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EC738 Revised 1948 Conditioning and Storing Corn

E. A. Olson

F. D. Yung

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CONDITIONING AND STORING CORN

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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, ACTING
DIRECTOR, LINCOLN.

Table of Contents

	Page
Introduction	1
Methods of Removing Moisture	1
Field Drying	1
Husking and Cribbing	2
Crib Requirements	3
Natural Ventilation	4
Forced Ventilation	6
Fans for Forced Ventilation	6
Mechanical Ventilation Without Heat	8
Operation of the Fan	8
Mechanical Ventilation with Heated Air	9
Heater and Fan Capacities	10
Air Temperature	10
Equipment for Drying with Heat	10
Operation of Drying Equipment	12
Adapting Cribs for Ventilation with Fans	12
Drying Shelled Corn	15

CONDITIONING AND STORING CORN

E. A. Olson and F. D. Yung*

Wet corn containing in excess of 20 per cent kernel moisture cannot be stored safely unless steps are taken to remove the excess moisture. Special precautions during storage, plus aids to natural ventilation, will permit cribbing of ear corn with a moisture content as high as 25 per cent. Corn containing in excess of 25 per cent will generally require the use of special equipment for forced ventilation. Ear corn with 30 per cent kernel moisture contains about 2500 gallons of water per 1000 bushels that must be removed to reduce the moisture content to 15 per cent. The removal of this amount of water in a relatively short time requires large quantities of heat and air. Therefore, high moisture cribbed corn requires special care in storage and, in the more extreme cases, the selection and proper use of special drying equipment.

METHODS OF REMOVING MOISTURE

Ventilators, properly designed and spaced in cribs, will aid the natural air movement sufficiently to dry out the corn when the moisture content of the kernels ranges up to 25 per cent. However, when the water content is more than 25 per cent, even ventilators will not generally give sufficient air, so other means must be employed to prevent damage. In this moisture range, mechanical forced ventilation can be of considerable help. If the kernel moisture of ear corn exceeds 30 per cent, it should be left in the field until dry, or conditioned in the crib by use of forced air and considerable heat. The upper moisture limit at which corn can be dried economically with heated air is rather indefinite. At the higher moisture levels, this method of handling corn becomes more expensive and more hazardous. In such instances, it might be more practical to store the crop in the form of ensilage.

Local facilities used by elevators or other services are generally available for checking moisture content of corn before cribbing.

FIELD DRYING

Soft corn will become drier if left in the field until late in the harvest season. Some loss may occur in the field, but where relatively small quantities are involved this may not be as great as the loss from spoilage or the cost of remodeling cribs and providing a fan and heating unit. Later cribbing of ear corn when temperatures are lower will also help to reduce the growth of mold.

*Agricultural Extension Engineer and Research Engineer in Rural Electrification, Respectively.

HUSKING AND CRIBBING

Clean husking is of utmost importance when storing wet ear corn because the presence of husks and silk seriously retards uniform air movement through the crib. Every effort should be made to remove all foreign material.

Portable elevators not already supplied with screens can be equipped with a simple separator as shown in Figure No. 1. The rod section placed in the elevator spout will allow shelled corn, chaff, and dirt to be separated from the ears. This debris can be fed to livestock or spread in thin layers elsewhere to prevent spoilage.

