Performance of AUGER CONVEYORS FOR FARM FEED MATERIALS

at restricted delivery rates

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Bulletin 666

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

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Urbana, Illinois December, 1960

Publications in the Bulletin series report the results of investigations made
or sponsored by the Experiment Station

Auger conveyors are popular devices for conveying farm products. Thousands of portable units have been used to move or elevate grains into and out of storage bins. As one aspect of increased farmstead mechanization, many auger conveyors are being installed as integral parts of continuous-flow systems. For economical installation and dependable performance, the capacity and power requirement of each component of a system must be accurately predicted.

The maximum capacity and power requirements of an auger conveyor vary as functions of many parameters that influence auger-conveyor characteristics, including auger speed, diameter, angle of inclination, design of intake section, clearance between auger and tube, pitch of auger flighting, and type of material being conveyed.

Extensive testing programs to determine auger conveyor characteristics with agricultural products have been conducted and reported (see the other reports listed on page 12). All of these tests, however, were conducted with the intake of the conveyor freely removing material from a large mass and, except at higher speeds, the conveyors were operating full.

When, however, a number of auger conveyors operate successively as a single, continuous-flow system, all convey at the same rate regardless of factors affecting performance. In even the most carefully designed system, it is therefore unlikely that more than one of the individual conveyors operates at maximum capacity. Some of the above-listed parameters affecting capacity, such as design of intake section, will then be of lesser importance.

In feed-distribution systems, metering devices and processing operations often cause unusual restrictions on delivery rates. For instance, the popular 2-horsepower blender-grinder delivers about 1,200 pounds per hour. This is much less than the usual capacity of even the smallest auger conveyors available. Thus conveyor characteristics at extremely low delivery rates must be known for some types of installations.

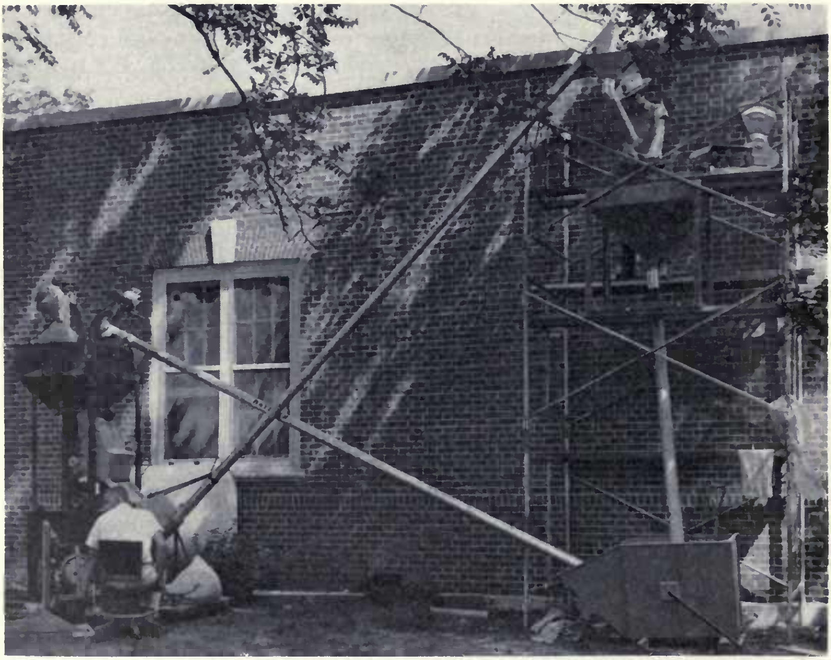
Field experiences have indicated that results of full-conveyor tests cannot be applied to accurately predict operating characteristics of partially filled conveyors. The tests reported here were conducted to determine the effects of those parameters believed to have the greatest influence upon auger-conveyor capacities and power requirements when handling materials at low, regulated rates. The four variables tested were auger rotational speeds, conveyor inclinations, rates of feed delivery, and types of feed material.

