

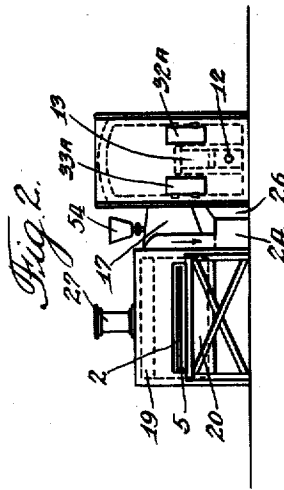
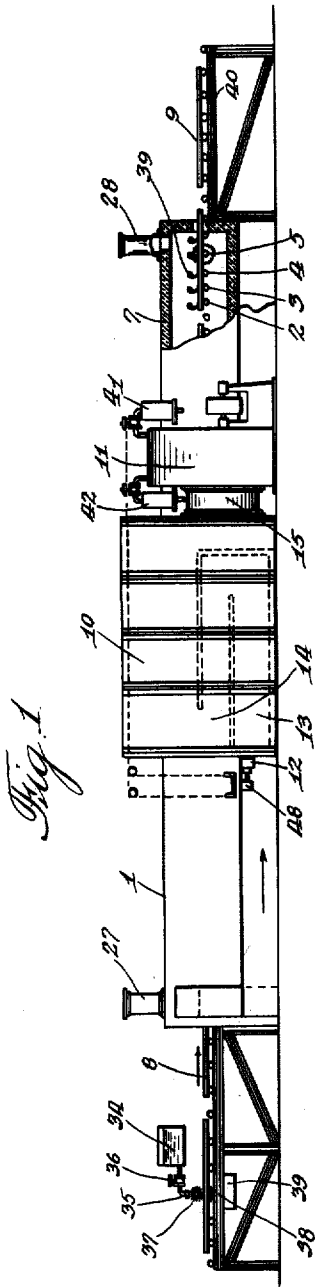
Nov. 8, 1938.

W. A. DARRAH

2,136,166

DRYING APPARATUS

Original Filed Oct. 15, 1930 2 Sheets-Sheet 1



*Inventor:*  
*William A. Darrah*  
*By John Addington, Am & Sebald*  
*Attys.*



# UNITED STATES PATENT OFFICE

2,136,166

## DRYING APPARATUS

William A. Darrah, Chicago, Ill., assignor to  
United States Gypsum Company, Chicago, Ill.,  
a corporation of Illinois

Original application October 15, 1930, Serial No.  
488,852. Divided and this application April 25,  
1935, Serial No. 18,133

12 Claims. (Cl. 34—12)

This application is a division of my application  
Serial No. 488,852, filed October 15, 1930, now  
matured into Patent No. 2,000,663, issued on  
May 7, 1935, which said application was in part  
a division of application Serial No. 361,920, filed  
May 10, 1929, for Process of drying materials and  
apparatus therefor.

The present invention relates to equipment and  
appurtenances for the drying of materials and is  
particularly applicable to such objects as boards,  
sheets, plates and similar flattened shapes in  
which the ratio of surface to volume is very  
great. Some of the objects of this invention are  
to provide economical, simple and efficient means  
for drying such articles as wallboard, insulation  
board, veneer, paper, cloth and similar materials  
without damage. Another object of this inven-  
tion is to carry on drying, economically, rapidly  
and without discoloration of the material being  
dried.

This invention provides simple, continuous and  
automatic means for accomplishing the above re-  
sults. Other objects of this invention will be  
apparent from a perusal of the drawings, specifi-  
cation and claims attached hereto.

Referring to the drawings:

Figure 1 shows a side elevation partly in sec-  
tion of one form of my device;

Figure 2 shows a vertical section of one form  
of my device; and

Figure 3 shows a plan view partly in section  
of one form of my device.

Referring to the drawings, 1 indicates a hous-  
ing or container through which the material to  
be dried is conveyed. 2, 3 and 4 indicate several  
of a series of conveying rolls for moving ma-  
terial through my device. In place of the rolls  
shown, I may use any desired form of conveyor  
mechanism such as a series of chains, or other  
commonly known mechanism. The rolls 2, 3 and  
4 indicated may each be driven by a sprocket as  
indicated at 5, over which a continuous length of  
chain 6 is passed, serving to keep the above rolls  
in continuous movement at uniform rate and in  
the same direction. These constructional details  
form no fundamental part of my invention and  
are merely illustrated to make clear one form of  
mechanism which I have found convenient to  
use.

