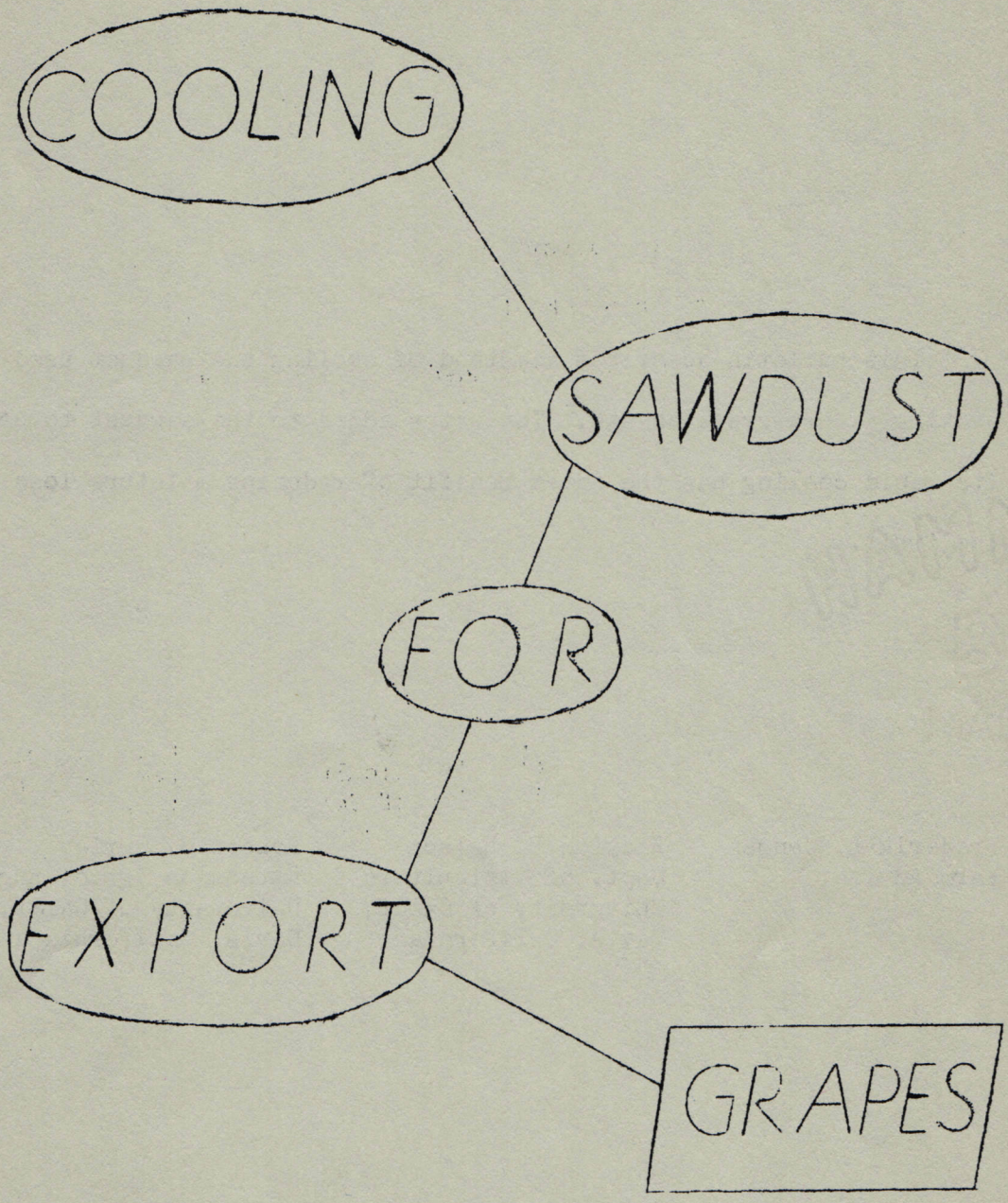

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This bulletin describes a method of cooling the sawdust used for packing export grape chests. The water added to the sawdust to permit its rapid cooling has the added benefit of reducing moisture loss from the fruit.

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COOLING SAWDUST FOR EXPORT GRAPE CHESTS

Table grapes for the more distant export markets are packed in fully enclosed containers called chests. Thirty-two to thirty-four pounds of fruit are packed in each chest, to which is added eight to ten pounds of a specially screened sawdust from non-resinous woods. This material fills the chest including the air spaces between the berries, serving to cushion the fruit from rough handling, absorb juice from injured berries, retard rapid temperature changes, and prevent condensation of moisture on the fruit.

