(No Model.) 6 Sheets—Sheet 1.

F. D. CUMMER.

DRYING APPARATUS.

No. 545,120. Patented Aug. 27, 1895.

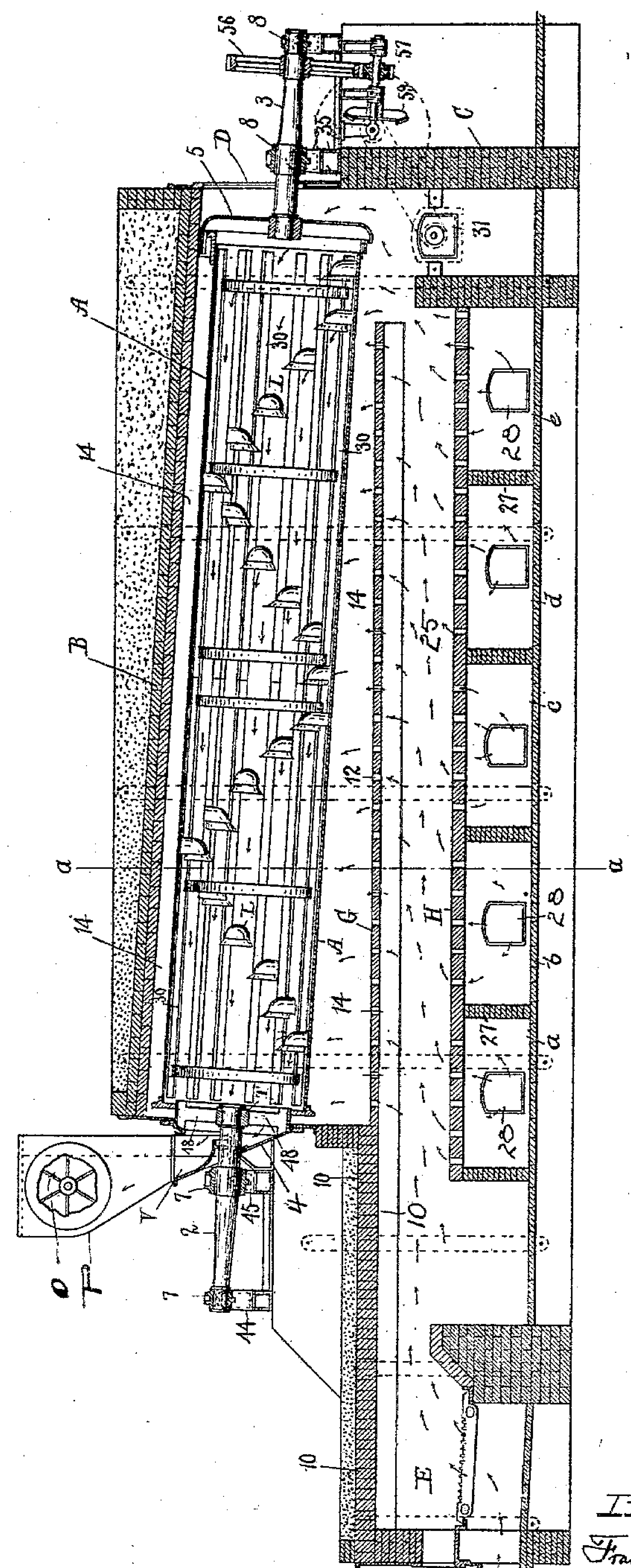

Fig. 1.

Witnesses.
Louis P. Abell.
W. B. Moser

Inventor.
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(No Model.)

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F. D. CUMMER.

DRYING APPARATUS.

No. 545,120.

Patented Aug. 27, 1895.

