

AIDS to PLANNING an ARTIFICIAL CURING SYSTEM for HAY

J. L. BUTT, Associate Agricultural Engineer

Artificial curing of hay has become a common practice in many parts of the Nation. The farmer whose margin of profit depends upon a continuous supply of high quality feed for his cattle is responsible for the rapid adoption of this method of preserving forage. Artificial curing is popular because it reduces field losses due to leaching by rain and dew, bleaching by sun, and shattering of leaves during the field handling operations. It also helps to eliminate the risk of losing a crop due to bad weather, since artificial curing does not depend upon atmospheric conditions for drying air. When done properly, losses of hay and property due to spontaneous combustion are eliminated by artificial curing.

PROCEDURE for ARTIFICIAL CURING

When alfalfa hay is cured artificially, it is mowed and allowed to cure in the swath for about 3 to 4 hours. Then it is windrowed and left in the field another 1 to 2 hours. The hay should be placed on the drier just before the leaves begin to shatter. This 4- to 6-hour period of field curing will usually reduce moisture content of the hay from about 75 per cent at time of mowing to about 40 per

cent. This means a considerable saving in cost of artificial drying, since most of the water will be evaporated by the sun. Data in the following table show the amount of water that must be removed to produce a ton of 20-per cent moisture hay:

MOISTURE CONTENT OF HAY	WATER TO BE REMOVED TO PRODUCE A TON OF 20- PER CENT MOISTURE HAY
<i>Per cent</i>	<i>Pounds</i>
75	4,400
60	2,000
50	1,200
40	667
35	462
25	133
20	0

After the hay has been placed evenly on the drying floor, the fan and heater should be turned on and operated continuously. Usually, the hay will dry in about 60 hours if the conditions described in this leaflet are followed. It will be necessary to check the top layer to be sure it has dried thoroughly. The curing time will vary considerably because of condition of the hay, weather, and efficiency of the drier. After the hay has been checked and appears dry, the fan and heater should be turned off. After 18 to 24 hours, it is advisable to turn on the fan for a few minutes and again check the hay for warm

**AGRICULTURAL EXPERIMENT STATION
of the ALABAMA POLYTECHNIC INSTITUTE**

E. V. SMITH, Director

Auburn, Alabama

spots, musty odor, or other signs that might indicate spots of uncured hay. If no such signs are found, the hay may be considered safe for storage. **CAUTION:** If the hay is not distributed evenly and loosely over the drying floor, there will be packed areas through which the drying air will not pass and moldy hay will result.

DETERMINING EQUIPMENT NEEDED

Air Requirements. To select a fan of the proper size, the quantity of air needed must first be determined. Where supplemental heat is supplied, an air flow of 600 cubic feet per minute (c.f.m.) per ton of cured hay is sufficient. If natural air alone is used, the hay should receive at least 800 c.f.m per ton of cured hay. Therefore, to determine the size fan to select, multiply the maximum number of tons of cured hay that will be placed on the drier at one time by 600 c.f.m (or 800 c.f.m if using natural air) and the result will be the volume of air needed. For example, if 20 tons of hay (27 tons before drying) are to be placed on the drier (20 tons × 600 c.f.m. per ton = 12,000), 12,000 c.f.m. of air will be needed.

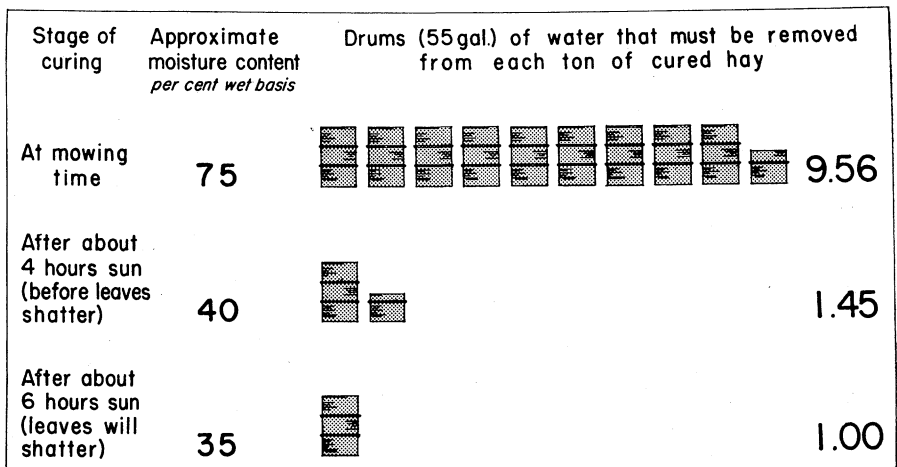
Fans and Blowers. There are many different types of fans capable of delivering

12,000 c.f.m. of air, but they are not all suitable as hay-curing fans. A fan used to dry hay must be capable of delivering this quantity of air through the hay in spite of the resistance to air flow offered by the hay. This resistance in loose hay 8 to 10 feet deep, may be as much as 1 inch static pressure¹ (in chopped hay, 1½ inches). Therefore, in selecting the fan, one should be chosen that will give 12,000 c.f.m. at a resistance or static pressure of 1 inch.

