A HOP DRIER

for Oregon Farms

By
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Agricultural Experiment Station
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Corvallis

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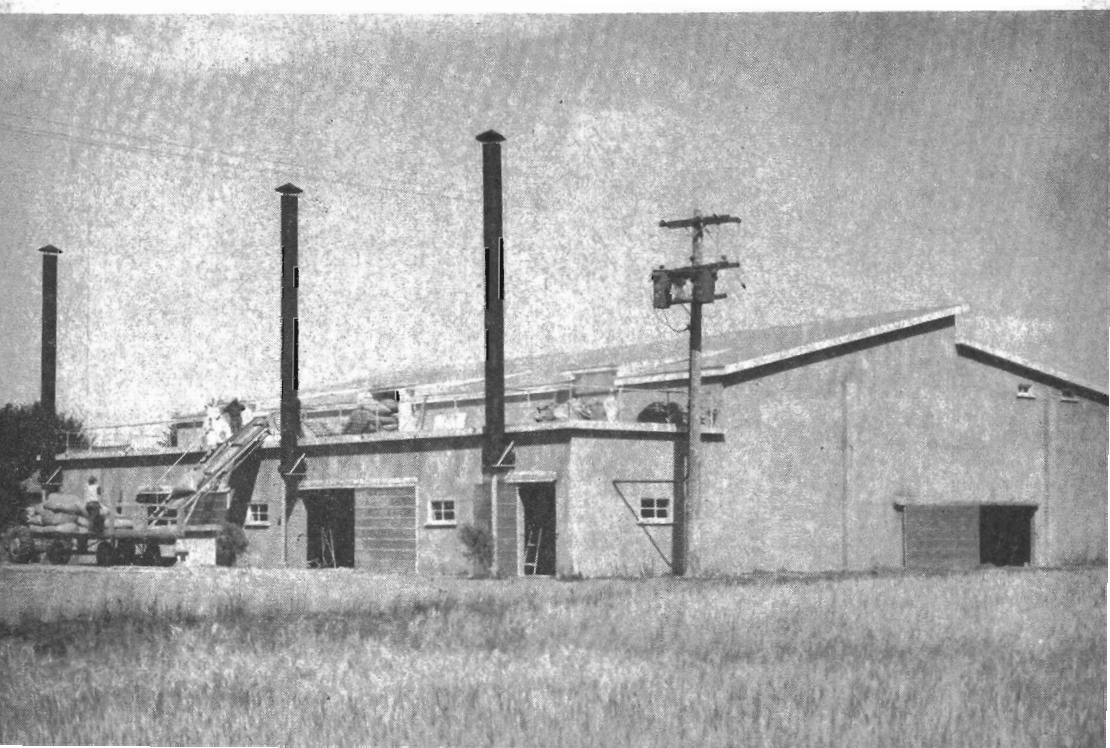

A Hop Drier *for Oregon Farms*

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Oregon grown hops, first produced in 1845, now account for slightly more than one-fourth of the national hop production and nearly one-eighth of the world's total. Within the state, hop production is limited to 12 counties, and most of the hop farming is done on a small scale. Sixty per cent of the hop growers of the state have less than 25 acres of hops. Another 20 per cent have between 26 and 50 acres.

All of the hops produced must be artificially dried. There has been a real need for a modern, efficient, fire-safe drier—designed to meet the needs of the small operator. The plans shown here were designed for that purpose. Since the plant is built in units, it can be adapted to various sizes of operations simply by adding more units. The design is based on research work, tests, and observations made by the Department of Agricultural Engineering since 1933.

Requirements of a good drier

A drier which meets the following specifications will dry hops satisfactorily, without loss of quality:

1. Drying temperature of around 150° F. Hops dried at or near this temperature are of higher quality than those dried at lower temperatures.
2. Air Circulation
   - Positive air circulation by fans.
   - Minimum air volume, 35 cubic feet per minute per square foot of kiln area.
3. Provision for loading the kiln to a depth of 36 inches.
4. Provision for sulphur burning. (Sulphur recommended: $\frac{1}{2}$ to 1 pound burned per 100 pounds of green hops in the kiln.)

Size and type of drier needed

The following factors should be given careful consideration in order to determine the size and type of drier suited to individual requirements:

Acreage of hops.