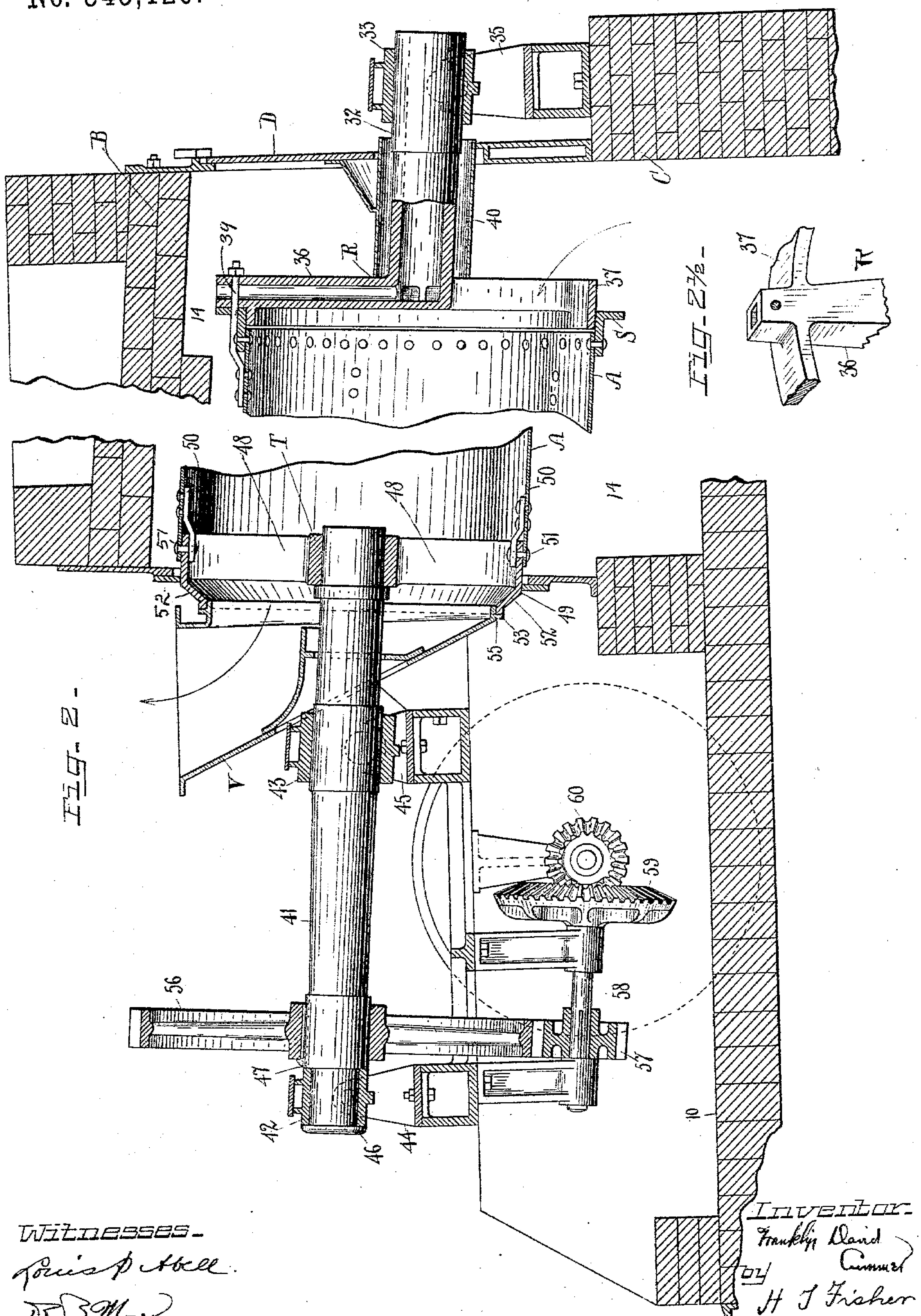

Fig. 2½.

Fig. 2.

Witnesses.
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(No Model.)

6 Sheets—Sheet 3.

F. D. CUMMER.

DRYING APPARATUS.

No. 545,120.

Patented Aug. 27, 1895.

Fig. 3.

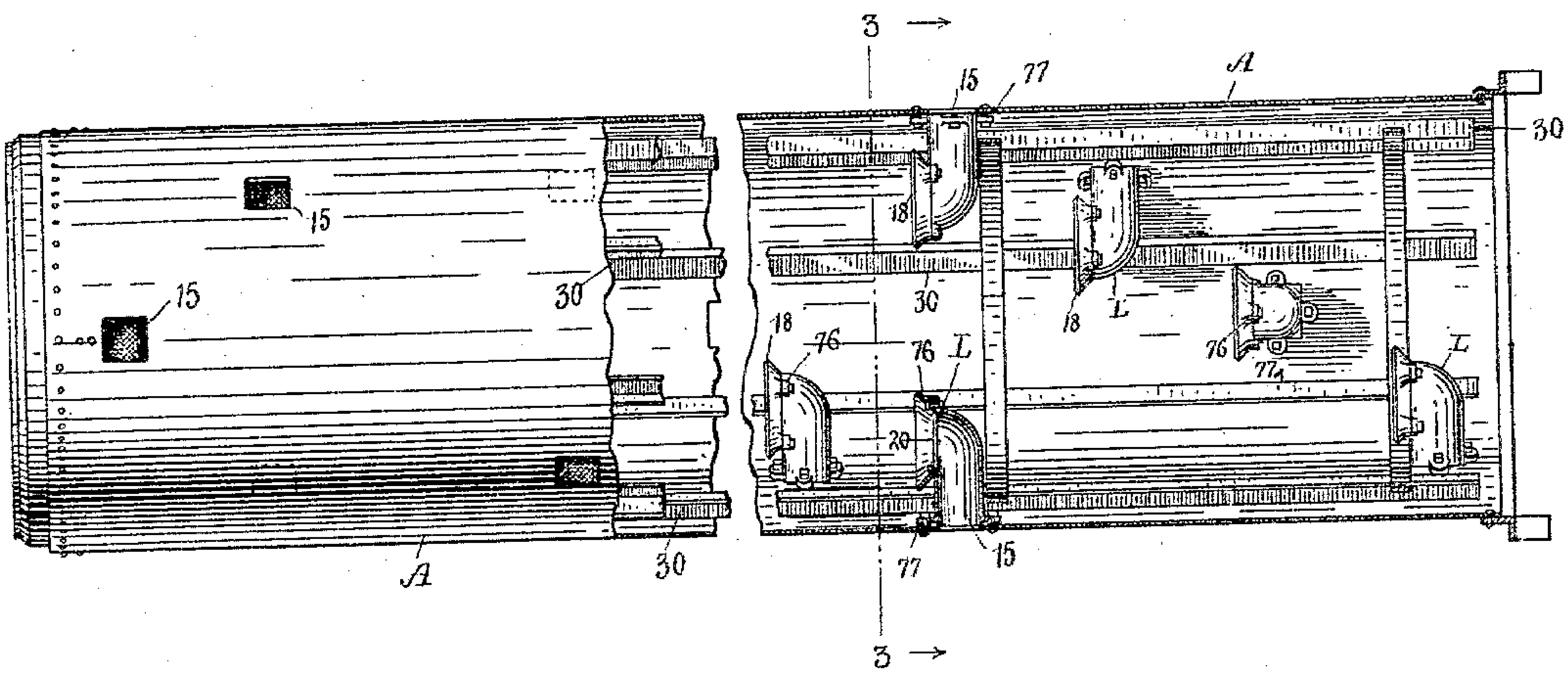


Fig. 4.