TESTING APPARATUS

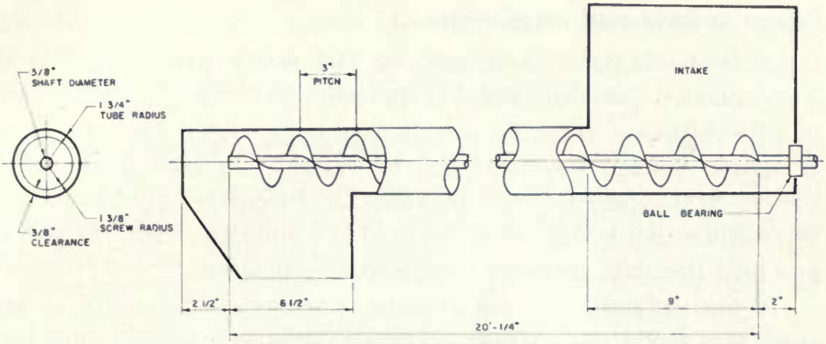
The testing apparatus (Fig. 1) consisted of the test conveyor, an input metering assembly, a power supply and measurement assembly, a delivery-weighing apparatus, and a return auger conveyor to the supply bin.

Test conveyor

A commercially produced nominal 4-inch auger conveyor (Fig. 2) was used in all tests. As commonly fabricated for farm use, this was approximately a "full-pitch" auger with 3-inch pitch of the flighting and a 2¾-inch auger diameter. Auger flighting and shaft showed no special treatment or coating. The conveyor tube was galvanized. The test conveyor was not specially selected, and a small amount of shaft nonlinearity was found in the auger. This was assumed to be typical of such low-cost conveyors.



Arrangement of equipment for determining auger-conveyor characteristics, including drive unit, feed holding and metering apparatus, test conveyor, feed weighing scale, and feed return conveyor. (Fig. 1)

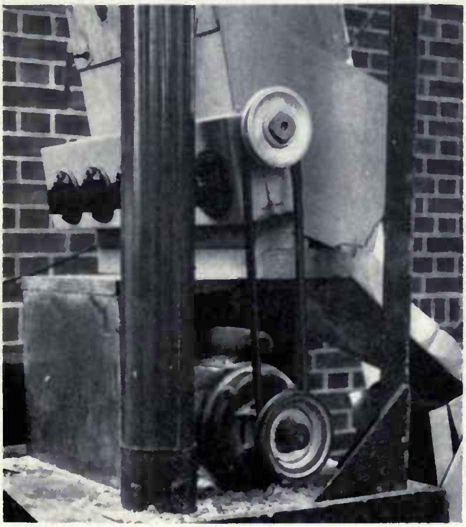


Design and dimensions of nominal 4-inch auger conveyor that was used for all tests. **(Fig. 2)**

The test conveyor was mounted to pivot at its lower end so that its angle of inclination could be varied from horizontal to vertical.

Input rate control

The input rate through the test conveyor was regulated by the metering portion of a commercial blender-grinder (Fig. 3). This unit, mounted directly beneath a supply bin, was driven by a separate motor. Output of the meter could be varied by appropriate adjustments of five calibrated knobs. From the meter the feed material was funnelled into the intake of the test conveyor.