Estimated yield per acre.

Ripening dates of varieties grown.

* Formerly assistant agricultural engineer; now agricultural engineer, U. S. Department of Agriculture, Alaska Experiment Station, Palmer, Alaska.

Method of picking hops.
Capital available for the initial investment.
Source and availability of fuel and power.

The approximate average yield of green hops on Oregon farms is 4,000 pounds per acre. This quantity will dry down to about 1,000 pounds of dry hops.

Kiln area required

Table 1 has been prepared to help determine the size of drier needed for different sized farms.

Table 1. SQUARE FEET OF KILN AREA REQUIRED TO DRY ONE ACRE OF HOPS*

Yield of dry hops per acre†	Kiln area required		
	10 loadings per season	15 loadings per season	20 loadings per season
	Square feet	*Square feet*	*Square feet*
1,000 pounds	25.66	17.11	12.83
1,500 pounds	38.49	25.66	19.24
2,000 pounds	51.32	34.22	25.66

* Based on a drier designed for forced air circulation at 150° F. and loaded to a depth of 36 inches.
† Average for Oregon is 1,000 pounds per acre.

To determine the number of square feet of kiln area needed, first estimate the yield of dry hops and the number of times the drier will be loaded. The square feet of kiln area needed can then be determined from the above table.

Table 2 may be used in determining the approximate weight of green hops per 100 square feet of kiln area for various depths of loading.

Table 2. AVERAGE WEIGHT OF GREEN AND DRIED HOPS PER 100 SQUARE FEET AT VARIOUS LOADING DEPTHS

Depth of loading	Weight of hops per 100 square feet	
	Green	Dry*
	Pounds	*Pounds*
24 inches	930	250
36 inches	1,395	380
42 inches	1,630	440

* "Dry" hops retain about 8 per cent moisture.

Air and time requirements

A minimum of 35 cubic feet of air per minute per square foot of kiln area should be maintained until an hour after the heat breaks through, at which time the air volume can be reduced approximately one-third as long as the temperature is maintained constant. The fan used must deliver the required amount of air against the total static pressure of the furnace ducts and hops. This pressure will vary from ¼ inch of water for an air velocity of 35 cubic feet per minute per square foot of kiln area with a 24-inch loading to approximately 1 inch static pressure for 70 cubic feet per minute per square foot of kiln and a 42-inch loading. The fans should be purchased on a guaranteed performance basis.

The time required to dry hops, assuming a constant air temperature, depends on the depth of loading and the volume of air per square foot of kiln area. For a 36-inch loading and 35 cubic feet of air per minute, the time required will be approximately 12-13 hours.

A table showing the relation of fan and furnace requirements to drying time in the hop kiln is shown on Drawing 1.

Furnaces

Modern furnaces are of welded steel construction with firebrick protection for the combustion chamber. An adequate amount of heating surface is required so that the furnace stays well below the red heat. To eliminate a fire hazard, the heating plant should be placed adjacent to the kiln but not beneath it. Enclosing the furnace area with a non-combustible material such as reinforced concrete or hollow tile also eliminates much of a drier's fire hazard. Wood, sawdust, and hog fuel can be used to fire the furnace, but the risk of sparks from these fuels makes them more dangerous than oil or gas fuels. Automatic safety devices can be used to advantage with oil or gas but cannot be used effectively with wood. Furnaces should be obtained from a reliable manufacturer or engineering firm on a basis of guaranteed B.T.U. output per hour.

Passing the combustion gases of oil and gas-fired furnaces directly through the hops is a procedure which has been used to some extent in the Pacific Northwest. No statement on the merits of this method can be made since no data are available on such driers. If this type of design is contemplated, an adequate sized spun-glass filter should be installed between the heating plant and the hop kiln to catch and extinguish any sparks or ignited pieces of material.

Drier design

The drier design shown in the drawings provides for one unit 28′ wide and 75′ deep. It includes a furnace room, kiln, cooler and storage, and baling room. If additional drier capacity is necessary, one or more units may be added to the pilot unit to provide the desired space.