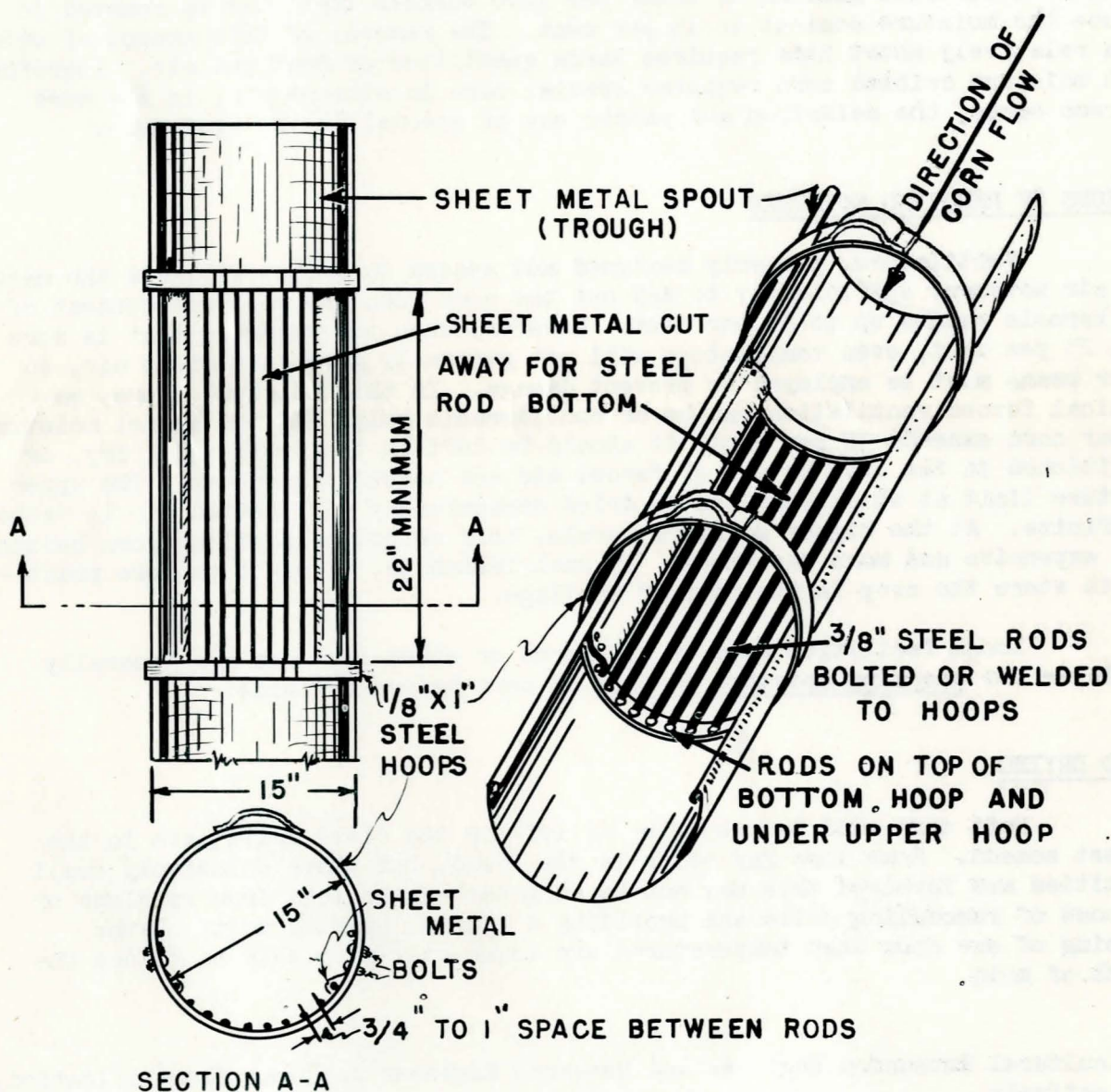


FIG.1 SPOUTING EQUIPPED WITH ROD BOTTOM

Corn should be evenly distributed as the crib is filled. Ear corn dropping into the crib will cause some shelling. Elevators tend to concentrate this in one spot thus retarding air circulation. To overcome this difficulty the location of the elevator spout should be changed often and the crib filled uniformly.

CRIB REQUIREMENTS

A wide crib filled with corn offers more resistance to natural air movement through the corn than a narrow one. The maximum crib widths recommended for Nebraska are shown in Figure No. 2. Temporary cribs should be built long and narrow. Wide cribs and large diameter round cribs should be avoided.

Good drainage and a floor are necessary to protect corn from ground moisture. Floors placed above the ground to permit natural air circulation under them will give best results.

A tight roof is also essential if the corn is to be stored through the late spring and summer months.

The crib should not be sheltered from the wind by trees or by other buildings. Wind pressure increases air circulation through the crib, thus lowering the moisture content.

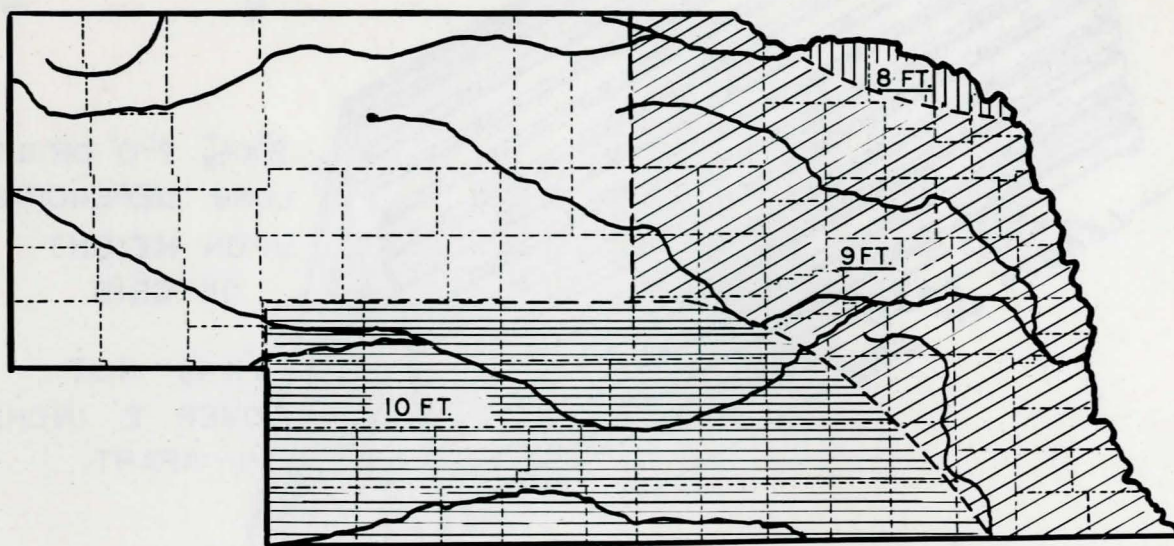


FIG.2 MAXIMUM RECOMMENDED CRIB WIDTHS FOR NEBRASKA

NATURAL VENTILATION

Natural drying of ear corn in cribs takes place rather slowly. The best drying periods occur early in the fall and late in the spring when the weather is warm. Very little drying takes place during mid-winter when temperatures are low and when the humidity is higher than any other time during the year. This is true even in well ventilated cribs. However, corn containing up to 25 per cent kernel moisture can be handled by this method if special precautions are taken.

Several types of removable ventilators can be used to increase air movement through corn in cribs.

The A-frame ventilator, Figure No. 3, should run through the center of the crib from end to end to allow the passage of air. These ventilators have been successful with blocking midway in the length of the ventilator and also without blocking. Filling above the top of the ventilator should be delayed