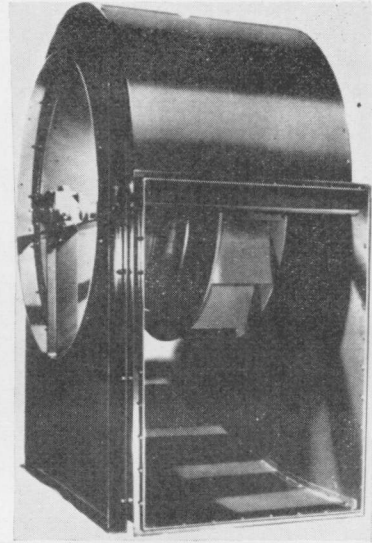
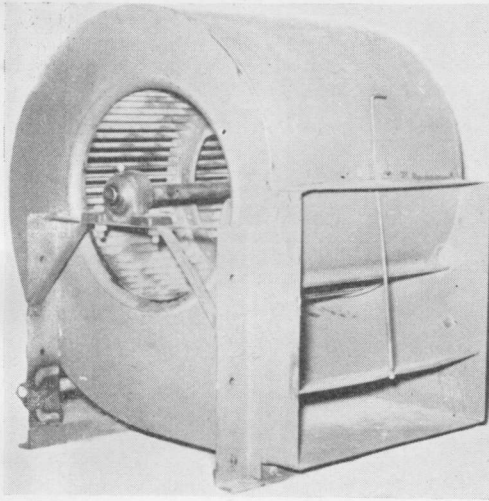
The types of fans generally used in hay curing are forward curved and backward curved centrifugal blowers, and propeller fans. Forward curved centrifugal blowers are relatively low-priced, operate quietly, but tend to overload the motor at low static pressures. Backward curved centrifugal blowers cost more, but do not overload. Propeller fans are low priced, non-overloading, but noisy.

Electric Motor. After the fan has been selected, the size of the electric motor needed to drive the fan can be determined from the fan catalog which should accompany the fan. In general, the fan

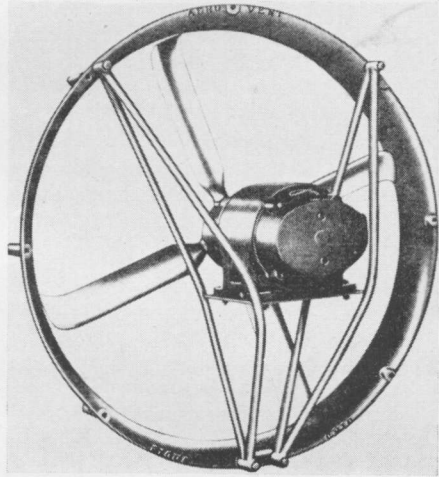
¹ 1 inch of static pressure refers to the lateral pressure of the air under the hay, which is enough to elevate a column of water in a U-tube open to the atmosphere by 1 inch.



Most of the moisture in alfalfa is removed during first few hours in the field. Drying economy will be obtained if hay is field cured until just before leaves begin to shatter, and then placed in drier for finishing.



Types of fans used for artificial drying:
Upper left — forward-curved blade centrifugal; upper right — backward-curved blade centrifugal; right — propeller type.



should deliver 2,500 to 3,500 c.f.m. for each horsepower. Most rural lines cannot carry an electric motor larger than 5 h.p. This limits the size of the hay drier and sometimes makes it necessary to divide the haying operation into two parts, delaying the second part until the first is cured and moved from the drier.

Belts and Pulleys. Belts and pulleys should be selected to give the proper fan speed, as determined from the fan catalog. Double-groove pulleys with matched B-section V-belts of the proper length are recommended for a 5 h.p. load.

Electric Controls. The local power company representatives should be consulted regarding proper switches and wire sizes, since they will vary according to the load and distance from meter.

