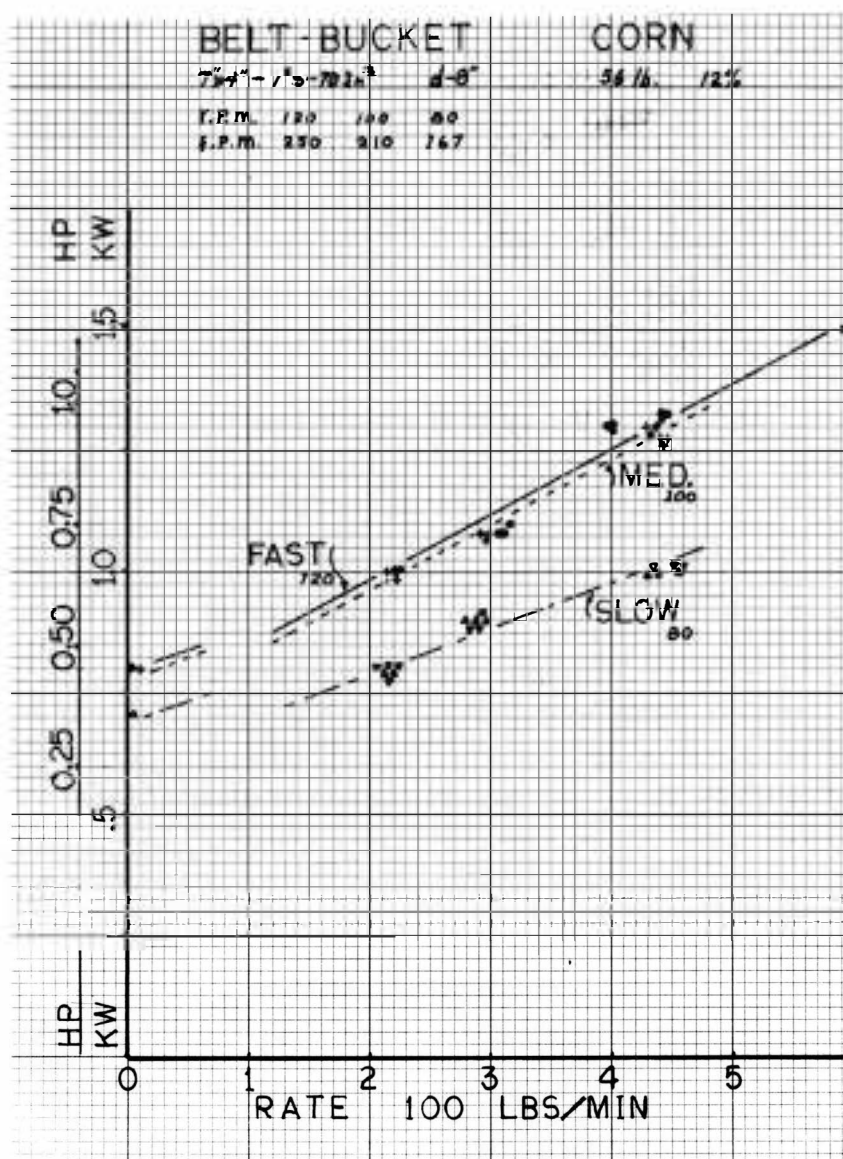


Figure 3. Grain quantity delivered vs. power used (belt bucket, corn).