Housing 1 is preferably insulated with heat  
retarding material 7, formed in a shell or cover  
around housing 1. Reference numeral 8 indi-  
cates a board about to enter my device and 9  
represents a board leaving my device, the direc-  
tion of travel being indicated by the arrow on

the board. A heating means is shown diagram-  
matically at 10 connected to a fan or gas moving  
device 11. The heater may consist of an en-  
closed shell of steel or other material properly in-  
sulated and arranged to burn a desired fuel such  
as gas, oil, coke, coal, etc. I prefer to use gas  
or oil, although in many cases powdered coal or  
other fuels may be employed to advantage by  
reason of the lower cost. The exact details of  
construction of my heater are not of particular  
importance in this case, although I prefer an  
arrangement in which the fuel is supplied by  
means of a burner 12. Burner 12 mixes the  
fuel with air and delivers it to a combustion  
chamber 13. The products of combustion leave  
chamber 13 by means of an outlet 14 and enter  
mixing chamber 15 between fan and combustion  
chamber. The fan, which may be of any com-  
mercial type, is driven by a motor or equivalent  
indicated by 16 and serves to maintain a sub-  
stantially continuous circulation of drying gases  
and products of combustion through the system.  
The gases leaving fan 11 pass through discharge  
duct 17 and enter drier housing 1, where they  
are distributed by a series of nozzle ducts 18,  
19, 20 and 21 arranged substantially symmetri-  
cally. These distributing ducts serve to direct  
the flow of hot gases toward each end of the de-  
vice, as shown by the arrows. The hot gases  
travel over the material being dried, preferably  
both above and below it, although if desired, on  
one side only. The circulating gases return  
through openings 22 and 23 to return ducts 24  
and 25 which lead to duct 26, where they are  
mixed with additional products of combustion  
and pass through the equipment again. If de-  
sired, vent stack 27 and 28 may be placed on  
the equipment preferably near the ends and pro-  
vided with dampers for exhausting a portion of  
the moist gases.

In certain cases where the permissible tem-  
peratures are low, I may exhaust the gases en-  
tirely at the ends of the equipment instead of re-  
turning them to be reheated. In other cases, I  
may pass the circulating and drying gases in one  
direction only, these being details subject to  
practical operating conditions.

A tank or container 34 for liquid is arranged  
above the entrance portion of the drier and con-  
nected with a discharge duct 35 controlled by a  
valve 36 in such a manner as continuously to de-  
liver liquid to the rotating distributor 37 which  
rubs or brushes the surface of the article 8 being  
dried. A similar brush or roll 38 supplied with

liquid from a reservoir 39 serves to apply liquid to the underside of the board.

This equipment is particularly applicable to those installations in which the drying process is carried to substantial completion within the drier and in which the operating temperatures exceed 212° F. In these cases the discoloring effect of sulphur and other acids is particularly marked. This equipment is also of great importance in those cases in which the products of combustion are recirculated either all or in part, being reheated and delivered back to the drier.

Instead of applying the neutralizing liquid from tank 34 onto the sheets or boards being treated, I may neutralize the effect of the acid by adding directly to the circulating gases a proper material for absorbing or combining with the acid gases. This result may be accomplished by spraying into the discharge of circulating fan 11 or introducing into the intake 15 of said fan a finely powdered material such as soda ash, lime, etc. I prefer to use slaked lime, although quicklime will accomplish a similar result but apparently slightly less effectively. I have found that ammonia is particularly effective, and I may also spray a solution of caustic soda, soda ash, ammonia, etc.

The material should be so added as to become distributed fairly uniformly through the circulating gases prior to the time that they come into contact with the material being treated.