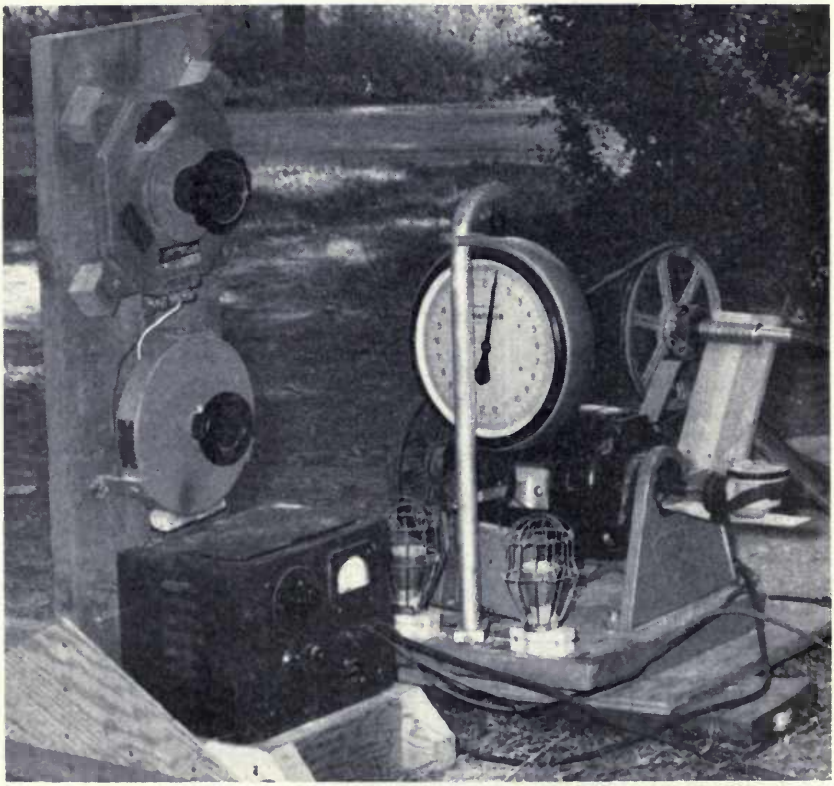


The input metering mechanism, part of a commercial blender-grinder, was mounted beneath a supply bin and was driven by a separate electric motor. **(Fig. 3)**

Power supply and measurement

A cradle-mounted ¾-horsepower DC motor, functioning as a dynamometer, drove the auger of the conveyor (Fig. 4). Direct current for the motor armature was supplied by a 3 KVA DC generator. Its output voltage was controlled by variable rheostats in the field circuit. Motor field flux was provided by a separate variable-voltage DC rectifier unit which, when adjusted in conjunction with the armature field rheostats, provided precise speed regulation.

At low inclinations of the conveyor, power was transmitted to the auger by a single, size A, V-belt. Large sheaves were used to minimize belt slippage and flexure losses. At conveyor inclinations greater than 30°, a flexible steel shaft was placed between the driven sheave and



Power supply and measurement unit, including rheostats for the field of the DC generator (not in photo), a DC power unit for the motor field, and the DC cradle-mounted motor used as a dynamometer. (Fig. 4) the auger. In duplicate tests, no appreciable difference in power requirements was noted between the two drives. A multi-range tachometer was connected directly to the motor shaft.

Delivery-weighing apparatus

By using a metal container and a stopwatch, test conveyor output was collected for timed intervals. Gross weight of each amount collected was determined to 0.01 pound.

TESTING PROCEDURE

To determine the effects of different types of conveyed feedstuffs upon operating characteristics of the conveyor, three different materials were used:

Shelled corn at 10.7 percent moisture (wet basis), test weight 57 pounds per bushel

Oats at 12.3 percent moisture (wet basis), test weight 42 pounds per bushel

Ground feed mixture, 11.5 percent moisture (wet basis), test weight 43 pounds per bushel, and modulus of fineness 2.72