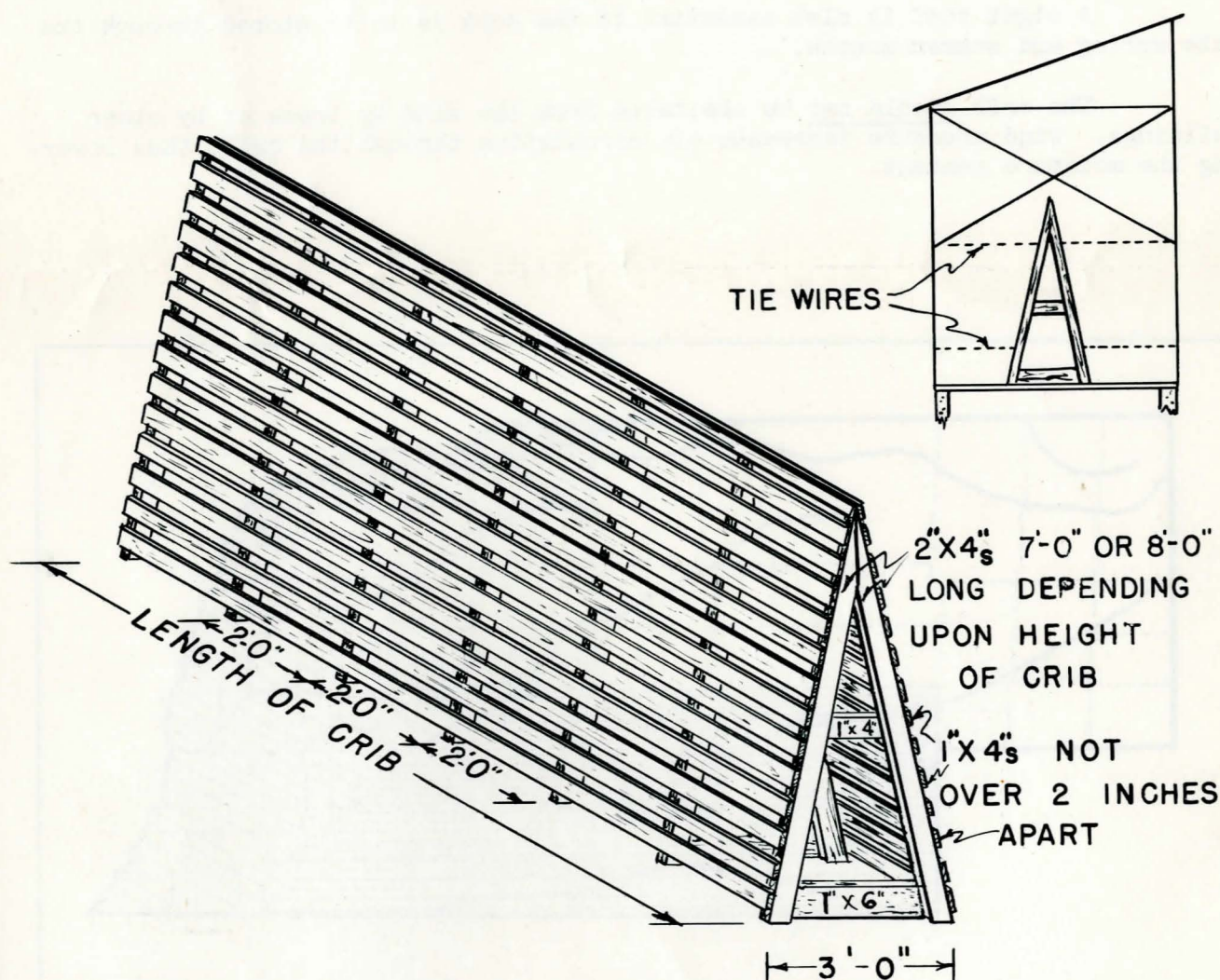


FIG. 3 "A"-FRAME VENTILATOR

until the latter part of the harvest season, when the corn will be drier and the temperatures lower. This ventilator sets below and clear of the cross ties in the crib, and can be built in sections that are short and not difficult to handle. These frames cause some inconvenience in emptying the crib, but do afford a possibility for using forced ventilation if necessary.

The picket cribbing type of ventilator shown in Figure No. 4 with vertical slats is lighter in weight and cheaper than the A-frame, but does not afford the opportunity for forced ventilation. It is built in sections; the height of the fencing is usually 4 feet. These sections can be set one above the other to the height of the corn. It is best adapted to crosswise placement in the crib from wall to wall, and can be braced between studs and spaced as close as required according to the condition of the corn. For corn of 25 per cent moisture content a spacing of 4 feet is suggested. Cross bracing of the crib does not interfere with an installation of this type, and the ventilators can be removed to reduce inconvenience when emptying the crib.