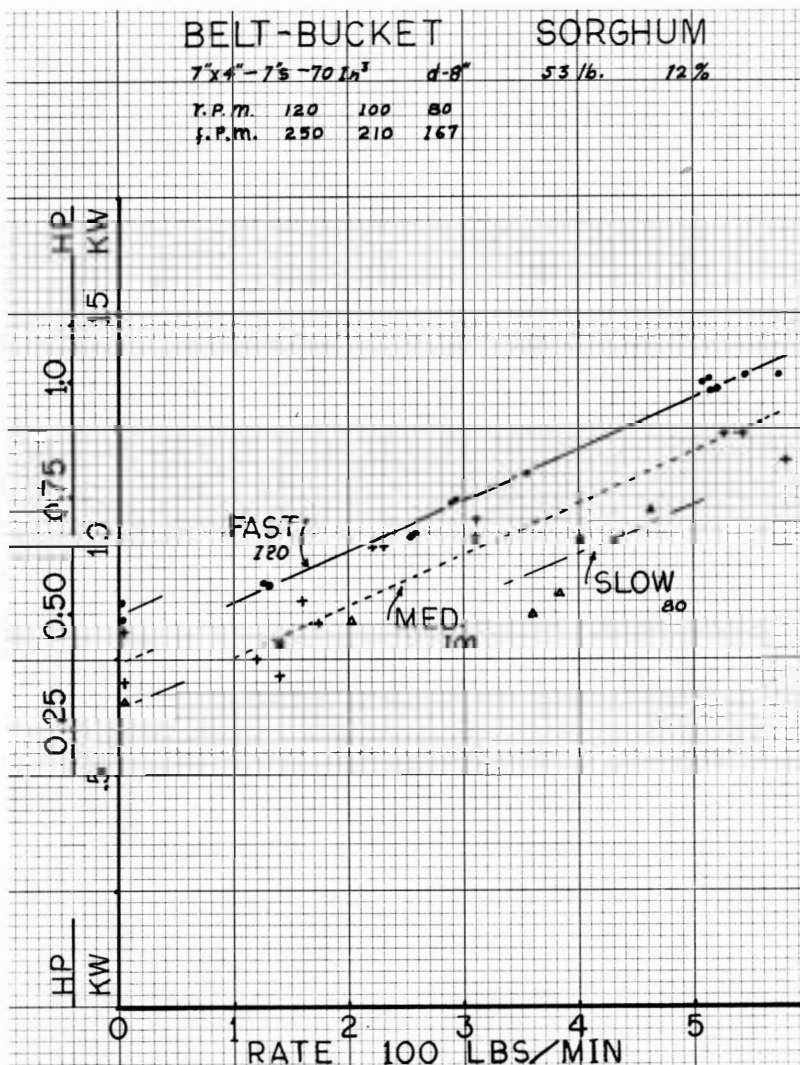


Figure 4. Grain quantity delivered vs. power used (belt bucket, sorghum).

veyors must be installed. To get free running spouts under all conditions, an angle of 60 degrees from the horizontal is advisable. This means that for a given horizontal run, the eleva-

tor must have 1.73 times that distance in additional height. Figure 5 shows general layout for a gravity run system (A) and for a horizontal conveyor auxiliary system (B).

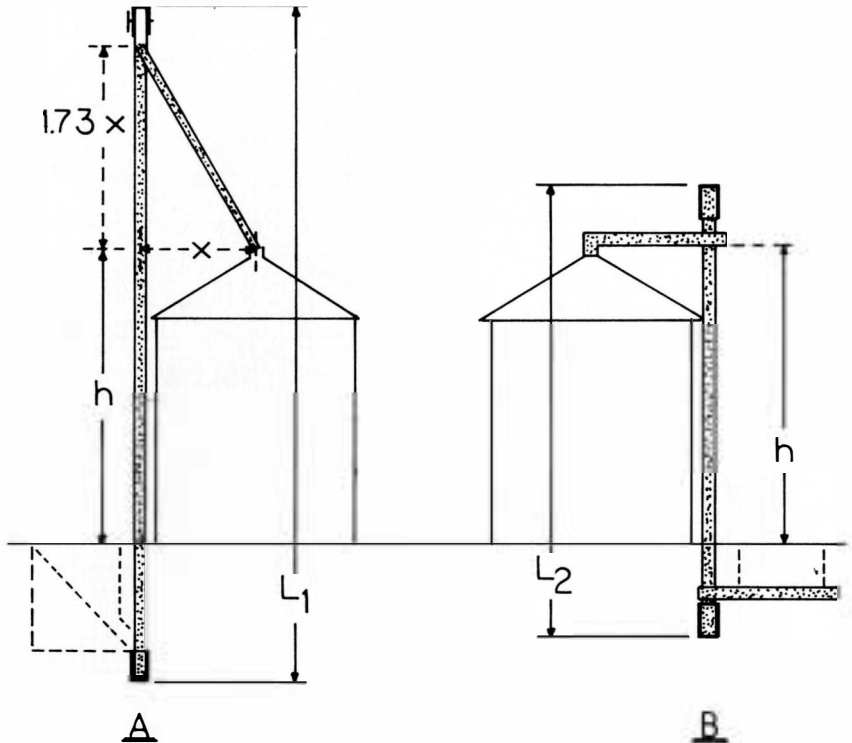


Figure 5. General layout for a gravity run system (A), and for a horizontal conveyor auxiliary system (B).

### THE VERTICAL AUGER ELEVATOR

The auger conveyor has become one of the most versatile machine elements in conveying farm products. It can be used horizontally, in an inclined position, or vertically. Some manufacturers hesitate to use the auger in the vertical position. A decision was made to test such equipment to see how well certain

models would perform, and how near they would approach the efficiency of belt and bucket elevators.