Block construction and a metal roof are recommended in order to minimize the fire hazard. The furnace and fan room, adjacent to the kiln but on the opposite side of the building from the cooler and storage, is constructed of blocks with a 4″ reinforced concrete roof slab. This slab serves a dual purpose since it acts as the roof of the furnace room and as a loading porch for the hop kiln. A railing of ¾″ pipe is placed around the loading porch for safety purposes. The hops are conveyed from the trucks to the loading porch by a conventional hop elevator. The studs on the gable ends of the building above the blocks should be covered with metal as a safeguard against fire.

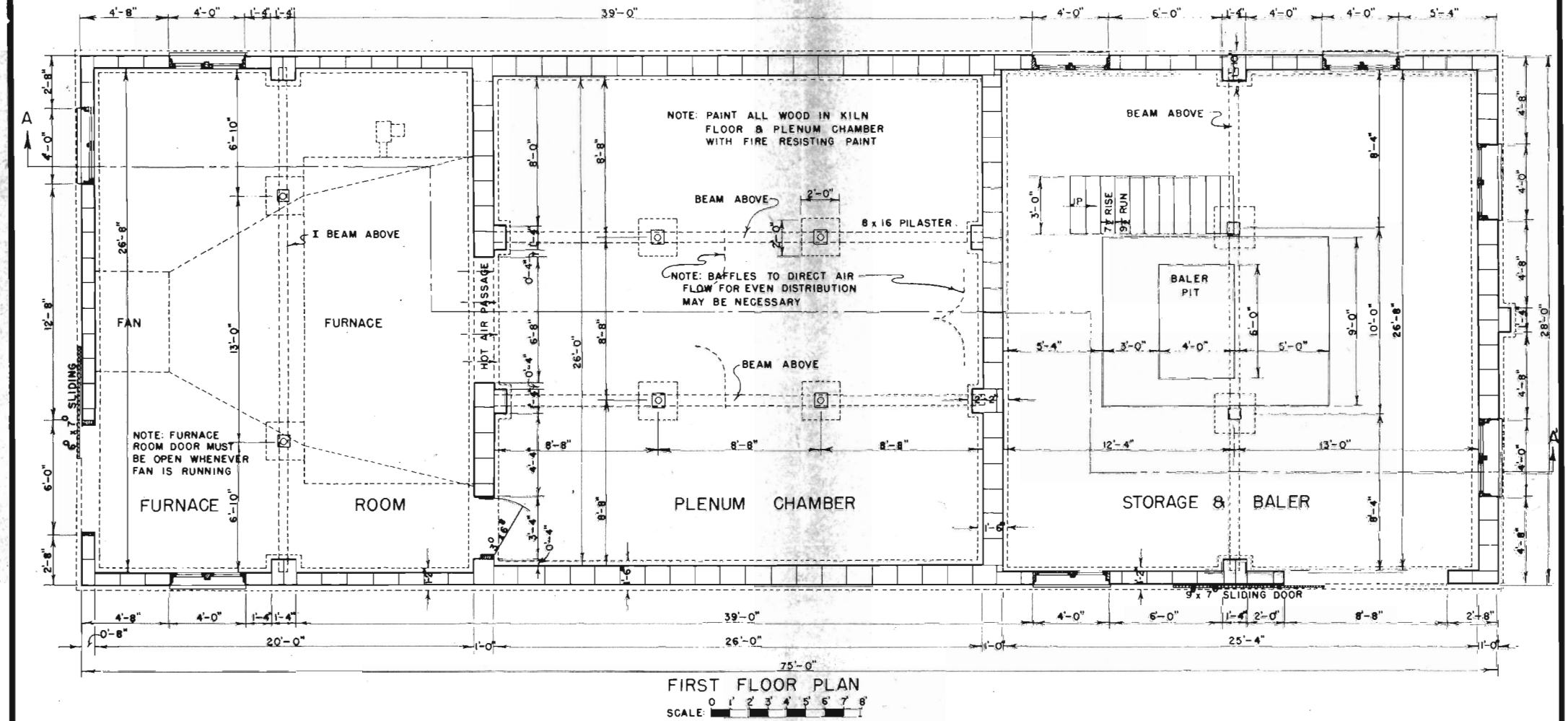
The kiln floor measures 26′-0″ x 26′-8″ inside for a floor area of 692 square feet. A kiln this size will hold approximately 9,675 pounds of green hops when loaded to a depth of 36 inches. The kiln floor is constructed of 1 x 2 inch material on edge spaced ¾″ apart. The floor is supported by 2″ x 8″ joists 2′-0″ o.c. The conventional burlap kiln cloth is laid over the 1 x 2 floor. It is recommended that the cloth be treated with a fire retardant chemical. To further fireproof the drier, it is recommended that all wood in the plenum chamber and kiln be painted with a fire-resistant or retardant paint. These paints have been found to be effective and may be applied with a brush or sprayer.