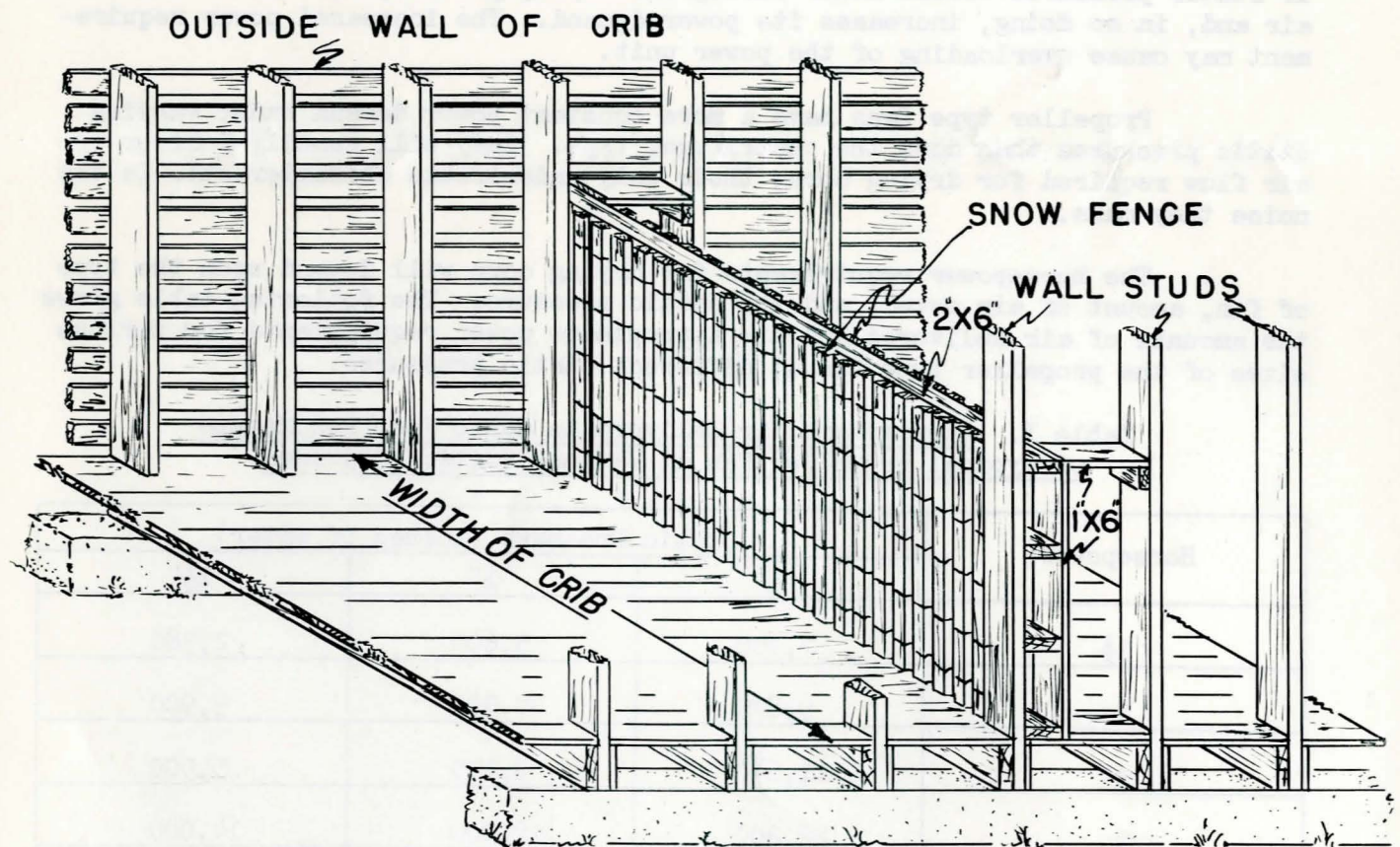


FIG. 4 CROSS TYPE VENTILATOR

Small removable type flues may be placed across either rectangular or round cribs. They can be made of available material or purchased commercially. Flues should be constructed about one foot shorter than the width of the crib, and placed across the crib in tiers about 3 to 5 feet apart, depending on the moisture content of the corn.

FORCED VENTILATION

Fans for Forced Ventilation

A fan or blower capable of delivering 5 to 10 cubic feet of air per minute for each bushel of ear corn is suggested. For a 1,000 bushel crib, the fan should have a capacity of 5,000 to 10,000 cubic feet of air per minute against a static head of at least $\frac{1}{2}$ inch of water.

The propeller type fan is quite popular for drying corn due to its favorable operating characteristics. However, the centrifugal type fan can be used when operating conditions are carefully controlled.

The centrifugal or "squirrel-cage" fan is quiet in operation, and is ordinarily capable of delivering the air flow needed for corn drying. The forward-curved type, commonly used, has one objectionable characteristic in that if static pressures become lower during the drying process, the fan handles more air and, in so doing, increases its power demand. The increased power requirement may cause overloading of the power unit.

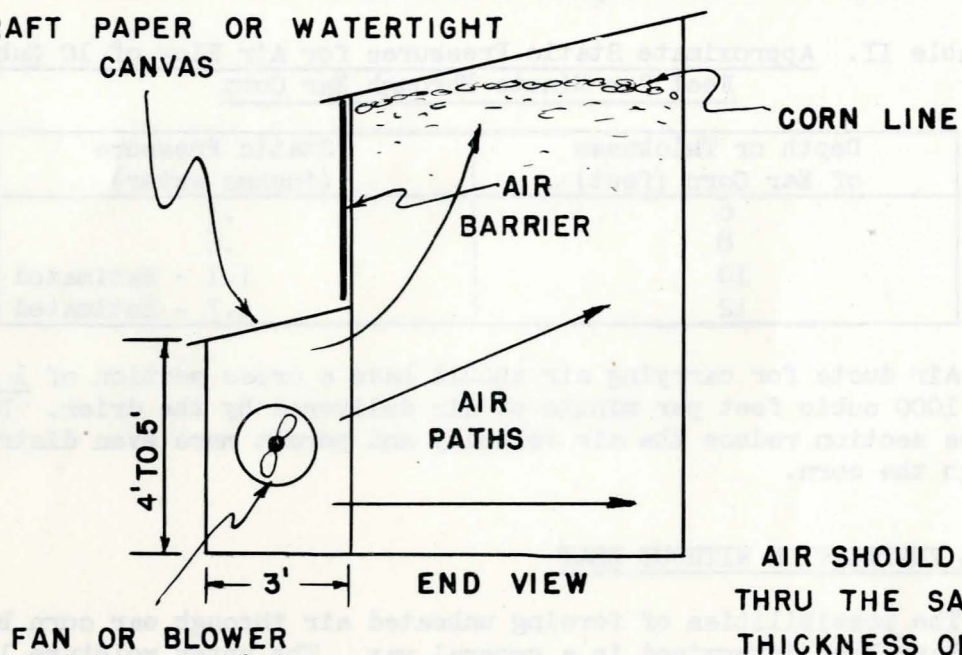
Propeller type fans have a more constant power demand under varying static pressures than does the centrifugal type. They will readily deliver the air flow required for drying corn; their only undesirable characteristic is the noise they make.

The horsepower requirements for drying corn will depend upon the type of fan, amount of air moved, and the static pressure. The following table gives the amounts of air delivered and the approximate power requirements for various sizes of the propeller type fan at different static pressures.

Table I. Approximate Air Delivery in Cubic Feet Per Minute of Typical Propeller Fan at Various Static Pressures.

Horsepower	Static Pressure (inches of water)		
	$\frac{1}{2}$ "	1"	$1\frac{1}{2}$ "
$1\frac{1}{2}$	7,350	5,600	2,380
2	9,875	7,700	3,900
3	11,640	9,175	5,500
5	22,200	18,200	14,000
$7\frac{1}{2}$	26,600	22,500	17,400

TEMPORARY FRAMEWORK COVERED WITH
AIR BARRIER MADE OF REINFORCED
CRAFT PAPER OR WATERTIGHT
CANVAS



AIR SHOULD FLOW
THRU THE SAME
THICKNESS OF CORN
IN ALL DIRECTIONS

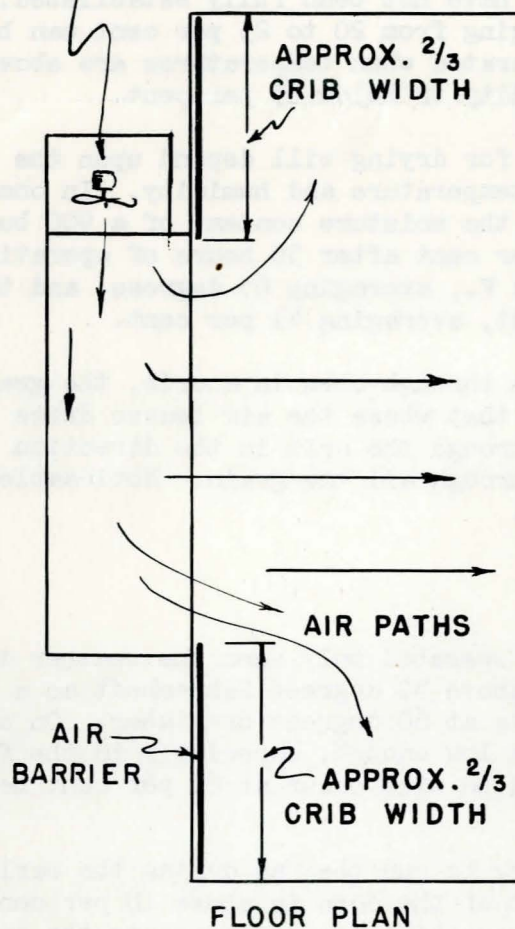


FIG. 5 SINGLE CRIB ADAPTED FOR FAN.

