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EC736 Grain Drying with Forced Air Circulation

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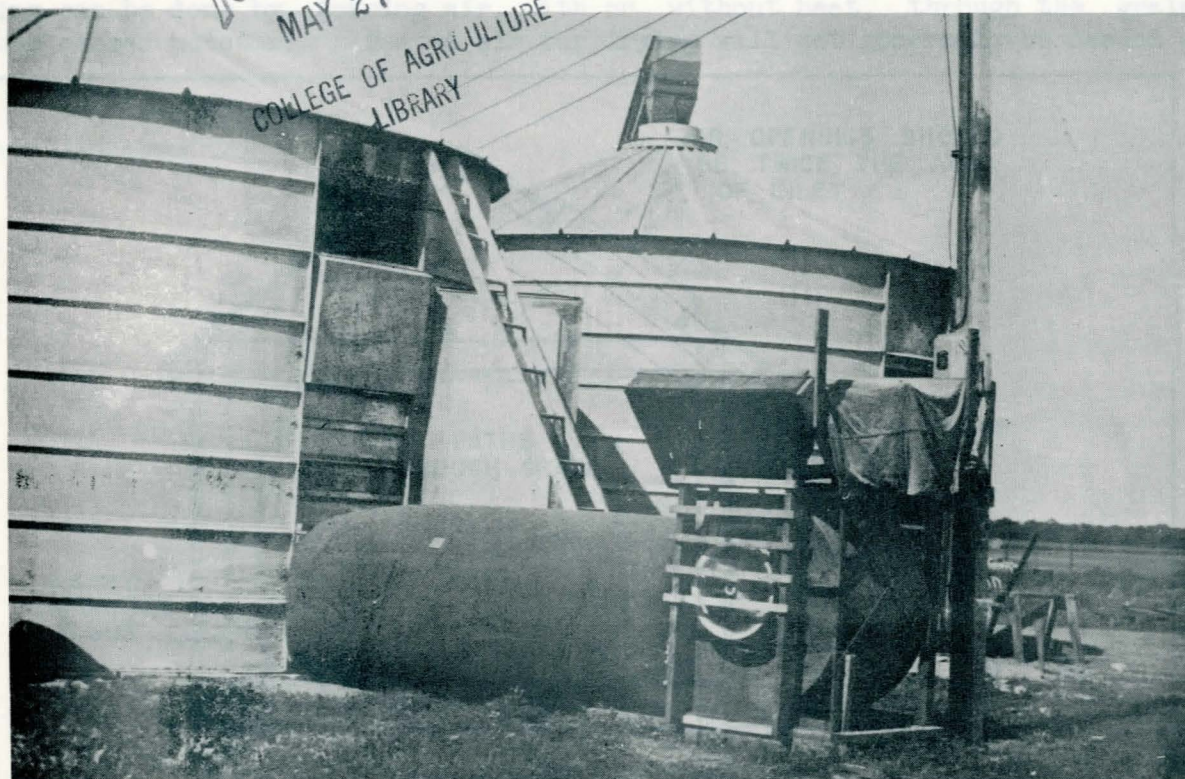
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GRAIN DRYING