Cooling and storage space is provided adjacent to the kiln. Catwalks hung from the rafters in the "cooler" make it possible to truck the dried hops quickly to any part of the "cooler." The baling room is at grade level directly below the "cooler" and storage space and is reached by a stairway. Provision is made for a baler pit in the baling room, if one is necessary. To secure enough head room there is also an opening in the floor of the "cooler" which allows the baler to extend up through the floor.

Fire resistant features of the Oregon State College hop drier plan are as follows:

- The use of non-inflammable masonry block construction.
- The use of metal-surfaced roofing material.
- Erection of the smoke stack adjacent to the heating plant, but outside the building.
- Installation of an effective spark arrestor on the smoke stack.
- Treatment of the kiln-cloth with a fire-resistant chemical.
- Placement of the heating plant in a fireproof enclosure adjacent to the drier kiln but not directly beneath it, and under a positive air pressure so that air will tend to leak into the furnace instead of away from it.
- The use of an automatic air-pressure switch to shut off the burner on automatic installations and to sound an alarm on manually operated systems whenever the fan fails to circulate air.
- The use of a concrete floor beneath the kiln to facilitate cleaning and to reduce hazards incident to burning sulphur.
- The use of fire (retardative) paint on the kiln floor and on all wood surfaces beneath it.

Acknowledgments: The author is grateful for the whole-hearted cooperation of the other workers who helped plan and conduct this study. F. E. Price directed early research work and reviewed the manuscript; J. B. Rodgers cooperated in the preparation of data for publication; W. L. Griebeler prepared the hop drier plans; D. E. Bullis made the necessary chemical analyses in drying tests; and G. R. Hoerner helped in the preparation of the manuscript.



FIRST FLOOR PLAN

SCALE: 0 1' 2' 3' 4' 5' 6' 7' 8'