The air pressure, called static pressure, required to force air through ear corn will vary with the depth or thickness of corn for a given flow of air. The table below gives the various static pressures for a flow of 10 cubic feet of air per minute for various depths of ear corn.

Table II. Approximate Static Pressures for Air Flow of 10 Cubic Feet Per Minute Through Ear Corn

Depth or Thickness of Ear Corn (feet)	Static Pressure (inches water)
6	.3
8	.6
10	1.1 - Estimated
12	1.7 - Estimated

Air ducts for carrying air should have a cross section of 1 square foot for every 1000 cubic feet per minute of air delivered by the drier. Ducts of large cross section reduce the air velocity and permit more even distribution of air through the corn.

MECHANICAL VENTILATION WITHOUT HEAT

The possibilities of forcing unheated air through ear corn by using a large fan have been determined in a general way. The upper moisture limits at which ear corn can be dried have not been fully established. Ear corn with a kernel moisture content ranging from 20 to 25 per cent can be dried with unheated forced air if the fan is operated when temperatures are above 50 degrees Fahrenheit, and the relative humidity is below 65 per cent.

The time required for drying will depend upon the moisture content of the corn and conditions of temperature and humidity. In one Nebraska experiment in 1945 using unheated air, the moisture content of a 900 bushel crib of ear corn was lowered from 26 to 21 per cent after 50 hours of operation. Air temperatures ranged from 55 to 76 degrees F., averaging 65 degrees, and the relative humidity varied from 26 to 76 per cent, averaging 41 per cent.

When air is forced through corn in a crib, the grain at the air intake side dries most rapidly and that where the air leaves dries the slowest. The zone of drying progresses through the crib in the direction of air movement until it finally has passed through all the grain. Noticeable shrinkage occurs as the excess water is removed.

OPERATION OF THE FAN

The fan should be operated only when the weather is favorable for drying, using temperatures above 50 degrees Fahrenheit as a rough guide. More rapid drying will be possible at 60 degrees or higher. On clear days, the relative humidity usually is low enough, especially in the fall and winter, for favorable drying. Good results will occur at 65 per cent relative humidity and lower.

It may be necessary to run the fan during the early part of the spring in case the moisture content of the corn is above 18 per cent. The drying can be speeded up and any further possibilities of damage to the corn reduced.

MECHANICAL VENTILATION WITH HEATED AIR

Heated air is necessary to assure safe conditioning of ear corn with a moisture content above 25 per cent. It shortens the time of drying and permits drying to continue in weather when it would be impractical without heat.

Except when corn is to be used as seed, temperatures below 130 degrees Fahrenheit apparently do not cause damage.

Precautions should be taken against fire. Before purchasing units for heating air, the Fire Insurance Company should be consulted to check the effect, if any, on insurance coverage. The safety features of both homemade and commercial drying units should receive special attention. For example, the air opening to the fan or furnace should be screened to prevent the entrance of husks. An additional filtering of the flue gas is desirable if it is mixed with the air forced into the crib. Ducts close to the furnace should be of all-metal construction. The burner should be provided with an automatic cut-off so that in case of fan failure excessive temperatures will not develop. Apply the old adage "better be safe than sorry".

AIR SHOULD FLOW THRU THE SAME
THICKNESS OF CORN IN ALL DIRECTIONS

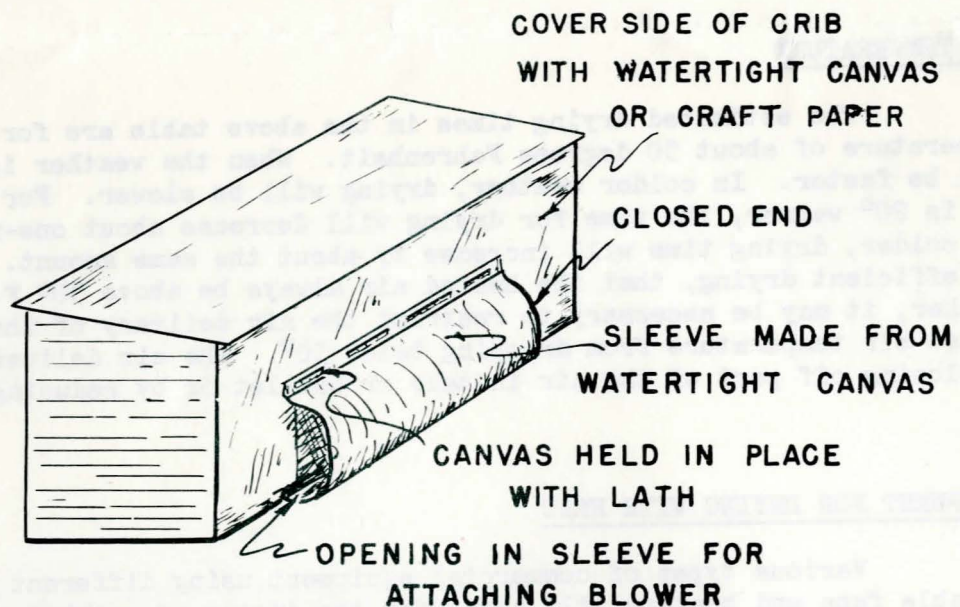


FIG.6 SINGLE CRIB ADAPTED FOR FAN

HEATER AND FAN CAPACITIES

Assuming that oil is to be used as fuel and the flue gases are to be discharged into the drying air, the recommended capacities of heaters and fans for drying 1,000 bushels of ear corn having a moisture content of 30 per cent or more are given in the following table:

<u>With This Heater</u> <u>Capacity</u>	<u>With This Fan</u> <u>Capacity</u>	<u>Approximate Drying Time</u> <u>Will Be -</u>
<u>Gallons per Hour</u>	<u>Cubic feet per</u> <u>Minute</u>	<u>Days</u>
4.0	5,400	4 to 6
2.0	3,600	8 to 12
1.0	2,700	16 to 24
0.5	2,700	32 to 48

With corn of higher moisture content, the time required for drying will be longer and with lower moisture content, it will be shorter than shown in the tabulation.

