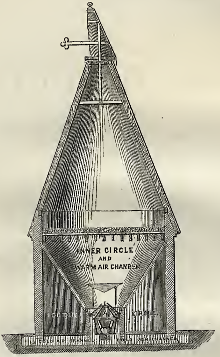
HOP KILN AND EVAPORATOR.



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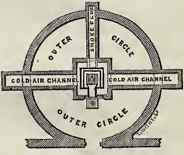

PLAN.

OBSERVATIONS

ON

HOP DRYING;

BEING

AN ATTEMPT TO REDUCE THE DIFFERENT MODES NOW IN USE
TO A GENERAL SYSTEM:

WITH

A DESCRIPTION OF A NEW AND
ECONOMICAL APPARATUS,

BY

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The art of drying hops has made a marked advance within the last few years. There has been an amount of emulation amongst landlords and tenant farmers, in regard to the construction of their oasts, which has led to the happiest results.

A comparison of the form of kiln now generally adopted, as compared with those in use five-and-twenty years ago, will convincingly demonstrate, not only the necessity which existed for improvement, but also the skill and science with which that improvement has been effected. Generally speaking nothing much better could be devised as to form and proportions, than the kilns which have recently been erected in the Hop growing districts.

In reference also to the apparatus used in the process of drying, the same desire to introduce the best has exhibited itself; and if the grower had in this case equally certain data to guide him, with those which determine the form and construction of the building, little more would be requisite.

Unfortunately, however, the various kinds of apparatuses which have been introduced, or recommended, have generally been based upon no scientific appreciation of the object to be obtained; and the application of them has frequently been a cause of expense, disappointment and failure.

So far as mechanical inventions have been applied in aid of the dryer, little benefit has ensued; and it may not unfairly be said that nothing really better than the old fashioned and expensive open fire of coke or charcoal is generally known.

A great number of private individuals, largely interested in drying better, cheaper, or more quickly, have continued to bestow unfailing attention to the subject, and in many instances with decided success. Upon a comparison of the results obtained with the various modes in which they have been effected, one is struck with the great dissimilarity of means used. While one grower has used an open fire with or without an inner circle, another has attained to equal success with a tunnel kiln and furnaces, while a third has the most convincing reasons for recommending the use of a cockle.

To account for the success which has attended the use of modes so various, one must search, not for the points in which they differ one from the other, but for the circumstances in which they all agree; and upon examination of the best examples, and a careful comparison of the different descriptions of oasts, which have been laid before the public, it is impossible to fail to recognize, in the liberal introduction of air into the kiln, that circumstance which has largely influenced success.

Adopting this proposition as the basis of a successful system of Hop Drying, it is proposed, from previously recorded observations, to eliminate such general principles as may appear to be of universal application, and to pursue the inquiry into the details of the arrangement, as affecting the proportions and dimensions of the kilns and the construction of the furnaces.

Hop-drying is a process of desiccation, of which the object is to drive off the superfluous moisture from the hops. There are two familiar modes of drying anything—one by exposure to the wind or a current of air, and the other by exposure to a high temperature in comparatively still air. By either method moist bodies may be deprived of their moisture, and the drying accomplished. The completeness of the process, and the time in which it is effected, is, however, dependent upon the circumstances under which it is performed. We know that a hot wind, generally speaking, dries more quickly than a cold one; that is, of two currents of air of equal velocity, that which has the highest temperature will absorb moisture from any substance over which it passes more rapidly than the cooler current will; that is, always supposing that the hygrometric conditions are the same. It is not, however, so generally apprehended that the converse of the above proposition is also true, and that, with equal temperatures, that substance over which most air passes in a given time will part with a larger portion of its moisture. The application of the latter principle has been illustrated in low-temperature drying, which seems to have been managed by introducing a considerable quantity of external air into the space beneath the hair, by knocking holes in the external walls. Experiments of this sort, where they had answered, had been held to be conclusive as to the superiority of low-temperature drying. This, however, is not exactly the case, because as much heat would pass through the hops as before, as long as the fires were kept up as usual; and the true explanation of the circumstance is that the improved drying is due to the larger quantity of air passed through the hops, rather than to the temperature being reduced. If the fires had been lessened, the temperature might have been lowered as much as was done by the admission of cold air; but in that case the hops, instead of drying better, would have been found not to dry so well as at the higher temperature. Treating hops simply as a substance from which a given quantity of moisture is to be evaporated, that object would be most speedily effected by admitting as much air as possible at the highest attainable temperature. The peculiar properties of the hop were, however, said to depend upon the lupulin—an extremely light matter about the roots of the leaves—which became very liable to be disengaged in handling, if the hop were dried above a certain temperature. It only remained, then, to fix upon the temperature at which the kiln (so to speak) should be pitched, and then the problem to be solved would be, how much air at that temperature would be necessary to dry a given load of hops? The tendency of recent improvements in the construction of oasts has been to introduce a larger supply of air to the lower part of the kiln. Where this has been done, even with old kilns, it has been found that the hops were better dried, although the old fires or cockles may have been retained. The resolution of a meeting, at the Maidstone Farmers' Club, at which the subject was discussed, puts the matter in a very clear light. It states that "Open fireplaces without any inner circles, inner circles with one or more fireplaces, and cockles with flues, have been found to answer very well in different kilns, but that in all cases, it is indispensable that a large quantity of external air be freely admitted to the space beneath the hair."

