Station Circular 40 April, 1923

Oregon Agricultural College

Experiment Station

Recirculation Driers

By

ERNEST H. WIEGAND

Horticulturist (Horticultural Products)

CORVALLIS, OREGON

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION

STATION STAFF

Recirculation Driers

By

ERNEST H. WIEGAND

With the increased acreage of prunes coming into bearing there has arisen a need for new and better driers. The Experiment Station has been working on this problem for four years and has evolved a type which meets the needs of the Northwest grower. This drier is a new type which recirculates the heated air. The principles involved in drying by recirculation and the construction and operation of this drier are briefly discussed below.

ADVANTAGES IN RECIRCULATING THE AIR

The main advantages of recirculating the air in prune driers are as follows:

1. **Saving Heat and Fuel.** In natural draft driers the air is usually taken into the furnace pit at 50 degrees F. and heated to 175 degrees F. In passing over the fruit it loses about 35 degrees of its heat; the remainder, about 140 degrees, passes out through the stack and is wasted. This represents an approximate loss of ⅘ of the heat. When recirculating the heated air at 140 degrees F. a minimum loss is sustained.

2. **Adding Moisture to the Air.** By returning the air to the furnace pit a humid air is built up for drying purposes. This humid or moist air prevents surface drying or "case hardening," and drying takes place under moist air conditions as it does in nature. The fact that case-hardening is prevented permits of more rapid diffusion of the moisture from the center of the fruit.

3. **Decreasing Drying Time.** The drying time is decreased: first, because the circulation of the air is increased and maintained; second, because the humidity, in keeping the skin soft and pliable, results in a more rapid elimination of the water; third, because with the humidity there is a better conduction of the heat.

4. **Lowering Drying Cost.** The drying cost is lowered as can be deduced from the foregoing explanation. The more efficient method of handling in connection with the factors decreasing the drying time lowers entire cost of operation.

5. **Increasing the Quality by Lowering the Temperature.** When recirculating the air at a greater speed it is not desirable to maintain a high heat. With a temperature of 150 degrees F. the quality of the product is superior to that of fruit dried at temperatures around 175 degrees F. The rapid movement of the air increases the drying rate, keeping the fruit in cool conditon, which prevents any chance of the sugars scorching or extreme oxidation setting in.

DRIERS ADAPTABLE TO RECIRCULATION

Recirculation systems can be installed with only minor changes in all tunnel driers regardless of type. The stack type of drier is not as easily changed over; in this case it would be more desirable to remove the stacks and substitute the tunnel system over the old furnace pit. This cost will not be prohibitive and will make a more efficient drier of the old unit.

REMODELING THE OREGON TUNNEL

It costs less to remodel the Oregon tunnel to double the capacity than it does to build additional units for the same purpose. To install the recirculation system in the tunnel drier it is necessary to bring the air back to the furnace pit with a fan. This can be done by ducting the air from the tunnel to the fan and from there to the pit in the manner shown in Fig. 1.