AIR TEMPERATURE

The estimated drying times in the above table are for an outside air temperature of about 50 degrees Fahrenheit. When the weather is warmer, drying will be faster. In colder weather, drying will be slower. For example, if the air is 20° warmer, the time for drying will decrease about one-fourth. If it is 20° colder, drying time will increase by about the same amount. It is advisable for efficient drying, that the heated air always be above 50° F. In very cold weather, it may be necessary to restrict the air delivery of the fan to keep the heated air temperature from dropping below 50°. The air delivery can be restricted by closing off part of the air in-take or out-let or by reducing the speed of the fan.

EQUIPMENT FOR DRYING WITH HEAT

Various types of commercial equipment using different combinations of suitable fans and heaters will serve for the drying of cribbed ear corn. Units that are commonly used for the mow curing of hay are satisfactory for forcing heated air as well as natural air through the corn. Several manufacturers are building driers which contain the fan, motor and the heater combined into a mobile unit.

Heating units differ in two respects. In one case the gases of combustion are used with the heated air. In the other case the air is heated by a heat exchanger. The types using the gases of combustion for drying are more efficient, and the expense of a heat exchanger is eliminated. However, equipment

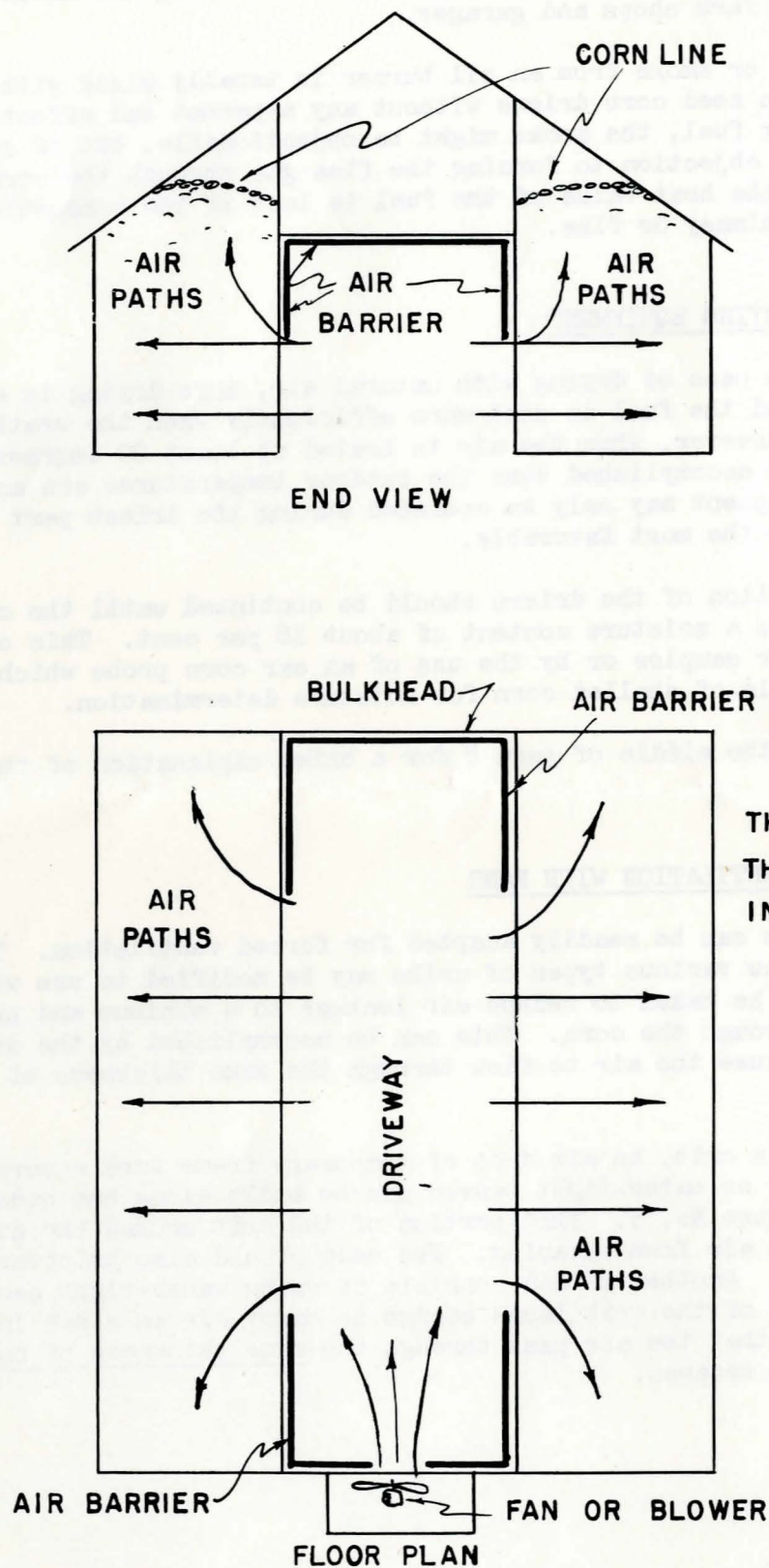


FIG. 7 METHOD OF USING BLOWER ON A DOUBLE CRIB

using the heat exchanger has the advantage of greater safety, and the possibilities of use for a number of other purposes such as heating the interior of livestock buildings or farm shops and garages.

Flue gas or smoke from an oil burner is usually mixed with air forced through the corn in seed corn driers without any apparent bad effect on the corn. If coal is used for fuel, the smoke might be objectionable, but if coke is used there should be no objection to forcing the flue gas through the corn. From 20 to 50 per cent of the heat value of the fuel is lost if the combustion gases are carried off in a chimney or flue.

OPERATION OF THE DRYING EQUIPMENT

As in the case of drying with natural air, more drying is accomplished with heated air, and the fuel is used more efficiently when the weather is favorable for drying. However, when the air is heated at least 20 degrees, considerable drying will be accomplished when the outdoor temperatures are as low as freezing. The equipment may only be operated during the driest part of the day when conditions are the most favorable.