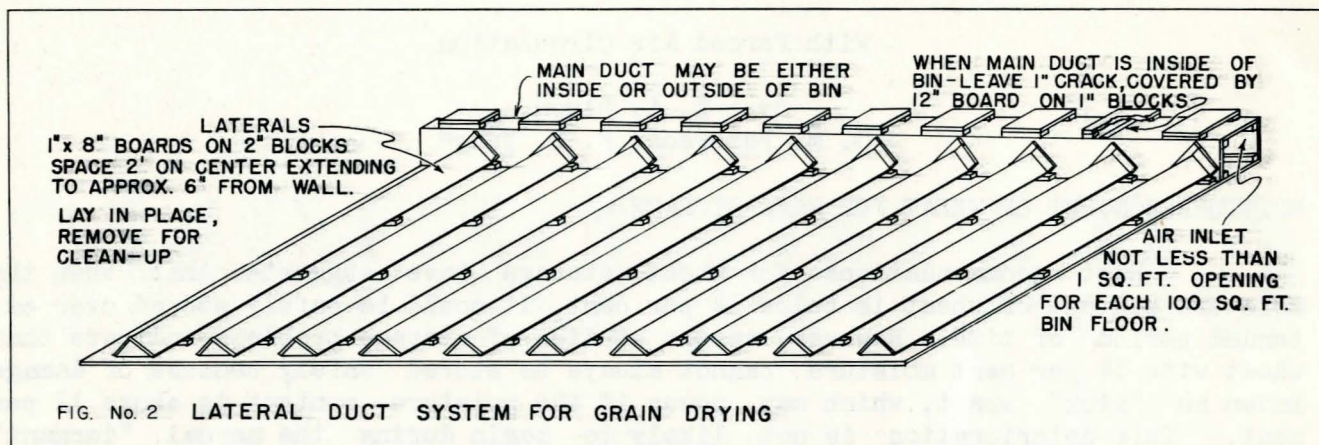
WITH

FORCED AIR CIRCULATION



COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE, AND THE UNITED
STATES DEPARTMENT OF AGRICULTURE COOPERATING, H.G. GOULD, ASSOCIATE
DIRECTOR, LINCOLN.

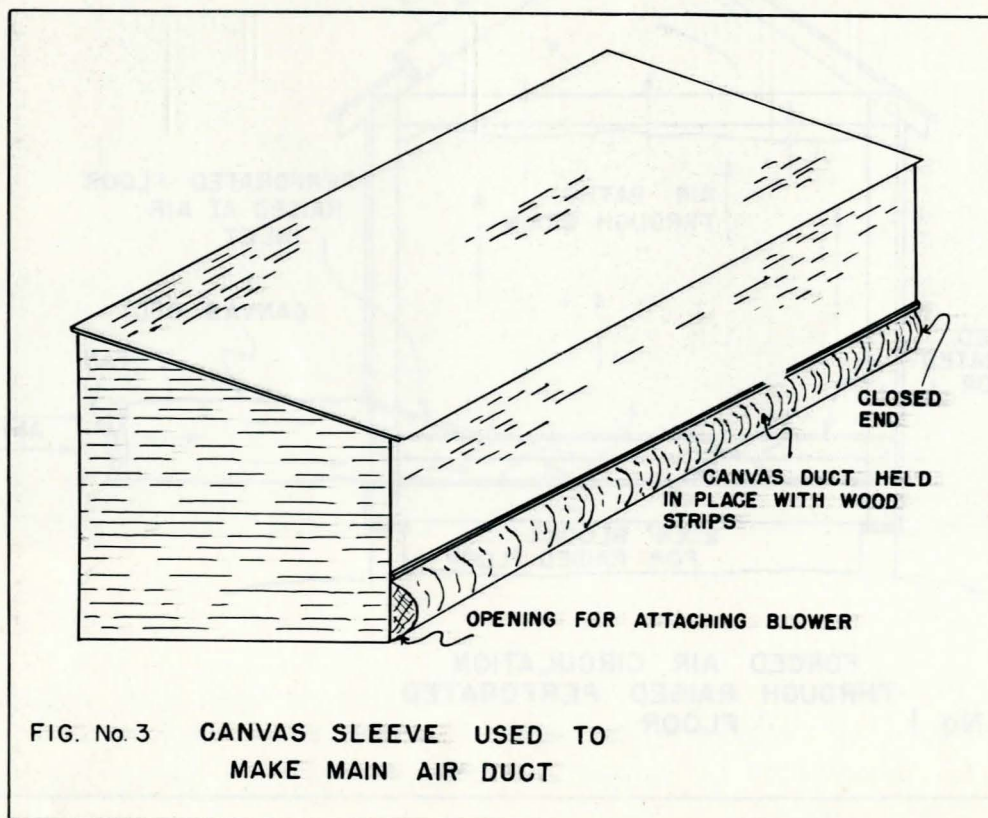
NEBRASKA WESLEYAN UNIVERSITY



Nebraska temperatures and humidity are favorable for drying at harvest time. The use of heated air may present a fire hazard, increase the investment in equipment, and may increase the cost of drying, but may be very important under adverse weather conditions in making possible the saving of a crop.