Sawdust has several disadvantages as a packing material: 1) It is expensive, both as a raw material and to handle in a packing operation; 2) It dries out the berries and stems; 3) It rubs off part of the bloom; 4) It leaves indentations in the berries; and 5) It often sticks to the fruit and is difficult to shake out in the market.

Warm sawdust should not be added to cold grapes since it raises the temperature of the fruit. More important is that warm sawdust is usually drier than that which has been properly cooled and has a more pronounced drying effect on the berries and the stems in particular.

The most common container for handling sawdust is the paper or burlap bag. The sawdust-filled bags are piled in refrigerated rooms to cool--a process that may take two weeks or more and thus ties up considerable cold storage space for extended periods. This aspect plus the large amount of hand labor involved in moving the sawdust in and out of the cold rooms, makes the handling process slow and expensive. For these reasons, possibilities of rapidly cooling the sawdust and more efficient methods of handling were investigated.

Sawdust cools rapidly with forced air: While sawdust cools slowly when cool air is circulated around it (as occurs in the conventional cold storage room), it cools rapidly if cold air is forced through it. Temperatures are reduced from 80° to 40° F in one hour if certain requirements are met in such a forced air system.

In the first place, the sawdust must contain 10 1/2 to 12 1/2 per cent moisture.[1] If the sawdust contains less than this (commercial sawdust usually contains 5 to 7 per cent moisture), cooling proceeds to the point where water vapor from the cold air begins to condense onto the sawdust. This process of condensation releases tremendous quantities of heat (opposite of the process of evaporation which takes up the same amount of heat per pound of water) which almost stops the cooling process. However, if water is added to the sawdust before precooling, this "blockage" is eliminated. This additional water has the added advantage of reducing subsequent drying of the stems and berries.

How much water to add: The basic objective is to raise the moisture percentage to 11 1/2 per cent. One quart of water per sack (3 1/4 cu. ft. of sawdust) will raise the moisture content to about 11 1/2 per cent at which point no cooling blockage occurs.

Effect of moisturized sawdust on fruit quality: Sawdust absorbs or loses moisture depending upon the relative humidity to which it is exposed. Grapes give up water until the relative humidity reaches 98 per cent at room temperature. Grapes in sawdust continue to lose moisture until the sawdust reaches a moisture content of 17 to 20 per cent. This moisture transfer takes a month or longer at storage temperatures. The higher the moisture content of the sawdust to begin with, the less the

[1] All moisture percentage expressed on wet weight basis. See explanation on page 8.

loss from the grapes, and hence, the better the appearance of the fruit.

Two factors restrict the amount of moisture which can be safely added to the sawdust: 1) Increase in mold growth which is correlated with the moisture level, and 2) Increase of sticking of sawdust to the stems. Both mold and sticking become appreciable problems if the moisture content of the sawdust (as added to the fruit) is above 13 per cent. It seems paradoxical that these difficulties occur with too-moist sawdust since either dry or moist sawdust reaches the same moisture content of 17 to 20 per cent after a storage period of a month. An explanation of this phenomena cannot be offered at present.

Considerations in Designing a Forced Air Cooler: The following factors can be used to design a forced air sawdust cooler for a given capacity:

1. Sawdust requirements - Sawdust used for packing grapes weighs about 14 pounds per cubic foot. Each chest requires about 10 pounds of sawdust or .7 cubic feet.
2. Air rate - An air rate of approximately 5 cubic feet per minute per cubic foot of sawdust in the cooler is suggested. Maximum recommended depth of sawdust through which the air will travel is 3 feet.
3. Static pressure - The static pressure required to force air through a 3-foot depth of sawdust at the above rate is approximately 1.0 inches of water. If the refrigeration system will not provide the static pressure, a fractional horsepower supplemental fan will be necessary. Fan horsepower may be estimated by the following formula: $\frac{V \times 5 \times 1}{4700}$
   V = cu. ft. of sawdust in the cooler.
4. Cooling time - If the above air rate is used and the sawdust is at the proper moisture content, the temperature difference

between sawdust and cooling air can be reduced by 7/8 in one hour.

5. Cooler size and type - Size of cooler is determined primarily by the packing rate and the length of cooling time. The cooler may be either a batch type or a continuous type. A schematic end view of a continuous type cooler which feeds cooled sawdust directly into the grape chests on the packing line is shown in Figure (1). A continuous cooler to cool sawdust for 300 chests per hour would need to be 3 feet wide, 8 feet high in the region where air pases through the sawdust, and 10 feet long. The capacity of a unit of this type may be adjusted to fit requirements by increasing or decreasing the length or height. For example, reducing the length by 50 per cent would reduce the capacity by 50 per cent, etc.