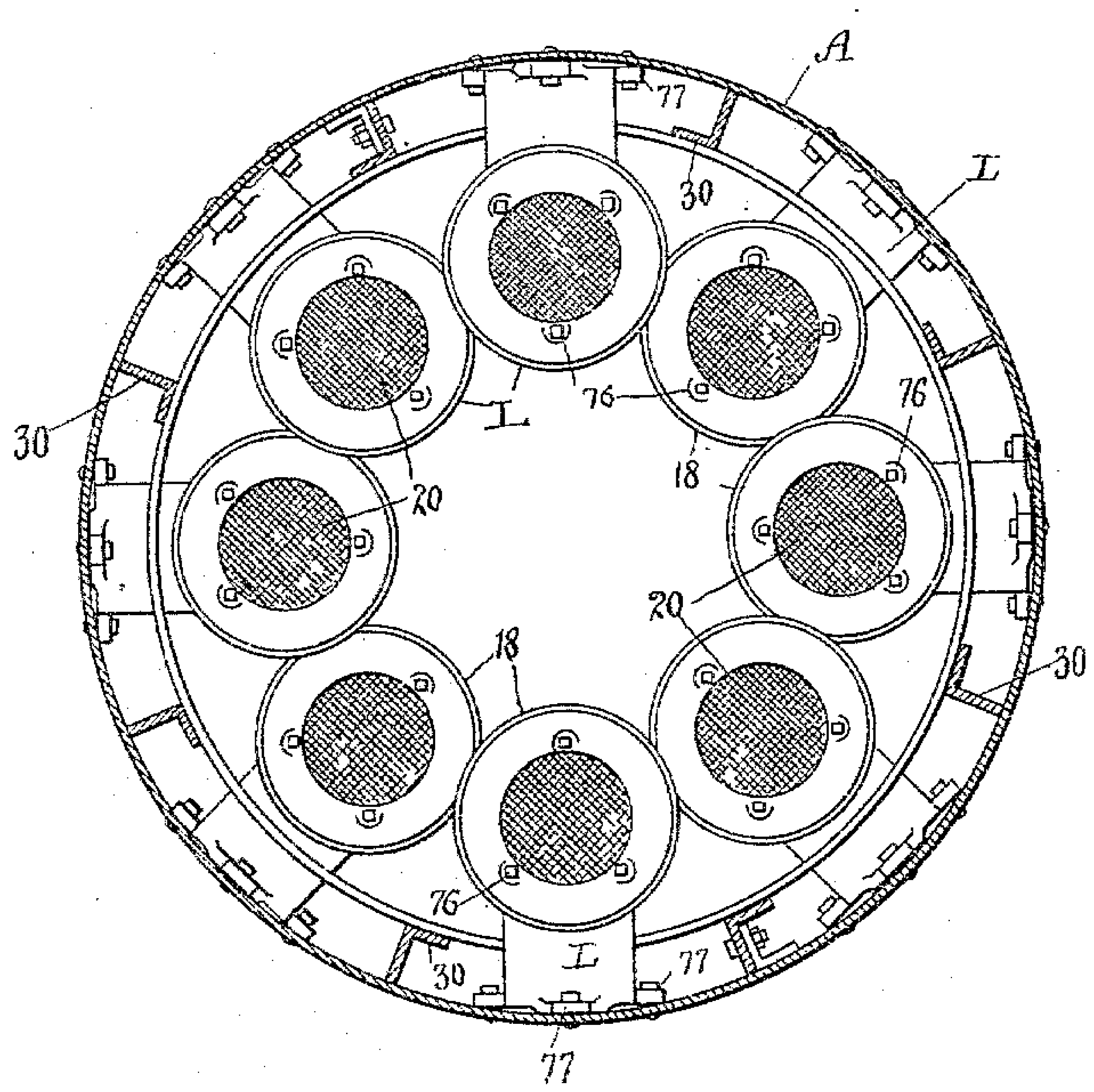
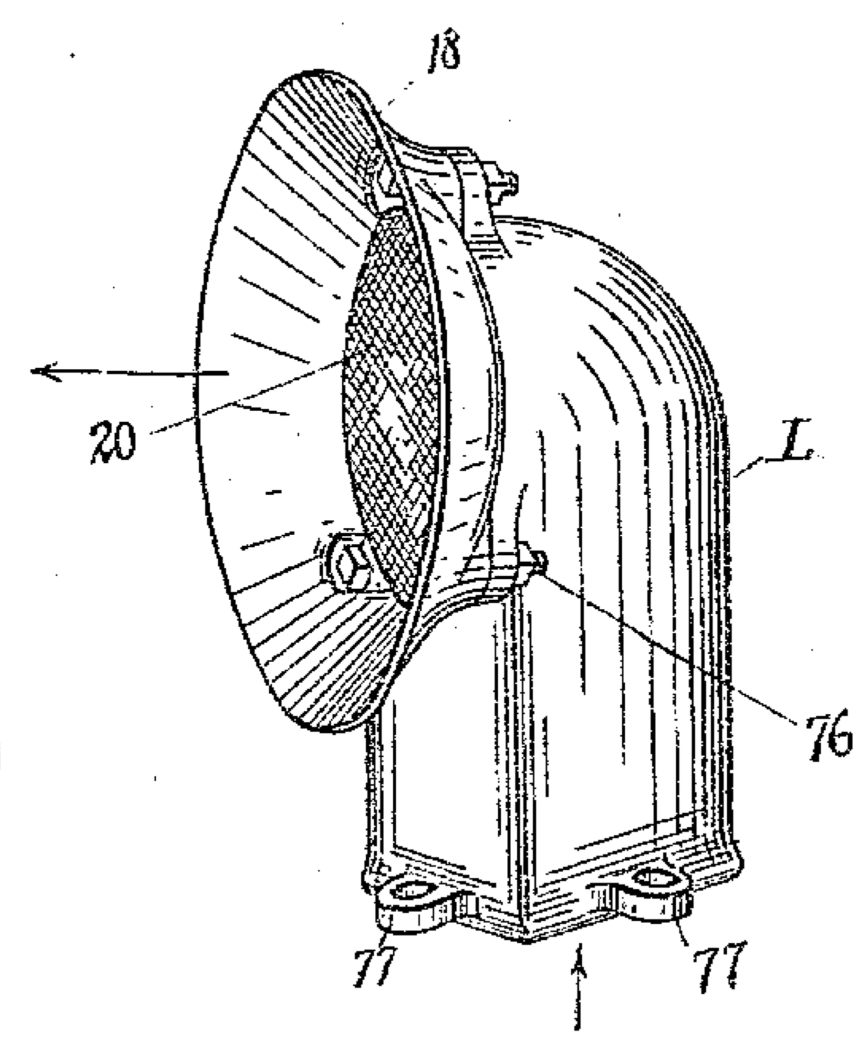


Fig. 5.



Witnesses.

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Atty.

(No Model.) 6 Sheets—Sheet 4.

F. D. CUMMER.

DRYING APPARATUS.

No. 545,120. Patented Aug. 27, 1895.

Fig. 6.