COOPERATIVE RESEARCH & EXTENSION WORK IN AGRICULTURE & HOME ECONOMICS

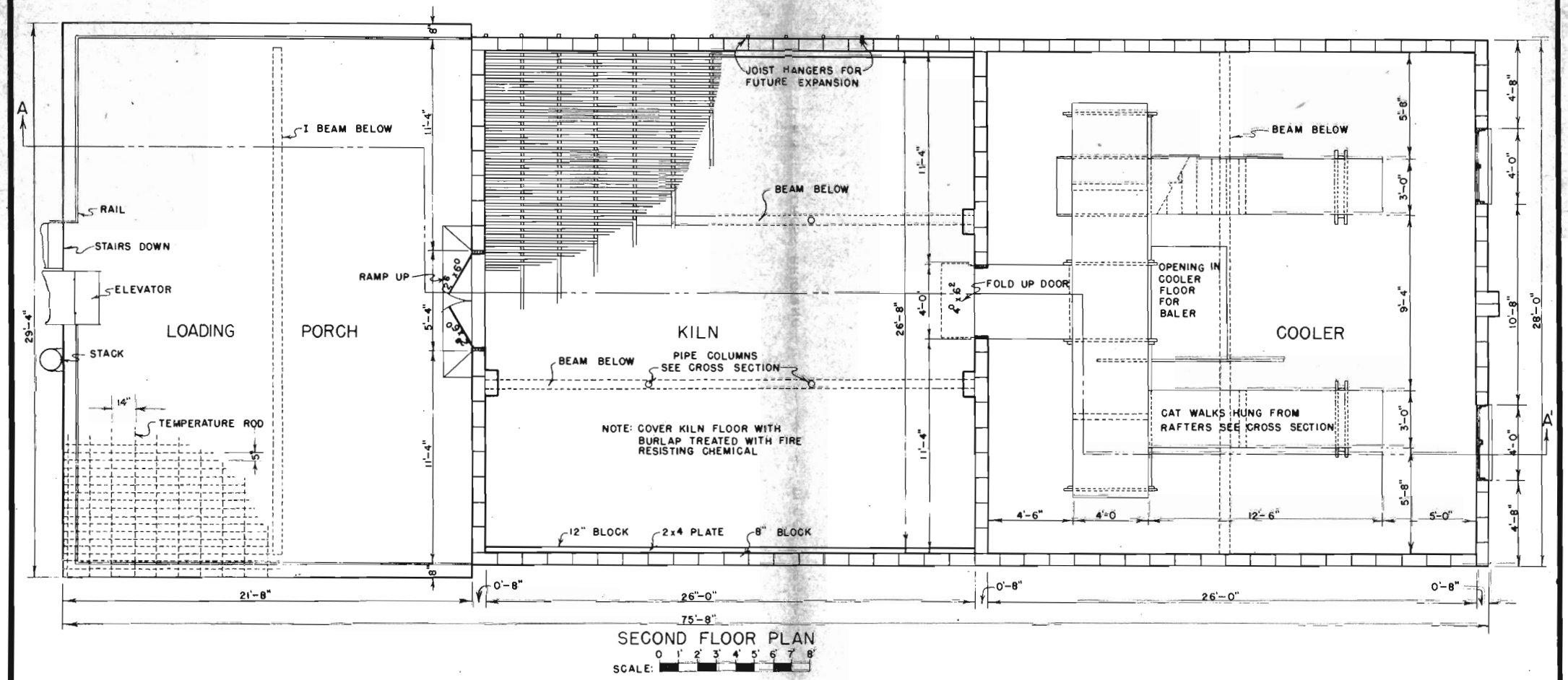
OREGON STATE COLLEGE
CORVALLIS, OREGON

DEPT. OF AGRICULTURAL ENGINEERING
U.S. DEPT. OF AGRICULTURE COOPERATING

HOP DRIER

OREGON | NUMBER 5.8 | SHEET 2 OF 4

DESIGNED BY
C. I. BRANTON, A.E. W.L. GRIEBELER, A.E.



SECOND FLOOR PLAN

SCALE: 0 1' 2' 3' 4' 5' 6' 7' 8'