6. General - The cross section of the air supply and return ducts should be large enough to provide a minimum of one square foot of cross section for each 1,000 cubic feet of air per minute. Refrigeration requirement for cooling sawdust is nominal. Approximately one ton of refrigeration capacity is required to cool 1,000 pounds of sawdust 40° in one hour. The formula for calculating refrigeration capacity for cooling sawdust is as follows:

$$\text{Tons Refrig.} = \frac{W \times C \times T}{12{,}000}$$

W = Required cooling rate, pounds sawdust per hour.

C = Specific heat of sawdust, 0.3 BTU per pound per degree Fahrenheit.

T = Temperature reduction, degrees Fahrenheit.

Hardware cloth of 1/8 inch mesh is satisfactory for the perforated wall portion of the cooler. Some of the fine particles

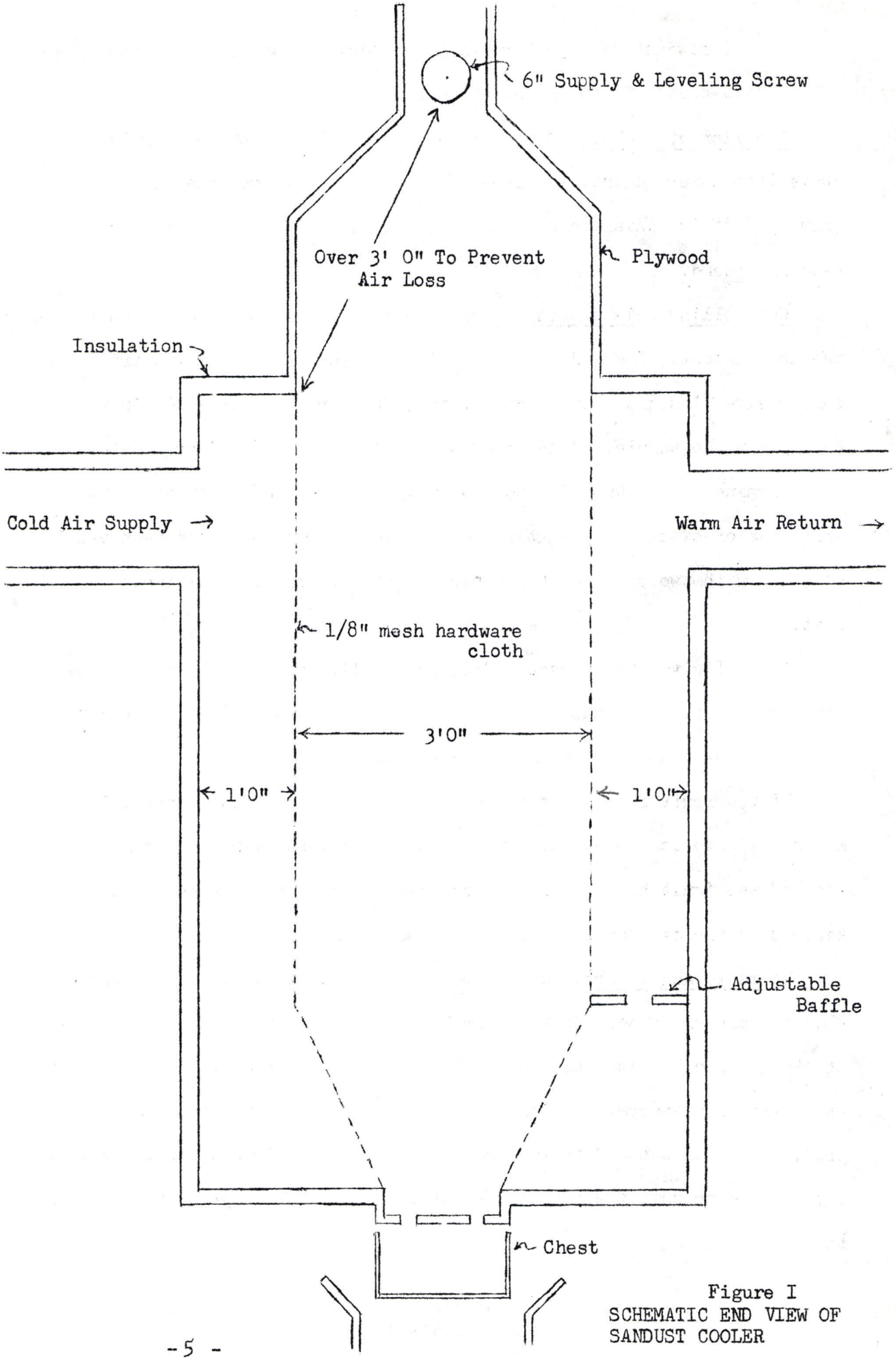

Figure I
SCHEMATIC END VIEW OF SANDUST COOLER

of sawdust will go through the hardware cloth so a cleanout-door is needed in the plenum chamber.