The operation of the driers should be continued until the corn next to the outside wall has a moisture content of about 18 per cent. This can be checked either by taking ear samples or by the use of an ear corn probe which is used to obtain a small sample of shelled corn for moisture determination.

Refer to the middle of page 8 for a brief explanation of the drying process.

ADAPTING CRIBS TO VENTILATION WITH FANS

Most cribs can be readily adapted for forced ventilation. The illustrations indicate how various types of cribs may be modified to use with fans or blowers. Care must be taken to reduce air leakage to a minimum and provide a uniform air flow through the corn. This can be accomplished by the use of air barriers so as to cause the air to flow through the same thickness of corn in all directions.

In a single crib, an air duct of temporary frame work covered with reinforced craft paper or water-tight canvas can be built along one side of the crib as shown in Figure No. 5. That portion of the crib around the duct should be sealed to prevent air from escaping. The ends should also be covered as shown in the illustration. Another method consists of using water-tight canvas to form a sleeve on the side of the crib large enough to carry air as shown in Figure No. 6. It is important that the air pass through the same thickness of corn in all directions before it escapes.

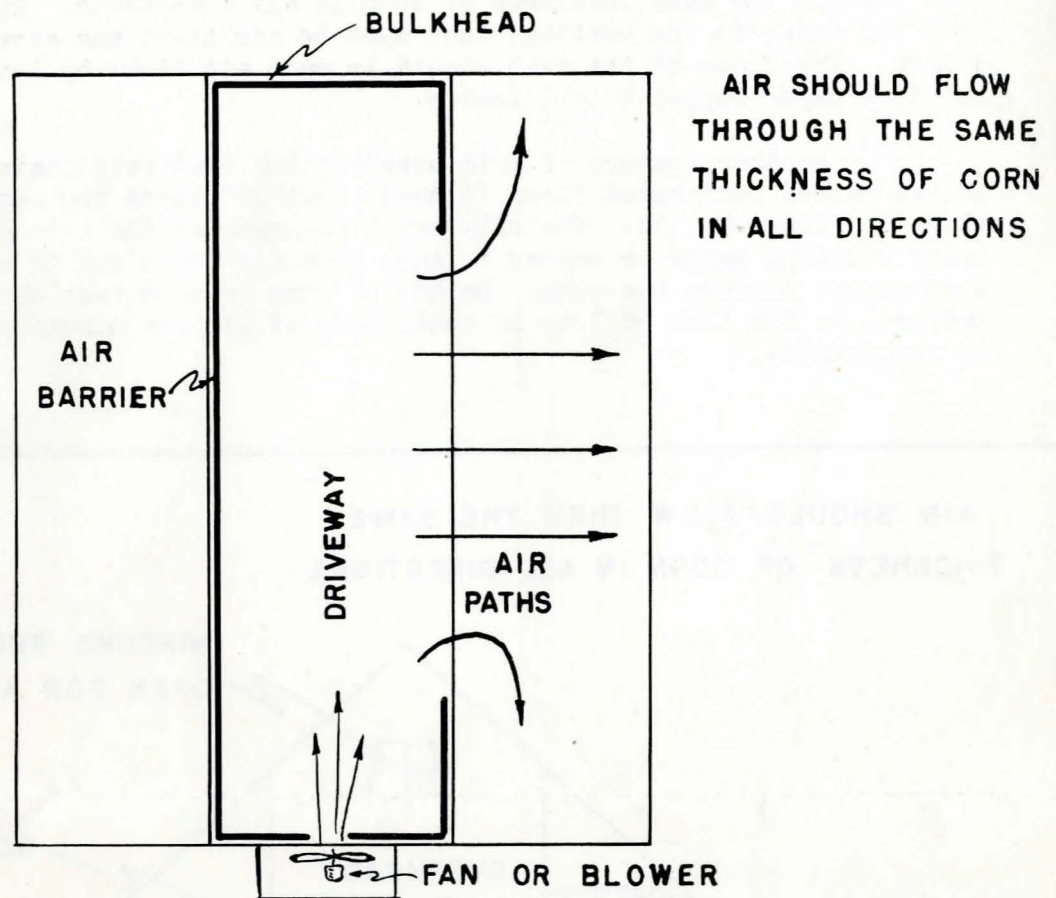


FIG. 8 METHOD OF USING BLOWER
ON ONE SIDE OF CRIB

A double crib can be adapted for forced air ventilation by closing off the driveway and using it for the main air duct. See Figures No. 7 and 8. The fan and the motor can be placed in the driveway at one end of the crib, and the doors tightly closed and sealed at the other end. The important thing is to be sure that there is no air leakage. The upper part of the crib walls and the underside of the roof over the driveway should be lined as shown. The ends of the crib should also be covered. The object is to force the air through the corn rather than through the walls.

In a double crib with overhead bins, the job of adapting it for fan drying is somewhat simpler as shown in Figure No. 9. All free openings to the space above the overhead bins should be closed tight. Some adaptations may be necessary by lining portions of the side walls to insure the air passing through the same thickness of corn in all directions.

Ear corn in a circular temporary storage can be dried by constructing the crib as shown in Figure No. 10. The vertical duct should be of heavy wire or other perforated material and 3 to 4 feet square, built so air will have to pass through the same thickness of corn in all directions. The air duct leading from the drier to the vertical duct must be air tight and about 3 to 4 feet square. The floor of the crib should be made air tight by covering with heavy building paper lapped 4 to 6 inches.

Another feature of crib construction that facilitates uniform drying is the raised perforated floor (placed about 12" above the regular floor) as shown in Figure No. 11. The side-walls and ends of the crib are covered with heavy building paper or canvas to make them air-tight and to cause all air to move upward through the corn. Depths of corn up to 8 feet can be dried in this manner. An air flow of 5 to 10 cubic feet of air per minute per bushel of corn is recommended.