This machine is simply constructed with the tube for a housing and frame and the auger as its one moving part. Short lengths may have only one bearing at the drive end. Two bearings, however, provide for

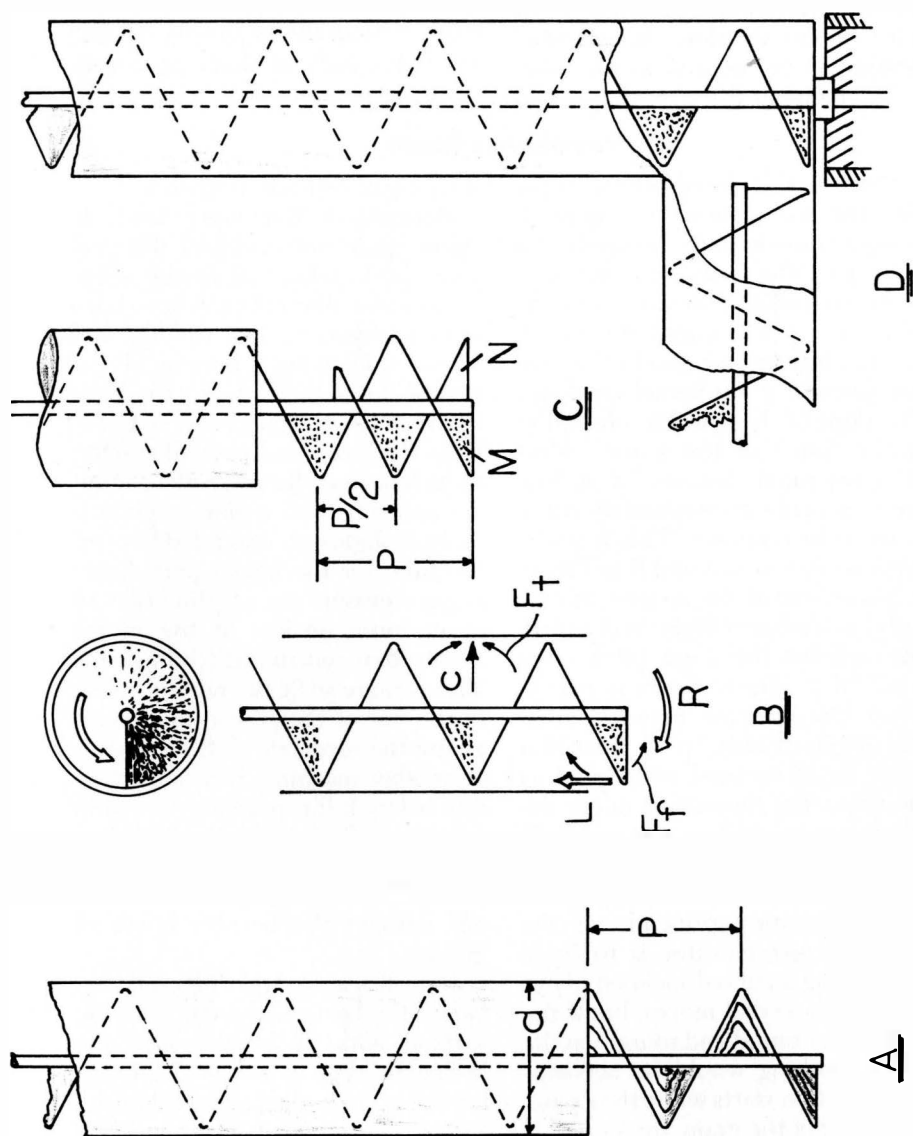


Figure 6. Construction details of auger elevator.

quieter operation. Very long elevators may also have intermediate bearings as well as end bearings; but at such places, the auger flight must be cut to allow the mid-way bearing to be secured to the tube.

By changing the size, shape, and

speed of operation the auger has been adapted to the handling of grains, ear corn, silage, and even straw with grain, or freshly cut forage. This bulletin deals only with the vertical auger used with grains.

### Construction Details

Construction details of the auger elevator are shown in Figure 6. Length is made to fit the needs of a given job. The diameter of the tube is the controlling dimension, and the diameter of the auger flights are enough less to give good clearance and prevent grain kernel crackage. The slope of the spiral is referred to as the "pitch of the screw." Most often the pitch, distance "p" in Figure 6, is made approximately equal to the tube diameter. This is single pitch, as shown in A and B in Figure 6. Sometimes at the auger entrance end the number of flights is doubled, but each has the single pitch slope ("m," "n"). This is shown in part C where the distance between adjacent flights is only "p"/2. Should a single flight be used with "p"/2 as the slope, the theoretical auger delivery rate would be cut to one half,

with equal respective r.p.m.'s.

Rotation of the auger tends to throw grain outward and this prevents perfect loading of the auger at the entry. Several ways have been used to overcome this trouble, and Figure 6-D shows a horizontal section of "force feed" auger that feeds the vertical. A second way is to enlarge the lower end screw diameter, to have a short flared section of auger and tube. On a plain auger, usually  $1\frac{1}{2}$  flights are extended beyond the tube for the intake part. Some auger elevators use a sliding boot to cover more or less of the intake flights, thus controlling feeding rate. This is more to fit the rate of intake to the size of the power unit, or regulate the feed rate to the capacity of another machine. Restricting the rate below full capacity reduces the operating efficiency of the machine.

### Principle of Operation

The operating principle of the vertical auger elevator is to force grain along a curved inclined plane. It is the plane that moves, but if the grain rode "round and round" on the flights, nothing would be accomplished. Action starts when the r.p.m., or turning of the grain, forces it outward. Friction occurs between grain and tube wall surface to retard the grain from rotation. The grain then tends to slide along the flights of the auger; but not without friction, and

not without the counter effect of gravity.