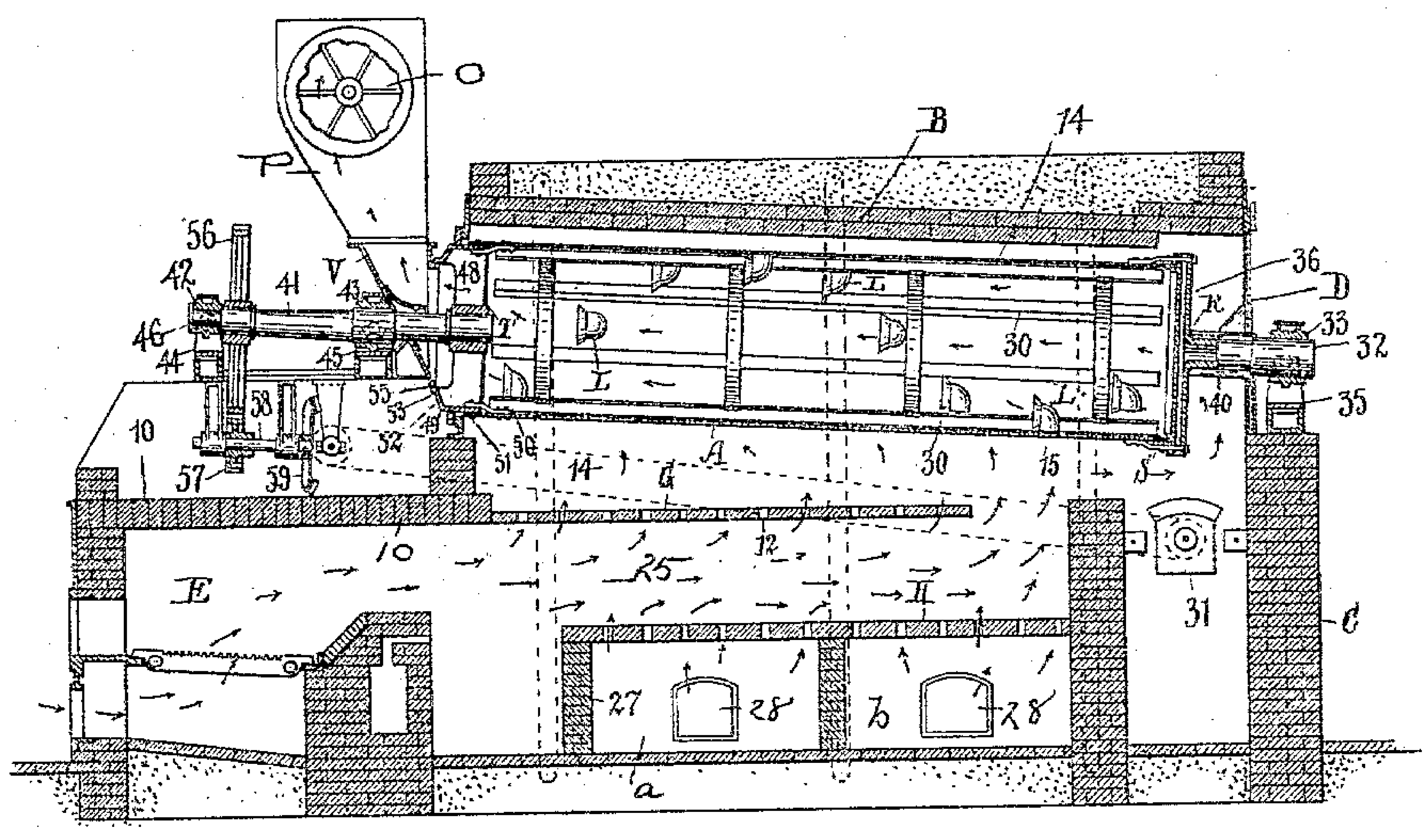


Fig. 7.