According to tests which I have made, the addition of the neutralizing material to the gases does not result in wholly neutralizing the sulphur in the gases. It appears, however, that the materials added collect in part upon the sheets which are passing through the drier and in this manner serve to neutralize the acid fumes in the circulating gases at the time that the fumes approach the sheets. I have made tests of the gases taken from the system when the neutralizing effect on the sheets was quite complete and have found that the gases still give ample evidence of a large acid content. In the case of adding a solid material in quantity, such as hydrated lime, soda ash, etc., a certain amount will collect and leave the drier with each sheet. This is somewhat troublesome in some cases, and in order to overcome this difficulty I have provided a series of scrapers or brushes 39 to remove the excess of material. I may also add to one of the rolls on the discharge end of the drier, as for example 40, a cushion or scrubber made, for example, from a strong fabric. This will serve to remove the excess of neutralizing material from the under side of the sheet.

41 indicates a tank or container for holding the alkaline material, as for example liquefied ammonia. 42 represents a similar tank. Tanks 41 and 42 are connected by ducts 43 and 44 respectively to the air ducts entering the drier 1. As an alternative arrangement, duct 26 is shown leading from tank 42 to the intake of fan 11.

Ducts 43 and 44 are provided with control valves 45 and 46, respectively. These valves make it possible to control the relative amounts of neutralizing material delivered into the ducts. Oil burner 12 is provided with a control valve 48 which may be automatically or manually operated as required. Valve 48 is mechanically interlocked with valves 45 and 46, so that the opening or closing of valve 48, thus delivering more or less fuel to heater 10, will automatically deliver more or less neutralizing agent to the drier 1. This mechanical interlocking is indicated dia-

grammatically by the cables 50 and 51, although obviously any similar mechanical expedient may be employed. The lines indicating the dotted cable 52 and 53 show a familiar method of control in the alternative case in which the neutralizing material is added into the intake 15 of fan 11. Obviously, in most cases, either one or the other alternative would be employed, as it is unnecessary to use the two.

In Figure 2 I have shown an alternative arrangement in that hopper 54 delivers a supply of powdered material to the circulating gases. Hopper 54 may be controlled automatically as to volume if desired. Hopper 54 indicates a simple method of adding finely divided solids to the circulating gases, accomplishing substantially the same result as in the case of adding atomized liquids or gaseous ammonia.

In most cases I prefer to use gaseous ammonia, as I have found that very much smaller amounts are required to accomplish proper neutralization. Furthermore, the products which result from the neutralization when ammonia is used consist essentially of ammonium sulphate and sulphite. These substances appear under ordinary conditions as very fine powders whose quantity is so small as to be substantially unimportant. In many instances, therefore, when gaseous ammonia is used to neutralize the acid conditions, it is unnecessary to remove the resultant solid, and in most cases a small air blast directed onto the sheet will readily remove all traces of this substance. By way of example, I have found that when drying gypsum wallboard with this system, and burning in the neighborhood of from forty to sixty gallons of fuel oil per hour, it is advisable to use between fifteen and twenty pounds of slaked lime per hour in case the oil contains around 1/2 of 1% of sulphur.

The same result may be obtained by using between one-half pound and one pound of liquid ammonia (gasified). While the liquid ammonia costs inherently much more than lime, the ease of handling it and applying it, the smaller amount of residue and the elimination of the necessity for cleaning, usually make the ammonia a more economical material.

Owing to the inherent expense per pound for ammonia, it is advisable to apply only the amount required to neutralize the acid conditions resulting from the fuel. In some cases, the use of a large excess of ammonia causes a difficulty, in interfering with the sizing of the sheet or board, influencing color, etc. It is therefore highly desirable, for reasons of economy and also in order to obtain the desired quality of product, to proportion roughly the amount of neutralizing material added to the amount of sulphur delivered. Under any given set of conditions, this would mean that the amount of neutralizing material should be varied roughly with the amount of fuel delivered to the heater, since with a constant grade of oil the amount of sulphur will vary with the amount of fuel burned.

I therefore have found it to great advantage to provide automatic means as shown for varying the amount of neutralizing material with the amount of oil.

It is to be understood that the ratio should be held substantially constant under any set of conditions but that a different ratio is required for different sets of conditions. For example, if the ratio proves to be correct when one pound of ammonia is added to the circulating gases for each sixty gallons of oil burned,

assuming the oil to contain one-half of 1% of sulphur, then if the oil should contain 1% of sulphur the amount of ammonia required would be at least twice as great, or two pounds per each sixty gallons burned. In either case, the ratio should be held constant when burning varying amounts of oil having the same sulphur content.