Here lies a marked difference between the horizontal auger and the vertical. Gravity greatly aids the horizontal type in its work by keeping the grain in the lower half of the auger tube while it is pushed one flight distance every revolution. Gravity plays no helpful part in the vertical auger. The forces acting are shown in Figure 6-B. In this figure, "r," shows the turning action, and  $F_r$

Table 4. Rotational speeds for vertical augers

Source	Range for rotational speeds of vertical auger elevators (rpm)			
	4 inch	6 inch	8 inch	10 inch
A .....	450	300	250	250
B .....		450-540		
C .....	300-700	300-700		
D .....		200-800		
E .....	300-600	300-600		
F .....	575-600	575-600	575-600	575-600
G .....		440-540*		

\*Source G: from tests shown in figure 7 and figure 8.

the frictional force on the grain that causes it to move with the flight. Centrifugal force is one resultant, shown at "c." This then causes grain frictional force at "f<sub>r</sub>." When "f<sub>r</sub>" is greater than "f<sub>g</sub>" and gravity, the grain will move up the inclined plane.

Rotational speeds are important

as they set up the primary action. Experience on the part of many investigators has determined the workable r.p.m.'s for vertical augers, as shown in Table 4. These recommendations reflect the desires also to attain a reasonably high rate of discharge within the best efficiency range.

### Volumetric Efficiencies and Equations

The volumetric displacement of an auger is defined as the free volume between adjacent flights times the r.p.m. By equation this can be expressed

$$\left(\frac{\pi}{4} D^2\right) - \left(\frac{\pi}{4} d^2\right) \times P \times \text{r.p.m.}$$

in which "D" is diameter of the tube, "d" diameter of the shaft, and "P" the distance between flights. The shaft diameter is usually not great and many times the following equation is used:

$$Q \text{ ft}^3/\text{min} = \frac{\pi D^2}{4} \times P \times \text{r.p.m.}$$

On standard single flight augers where "P" is equal to "D" the equation becomes:

$$Q \text{ ft}^3/\text{min} = \frac{\pi D^3}{4} \times \text{r.p.m.}$$

Actual delivery is far less than this equation would indicate. Reduced delivery shows that the grain travels

in a circular path more than it does in a vertical direction. Figure 7 shows the actual rates of delivery plotted in pounds/min. as related to Kw. of power used. The delivery rates are plotted with different r.p.m.'s; and these fell within a close range. When the weight of grain delivered is translated to a volume figure, and this compared to the displacement volume of the auger, there is a marked difference. At tests where r.p.m. was 530, feeding rate near full capacity for the 6 inch auger; the delivered grain volume was 10.7 ft.<sup>3</sup>, and the theoretical volume delivered was 51.9 ft.<sup>3</sup> This gives a performance factor of .206.

The elevator rate is partly controlled at the entrance by gate setting or force feed arrangement and it can be throttled down to zero if the occasion should call for that. The elevators were tested at full capacity