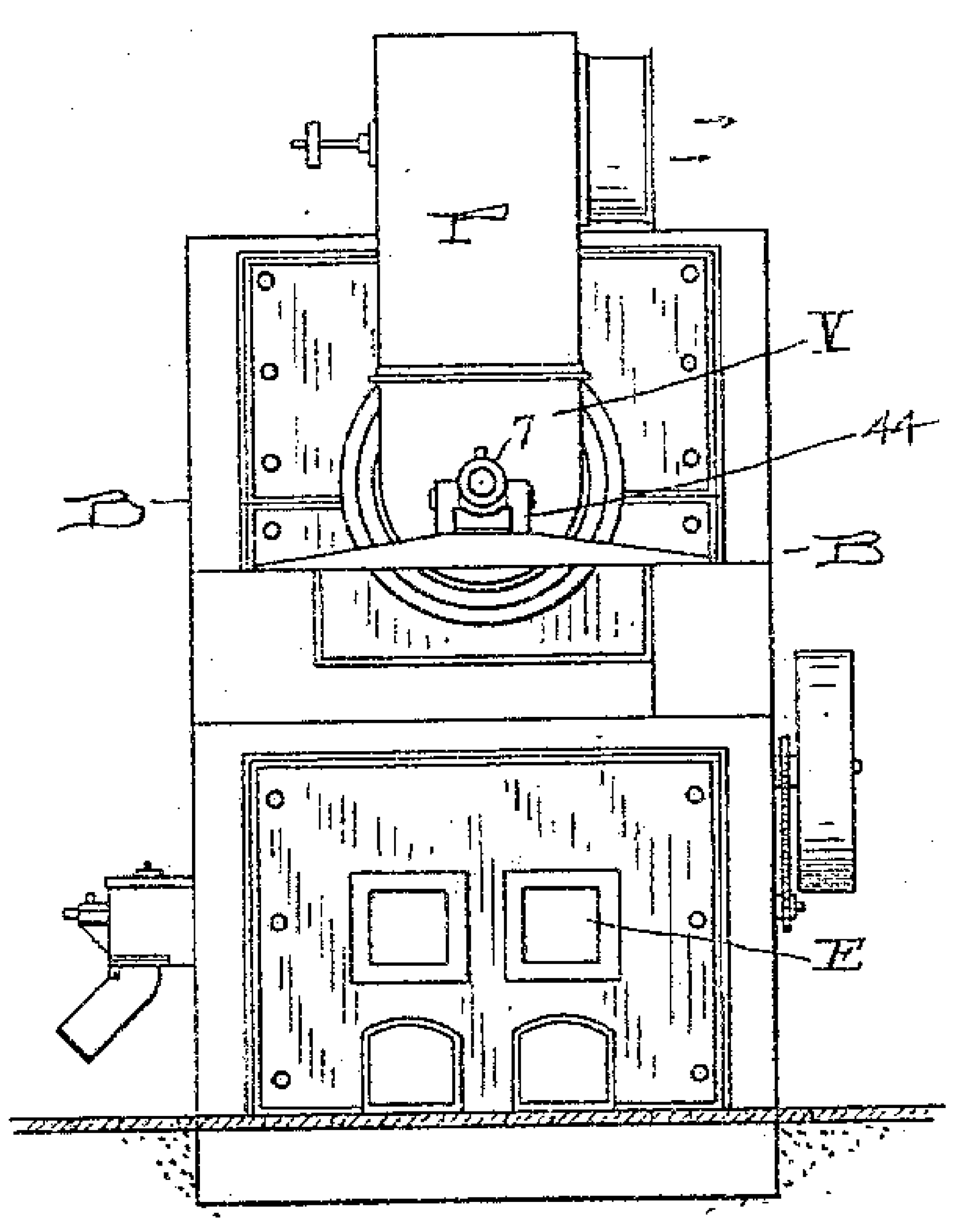
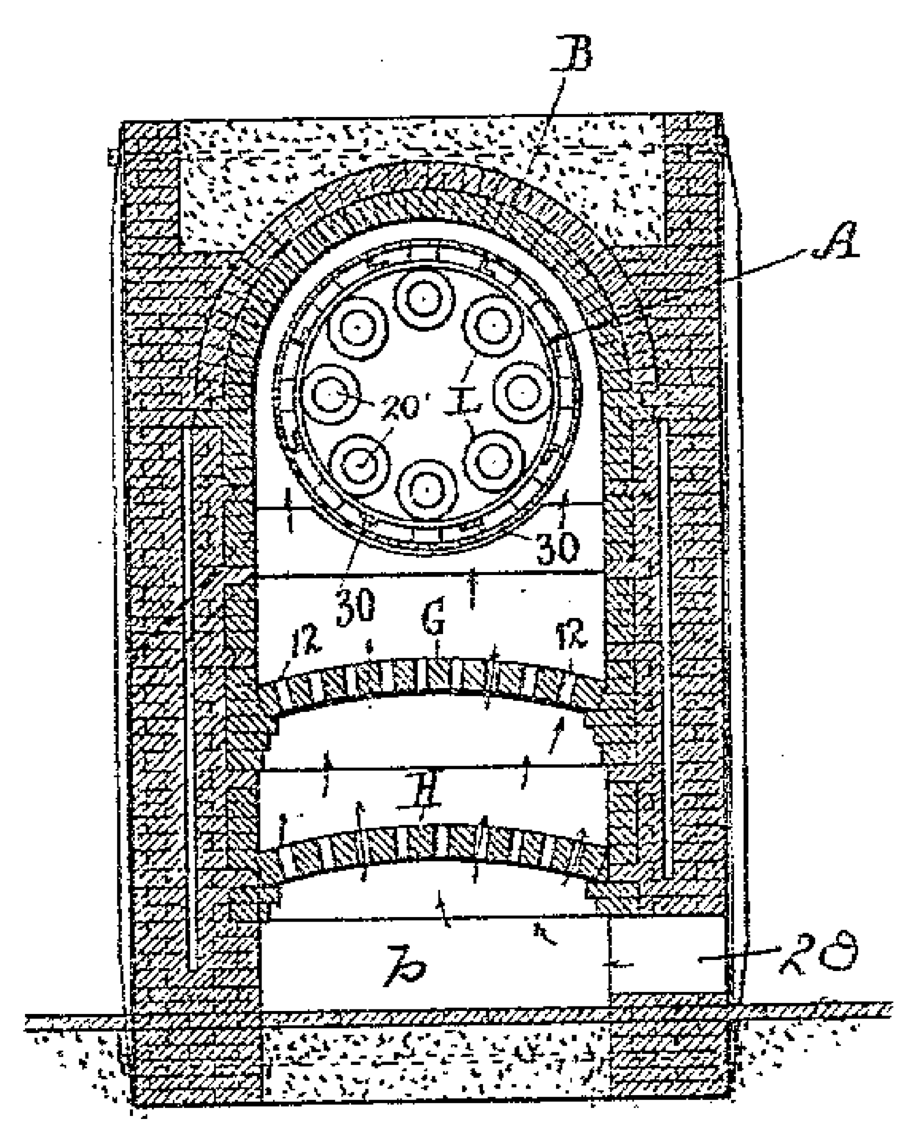


Fig. 8.



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(No Model.)

6 Sheets—Sheet 5.

F. D. CUMMER.

DRYING APPARATUS.

No. 545,120.

Patented Aug. 27, 1895.