I have further found that the amount of neutralizing material required is greater when operating at higher temperatures than when operating at lower temperatures, independent of the amount of sulphur contained in the oil or the amount of oil burned. As a theory, I account for this difference as being due to the much more rapid action of the sulphur acids at the higher temperatures.

Referring now to the operation of the equipment and process which I have invented, it should be understood that to dry satisfactorily boards and similar materials they should be subjected to a stream of warm gases. The maximum temperature to which the boards may be subjected varies of course with the nature of the material from which they are formed and various other factors. In the case of gypsum board, temperatures ranging from 300° to 400° F. are not unusual, while in the case of fiber or insulating board, temperatures as high as 500° to 600° F. are frequently permissible. It will be noted that at these temperatures the gases which convey the heat and remove the moisture are well above the dew point regardless of the amount of moisture carried by them.

I have found that drying may be accomplished satisfactorily when operating at the temperatures mentioned above with little regard to the amount of water carried by the circulating gases. In other words, an atmosphere consisting almost entirely of water vapor would form a very effective drying medium under these conditions. By returning the flow of circulating gases and reheating them, I am able to reduce materially the fuel requirements for a given installation. Further, by adding the products of combustion directly to the circulating gases, I avoid the so-called stack loss due to exhausting these products of combustion, which has hitherto been common practice. In general, therefore, I prefer to obtain my drying results by passing a continuous stream composed principally of air and water vapor but containing also a few per cent of carbon dioxide.

It will be obvious that since the products of combustion are mixed with the circulating gases and caused to pass continually in contact with the surface of the material being dried, any substance within the products of combustion which may have a tendency to attack or combine with the material being dried is likely to cause damage.

It is, of course, well known that ordinary fuel oil contains appreciable amounts of sulphur and in some cases sulphuric acid as well as other materials such as chlorides, etc. Under the conditions existing in the type of equipment here disclosed, any sulphur present will be oxidized to sulphur dioxide, which in contact with the moisture in the air and in the board will tend to form both sulphurous and sulphuric acid. Any sulphates present in the oil due to the neutralization of the acids used in refining, or due to the natural impurities, will tend to form sulphur trioxide when the oil is burned, which of course,

in contact with the moisture present, will normally form sulphuric acid.

I am emphasizing the effect of sulphur and using it to describe my invention because it is a common and marked condition and serves clearly to illustrate my invention. I do not, however, wish to be confined to means for neutralizing the effect of sulphur only, as under some conditions other materials may be equally troublesome.

I have found that when traces of sulphuric acid are present in the circulating gases, a portion of the acid is absorbed by the moisture on the surface of the material being dried, with the result that the surface of the material becomes decidedly acid.

As the drying progresses further, I have found that the water at the surface of the board is evaporated while the sulphuric acid produced is evaporated to a very much lesser extent. This, of course, results in the formation of a fairly concentrated acid on the surface of the material being dried. If the material being dried contains large quantities of organic material such as cellulose, starch, dextrine or other carbohydrates, the addition of heat will rapidly cause discoloration, which is usually objectionable, particularly in the case of drying wallboard, insulating board, gypsum board, etc.

I have found that a concentration of acid as little as three parts in one hundred will cause a dry sheet of paper, similar to that used in the case of gypsum wallboard, to become jet black when the temperature is raised to around 400° F. The same paper without the acid will withstand a temperature of 400° F. for a limited time without serious change of color.

When it is considered that most wallboards are used as building materials for finishing the interior of buildings and, therefore, are subjected to rigid purchasing specifications as to color, uniformity, etc., it will be appreciated that the effect of acid discoloration may be so serious as to render the product unsalable.

In order to overcome this difficulty, I have developed the equipment and process here disclosed. I have found that by adding to the surface of the board or sheet before it enters the drier a solution designed to neutralize the effect of the acid without discoloring the surface of the board or sheet, it is possible to dry rapidly at high temperatures with direct products of combustion under conditions which would otherwise be impossible.

A wide range of materials may be employed, depending upon the conditions which must be met.