SAFE MOISTURE CONTENT FOR STORAGE OF OTHER GRAINS

The moisture content for safe storage of shelled corn over long periods of time is 12-13 per cent, and for sorghum 13 per cent. At the present time, no definite figures can be given for oats and barley.



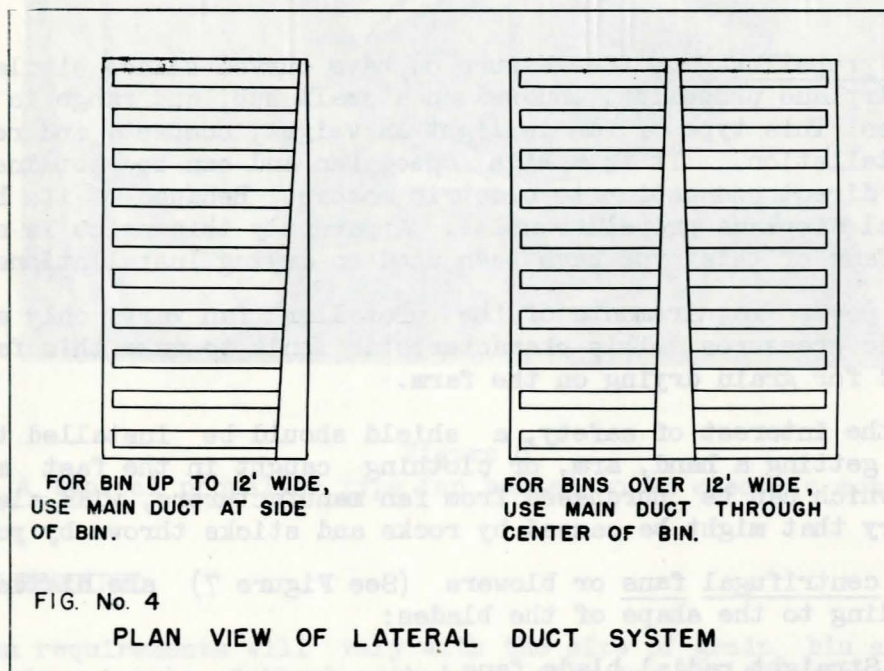
ADAPTING BINS FOR FORCED AIR CIRCULATION

In drying with forced air circulation, arrangements must be made to secure uniform air flow through the grain for satisfactory results. One method of doing this is to install a perforated floor as shown in Figure 1. This perforated floor must be placed above the bin floor and supported to allow free air passage to all parts of the air chamber below the grain. Information on new storage structures adapted for drying is available from County Extension Agents.

The lateral duct system shown in Figure 2 can also be used for adapting bins for forced air circulation. The main duct can also be built on the outside of the bin and used in drying successive bins of the same size. Waterproof canvas serves as a simple means for forming an outside duct as shown in Figure 3. When the duct system is used in bins wider than 12 feet, the main duct should be placed in the center of the bin floor as shown in Figure 4.

Metal perforated flooring is excellent for use in bins with raised floors. (See Figure 5). The total area of the perforations should be at least 7 to 10 per cent of the floor area. Information on obtaining such flooring can be secured from the County Agents' office. Floors can be constructed of such materials as landing mat, hardware cloth, or other wire mesh, properly supported and covered with fly-screen wire.

The practical limits on grain depths for forced air drying are about 8 to 10 feet. For satisfactory drying, the grain should be evenly distributed at a uniform depth in the bin. During the filling process, the grain should be leveled frequently to reduce packing under the elevator or blower spout and to prevent the accumulation of chaff or cracked grain in one part of the bin.