AIR SHOULD FLOW THRU THE SAME
THICKNESS OF CORN IN ALL DIRECTIONS

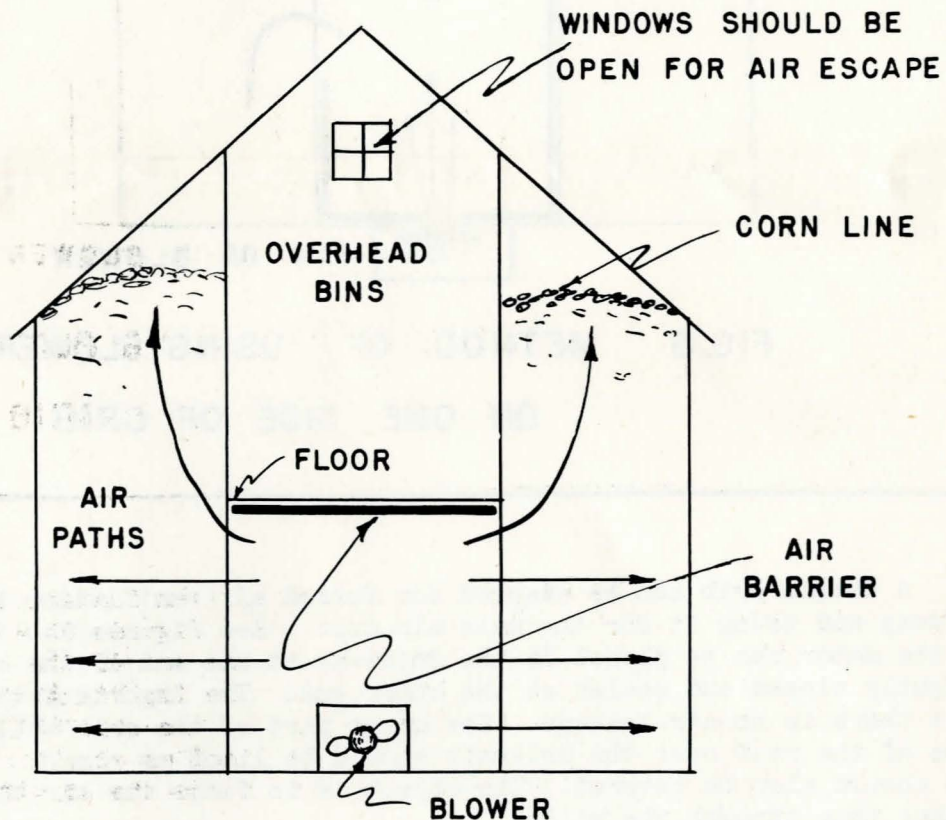


FIG. 9 DOUBLE CRIB WITH OVERHEAD BINS

DRYING SHELLED CORN

Shelled corn can be dried successfully with heated air. The amount of moisture to be removed is less than with ear corn, since the cob moisture must be evaporated if the corn is dried on the ear. Shelled corn should be dried to 12-13 per cent moisture for safe storage, while ear corn can be safely stored at 18-20 per cent.

The power required to force air through shelled corn is much greater than for the same depth of ear corn. Depths of 4 to 6 feet are usually recommended for economical drying. The following table gives the various static pressures for various depths and air flows.

Table III. Static Pressures for Air Flows of 6 and 10 Cubic Feet Per Minute Through Shelled Corn.

Depth of Shelled Corn	Pressure for Delivering	
	6 cubic feet of air per minute	10 cubic feet of air per minute
4	.68	1.6
6	1.9	4.1
8	4.0	9.0

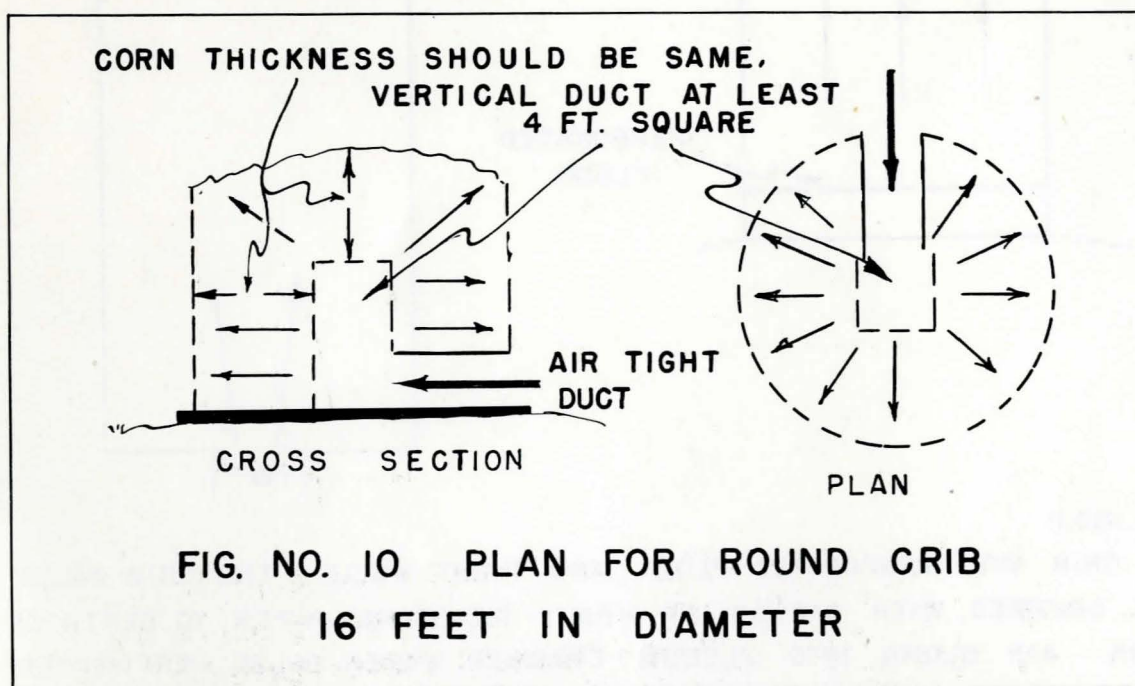


Table No. 1 on page 6 shows approximate power requirements and air deliveries at various static pressures.

Low air temperatures are preferred for uniform drying of shelled corn. Best results will occur if the air is heated to between 10° and 25° F. above atmospheric temperature. When the temperature of the air is raised as much as 70° the bottom layers of corn may be dried to as low as 5 or 6 per cent moisture before the upper layer starts drying.

The advantage of low temperatures for drying is the resulting uniform moisture throughout the bin. With higher temperatures, not exceeding approximately 130° F, drying can be completed in a shorter time and at a lower total cost.

High rates of air flow shorten the drying time, increase the fuel consumption, and improve the uniformity of drying. It should also be kept in mind that high rates of air flow increase power requirements.