Heater. A temperature rise of about 30°F (degrees Fahrenheit), that is 30°F above atmospheric temperature, will give satisfactory drying under Alabama weather conditions. A rule of thumb that can be used to determine the size of heater needed is to multiply the desired tempera-

ture rise by the c.f.m. of air delivered by the fan. This will give the size of heater, which is expressed in B.T.U.² per hour. For example, 12,000 c.f.m. × 30°F. temperature rise = 360,000 B.T.U. per-hour or size of heater needed.

Heaters may be of a direct or indirect type. Direct-type heaters burn in the air stream on the inlet side of the fan. In-

² B.T.U. is the abbreviation for British Thermal Unit, a term used to measure quantities of heat. A B.T.U. is 1/180 of the heat required to raise the temperature of 1 pound of water from 32°F. to 212°F.

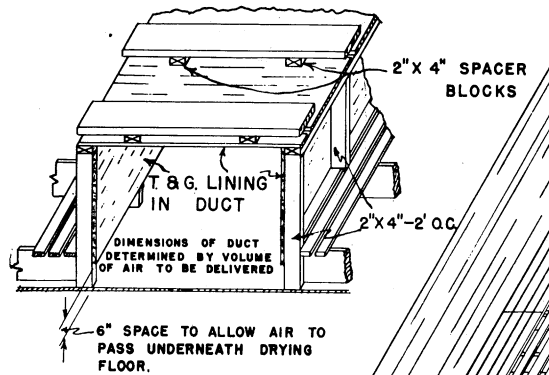
direct heaters burn in a vented fire box and the air is passed around the box. Direct heaters are more efficient, since all of the heat is used; indirect heaters are generally considered safer from the standpoint of fire hazard. Heaters may be purchased to burn any particular fuel that is locally available. The most commonly used fuels are fuel oil, propane, butane, and natural gas. The selection of the type of fuel depends largely upon availability and local price. Safety controls that should be on the heater are (1) one to cut off the fuel if the fan should stop, (2) one to cut off the fuel if the electric current fails, (3) one to cut off the fuel if the pilot goes out, (4) one to select the desired temperature, and (5) an upper limit temperature cut-off switch. A local fire insurance agent should be consulted before a heater is installed. Some heaters are approved by Underwriters Laboratories and are as safe as the heaters used in homes.

Other Equipment. In addition to the equipment comprising the drier, the following are labor savers: hay track with winch and forks, blower for loading chopped hay, hay loader for loading loose hay on wagons and forage harvester for field chopping from windrow.

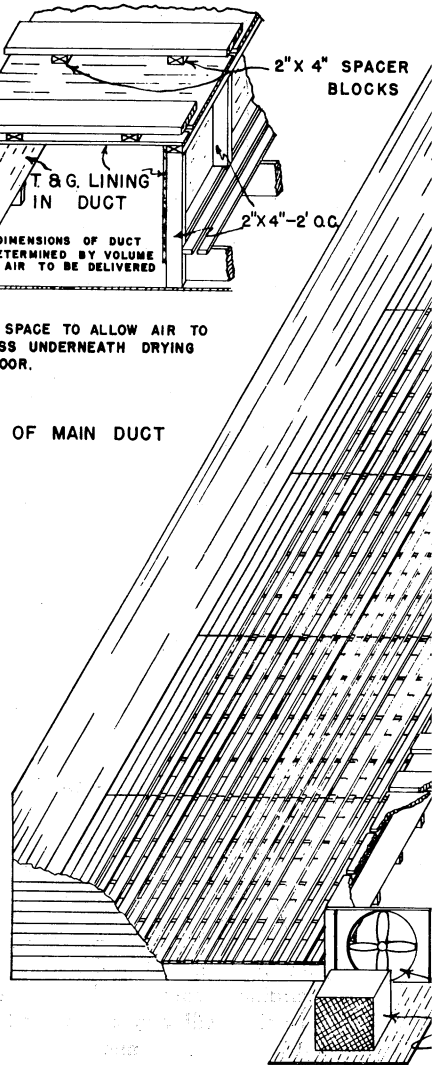
PLANNING AIR DISTRIBUTION SYSTEM

The design of the air-distribution system will depend upon the barn or other structure in which it is to be located. Hence, many different types of systems have been built to suit varying conditions. If a few rules are followed, most of these systems will perform satisfactorily.