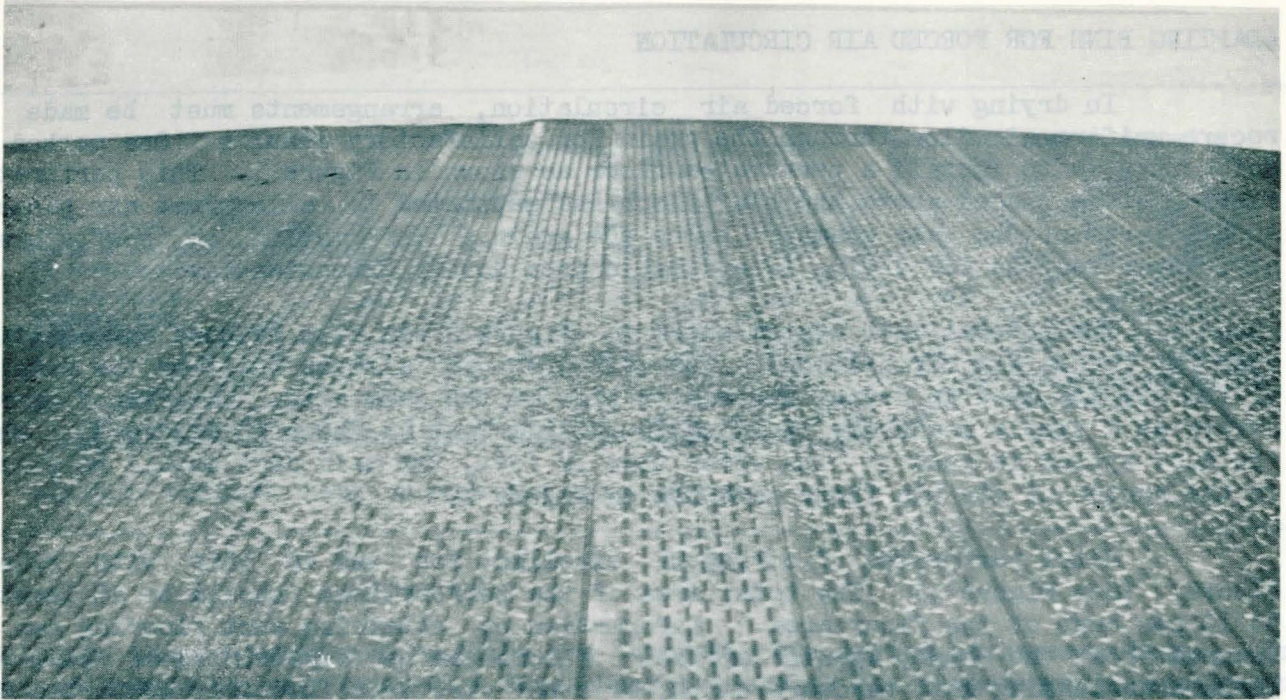


Figure 5

One type of perforated floor used in a steel bin in experimental drying work by the Department of Agricultural Engineering at the Nebraska Agricultural Experiment Station.

FANS OR BLOWERS

Two types of fans have been used for grain drying; the propeller, (axial flow) and the centrifugal. Fans will range in cost from about \$175 to \$250 without the motor.

The propeller fans (See Figure 6) have curved blades similar in shape to those of an airplane propeller, mounted on a small hub, and range in diameter from 24 to 60 inches. This type of fan is light in weight, compact, and requires little space for installation. It is a high speed fan and can be obtained with pulley drives or for direct connection to electric motors. Because of its high speed, it emits a typical airplane propeller noise. Apparently this noise is not objectionable as many fans of this type have been used on drying installations.

The power requirements of the propeller fan vary only slightly with changing static pressures. This characteristic tends to make this fan particularly well suited for grain drying on the farm.

In the interest of safety, a shield should be installed to prevent the operator from getting a hand, arm, or clothing caught in the fast moving blades. This shield, which can be purchased from fan manufacturers, will also protect the fan from injury that might be caused by rocks and sticks thrown by youngsters.

The centrifugal fans or blowers (See Figure 7) are divided into three classes according to the shape of the blades:

1. Straight radial blade fans.
2. Forward curved blade fans with blades curved forward in the direction of rotation.
3. Backward curved blade fans curved backward opposite to the direction of rotation.