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HOP DRIER

OREGON	NUMBER 5.8	SHEET 3 OF 4

DESIGNED BY
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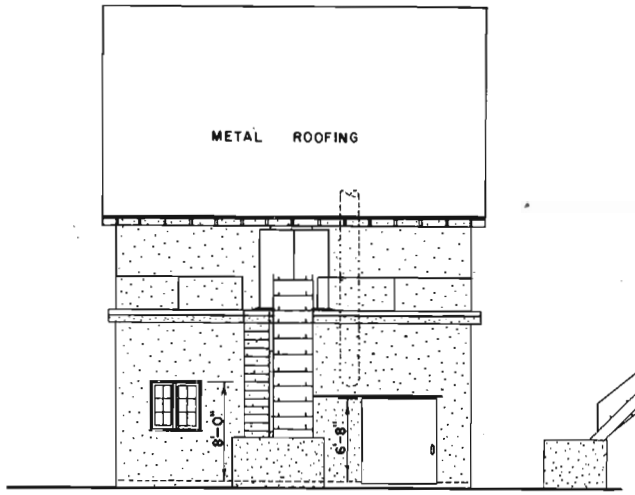
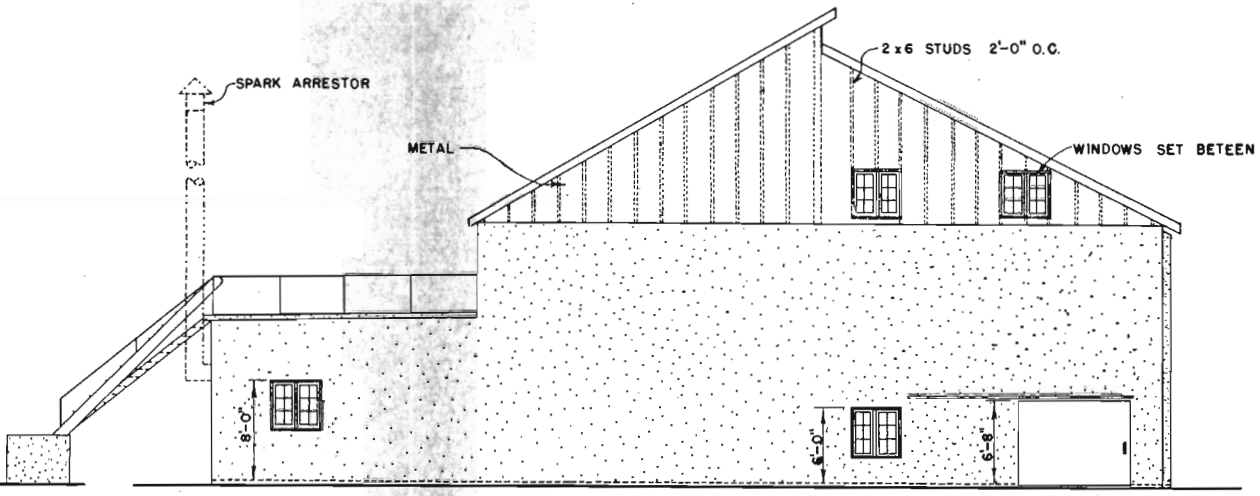
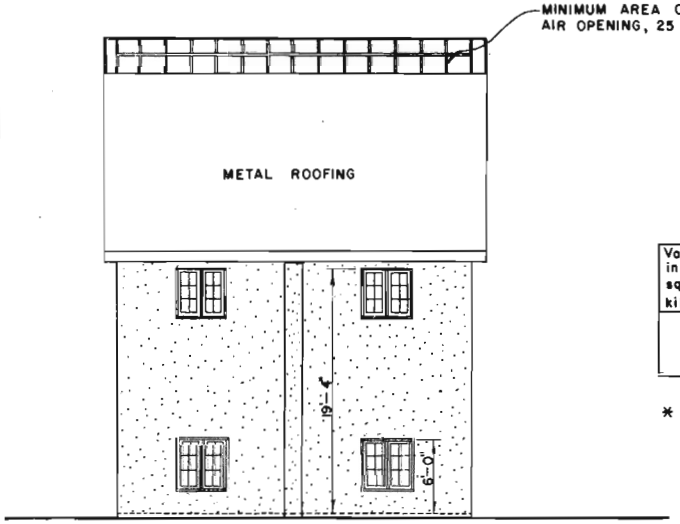


FRONT ELEVATION



SIDE ELEVATION



REAR ELEVATION

NOTE: ALL SASH $1^{10} \times 3^{5}$
ALL MASONRY OPENINGS 4'-0" x 4'-0"

NOTE: STACK HEIGHT AS RECOMMENDED BY FURNACE MANUFACTURER OR EXTEND 30" ABOVE GROUND & INSTALL INDUCED DRAFT FAN IF NECESSARY.

SCALE: 0 5' 10' 15' 20'

THE RELATION OF FAN AND FURNACE REQUIREMENTS TO DRYING TIME IN THE HOP KILN

Volume of air in cu. ft. per sq. ft. of kiln area	Total volume fan is required to deliver in cu. ft. per min.	* Static pressue in inches of water required to force air through green hops			Total heat required in Btu. per min.	Total effective heating surface required in sq. ft.	Drying time in hours		
		24 in. depth of green hops	36 in. depth of green hops	42 in depth of green hops			24 in depth of green hops	36 in depth of green hops	42 in depth of green hops
35	24,200	0.24	0.31	0.34	33,800	582	8.5	12.7	14.8
50	34,600	0.32	0.50	0.59	48,300	825	7.3	11.0	12.8
70	48,500	0.48	0.71	0.92	67,600	1,160	5.2	7.8	9.1

Computed for outside air at 60° F. dry bulb and 50 % R. H. and based on a furnace output of 3500 Btu/sq. ft./hr.

* Allowance should be made for the additional resistance encountered in forcing air through the heating plant and duct work.