Main Duct. The main air duct that connects to the fan outlet is sometimes located in the center of a mow and sometimes to one side. Its purpose is to channel air from the fan to the drying floors located under the hay. Regardless of where it is located, it should be large enough so that the air inside will not move faster than 1,000 feet per minute (f.p.m.). To determine this size, divide the c.f.m. delivered by the

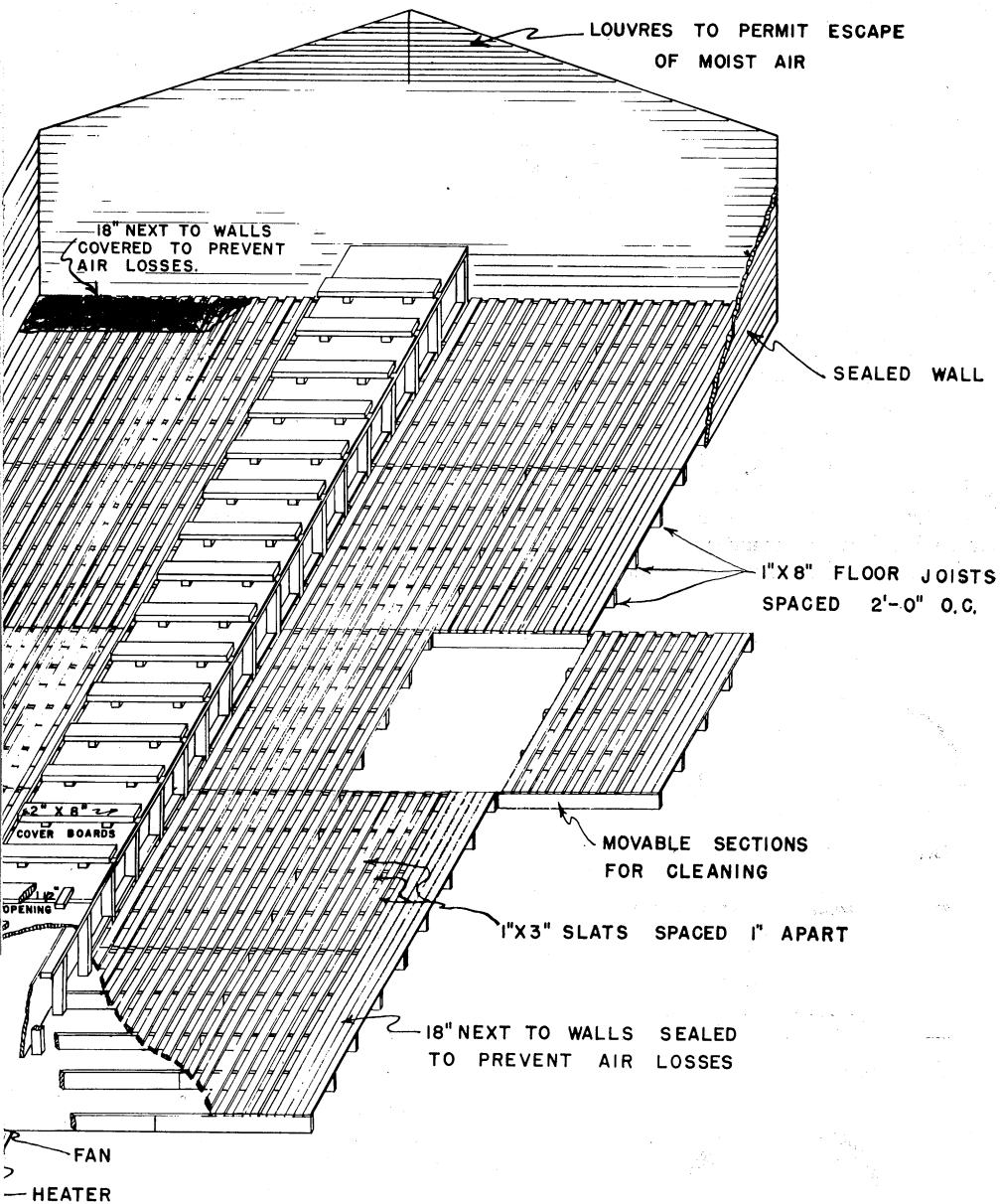


VIEW OF MAIN DUCT



A SLATTED FLOOR HAY DRIER

DIMENSIONS, FAN AND HEATER SIZE AND OTHER DETAILS ARE EXPLAINED IN THIS LEAFLET.