Of the centrifugal fans, the backward curved type will be most satisfactory for grain drying. Power characteristics of the backward curved fans are not as favorable as those of the propeller type under conditions of varying static pressures. When static pressures are reduced, the power requirements will tend to increase and may cause overloading of the power unit.

The major disadvantages of this fan are its weight, size, and cost. At present, almost all fans of this type are especially designed for high efficiencies and quiet, continuous operation.

Where electric power is available, an electric motor will be the most convenient source of power for forced air circulation. Where electric power is not available, gasoline engine power units can be used. When a gasoline power unit is used, the engine may be shrouded so that ingoing air is circulated past the engine before going through the fan. The heat thus gained from the engine will cause some increase in drying rate. If the engine is shrouded, exhaust gasses should be discharged outside the shroud, not permitted to pass through the grain.

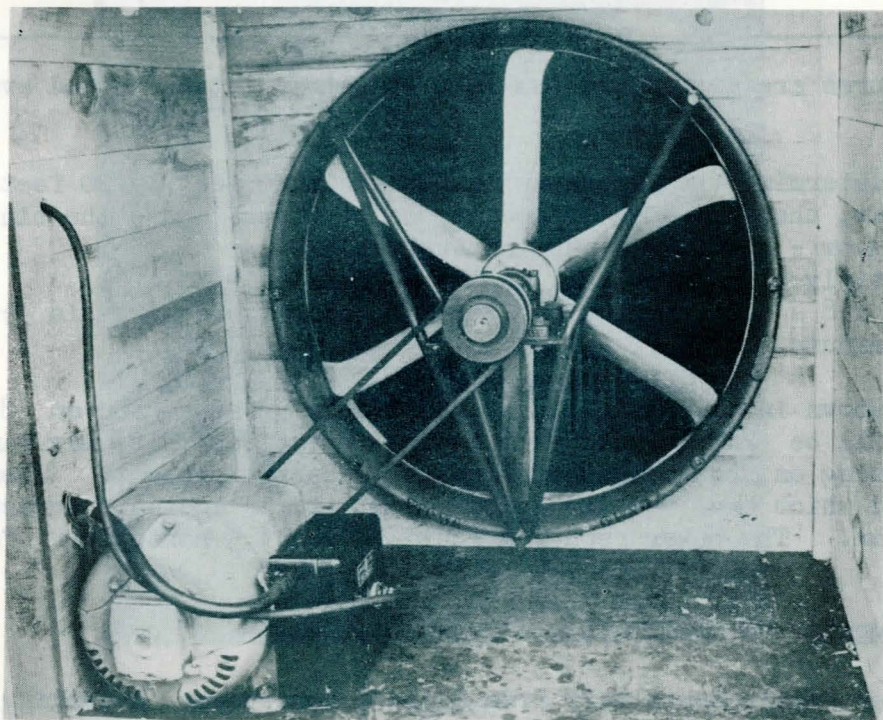


Figure 6

A typical propeller fan belted to an electric motor.

FAN CAPACITY REQUIRED

Fan requirements will vary with the size of grain bin and the depth of grain involved. A rule of thumb method of figuring the fan capacity is to allow an air flow of one cubic foot per minute (c.f.m.) for each square foot of bin floor area and for each foot of depth of clean grain. The static pressure (back pressure) against which the fan must operate to produce this air flow increases as the depth of the grain increases.

Static pressure is commonly measured at a small hole in the wall of the duct through which the air is flowing. The pressure is usually expressed in terms of the height of the water column which could be supported by this pressure.

The following table shows static pressures which might be expected for different depths of various grains. The figures given are for clean grain. Under field conditions, the grain may contain chaff and cracked kernels which may increase the pressures to as much as twice the figures shown.