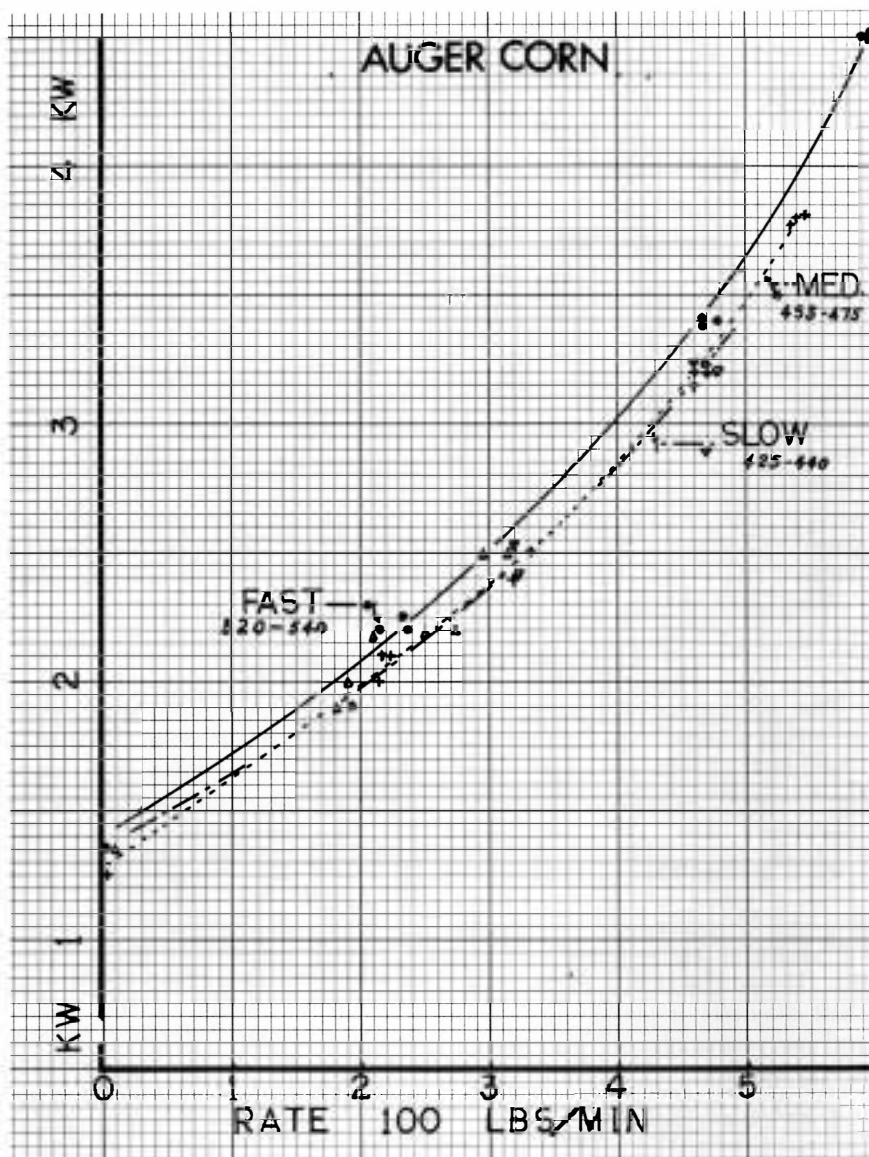


Figure 7. Grain quantity delivered vs. power used (auger, corn).

and then at partial capacity to form their performance curves shown in Figures 7 and 8. The elevators were also tested running empty or "no de-

livery" to find the part of the energy needed just to run the machine. The auger tested was 6 inches in diameter, tubings of the force feed type

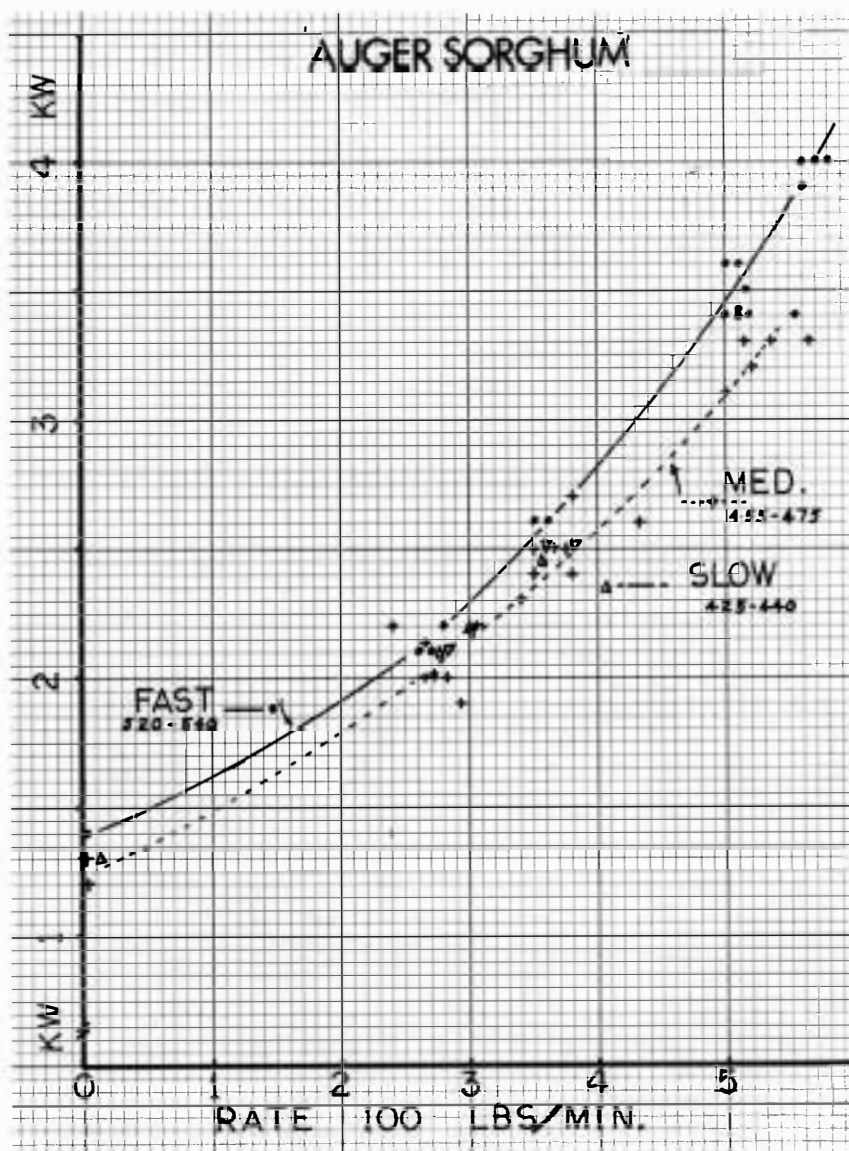


Figure 8. Grain quantity delivered vs. power used (auger, sorghum).