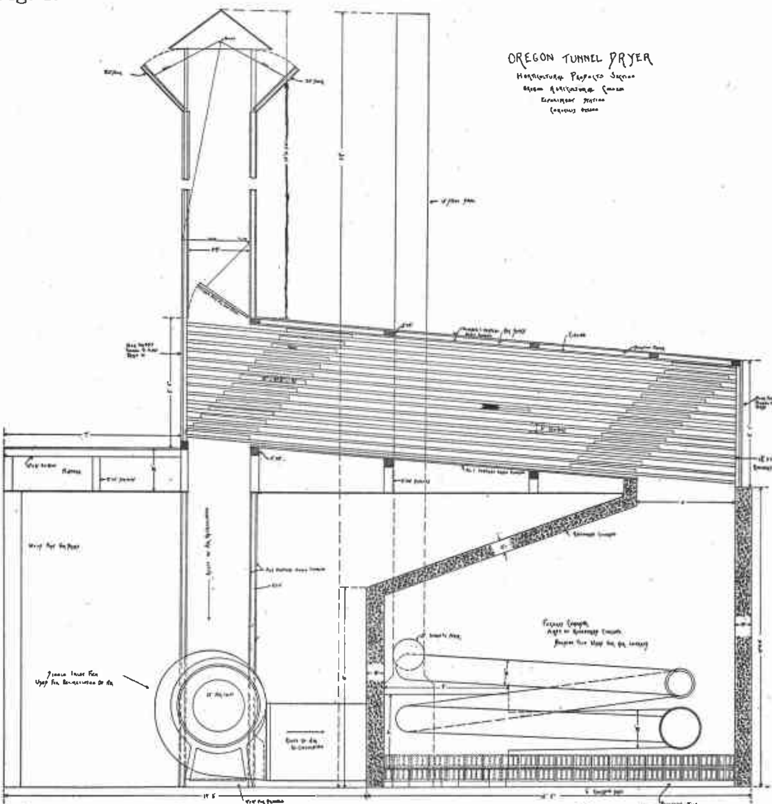

Fig. 1. Return Duct System for Recirculating air in Remodeled Oregon Tunnel Drier

The cost of remodeling a four-tunnel unit will be approximately $150 plus the cost of the fan. A fan sufficiently large to operate the air in a four-tunnel unit (25-30 feet in length) will require a 10 H. P. motor. This fan will cost approximately $370 plus the freight. These figures are approximate only and will vary with the size of the individual unit. Long tunnels with large capacity require more horse-power as it is necessary to remove a larger amount of water in a given time.

The cost of installing this system can be cheapened by doing the work early in the spring. At this time the drierman himself can do the work of installing, thus avoiding expensive and immediate labor which would be necessary near drying season.

POINTS TO BE CONSIDERED IN REMODELING

When remodeling the drier the following arrangements should be made:

(1) Seal all leaks in the furnace and piping, the furnace pit and the tunnels. This is necessary to conserve the heat and the circulation.

(2) Concrete the floor of the furnace pit to prevent dust.

(3) Place good strong locks or clamps on all doors and see that the doors fit snugly.

(4) Arrange the trap in the stack so it can be closed or opened as needed.

(5) Arrange a sliding door on the fan duct to act as fresh air intake.

(6) Where possible lengthen the tunnels to 30 or 35 feet, increasing the efficiency of the drier and decreasing the dripping.

BUILDING A NEW DRIER

When building a drier the first consideration is the size of the unit. This should be based on the acreage in bearing, together with the new fruit coming into bearing. Calculations should then be made for a twenty-day drying period which is the average length of the season. Knowing the approximate amount of fruit the orchard will produce and dividing this amount by twenty days the total daily drying can be estimated. Basing the daily production on the new model drier, which has a maximum capacity of 8½ tons per tunnel (Fig. 2), the number of tunnels can be determined by dividing this amount into the total tons to be received at the plant daily.

The Type of Drier to Build. The tunnel type with the addition of the recirculated air system is the type of drier to build. This drier is easily constructed and operated. The cost of construction is not as great as the natural draft drier because for the same capacity a smaller drier can be built. The illustration (Fig. 2) gives an idea of the type and manner of construction. This drier has been tried out and will be found to give very good results. It is economical to operate and has a large capacity. Smaller capacity can be had by reducing the size of the tunnel. This reduces the tonnage.

The Type of Heating Unit to Use. The best type of heating unit to use is the large round steel stove. This stove is constructed with tight seams and is economical in the use of fuel. The largest size, 3 by 6½ feet, is the best if it can be obtained. The square cast-iron stove cannot be made tight enough and must be patched continually when using fans to circulate the air. The leaking of this stove due to the air being forced through the many cracks keeps the fire from burning well and will cause much trouble.

The large 15-inch pipe should be used for conveying the smoke through the pit. This size permits steady flow and good draft, besides giving a large surface for radiation.

Where the old drier is rebuilt care should be taken to get the heating unit in good shape. The pipes should not be too long or of small diameter as they will cool down to a point where they will not draw. The high velocity of the air in the pit utilizes the heat faster than it did in the old system under natural draft.