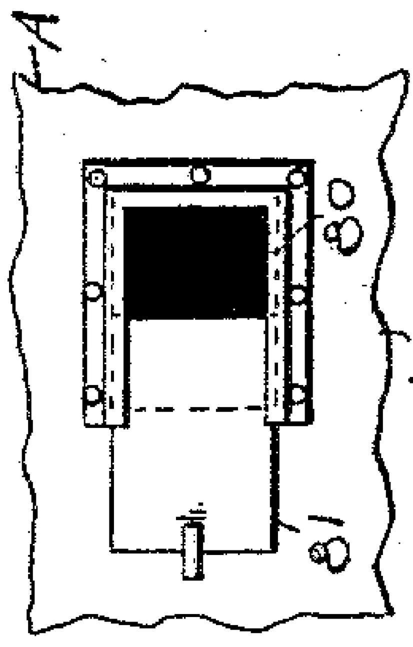

Fig. 9a

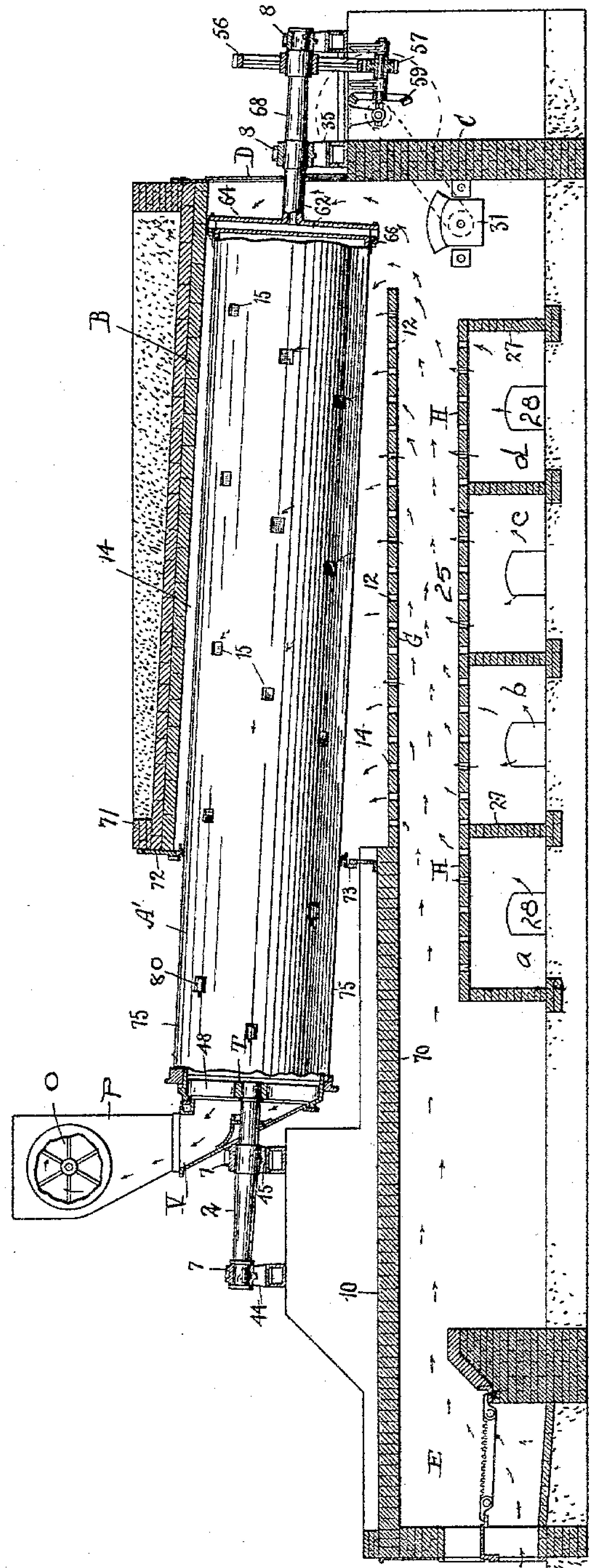

Fig. 9.

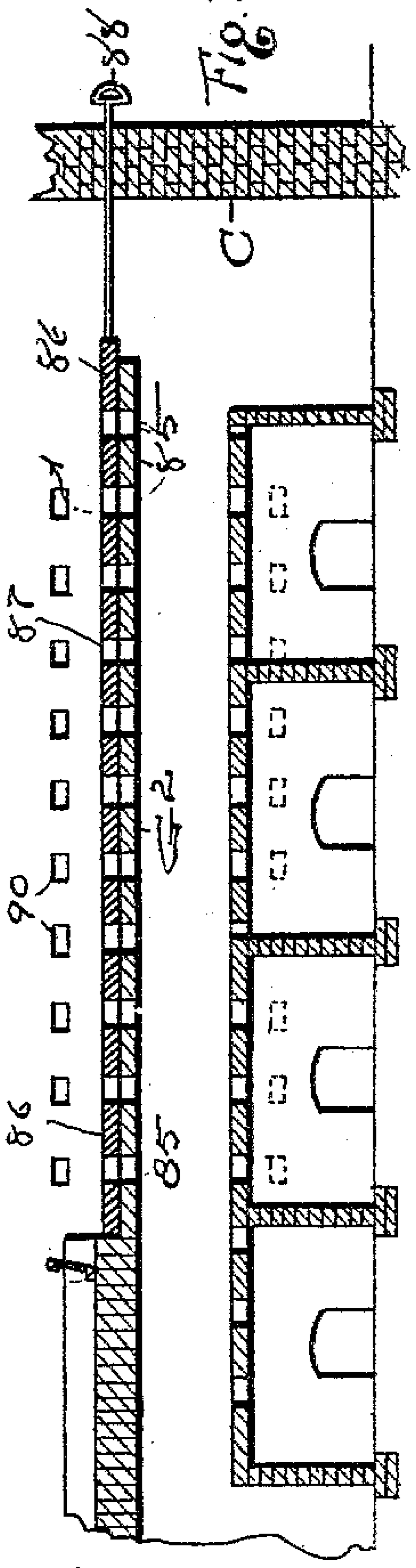

Fig. 13.

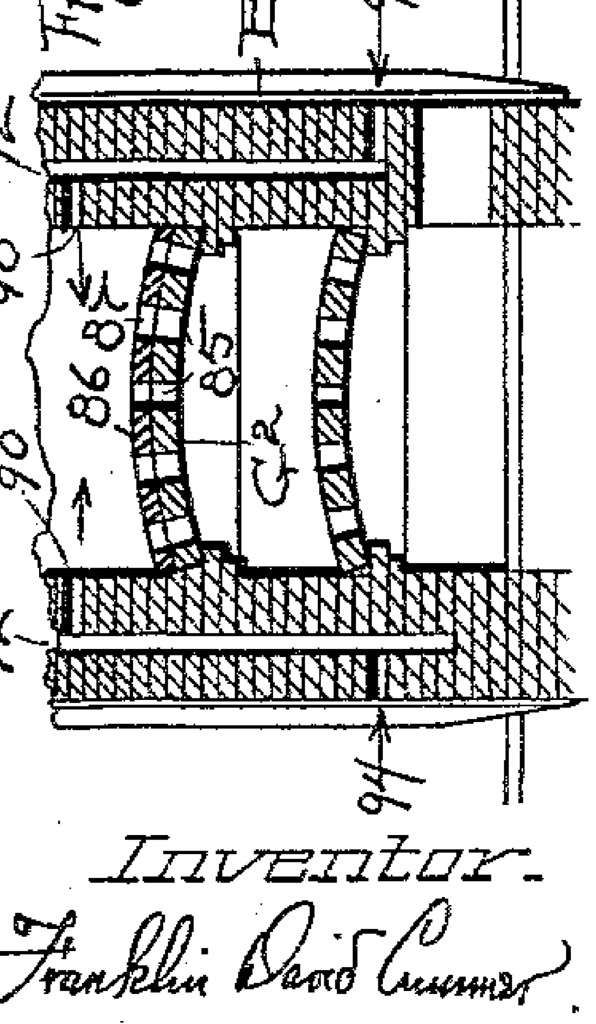

Fig. 14.