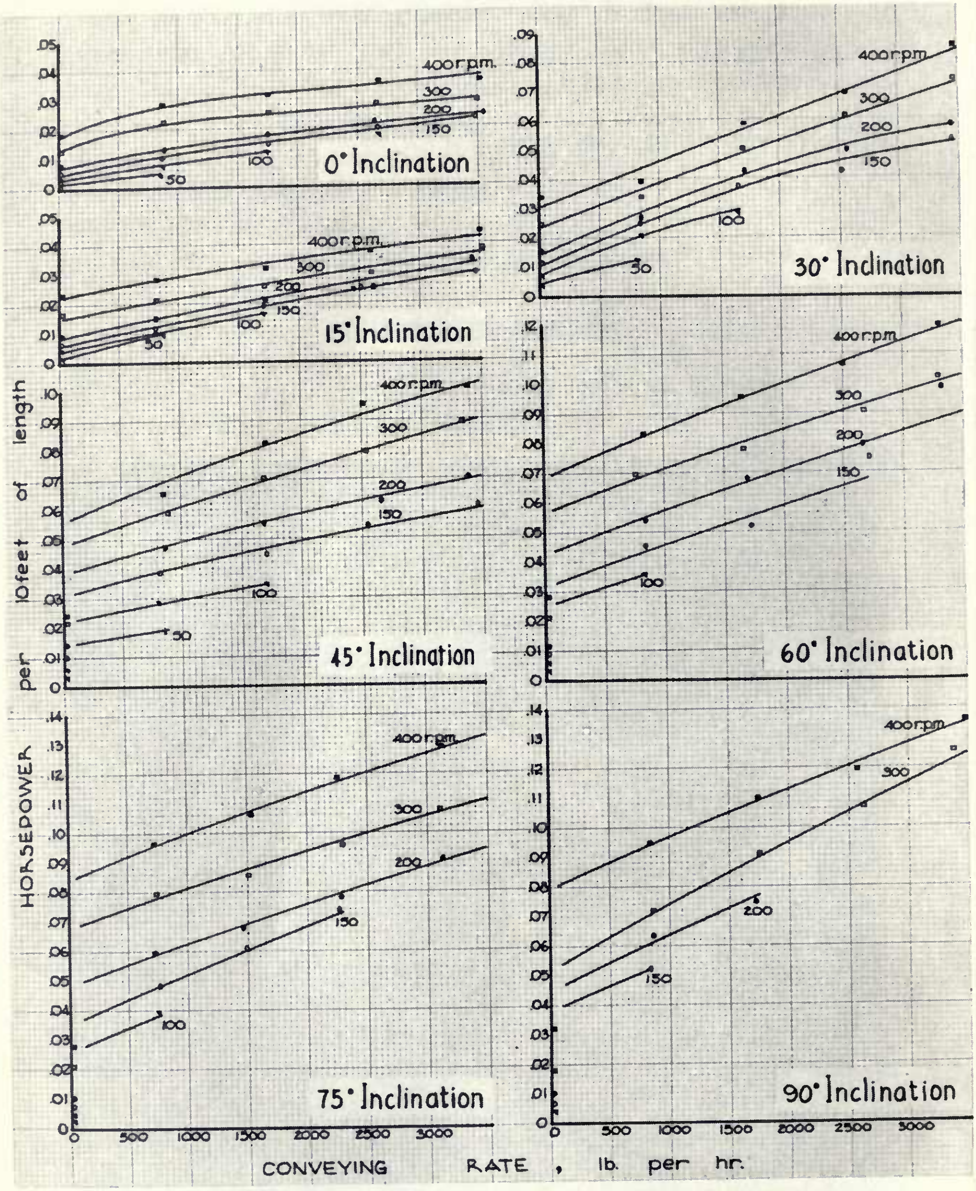
All combinations of auger speed, conveyor inclination, and delivery rate were tested with each of the three feed materials. Two observations were made at each combination. The following levels of these variables were tested:

Auger speeds: 50, 100, 150, 200, 300, and 400 revolutions per minute

Conveyor inclination: 0, 15, 30, 45, 60, 75, and 90 degrees from horizontal

Delivery rates: 5 adjustments of 0 to approximately 2,500 pounds per hour with ground feed and 0 to approximately 3,500 pounds per hour with oats and shelled corn

The testing apparatus was designed to be recirculating, with a second auger conveyor returning the feed material to the supply bin. Extensive pretest runs were made as deemed advisable to provide reliable data. Since the rate of delivery was measured to be plotted as a continuous function, adjustment of the input meters was not critical. The operator at the delivery-weighing apparatus signaled the beginning and end of each test run. During each run, the operator at the power supply and measuring apparatus maintained a constant speed and obtained an average scale reading from the dynamometer scale.