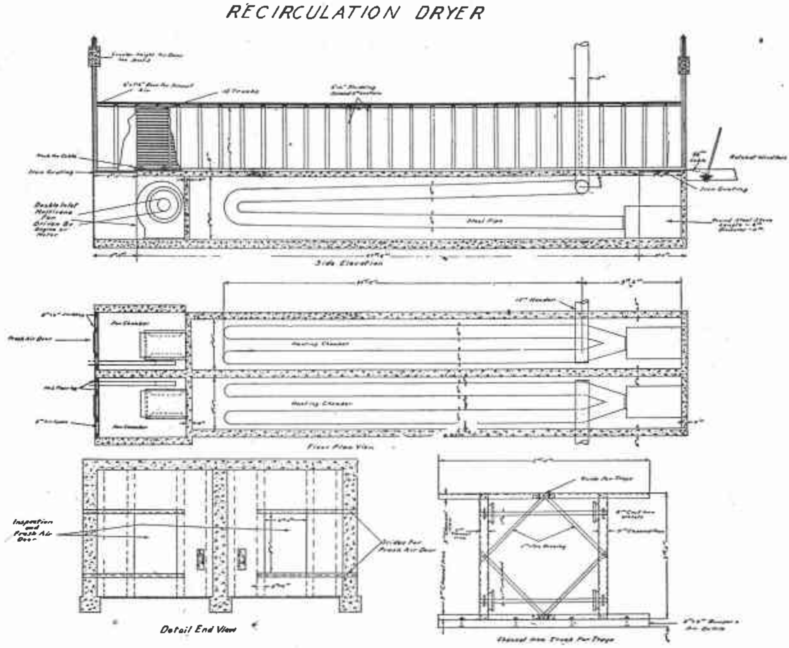

Fig. 2. Two-tunnel Recirculation Drier, 8½ tons per tunnel

Fans for Recirculating the Air. There are many types of fans that might be used for recirculating the air, but the most economical and efficient is the multivane. This fan is small and compact, economical in horse-power, and delivers a larger volume of air than any other fan of equal size. For remodeling the old drier the single-inlet fan can be used, while in new driers, as shown in Fig. 2, the double-inlet fan is best. The double-inlet fan is more efficient than the single-inlet as it will deliver a larger volume of air at less power cost. This fan is harder to adapt to the old drier than the single-inlet, thus it is advisable to use the single-inlet when remodeling.

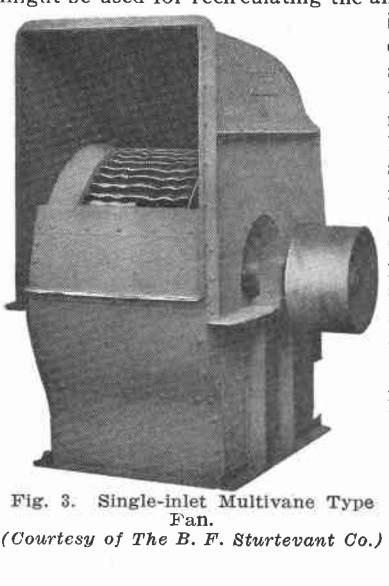

Fig. 3. Single-inlet Multivane Type Fan.
(Courtesy of The B. F. Sturtevant Co.)

When purchasing fans buy only from dependable firms having financial backing and a trained engineering force to test out their equipment. All fans constructed by these firms have a definite rating which can be depended upon.

Power for Operating Fans. The most convenient power is electricity where it is available. In many places, however, gasoline and even steam engines are used. Tractors are used in place of stationary engines as shown by Fig. 4. The Fordson will handle the operation of the fans successfully, providing the machine is not overloaded. The full rating of 20 horse-power of the Fordson should not be utilized. In computing the power, 18 to 19 H. P. would be the maximum for efficient operation. Since the engine will have to be operated continuously until the season closes, it should be thoroughly overhauled before starting.