Location of Cooler: Most convenient location of the cooler is above the shaker so that the sawdust feeds directly into the chests by gravity. It is easier to bring cold air to the cooler than to move sawdust around.

Controlling Moisture in Sawdust: Some type of a device is required to test moisture content. These devices are either electronic or gravimetric, the former gives instantaneous reading, the latter requires 5 - 10 minutes to dry out the sample. Samples of the sawdust as received are tested to determine the amount of water to add. Tests of the moistened sawdust provide a check of the results. Controlling the moisture has been easily attained with two or three tests per day of both dry and moistened sawdust.

Table I gives the amounts of water to add. At present, a 11 1/2 per cent moisture content is suggested. Values between 10 1/2 per cent to 12 1/2 per cent are within the acceptable range.

If the fruit is not exposed to the sawdust more than a month, it may be safe to use 13 per cent moisture. This further reduces moisture loss of the fruit but too long exposure results in some sticking of the sawdust to the capstems.

Where To Add Water: Add the moisture where the sacks are dumped. Flat or cone spray nozzles used for herbicides are available in a variety of sizes and calibrated to discharge a certain number of gallons per hour at a certain pressure. By installing two nozzle outlets over the dump area, both with cut-off valves and with a choice of 3 or 4 nozzles sizes, any desired amount of water may be obtained. Install a pressure gauge in the line.

TABLE I

MOISTURE ADDITION TABLE

	Moisture Per Cent of Sawdust		Ounces of Water to Add Per Sack To Bring To
	Wet Weight Basis	Dry Weight Basis	11½% Wet Weight Basis (13% Dry Weight Basis)
	5.0	5.3	49
	5.5	5.8	45
	6.0	6.4	42
	6.5	7.0	38
	7.0	7.5	34
	7.5	8.1	31
	8.0	8.7	27
	8.5	9.3	23
	9.0	9.9	20
	9.5	10.5	16
	10.0	11.1	12
Permissible	10.5	11.7	8
	11.0	12.4	4
Optimum	11.5	13.0	0
	12.0	13.6	0
Permissable	12.5	14.3	0
	13.0	15.0	0

Calculations based on 3 1/4 cubic feet of sawdust per sack with a net weight of 45 lbs. at 9% moisture, wet weight basis.

Dust Sometimes A Problem: Some of the fine particles in the sawdust may create a dust problem if the sawdust has a free fall into the cooler. If so, provide an exhaust fan to remove the dust. No dust escapes from the cooling tower into the warm air return once the tower is filled.

Provide Uniform Discharge: In order to cool all the sawdust for the same length of time, it must feed out uniformly. This is a matter of adjusting the exit holes properly. The number of exit holes to provide is roughly an average of one per foot. Provide adjustable openings with a maximum diameter of two inches.

With one inch clearance between the box and the opening, the sawdust feeds in by gravity and ceases filling automatically as the box fills. Feed in empty chests upside down as the dusting operation is completed so that the openings need not be readjusted each time.

NOTE CONCERNING MOISTURE PERCENTAGE

All the moisture percentage in this publication are expressed on a wet weight basis, (Pw). This is the common commercial expression; scientifically the dry ~~wet~~ *weight* basis (Pd) is employed. The difference between the two may be illustrated with an example. If a 100 grams of moist sawdust loses 13 grams of weight on drying, these are the calculations:

Wet Weight Basis-Pw

$$\frac{13}{100} \times 100 = 13\%$$

Dry Weight Basis-Pd

$$\frac{13}{100-13} \times 100 = 15\%$$

To Convert Wet Weight To Dry Weight

$$Pd = \frac{100\ Pw}{100-Pw} \text{ for example } \frac{100 \times 13}{100-13} = 15\%$$

To Convert Dry Weight To Wet Weight

$$Pw = \frac{100\ Pd}{100+Pd} \text{ for example } \frac{100 \times 15}{100+15} = 13\%$$