In the case of neutralizing the effect of sulphuric acid on gypsum wallboard, I have found that by washing the surface in the manner disclosed in the drawings with a solution of calcium hydrate, calcium carbonate, caustic soda, sodium silicate, sodium carbonate, borax, soap solution, etc., the desired result may be obtained. It should be understood that it is not necessary to add all of the materials specified above, as any one will be effective if added in the proper portions. On the other hand, in some cases I have found that the addition of several materials mixed together in solution will give desirable results, as for example by the prevention of the formation of crystals in the surface of the board, etc.

It will be evident from the above that the essential feature is to add a material which will combine with and neutralize the acid condition, thus

maintaining a concentration of acid so low that it will not discolor the organic materials present at the maximum temperatures that the board or sheet is subjected to during the drying process.

It is, of course, desirable to apply the material to both top and bottom surfaces of the board, and while I have shown the material applied just prior to the time that the board enters the drier, it will be apparent, of course, that the material may be applied at any time prior to drying. Thus the material may be added in the manufacture of the board or sheet or, in the case of the gypsum wall-board, in the manufacture of the paper covering which is on the board.

I have found in commercial practice that it is entirely impossible to produce a commercially clean or salable board with certain grades of fuel, unless the surface of the board is previously treated in the manner here outlined:

Certain materials are more satisfactory than others as neutralizers. In the case of a gypsum wallboard a solution of lime in water is quite satisfactory, as the net result of the reaction is to produce calcium sulphate which is chemically similar to gypsum and which as produced in this process is a fine white powder not directly noticeable on the surface of the board.

Solutions of caustic soda when passed through a drier under the conditions here specified frequently form sodium carbonates which are in turn converted into sulphates by the action of the acid. Under some conditions, large amounts of sodium sulphate will form visible needles or crystals which are objectionable.

The addition of small amounts of sodium silicate or other gelatinous or colloidal materials will frequently prevent the formation of noticeable crystals on the surface of the board or sheet, and I consider as one of the decided advantages of my invention the use of a mixture of colloidal materials with the neutralizing compound, so that the resultant product does not form large or unsightly or otherwise objectionable crystals. Traces of soap solution will serve the same purpose under certain conditions, as will also the addition of small amounts of commercial borax.

It should be understood that there are many possible modifications of my invention without departing from the spirit of this disclosure.

While I have referred primarily to fuel oil as a source of heat and also the source of discoloration, it should be understood that other fuels such as gas, coal or coke will frequently give similar results. My invention, therefore, should not be confined to devices burning oil only.

While I prefer to practice my invention by returning the gases for further recirculation, as this method gives greater economy, it should be understood that in general the same conditions exist and the same results are obtained in case a stream of hot gases containing products of combustion is circulated through the drier and then discharged without employing the recirculating principle.

Obviously, many forms of driers may be employed, such as chain conveyors, oscillating mechanism, cars, etc., or the process may be employed in the so-called batch type of drier in which a load of material is placed in a chamber, dried and then removed. I prefer the type of roller conveyor disclosed in the drawings but do not wish to be confined to this type only.

I wish it to be particularly understood that I have not described all of the possible neutralizing materials, as such a list would be extremely lengthy. I have indicated the general class of

these materials, and those skilled in the art will readily select additional materials which will be effective. In general, any compound which actively combines with the acid formed will be effective.

In the case of some oil, large amounts of excess alkali are present, finding its way into the oil either in the refining process or when the oil is taken from the ground. Such an oil would, of course, require the addition of an acid substance before the board entered the drier, but such instances are relatively rare whereas the presence of large amounts of sulphur in fuels is becoming quite common.

I find it convenient to add additional air to the circulating gases and to the products of combustion by means of openings 30A and 31A which are controlled by doors 32A and 33A, respectively. Air drawn in at this point serves the purpose of cooling the combustion chamber of the heater and also dilutes the active materials which tend to attack the board. I have not found, however, that in most cases where a considerable amount of sulphur is present in the fuel, the addition of air in practical quantities will overcome the difficulties here described.

In order to give a specific statement of conditions encountered, I wish to state that I have found that fuel oil containing 4% of sulphur will occasion serious difficulties in certain classes of paper covered gypsum board, and this difficulty can be overcome by the proper addition of a water solution of the various materials mentioned above.