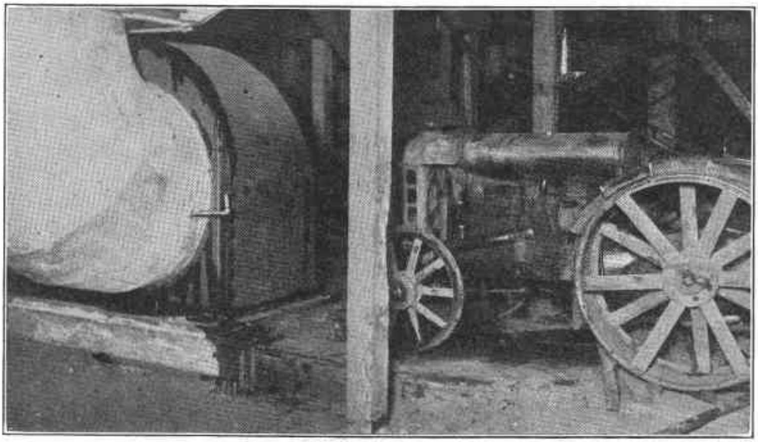

Fig. 4. Fordson Operating Recirculation Fan.
L. N. Miller Drier

The semi-diesel type of oil-burning engine is efficient, dependable, and economical. It consumes cheap fuel and will operate at approximately one-eighth the fuel cost of the gasoline engine. The initial cost of this machine is somewhat greater than gasoline engines.

COST OF DRYING BY RECIRCULATION

Under the present methods of drying by natural draft the cost has been out of all proportion to the charge made by the drierman for this service. During the past year many driermen have charged two cents a dry pound for drying, in most cases not realizing that they were losing money. Operators should keep accurate account of costs to determine the charge to be made for custom drying.

Below are some comparative cost figures on drying by recirculation and natural draft. The figures in the first column show the cost of drying in a drier of the type illustrated by Fig 2. These figures were taken from the Eugene Fruit Growers' Association drier at Eugene. Column two is a rebuilt Kurtz-type tunnel drier using a Fordson tractor for power. Figures in this column are taken from the Busenbark Bros. drier of Roseburg. The third column represents the tunnel type of natural-draft drier of the Eugene Fruit Growers' Association at Junction City.

	New Recirculating Drier	*Rebuilt Kurtz Drier*	*Natural Draft Drier*
Total Green Weight Italians	895,327	364,100	168,914
Total Dry Weight Italians	307,837	137,569	57,916
Labor	$1,913.53	$ 981.00	$ 953.41
Cost per ton	12.42	14.27	32.88
Fuel	312.50	156.00	280.00
Cost per ton	2.03	2.27	9.65
Wood used per ton	.4 cord	.37 cord	1.9 cords
Light and Power	250.00	260.20	12.00
Per ton	1.62	3.78	.41
Interest and Depreciation on plant at 10%	890.00	585.00	200.00
Per ton	5.80	8.50	6.90
Overhead 5% of income	308.00	137.57	57:92
Miscellaneous	....	55.00	....
Total cost	$3,674.03	$2,174.77	$1,503.33
Gross income at 2c per pound	$6,156.74	$2,751.38	$1,158.32
	Profit $2,482.71	Profit $ 576.61	Loss $ 345.01
Cost per dry pound	.012	.016	.025

OPERATING THE RECIRCULATING DRIER

In operation the recirculation drier does not differ much from the natural draft. There are a few points, however, that should be kept in mind when handling this type of drying system.

Temperature of Drier. The most desirable temperature for drying prunes under this system is 150 to 160 degrees F. The temperature should never exceed 160 degrees F. if a high-quality fruit is desired. It must be remembered that fruit will burn as readily in this system as in the natural draft drier; the temperature should therefore be watched closely to prevent a rise which might burn or scorch the fruit.