STATIC PRESSURES REQUIRED TO FORCE AIR THROUGH CLEAN GRAINS AT VARIOUS DEPTHS
(Based on air flow of 1 c.f.m. per square foot for each foot of depth)

| Grain | Depths of Grain | | | |
|----------------|-----------------|--------|--------|---------|
| | 4 Feet | 6 Feet | 8 Feet | 10 Feet |
| Barley | 0.15 | 0.35 | 0.65* | 1.0* |
| Corn (Shelled) | 0.055 | 0.18 | 0.4 | 0.8* |
| Oats | 0.19 | 0.45 | 0.85 | 1.4* |
| Sorghum | 0.2 | 0.47 | 0.9* | 1.5* |
| Wheat | 0.42 | 1.0 | 1.5* | 2.5* |

*These figures are approximations made by extrapolation beyond available data.

To determine the fan capacity for a bin 20 feet by 20 feet filled with 8 feet of wheat, the following method is used. First figure the bin area.

Bin area = 20' x 20' = 400 square feet

Multiply the bin area by depth of grain

400 x 8 = 3200 which gives the fan capacity required in cubic feet per minute.

As shown in the table above, the static pressure for an 8 foot depth of clean wheat will be 1.5 inches. In actual practice, this may range up to 2.5 inches, depending on the amount of foreign material present. Therefore, a fan will be needed which can deliver 3,200 c.f.m. of air against pressures up to 2.5 inches of water. The power required would be about 3 horsepower for a propeller type fan.

POWER REQUIREMENTS

Power requirements vary from 2 to $7\frac{1}{2}$ horsepower depending upon the type of fan, rate of air flow, and resistance pressures (static pressure). Requirements for any particular installation can be determined from information furnished to the local dealer by the manufacturer. When electric power will be used, the power supplier should be consulted regarding the maximum size motor which can be used. This will vary in different areas from 5 to $7\frac{1}{2}$ horsepower.

BIN OPENING FOR INTRODUCING AIR

At least $1\frac{1}{2}$ square feet of area should be provided at the air inlet to the bin for each 1,000 bushels of grain stored. The bin used in the example above (20' x 20' x 8') with a capacity of 2,500 bushels should have an air inlet opening with about 4 square feet of area. The air outlet from the bin should have at least double the area provided for the inlet. A flexible air duct made from waterproof canvas is generally used for connecting the fan outlet and the air

inlet to the bin. (See cover). These ducts can be provided or "made-up" by local dealers.

Air temperature affects the rate of drying -- faster drying at higher temperatures -- but the final moisture content of dried grain is determined by the relative humidity of the air, not the temperature. Tests have shown that grain exposed to air of 75 per cent relative humidity will dry only to about 14.5 per cent moisture; when relative humidity of air is about 50 per cent, grain will dry to 12 per cent moisture. Therefore, final drying must be done when relative humidity is below 50 per cent. Since relative humidity is such an important factor, a humidity indicator is essential. Instruments of sufficient accuracy are quite inexpensive and may be obtained for about the same price as a good thermometer.