Witnesses.

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W. B. Moser.

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by H. J. Fisher

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(No Model.) 6 Sheets—Sheet 6.

F. D. CUMMER.
DRYING APPARATUS.

No. 545,120. Patented Aug. 27, 1895.

Fig. 10.

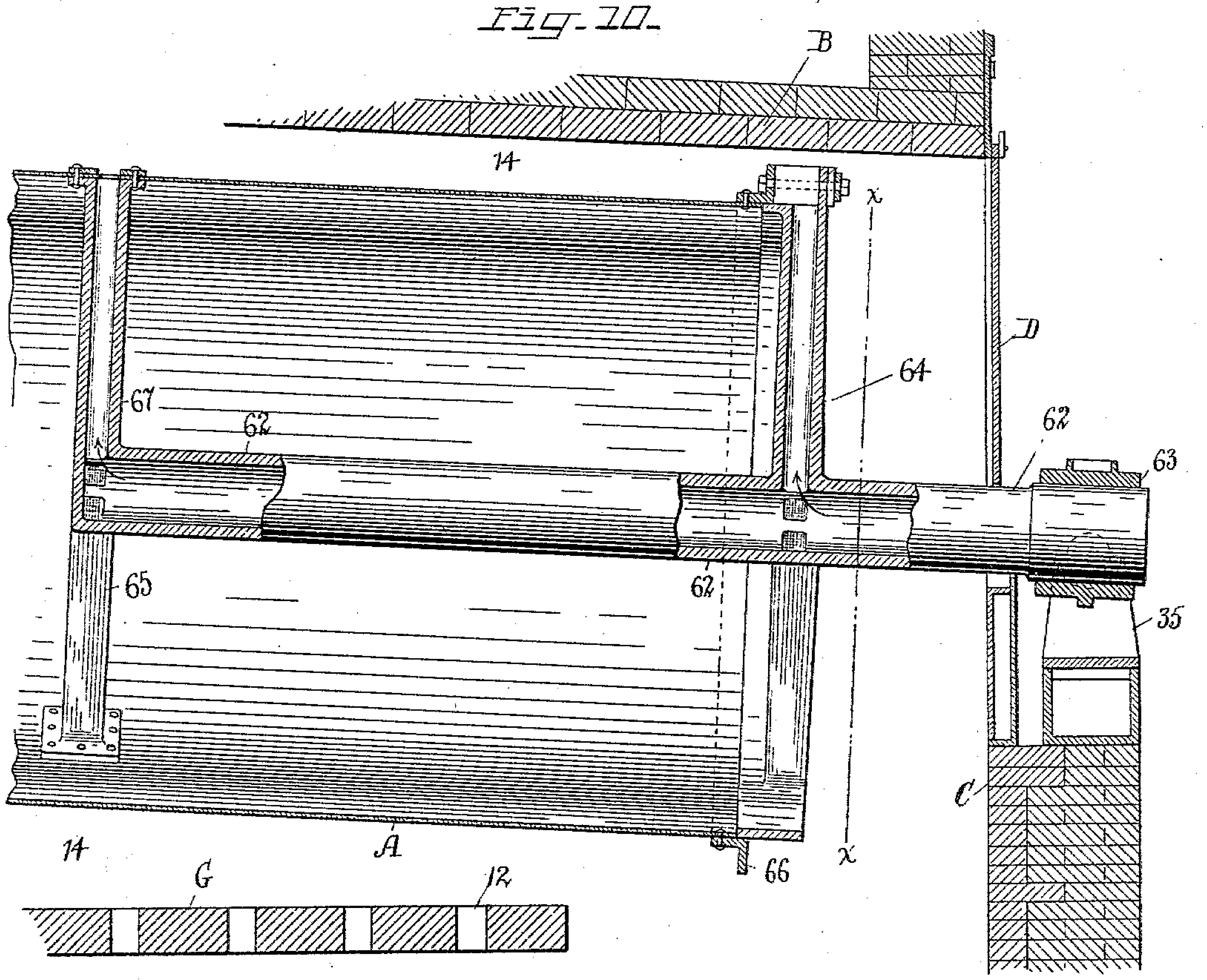


Fig. 11.