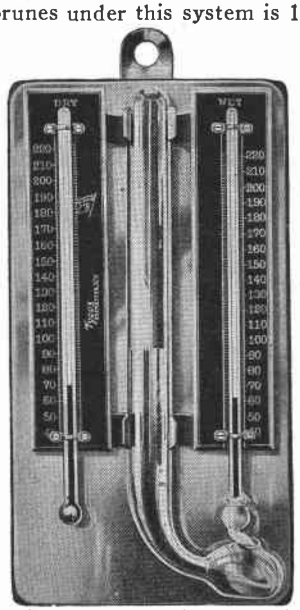

Fig. 5. Wet and Dry Bulb Thermometer. *(Courtesy of Taylor Instrument Co.)*

Humidity of the Drier. The humidity for the best results is from 15 to 30 percent This can be maintained by regulating the fresh air intake near the fan and the used air outlet on the stack. The amount of fresh air taken in is relatively small as is the used air let out. The regulating should be done after the humidity has reached about 20 percent at the throat of the tunnel as indicated by the wet and dry-bulb thermometer, Fig 5. Care should be exercised not to open the inlet and outlet too far as too much heat and moisture will be wasted. When the conditions within the drier are once regulated very little adjustment will be needed for the remainder of the season if the heat is kept at 150-160 degrees F. The filling of the tunnels is constant.

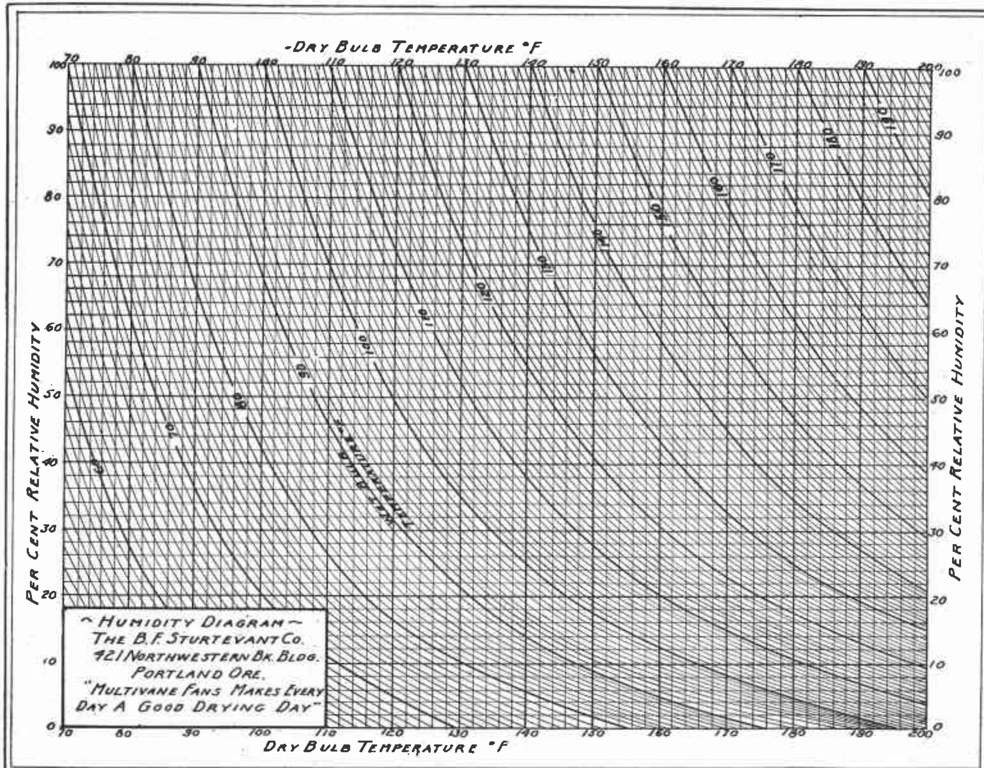

Fig. 6. Humidity Chart *(Courtesy of The B. F. Sturtevant Co.)*

To determine the percent of humidity within the tunnels by using the wet- and dry-bulb thermometers as above mentioned the chart (Fig. 6) can be used. This chart is so arranged that calculations will not be necessary, and direct readings can be made. The vertical lines represent the dry bulb of the thermometer, the curved lines the wet bulb. Where these two lines cross, the percent of relative humidity is indicated on the right margin of the chart.