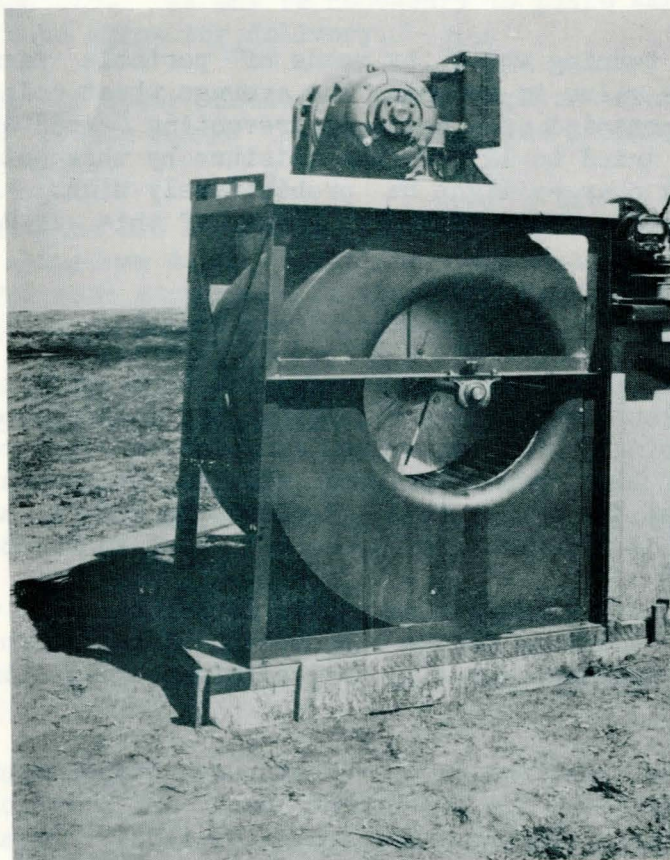


Figure 7

A centrifugal blower which can be used for forced air circulation.

OPERATION OF FAN

The fan should be started as soon as the grain can be spread over the bin floor to a uniform depth. Operation of the fan should be continued until the top layer of grain has reached a safe moisture content. The moisture can be determined by taking a grain sample to the local elevator. It is good practice to finish drying with as cool dry air as possible, perhaps by operating at night if the air is cool and dry. Then, if the bin is closed while the grain is cool and at a low moisture content, the grain will remain cool and dry for periods up to several months, assuming that the bin is in good repair with a tight roof and sidewalls.

It is a good precautionary measure after the grain has been in storage several weeks to take advantage of a cool dry period to force air through the grain to further dry and cool it. This should not be done unless the relative humidity is below 50 per cent and the air temperature below that of the grain. This may be done to advantage several times during the year.

TIME AND COST OF DRYING

The time required for drying may vary from one or two days up to two weeks. This will depend on weather conditions and also on the amount of moisture to be removed. Power costs for drying will depend largely upon the length of drying time. The cost may range from below one cent up to five cents per bushel.

DRYING BY SHIFTING GRAIN

Moving and turning wheat by means of portable farm elevators or by shoveling is of little value in reducing the average wheat moisture content. Such a practice is not recommended as a means of preventing "sick" wheat. It is doubtful if wheat could be dried to 12 per cent moisture by this method, and if it were possible, the handling charges might be prohibitively high. Some benefit may be derived from mixing damp wheat with dry wheat, if this is done before heating occurs.

GRAIN STORAGE

Once grain has been dried to a safe moisture content for storage, it is essential that it be kept dry. This requires a bin with a good floor, to prevent the grain from absorbing ground moisture, and also a tight roof and sidewalls. During long periods of high humidity, grain that is stored in bins with single thickness walls or damp floors may have a tendency to gain in moisture. Bins constructed of double walls and with dry floors will tend to reduce this problem.

Outside walls of storage bins should be painted with white, aluminum, or other heat-reflecting paint to reduce absorption of heat from the sun. The resultant lower storage temperatures will help eliminate deterioration of the grain in storage.

Plans for the construction of new storages (types approved by Production and Marketing Administration for government loan) are available through County Extension Agents, and also through many lumber dealers. Several of these plans show adaptations for drying.

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SUMMARY

The following steps are suggested for forced air grain drying:

1. Before harvest, check conditions of bins for storage -- make necessary repairs.
2. Determine type of drying system adapted to local needs -- raised perforated floor or lateral duct. Are needed materials available?
3. Figure fan requirements -- Allow 1 c.f.m. of air for each square foot of bin area and for each foot of grain depth. Select a fan large enough to allow some reserve capacity. It may be necessary to place orders several weeks in advance or needs to allow for delivery.
4. Determine amount of power needed -- What type is available -- tractor or electric motor? If the latter is used, determine local power supplier's limitations on motor size.
5. If weather conditions are favorable, start drying operation as soon as bin has been filled to a uniform depth. Continue until moisture in top layer of grain is low enough for safe storage. In the case of wheat, drying should be completed within 30 to 45 days after harvest.
6. Close bin openings to prevent grain "picking up" moisture from the air after drying operation has been completed.
7. Check moisture content of grain if it is stored through extended periods of damp weather. Further forced air circulation may be needed if grain is gaining moisture.