It is frequently possible to operate without the addition of neutralizing materials in case the amount of sulphur in fuel oil is one-half per cent or less. I do not, however, wish to be confined to any specific limitations as to quantities, as obviously these will vary widely with the temperatures used, nature of the material being dried, acid formed and other formations which must be determined in each individual case.

Having now fully described my invention, what I claim as new and wish to secure by Letters Patent is as follows:

1. An apparatus for drying materials which consists of a housing, means for passing material to be dried through said housing, a source of hot products of combustion, a device for circulating said products of combustion through said housing in contact with said material, and means automatically operable on the material for coating the surface thereof with an acid-neutralizing substance, and means for directing said substance from a supply to said coating means.

2. An apparatus for drying materials which consists of a housing, means for passing material to be dried through said housing, a source of hot products of combustion, a device for circulating said products of combustion through said housing in contact with said material, and means for treating the surface of said material being dried with an acid-neutralizing substance, said means being arranged to deliver said acid-neutralizing substance into the products of combustion prior to circulation in said housing whereby neutralization is uniform.

3. An apparatus for drying materials which consists of a conveyor, a housing, a source of hot products of combustion, a device for circulating said products of combustion through said housing, and means for coating the surface of said material being dried with an acid-neutralizing substance, said means being arranged to deliver said substance into the intake of said device for circulating.

4. An apparatus for drying material which consists of a housing, means for passing material to be dried through said housing, a combustion chamber, a device for circulating gases in contact with said material, a duct connecting said combustion chamber with said circulating device, a duct connecting said housing with said circulating device, and automatically operable means for applying an acid-neutralizing substance directly to the surface of said material before being dried.

5. An apparatus for drying materials which consists of a housing, a support for said material being dried, a source of hot products of combustion, a device for circulating said products of combustion through said housing in contact with said material, and means for neutralizing said products of combustion prior to circulation through said housing.

6. An apparatus for drying materials, consisting of a housing, a support within said housing for the material being dried, a combustion chamber, a burner device delivering fuel to said combustion chamber, a control device for controlling the amount of fuel delivered, a container for acid-neutralizing substance, means connecting said container for said acid-neutralizing substance with said drying apparatus, a device for controlling the amount of said neutralizing substance delivered, and means interlocking said fuel control device with the device controlling the delivery of said acid-neutralizing substance.

7. In a drier for articles consisting of or having a surface of cellulosic material the improvements which comprise a drier housing, means for passing combustion gases into contact with the material therein, means for conveying the articles through the housing, means for applying a neutralizing material to the surface of the articles prior to their exit from said housing, and means for removing some of said material from the surface of the articles after they are dry.

8. In a drier for articles consisting of or having a surface of cellulosic material the improvements which comprise a drier housing, means for passing combustion gases thereinto, means for conveying the articles through the housing, means

for applying a neutralizing material to the surface of the articles prior to their admission into the drier, and means for removing some of said material from the surface of the articles after they are dry.

9. In a drier for flat boards of building material the improvements which comprise means for conveying the boards into, through and out of the drier, means for applying an acid-neutralizing material to the surface of the boards before they encounter heated combustion gases which are circulating through the drier, and means for brushing neutralized and excess neutralizing material from the boards just prior to their discharge from the drier.

10. In a drier for articles consisting of or having a surface of cellulosic material, the improvement which comprises a drier housing, means for passing the articles therethrough, means for producing combustion gases, means for circulating said gases uniformly over the surface of said material, and means for constantly injecting into said circulating gases a sufficient flow of neutralizing agent to maintain neutralization of the acidic substances in said housing.

11. In a drier for articles consisting of or having a surface of cellulosic material the improvement which comprises a drier housing, means for passing the articles therethrough, a variable burner for producing combustion gases, means for circulating said gases uniformly over the surface of said material, and means variable in accordance with the variation of said burner for mixing with said gases a material capable of neutralizing acids contained in the gases.

12. In a drier for articles consisting of or having a surface of cellulosic material the improvement which comprises a drier housing, means for passing the articles therethrough, a burner for producing combustion gases, means for circulating said gases in contact with said material, means for injecting into said gases an agent capable of neutralizing the acidic substances of said gases, and means for varying the injection of said neutralizing agent relative to the amount of acidic substances in said housing.

WILLIAM A. DARRAH.