ING SYSTEM

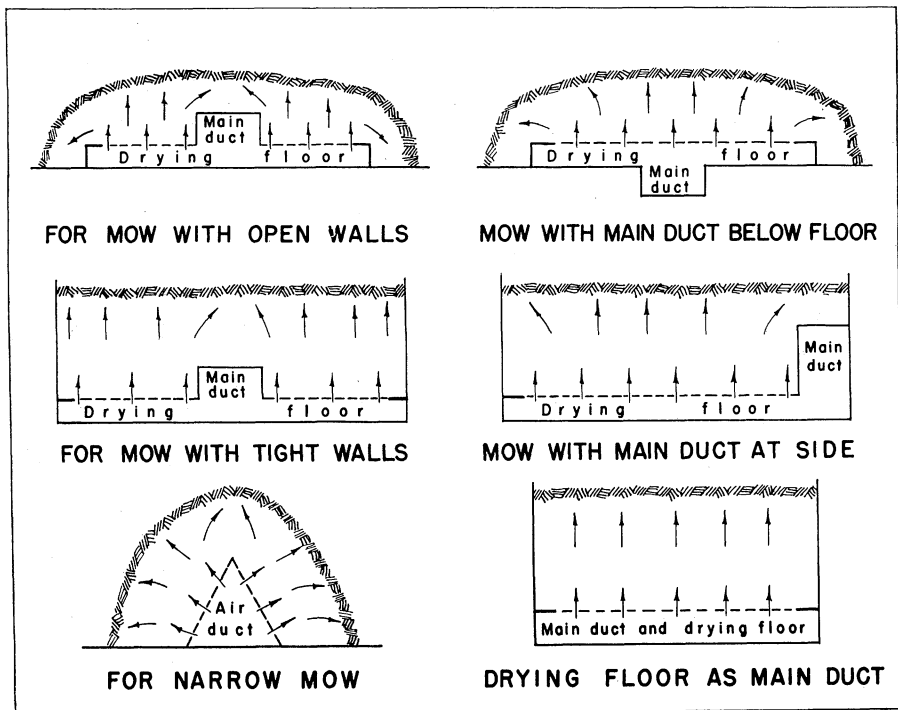
S, LOUVRE OPENINGS,

) ELSEWHERE IN

fan by 1,000 and the result will be the size opening required in the duct. For example, $12,000 \text{ c.f.m.} \div 1,000 \text{ f.p.m.} = 12$ square feet of opening in the duct. The inside dimensions of the duct then could be 3 by 4, 2 by 6, or $3\frac{1}{2}$ by $3\frac{1}{2}$ feet or whatever size best fits the fan discharge opening and is at least 12 square feet. Sometimes when the drier is not fully loaded, it will be found that more air passes through the hay that is farthest from the fan causing uneven drying. This can be corrected by placing boards or other obstructions in the main duct to distribute the air. Boards should be placed about one-fourth of the way down from the fan to block one-fourth of the area, half way down to block half of the area, and three-fourths of the way down to block three-fourths of the duct area. By blocking off in this manner, the air will be forced to feed more uniformly from the

main duct. If the main duct is located centrally, is 3 or more feet wide, and is to have hay stacked on top of it, a means for allowing some air to enter the hay above the duct must be provided. This can be done by leaving 1- to 2-inch cracks at 2-foot intervals for the length of the main duct. These cracks should be covered by boards supported on spacer strips to keep hay out of the duct.

Drying Floor. The drying air is discharged from the main duct underneath the drying floor. The drying floor supports the hay and is provided with openings for the air to penetrate the hay. To permit occasional cleaning, drying floors are usually made in portable or movable sections small enough to be handled by two men. These sections consist of joists that rest on the original mow floor and on top of which are nailed 1- by 3-inch boards



Shown above are some of the systems commonly used. Regardless of the one used, the hay should be stacked so that the air will pass through the same thickness of hay in all directions.

about 1 inch apart. It is referred to as a "slatted floor" system. The joists should be rough 1- by 8-inch boards spaced about 2 feet apart. The butt ends of the joists farthest from the main duct should be covered with boards. In hay mows where the hay can be stored level on the top from wall to wall, the drying floor should extend to the wall. In mows where the hay must be stacked higher at the center than at the sides, the drying floor should end about 6 feet from the outer edge of the stack. This is to insure that air will pass through the *same thickness of hay in all directions*.

General information. Enough open area must be provided overhead to permit the moist air leaving the hay to escape before it condenses on top of the hay. This is done by having louvers, windows, or other openings around the top of the mow. There should be at least one square foot of opening for each 200 c.f.m. of air delivered to the hay. For example, if 12,000 c.f.m. is to be delivered ($12,000 \div 200 = 60$), 60 square feet of opening should be provided.