Circulation of Air. The circulation of the air within the drier is controlled by the speed of the fan. This circulation should be kept at 650 to 750 lineal feet per minute between the trays. If for some cause the speed of the fan is reduced the circulation will be retarded and the drying time lengthened. It is advisable to test the speed of the fan from time to time by using a **speed indicator** to be sure the belt is not slipping and thus causing a loss of speed. Belts driving the fans should be kept tight enough to prevent slipping. It is suggested that a good belt dressing be kept on hand for emergency.

HANDLING PRUNES IN THE DRIER

The prunes coming from the recirculation drier should be carefully watched. The common method to test the fruit is to feel it to determine approximately what percent of mosture it contains. The fruit should contain about 18 percent moisture when it is removed from the drier. This is hard to determine and many operators will be uncertain as to the right time for removing the fruit in the recirculating drier as it feels much more moist than fruit from a natural draft drier. Do not dry the fruit down too far as it will become hard when cool. Where it is possible to control the conditions by testing for the proper moisture percentage it is desirable to do so. The fruit can contain as high as 20 percent moisture.

Cars or stacks should be removed from the drier at regular intervals. Do not open the door continually to test the fruit as much heat will be wasted. When the proper interval has been established it will be found that the fruit will be ready to come out at that time.

The trays should be unloaded on cooling tables as soon as possible if the fruit has been dripping, otherwise it can be cooled on the trays.

COMPILING COSTS

Costs should be kept of the drying operations in order to determine the total cost of drying fruit. This is for the satisfaction of the drierman as well as to determine correctly the charge for custom work.

To compute the costs, the fruit should be weighed as it comes to the drier and after it has been dried. The cost items can be listed under the following heads:

Labor. All labor both day and night including the labor or time given to the overseeing of the entire operation by the owner.

Fuel. All fuel for heat should be listed under a separate head.

Light and Power. Light and power can be listed together where electricity is used but generally separate meters are used and keeping account of this item is a simple matter.

Where gasoline and oil are used the items should be kept separate and later compiled under one heading.

Interest and Depreciation. These charges are more or less stationary and can be grouped together. Ten percent of the cost of the drier will cover these.

Overhead. This item, usually averaging about 6 percent of the income, covers such items as insurance, taxes, repairs, waste, and other miscellaneous charges. The charge for drying can be placed at 2 cents per pound, which is the income.

If these items are carefully compiled it will be an easy matter, by subtracting the total cost from the gross income, to determine whether the operator has made money.

BLUE PRINTS OF DRIERS

The Horticultural Products section of the Experiment Station will furnish blue prints of driers at cost ($1.50) to all growers desiring to build. Blue prints are available of both the natural-draft and recirculation driers. Assistance will be rendered in so far as possible to see that the installations will operate.

SOME MANUFACTURERS OF EQUIPMENT FOR DRYING

Dippers

- Salem Manufacturing Co., Salem, Oregon.
- L. N. Miller, Eugene, Oregon.
- August Hilfiker, Salem, Oregon.
- Anderson-Barngrover Mfg. Co., San Jose, California.

Prune Trays

- Dallas Planing Mill, Dallas, Oregon.
- Sheridan Box Factory, Sheridan, Oregon.
- J. G. Flook Co., Roseburg, Oregon.
- Manfield Box Co., Roseburg, Oregon.
- L. N. Miller, Eugene, Oregon.

Thermometers

- Taylor Instrument Co., 554 Colman Bldg., Seattle, Washington.

Stoves

- W. W. Rosebraugh Co., Salem, Oregon.
- L. N. Miller, Eugene, Oregon.

Fans

- B. F. Sturtevant Co., 421 Northwestern Bank Bldg., Portland, Oregon.
- American Blower Co., Detroit, Michigan.
- Buffalo Forge Co., Buffalo, N. Y.

Steel Furnace Pipe

- W. W. Rosebraugh Co., Salem, Oregon.
- J. A. Sinninger, Roseburg, Oregon.

Car Supplies

- L. N. Miller, Eugene, Oregon.