(6-inch horizontal leg) and was 31 feet total height with a net elevation height of 27 feet. Actual flights were 5½ inches in diameter to allow for clearance, which in turn allowed

for some leakage. This partly accounted for low volumetric efficiency, but the amount cannot be specifically identified.

## Tests on the Vertical Auger

A 3-horsepower electric motor was used as a source of power. Different V-belt pulley combinations made it possible to select one of three auger r.p.m.'s. This motor was not mounted as a reaction dynamometer; but power for the motor was measured with a recording watt meter. Figures 7 and 8 show the test data for corn and sorghum respectively.

When the KW consumption of the belt and bucket elevator is compared to the KW consumption of the auger elevator it is found that the belt and bucket uses approximately a third of the power of the auger ele-

vator to do the same work. Power for running the empty elevator is about a third that of full load delivery.

Curves in Figures 7 and 8 rise in a geometric relation with rate of delivery, rather than a straight linear relation of the belt and bucket elevator. When running empty, the auger elevator produces more sound and vibration than when it is full of grain. This type of elevator never cleans itself of its last bit of grain; and thus leads to mixing of grain as one changes from one kind of grain to another.

## ELEVATION OF GRAIN BY IMPELLER-BLOWERS

For many years the impeller-blower has been used successfully in some farm machines. An early application was the wind straw stacker or "blower" on the grain thresher. Similar fans were used in husker-shredders to stack the corn stover. Later, the "blower" was used for green forage on both field choppers for grass and corn, and at the silo for elevating the chopped forage.

Most fans are the straight blade type to clear themselves of solid matter. The fan blade must run close to the housing for the entire circle except where the outlet pipe is placed. Entering material is usually near the center so the first impact on the incoming material is at a minimum. Ideally the inlet opening is placed so that the material leaves in less than one turn of the fan. However, in practice there is always some material going around more than once, thus causing excess frictional drag.

A summary of former work is given in the Agricultural Engineers Handbook entitled "Impeller-blowers for Grain." Tests have shown

that the grain leaves the fan essentially at fan tip velocity. When this is near 4,000 ft./min. or slower, a low percentage of grain crackage occurs. Theoretical elevation heights go beyond 100 ft. vertically, but actual height limits are much less. At acceptable performance rates the practical limit has to be set near 20 feet. This is with an open elbow deflector at the top of the pipe.

The handbook gives the following equation for power relations:

$$HP = \frac{V^{4/3} W^{1/3}}{460}$$

V = blade tip velocity in ft./sec.

W = weight of grain per hour in cwt.

If this equation were used to get a comparative hp figure to the belt and bucket elevator test given in Figure 3, (36,000 lbs. per hours with 1.15 hp), the comparison would be:

For elevation of 36,000 pounds per hour a belt and bucket elevator would need 1.15 horsepower and an impeller-blower would need 8.2 horsepower.

The comparison does not put the blower in a favorable position.

## Tests with Two Experimental Blowers

The blower is a simple machine, and has only one major moving part. The delivery mechanism is a single steel tube. These features prompted us to test the blower to see if it would perform in a small size machine with a small electric motor drive.

A manufactured 20-inch diameter, 6-bladed fan with a 6-inch diameter delivery pipe was connected to a 27 foot vertical pipe, ending in a long curved elbow ( $R=2$  feet) of 90 degrees which was attached to a cyclone collector. The collector decreased the effective elevation height to 24 feet.

Elevation tests were run with both corn and sorghum. Power for the elevator was provided by a 2 hp, 1,725 r.p.m. electric motor. A special variable speed device driven by a  $\frac{1}{4}$  hp electric motor which could control a small auger speed from 0 to 40 r.p.m. was used as a feed rate controller. Figures 9 and 10 give the results of some very slow rate tests. The rates could not be increased because of frequent stoppage of the blower and pipe. At such times there was severe cracking of grain and cracking was noticeable in most of the tests. At 1,130 r.p.m. the fan blade tips were traveling at near 6,000 feet per minute. Air velocities at the outlet varied from outside to inside of the tube and were from 6,000 ft./min. to 4,000 ft./min. When the 27 feet of 6-inch delivery pipe, plus elbow, plus cyclone collector,

were attached, the air delivery was restricted. The pipe friction had reduced air velocity in the delivery pipe to 2,700 ft./min. This was still above the flotation velocity of large kernel grain, but below recommended conveying velocity.

The best test was with corn, (Figure 9) with 100 lb./min. delivered with 1.40 KW of power. When these data are applied to the handbook equation the hp theoretically would be 4.48. In general, the impeller-blower was found to be very slow, and high in power requirements and to give much trouble with plugging. Tests with the machine as purchased were abandoned.