The roof and walls should be weather-tight and the floor should be strong enough to support the hay, bearing in mind that it will be about 35 to 50 per cent heavier due to high moisture content. In addition, the floor must be air-tight to prevent loss of drying air.

If hay chutes or other openings exist in the mow, they must be boarded up to prevent a loss of air. Obstructions in the mow such as posts also allow air to escape because the hay does not pack tightly against them. Hay should be tramped around such obstructions to avoid this loss.

BALED HAY DRYING

Experiments in baled hay drying are not yet considered entirely satisfactory. While some excellent hay has been obtained, occasional "slow-drying" bales have resulted in moldy spots or excessive drying time.

Experiments³ to date have resulted in the following observations: (1) There should be at least two layers of bales, staggered to eliminate cracks (the maximum depth has not been determined); (2) the bales should be stacked together as tightly as possible and all large cracks between bales stuffed with hay; (3) the baler should be adjusted for the loosest possible bales that will stand careful handling; (4) the cut side of the bale should be placed against the drying floor, since air seems to flow best through that side of the bale; and (5) the operating cost of drying baled hay is about twice that for loose hay.

PORTABLE DRIER UNITS

There are a number of portable and semi-portable driers on the market. Fans, heaters, and controls are mounted together and sold as a unit. This eliminates the necessity of buying the equipment piece by piece and having it installed. With such units, a size must be selected that will meet the minimum air flow and heating requirements calculated by the method described earlier. Another advantage of this type of unit is that it may be used at several locations or in connection with seed and grain drying.

COST of ARTIFICIAL DRYING and EFFECT on QUALITY

Tests conducted by the Agricultural Experiment Station of the Alabama Polytechnic Institute and by other experiment stations throughout the country indicate that loose or chopped hay can be dried at an operating cost (fuel and electricity) of less than \$2 per ton.

The following table is from a U.S.D.A. Mimeograph, March 1950, "New Values in Good Hay and Silage for Dairy Cows," by L. A. Moore, head, Department of Nutrition and Physiology.

³ Baled hay drying experiments have been conducted in cooperation with the Dairy Department.

Alfalfa cured as shown	Carotene, per cent of crop as cut	Dry Matter, per cent of crop as cut	Protein, per cent of crop as cut	Expected milk yields, per cent of field cured hay damaged by rain
Crop, as cut	100	100	100	
Silage	28	84	84	140
Barn Cured with heat	9.7	87	78	145
Barn Cured no heat	7.5	81	76	135
Field Cured no rain	3.0	75	69	125
Field Cured rain	1.0	60	49	100

Dr. Moore states, "This shows that both siloing and barn drying have considerable advantage over field curing, and that field curing without rain damage has considerable advantage over rain-damaged hay. Under practical farm conditions, the amount of nutrients preserved by field curing would probably represent an average of the amounts preserved in rain-damaged hay and in hay harvested with no rain damage. Thus, by barn drying hay without heat, a dairyman would obtain about 20 per cent more milk per acre than by field-curing; by barn-drying with heat, he would obtain about 30 per cent more milk per acre. However, the cost of heat would cut down this advantage. By making silage, about 25 per cent more milk per acre would be expected. These figures, of course, apply to alfalfa and are dependent on the number of hay crops that might be damaged by rain.

"The results of these experiments indicate that siloing is the best method for preserving the nutritive values of the hay crop. The results also show that barn drying has considerable advantage over field curing. Siloing has the advantage over barn drying in that more carotene can be preserved because the crop can

be removed from the field with less chance of weather damage. Whether the dairyman uses one method or the other is an individual farm problem. His choice will depend on the buildings already on the farm and on the relative cost of building a silo and a barn drier.

"In summary, good hay and silage possess 'values' that are not contained in poor-quality forage. These 'values' are a cheaper feed, a source of vitamins and minerals, a greater consumption of forage, and an increased digestibility of forage. In preserving these 'values,' siloing or barn drying the hay crop is considerably more advantageous than field curing."

REFERENCES

- Cooper, A. W. and Miller, E. L. Planning and Operating a Mow Hay Curing System. Mimeo. No. 13. Dept. Agr. Engin. Ind. Agr. Expt. Sta. Nov. 1948.
- McKnight, Ralph E. and associates. Handbook on Design of Slatted Floor Barn Hay-Driers. Dept. Agr. Engin. Va. Poly. Inst. cooperating with Va. Farm Electrification Council. June 1946.