The questions then which remain for consideration are,—1st. The quantity of air necessary to be admitted. 2nd. The mode of its admission. 3rd. The method of heating the air. 4th. The proportion and construction of the kiln necessary to give full effect to the above arrangements.

1st. The quantity of air to be admitted is dependent upon the temperature at which the drying is to be conducted, and upon the weight of moisture to be evaporated. Air at various temperatures has an ascertained capacity for moisture. When fully saturated,—

Air at	32 deg.,	contains	1-160th part its weight of water.	
,,	59	,,	1-80	,,
,,	86	,,	1-40	,,
,,	113	,,	1-20	,,
,,	140	,,	1-10	,,
,,	167	,,	1-5	,,
,,	194	,,	2-5	,,
,,	221	,,	4-5	,,

The capacity of air for moisture being doubled by each accession of 27 degrees of Fahrenheit. If, then, we desire to know what quantity of air should be admitted to carry off a given weight of moisture at any of the above-named temperatures, we have only to multiply the weight of moisture by the increased capacity for moisture due to air raised from the temperature of the external atmosphere to that of the kiln. Supposing the weight of water to be evaporated to be 7 cwt., the temperature of the external air 59 degrees, and that of the kiln 113 degrees, 186 cwt. of air would be required to carry off this quantity of moisture. About 13 cubit feet of air weigh a pound, and rather more than 270,000 cubic feet of air must therefore be passed through the kiln during the time of drying. If we suppose this operation to be continued for ten hours, this will give 27,000 feet per hour, or about eight feet per second. To allow of the passage of so large a quantity of air, the openings for its admission must be of a corresponding area. Allowing a velocity of a foot per second to the entering air, we shall find that the openings for the admission of external air must altogether have an area of not less than eight feet. In practice, it is found desirable to have a larger proportion of openings than the theoretical quantity; because those on the leeward side of the kiln will often be rendered useless for the admission of air. In drying at higher temperatures, a less quantity of air will suffice. Thus at a temperature of 133 degrees, only half the above openings would be necessary. The actual quantity of moisture to be evaporated from the hops at different times is of course very variable, depending upon the ripeness of the plant, the state of the weather, etc.; but as it is better to admit too much air than too little, it would be well to adopt something like the following proportions of openings:—

6	feet superficial	for a	16	feet kiln.
8	,,	,,	18	,,
10	,,	,,	20	,,
12	,,	,,	22	,,

2nd. The mode of admitting the air is a very important consideration. A number of instances may be referred to where, in kilns previously constructed without any external opening, great benefit has been derived by making holes in the external walls communicating directly with the space under the hair. This position of the fresh air openings appears, however, objectionable for the following reasons. 1st. The cold air does not readily mix with the heated air, and if a moderate temperature only is required, it would be much better to heat all the air to the proper temperature than some of it too much and some not at all. 2nd. That through the external openings, the interior of the kiln becomes affected by the wind, causing the current of warmed air to be diverted to one side or other of the loading, which is thus dried unequally. When the kilns are constructed with an inner circle, the above objections need not apply, because, in that case, the additional quantity of air admitted through the external openings might be permitted to pass up between the brickwork of the fires, and so become partially warmed. The best plan, however, for admitting the necessary quantity of fresh air is to make underground channels of adequate size, communicating with the external air by openings anywhere about the outside of the kiln. The underground channels should all be conducted to the place where the fire is fixed, and their apertures should be so contrived as that the air brought in by them should impinge upon the heated substances which compose the sides of the fireplace, whether of metal or of brickwork. It is not necessary that the fire should derive its supply of air from the same source, as in certain arrangements —such, for instance, as a coal fire, it may be necessary to adopt another plan. It has already been intimated that the openings for the admission of fresh air should be made, as much as possible, independent of the direction of the wind. It is better, therefore, that they should not be on one side of the kiln only, but as much as possible dispersed about its exterior.