The fan was then rebuilt with fan blades extended to a 24-inch diameter wheel. The fan scroll was changed to an ever-increasing clearance from the "cut-off" point. A smaller and second impeller wheel was placed on the fan shaft to throw the grain into the main air stream above the fan. The r.p.m. was increased from 1,130 to 1,450 r.p.m. This speeded up the fan blade tips to 9,150 ft./min. while the smaller grain impeller blades traveled at 4,000 ft./min. The new fan developed a 7,000 ft./min. pipe velocity with an open pipe, but this was reduced to near 5,000 ft./min. with elevation pipe and cyclone collector added.

The slow delivery rates and the severe cracking of grain, discouraged any further work with this experimental model.

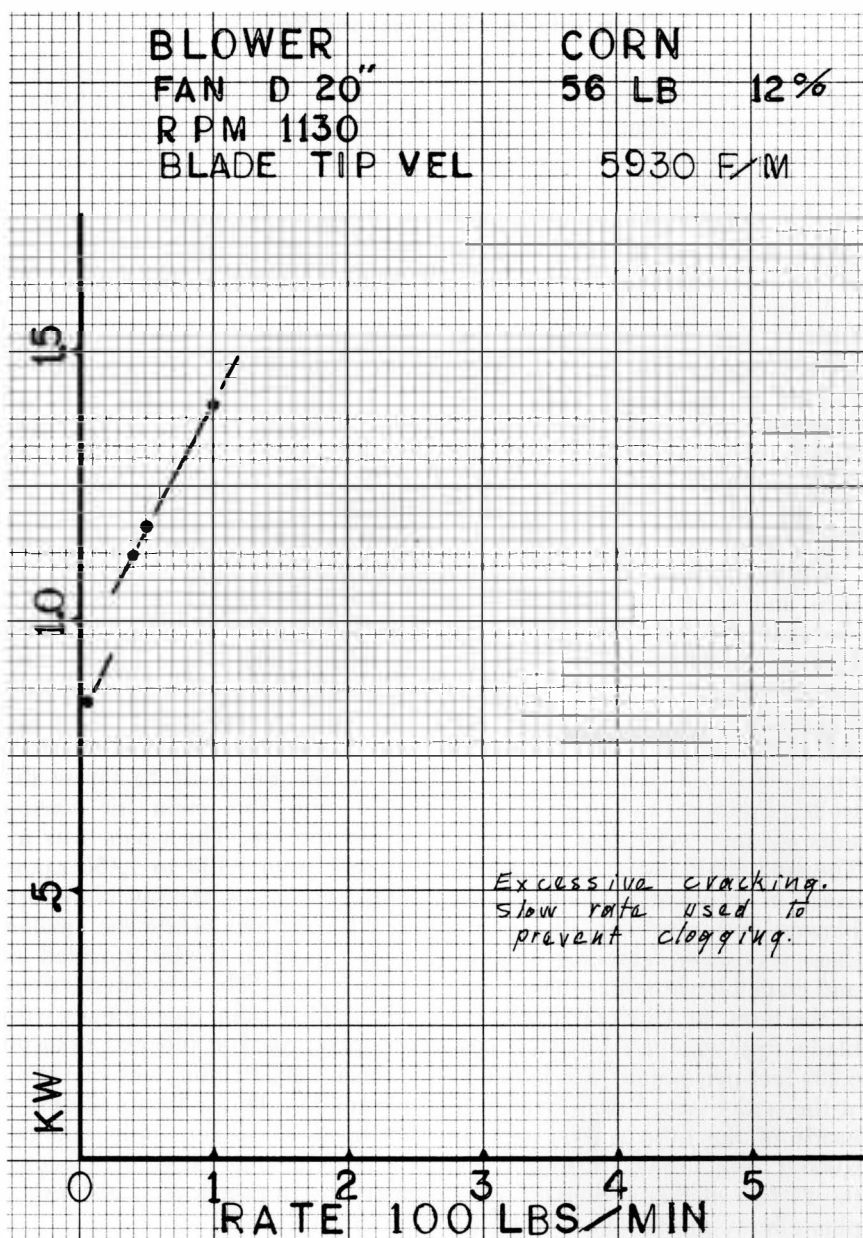


Figure 9. Slow rate tests with blower for corn.