SHELLED CORN: Horsepower and conveying rate at various inclinations and rotational speeds. (Fig. 5)

DISCUSSION OF RESULTS

As the primary purpose of this study was to determine auger-conveyor power requirements as a function of other variables, the data are plotted in Figs. 5, 6, and 7 as horsepower per 10 feet of conveyor length versus conveying rate for each auger speed, feed material, and inclination. The freehand curves approximate the apparent regressions, but because of the limited data for each individual curve, no statistical inferences were drawn or are implied. Instead, the curves are intended to provide a reasonable estimate of power requirements within the ranges of the delivery rates, auger speeds, inclinations, and feed material tested.

An individual curve that does not span the entire range of conveying rates indicates that auger rotational speed was insufficient for the greater conveying rates. In these instances, the curves are plotted to the highest test delivery the conveyor could accommodate.

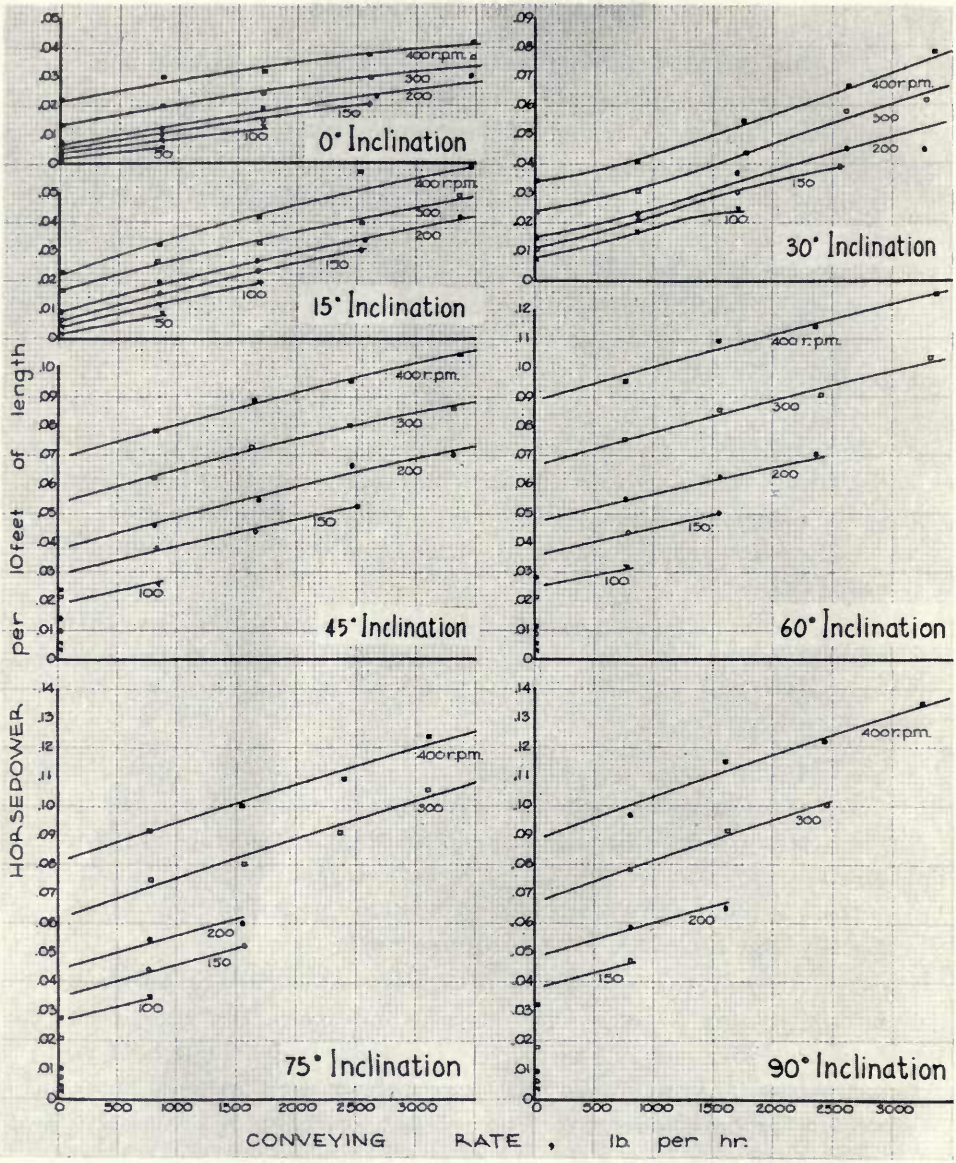
The following observations are based upon the test data illustrated in the charts:

1. These tests substantiated field observations that at less than capacity less power will be required than for capacity of an auger conveyor. The relationship between delivery rate and power is generally linear.

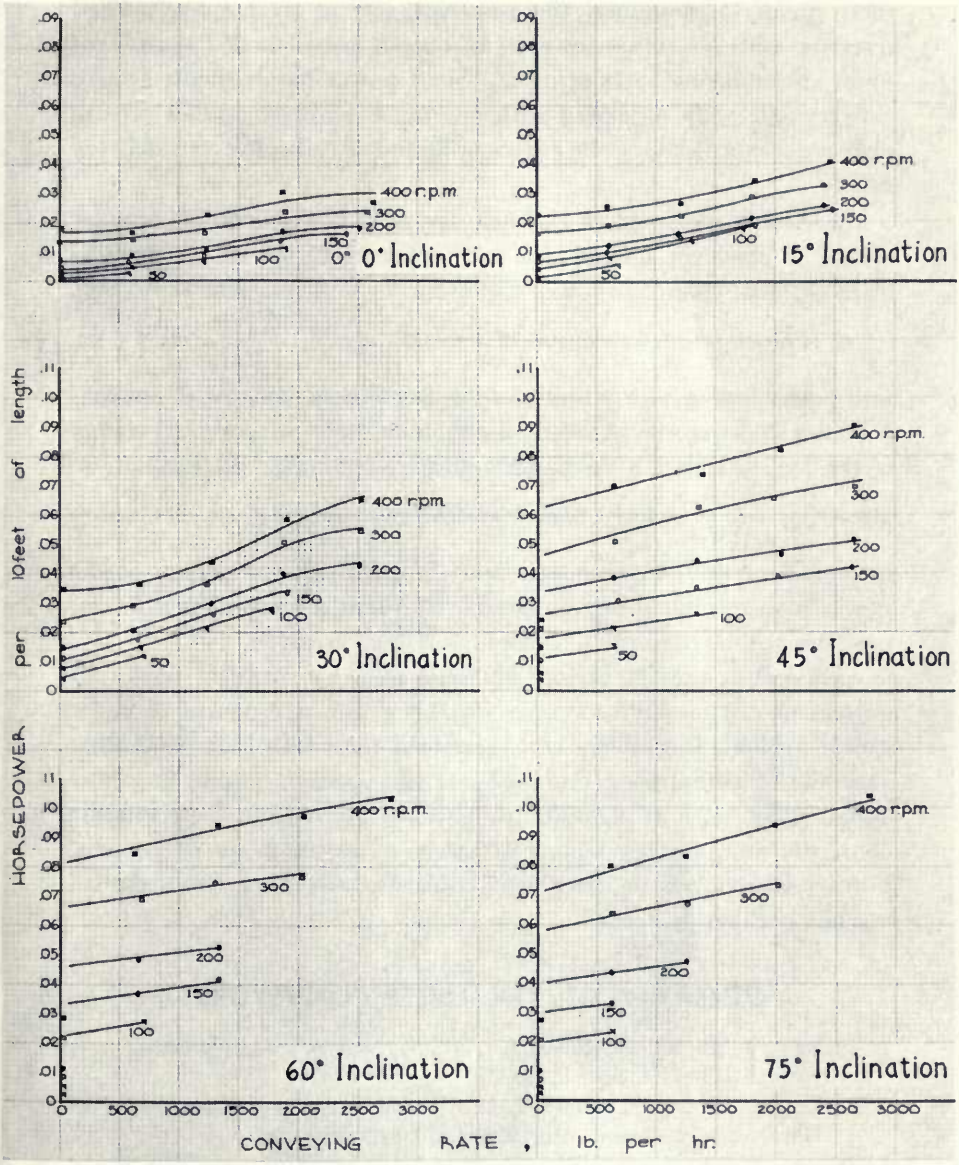
2. If the desired delivery rate can be obtained at a number of different auger speeds, selection of the lowest auger speed results in the least power requirement. An exception to this generalization was noted as the conveyor reached its maximum capacity at any specific speed. At that point a small increase in delivery rate led to an exceptionally large increase in power requirements.