3rd. The method of heating the kiln has been generally regarded as the most important point connected with hop-drying. Like many other matters upon which much uncertainty exists, an undue prominence has sometimes been given to particular methods:—arrangements which have been found to answer very well in some cases, have failed to give satisfaction when copied in other places, their success being due often not so much to this or that special contrivance as to the circumstances under which they were applied. In the foregoing remarks upon the quantity of air necessary to be admitted, and on the mode of its introduction, some of the preliminaries to success have been adverted to, and these we must suppose to be adopted, as, failing attention to them, the best arrangements for heating the air may disappoint expectation. It has been already remarked that it is much better to heat a large quantity of air to a low temperature, than to overheat a part and then cool it down by the introduction of cold fresh air. The mode of heating a large quantity of air to a low temperature is a problem which has been repeatedly solved. The requisite conditions are, that the heating surfaces should be largely extended, and that the contact of the air currents with the heated material should be perfect over the whole surface. Where the former of these conditions does not obtain, a large quantity of air cannot be heated; and where the latter does not exist, the overheating of the material and consequent burning of the air can hardly be avoided. In speaking of extension of surface, it should be explained that such extension is spoken of relatively as compared with the surfaces upon which combustion takes place. In an open fire, the heating surfaces are nearly as the area of the fire bars—in a common cockle they may be estimated as about 2-2½ to 1—and in the improved stove, or evaporator, they are as about 30 to 1.

The peculiarities in the construction of the improved stove are—1st. The situation of the fire in the centre or heart of the stove at a distance from the outer surfaces, which cannot therefore become overheated to the extent that takes place where the fuel is in direct contact with the sides. 2nd. The exceedingly small size of the firegrate as compared with the area of the fire bars, either of open fires or of ordinary cockles, and the consequent diminution in the consumption of fuel. It has been stated upon competent authority that the cost of drying hops by ordinary cockles was about 10*d.* per cwt., as compared with 3*s.*, where open fires and charcoal were used. By the improved stove, the loading of a sixteen-feet kiln might certainly be dried with one cwt. of coals. 3rd. The more perfect combustion of the fuel effected by lining the furnace with fire-brick and the higher temperature thereby induced have much to do with the efficiency of the stove. Not only does less of the fuel escape unconsumed, but the gases generated during combustion have a higher temperature, and consequently have more heat to give off through the sides of the cockle. 4th. The internal construction of the stove is such that almost all the useful effect of the fuel is absorbed before the smoke and gases leave the body of the stove. In the first place, we have in the pyramidal top a very large surface exposed to direct radiation, and the flame and smoke being compelled to turn over the upper edges of the fire-box and to descend between it and the outer casing, a large portion of heat is imparted to the sides of the stove. The smoke then continuing its descent, heats the bottom of the stove, and the outlet flue upon which the stove rests. The heat of the smoke is thus so thoroughly exhausted, that with well-managed fires the temperature of the bottom of the stove does not exceed that of boiling water. There is therefore no necessity for any horizontal flue beyond that required for connecting the stove to the chimney; and this portion of the flue will generally be underground. The common cockle being heated entirely by radiated heat, absorbs none of the heat from the smoke, which would escape at a very high temperature if a further portion of caloric were not abstracted from it in its circuit of the horizontal flues. 5th. The external construction of the stove is the feature by which its efficiency is mainly developed. Besides the opportunity afforded to the air to abstract heat rapidly, from the large extension of surface, the course of the air from the point at which it first comes in contact with the stove to the point at which it leaves it, is accurately prescribed, and a perfect contact of the particles of the air with every portion of the heated surface positively ensured. The channels by which fresh air is admitted are brought in under the bottom of the stove, so that the cold air first impinges upon the outlet flue and the bottom of the stove, which are the coolest parts of it. The rapidity with which heat is communicated by heated bodies to the air is dependent upon the difference in the temperature of the heating surface, and of the air to be heated. If then the fresh air have a temperature of 60 degrees, and that of the bottom of the stove be 200 degrees, the difference will be 140 degrees; and assuming that with this difference the iron parts with its heat to the air at the rate of 10 degrees per minute, we shall find that this part of the stove is twice as effective as if the flue were taken off from the top, when supposing the flue itself to have the same temperature, the difference between it and the air would not be more than 60 degrees, and the comparative rate of cooling would be only about 4 degrees per minute. The principle of bringing the air as it becomes warmed, in successive contact with still more highly-heated portions of the stove, is pursued throughout. The sides of the stove are surrounded by a brick wall, at a distance of about 6 inches from the stove at the narrowest part. This wall confines the air in its ascent, pressing it as it were against the sides, which are made to overhang, in order to give more perfect contact. On reaching the upper part of the side channels the current of warmed air is deflected by inclined cast-iron plates, and made to traverse the pyramidal top of the stove, where it receives its last portion of heat, and then escapes upwards through the tubes with which the deflecting plates are perforated. From this description it will be understood that every particle of the air receives its share of heat, and that every inch of the surface of the stove is in turn exposed to the cooling effect of the passage of a current of air over it. None of the radiant heat of the fire, or of the top of the stove, is thrown upwards to the air, and the hops, therefore, cannot be over dried or caked. In fact the drying of hops by this process is simply effected by the passage through them of a very large body of mildly warmed air, which takes up their moisture in the most gentle and gradual manner. There being no local admission of air, and no disturbance of the internal atmosphere of the kiln by cross currents of wind, the hops will be dried equally all over the floor, and, if the loading be not too thick, without any necessity for disturbing or turning them during the process of drying. Means of a simple description are provided in the stove for regulating the draught and sweeping the flues. The brimstone is burnt in a pan or sublimer upon the top of the stove. The use of a little separate furnace for this purpose has been suggested, and, with some constructions of kilns, would answer very well. In point of durability the stove has the advantage of every description of furnace or cockle, because the metal never becomes burnt; and the only repair requisite is the occasional renewal of the fire bars.