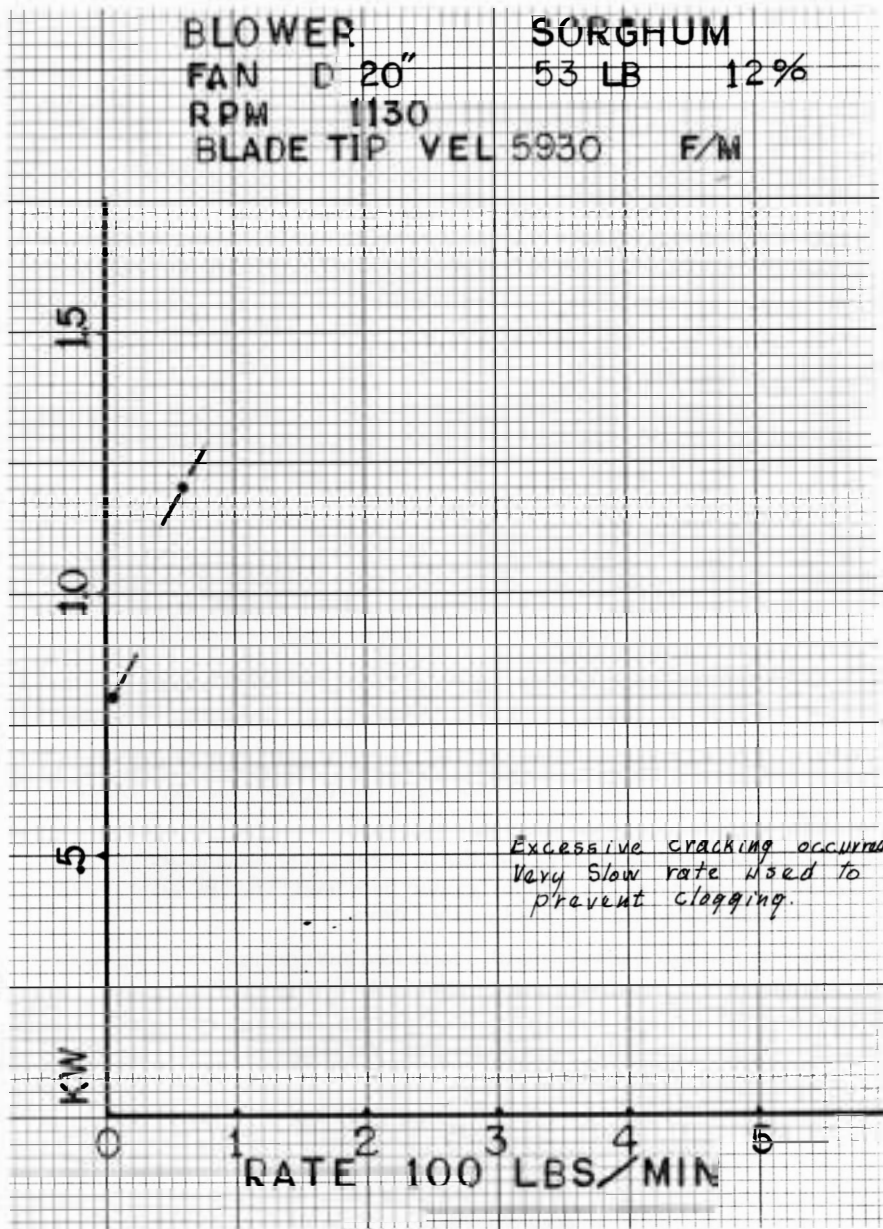


Figure 10. Slow rate tests with blower for sorghum.

## SUMMARY

1. The belt and bucket elevator remains the standard of comparison for locations where small grain is elevated vertically.
  - A. From the standpoint of power required, it will elevate more grain for a given power applied, than will the auger or blower.
  - B. This is because the power is applied essentially to the lifting of the grain, vertically, with a minimum of frictional loss. In spite of this there is still considerable power required to run the empty belt.
  - C. The belt and bucket elevator must run at a satisfactory speed to unload the buckets at the top pulley.
  - D. There must be feed-gate control at the lower end feeding chute so that the buckets are not overloaded. At the end of the run the gate should be closed. The elevator should be in motion before the gate is reopened.
  - E. The motor drive should be from the top pulley where the full belt weight adds to the tension of the belt to have good driving action.
  - F. Some installations call for an elevator of extreme height to get a satisfactory horizontal run through the discharge spout from the elevator top to an adjacent bin. (The motor is at the top and should be weather-proofed.)
2. The auger can be made to elevate vertically if enough power is supplied.
  - A. The power required is from 2 to 2¼ times that of the belt and bucket elevator.
  - B. The single closed tube of the vertical auger is a desirable feature, taking up a minimum of space. There is only one major moving part, enclosed within the tube.
  - C. The mechanical drive may be installed at either top or bottom, and the latter places the motor drive close to the ground floor level. The lower-end installation usually calls for an enclosed gearbox drive.
  - D. The vertical auger works best with a force feed arrangement, and a logical one is to have a short horizontal auger feeding into the vertical auger at the lower end.
  - E. The vertical auger will not clear itself of all of its grain, and causes some grain "mixing" problems from load to load.
3. The impeller-blower has not been successful in test work for lifting grain to 25 to 30 feet.
  - A. These machines were designed to elevate grain to heights of 20 feet or less and discharge through an open type elbow.
  - B. The test installation exceeded the 20-foot height, added a closed 90-degree elbow plus a cyclone collector; all of which caused extra friction and reduced air velocity in the pipe.
  - C. Cracking of both corn and sorghum was severe with both of the models used.







6-70—1.5M—10906