3. At conveyor inclinations of approximately 30° or less from horizontal with a given feed material and speed, the relationship between power and rate of delivery is usually linear throughout the range tested. This implies that a particle of feed material moves steadily through the conveyor from intake to discharge as a function of auger speed only.

4. At conveyor inclinations of approximately 45° or greater (depending upon speed and feed material), a full-pitch screw conveyor is entirely filled at all delivery rates above zero. Also, if initially full, the conveyor will remain full even when the input rate is zero. At



OATS: Horsepower and conveying rate at various inclinations and rotational speeds. **(Fig. 6)**



GROUND FEED MIXTURE: Horsepower and conveying rate at various inclinations and rotational speeds. (Fig. 7) these greater inclinations, the conveyor acts as a completely filled reservoir with instantaneous rates of output equal to and dependent upon instantaneous rates of input. Since power requirements at zero delivery rate were measured with an empty conveyor, values of zero delivery do not lie along the curves of finite (or full conveyor) delivery rates.

5. At any given speed and delivery rate, power requirements increase as conveyor inclinations are increased up to 60°. There is little apparent change in power requirements at inclinations above 60°.

6. The slope of any curve of constant speed, $\frac{\Delta \text{HP}}{\Delta \text{Rate}}$, shows the unit power increase for a unit increase in delivery rate. At 0° inclination, this slope represents mostly frictional losses as the potential energy of the feed material is unchanged during conveying. At inclinations above 0°, $\frac{\Delta \text{HP}}{\Delta \text{Rate}}$ includes both frictional and elevating power. Cursory inspection of the data indicates that the frictional component of the power requirements is highly variable and that a more refined testing program will be required to define the factors involved.

These data provide desired estimates of screw-conveyor power requirements at low delivery rates, exploring the parameters of auger speed, inclination, delivery rate, and feed material. However, other variables of perhaps lesser importance also exist. Thus in an actual design situation, it is suggested that values taken from these graphic charts be increased by factors of safety of as much as 20 percent. Further testing and analyses will reduce the effects of errors due to unevaluated parameters.

OTHER REPORTS ON AUGER CONVEYORS

1. Millier, W. F. Bucket elevators and auger conveyors for handling free-flowing materials. Agr. Engin. 40:450-452. 1958.
2. Regan, W. M., and Henderson, S. M. Performance characteristics of inclined screw conveyors. Agr. Engin. 39:552-555. 1959.
3. Ross, I. J. The forces acting in particle stacks and the capacities of enclosed screw conveyors. Doctoral thesis, Purdue University. 1959.
4. Ross, I. J., and Isaacs, G. W. Theory of operation and characteristics of enclosed screw conveyors. Unpublished paper 59-915, presented at ASAE Winter Meeting, Chicago, Illinois, December, 1959.

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