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HOP DRIER

OREGON	NUMBER 5.8	SHEET 1 OF 4

DESIGNED BY
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NOTE: IMPORTANT
PROVIDE SAFETY DEVICE TO SOUND WARNING & SHUT OF BURNER WHEN AIR TO FURNACE IS INSUFFICIENT

ALTERNATE #2:
METAL ROOF, ASPHALT PAPER AND CLOSED SHEATHING

ALTERNATE #1:
METAL ROOF WITH OPEN SHEATHING CEILED WITH CEMENT ASBESTOS BOARD

$\frac{1}{4}$" MESH SCREEN
2x6 PLATE
2x8 - 2'-0" O.C. 16'-0" LONG
2-2x8 STRUTS WITH BLOCK SPACER BETWEEN, 4' O.C.
12
7
2-2x8
2x8-2'-0" O.C. 20' LONG
PARTITION CEILED WITH CEMENT ASBESTOS BOARD
FOLD UP DOOR
CLOSE CORNICE WITH $\frac{1}{4}$" MESH SCREEN TO KEEP OUT BIRDS
15'-0"
8x8 PRECAST LINTEL
$\frac{3}{4}$" PIPE RAIL
4" CONCRETE SLAB, $\frac{3}{8}$" DEFORMED RODS 2$\frac{3}{4}$" BELOW SURFACE SPACE 5" O.C.
ALTERNATE RODS BENT UP AT SUPPORTS
$\frac{3}{8}$" TEMPERATURE RODS 14" O.C.
3'-0"
8'-8"
1x2-1$\frac{9}{16}$ O.C. WITH BLOCK SPACERS OVER JOISTS
2x8-2'-0" O.C.
8x5$\frac{1}{4}$ WF 17 lb I BEAM
WELD
8x8x16 BLOCKS
8x8 PRECAST LINTEL
4" PIPE FILLED WITH CONCRETE
12'-8"
FOR FURNACE & FAN SPECIFICATIONS SEE EXPERIMENT BULLETIN "INVESTIGATIONS IN DRYING OREGON HOPS" OR SHEET #1 OF THIS PLAN
13'-0"
12'-0"
8x16 PILASTER SEE PLAN VIEW
8x12 PRECAST LINTEL
HOT AIR PASSAGE
3'-4"
GRADE LINE
$\frac{3}{8}$"x6"x6" IRON PLATE WELDED TO PIPE
3-2x8
2x8 PLATE 16" LONG
6"x2" CHANNEL IRON WELDED TO PIPE
3" PIPE FILLED WITH CONCRETE
8x16 PILASTER SEE PLAN VIEW
CONCRETE - 4"
4"
GRAVEL - 5"
$\frac{3}{8}$"x6"x6" IRON PLATE WELDED TO PIPE
1'-2"
2'-0"
1'-8"
FURNACE ROOM
KILN
0'-8"
20'-0"
1'-0"
26'-0"
75'-0"

FIT WITH CURTAIN OR PANEL DOOR IF THIS OPENING FACES STORM WINDS
2 x 6 - 2'-0" O.C.
2x8 - 2'-0" O.C. 14' LONG
2x8 COLLAR BEAM 4' O.C.
2x8 PURLIN
12
6
2x8-2'-0" O.C. 20' LONG
METAL ROOF WITH OPEN SHEATHING
$\frac{1}{4}$"MESH SCREEN
2x8 PLATE
8x8 PRECAST LINTEL
15'-8"
8x8 PRECAST LINTEL
2x4
EQUAL ANGLES
2x4
2x6
2" PLANKING
14'-0"
8x16 PILASTER SEE PLAN VIEW
CROSS BRIDGING
1" FLOORING
BLOCK BRIDGING
8x8x16 BLOCKS
2x4 PLATE
2'x8
3-2x8
8x12 PRECAST LINTEL
NOTE: 8x16-6'-0" HIGH PILASTERS UNDER ENDS OF BEAM, SEE PLAN VIEW
7$\frac{1}{2}$"
9$\frac{1}{2}$"
6x6
4"
6'-8"
8x12x16 BLOCKS
2'-0"
2'-0"
2'-0"
BALING ROOM
1'-0"
25'-4"
1'-0"

CROSS SECTION A—A'

SCALE: 0 1' 2' 3' 4' 5' 6' 7' 8'

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