In adapting old kilns for these stoves, little alteration is necessary. It will always be requisite to make air channels of a size proportioned to the diameter of the kiln. The exact position of the channels will of course depend upon the arrangement of the buildings. If the kiln have already an inner circle, it will generally only be necessary to put the stove in place of the fires. If a tunnel kiln, the stove should be placed as near as possible to the centre of the kiln, and the tunnel continued up to the front of the stove. If the kiln have had only open fires, the stove should be fixed in the centre, and a tunnel constructed from the doorway to the front of the stove, or an inner circle may be made from the walls surrounding the stove to the outer walls under the hair. In all cases, it is better that the thoroughfare for the supply of fuel to the stove should be entirely isolated from the space beneath the hair, in order that no air may reach the hops but what is supplied through the stove.

In constructing new kilns, there are some points which it is desirable to bear in mind. Certain proportions for the fresh air, apertures, and rules for calculating them, have already been stated. The height of the upper part of the kiln and the diameter of the opening at the cowl are matters of importance, and they must be regulated with reference to the quantity of air and vapour to be discharged in any given time. Having ascertained the quantity of air necessary to evaporate the moisture contained in the hops, divide this amount by the time over which the drying has to be continued in seconds, for the quantity to be discharged per second; and this amount again divided by the velocity due to the temperature, and the height from the hair to the cowl, will give the area of the opening at top theoretically. The velocity of efflux is found by multiplying the difference in temperature between the interior of the kiln above the hair and the external atmosphere, by the height from the hair to the cowl; and, dividing this product by 480, the square root of the quotient multiplied by 8 will be the velocity in feet per second. By this rule, it will be seen that the greater the height from the hair to the cowl the smaller the opening at top may be, and *vice versâ*. In practice, however, it is desirable to allow at least 50 per cent. for retardation by friction, etc., which will be found to agree very nearly with the proportions in ordinary use—viz., an opening about one-seventh the diameter of the kiln, with a height above the hair equal to $1\frac{1}{2}$ times the diameter.

It is desirable in building kilns to use every precaution to prevent the loss of heat by radiation to the surrounding atmosphere. This may be effected by building the external walls hollow, or with hollow bricks. An inner circle answers nearly the same purpose if there is a door to shut off the communication with the shed, and no openings through the external walls. The roofs should also be plastered with lime and hair under the tiles before the inner plastering is done. Attention to this point and to carefully stopping all air passages at the foot of the rafters, will prevent the condensation of the reek upon the interior of the kiln.

By the adoption of the above precautions, in addition to the introduction of the recent improvements in the form and proportions of kilns, and the use of the improved stove, hops may be dried at much less cost, in a superior manner, and, if need be, in less time than by any of the present methods ; the process of drying, hitherto so uncertain, may really be judged of by fixed rules, and the grower may so construct his kilns as to dry at any temperature, and almost in any time, that he may consider best.

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