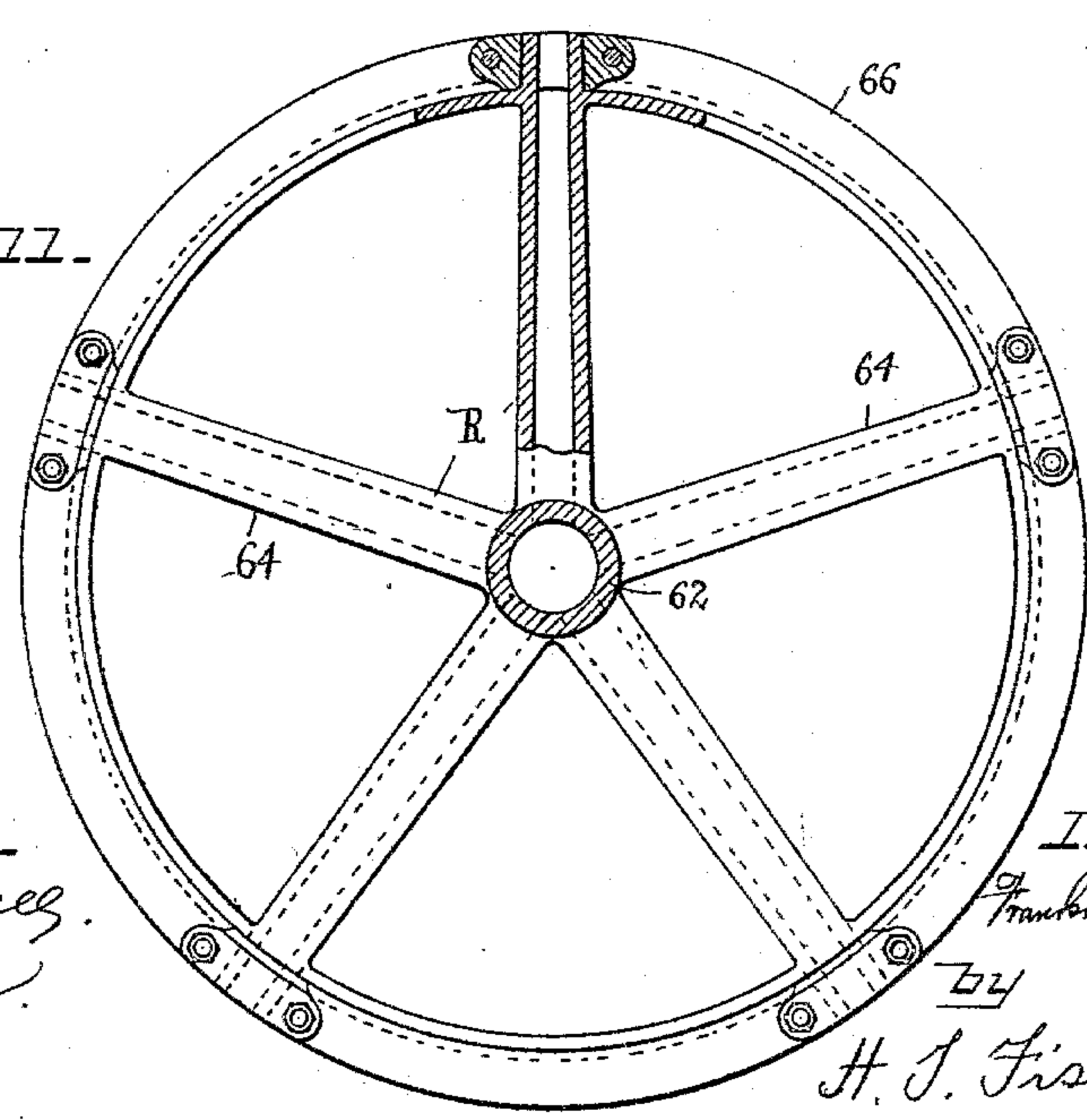
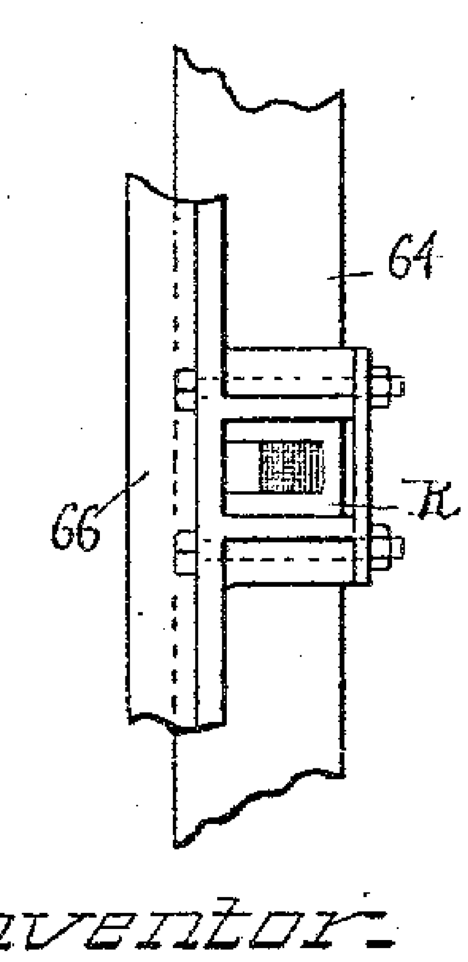


Fig. 12.



Witnesses.
Louis P. Abell.
R. B. Moser.

Inventor.
Franklin David Cummer.
by
H. J. Fisher. Atty.

UNITED STATES PATENT OFFICE.

FRANKLIN DAVID CUMMER, OF CLEVELAND, OHIO, ASSIGNOR TO ELIZA E. CUMMER, OF SAME PLACE.

DRYING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 545,120, dated August 27, 1895.

Application filed March 5, 1895. Serial No. 540,582. (No model.)

To all whom it may concern:

Be it known that I, FRANKLIN DAVID CUMMER, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Drying Apparatus; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

My invention has reference to drying apparatus in which heated air, coming directly into contact with the material, is chiefly relied on as the active drying agent, and the invention is an improvement in the style of drier disclosed in my application for Letters Patent, Serial No. 506,856.

In the accompanying drawings, Figure 1 is a longitudinal sectional elevation of my improved drier, showing the power-driving mechanism at the rear instead of at the front of the apparatus, as in Fig. 6, and having the dual bearings at the rear instead of at the front, and differing in other particulars, as will appear in the description further along. Fig. 2, Sheet 2, is an enlarged sectional elevation of the ends of the drier-cylinder and the trunnions or spindles therefor with bearings and driving mechanism, as shown in Fig. 6. Fig. 2½ is an enlarged detail of the outer end of one of the rear spider-arms and the rim integral therewith. Fig. 3 is a part plain elevation and part longitudinal sectional elevation of the drying-cylinder alone, broken out at the middle, and showing the arrangement of the ventilating-hoods in the right-hand section and openings for hoods in the left-hand section. Fig. 4 is an enlarged cross-section of the cylinder on a line corresponding to 3 3, Fig. 3, looking to the right and showing the disposition of the hoods as appears from that point. Fig. 5 is a perspective view of one of the hoods alone and considerably enlarged over Fig. 3, so as to clearly disclose its construction. Fig. 6 is a vertical central sectional elevation of a drier in which the power is applied at the front of the machine. Fig. 7 is a front elevation of the drier constructed according to the form in Fig. 1. Fig. 8 is a cross-section on a line corresponding to *a a*, Fig. 1. Fig. 9 is a vertical central sectional elevation longitudinally of a modified form of drier, in which the drying-cylinder is exposed to the outside air for some distance at its front, as hereinafter fully described. Fig. 9[a] is an enlarged section of a portion of the cylinder exposed to the outside air, as in Fig. 9. Fig. 10 is an enlarged sectional elevation of one end of the drying-cylinder and a modification of the spindle and spider at the rear, shown in Fig. 2. Fig. 11 is an elevation at right angles to Fig. 10, looking from line *x x* inward and applicable as well to a corresponding view of Fig. 2. Fig. 12 is a view of a section of the rim of the spider, shown alike in Figs. 2 and 10, and disclosing a small section of the cylinder, looking on the edge of Figs. 2 or 11. Fig. 13 is a longitudinal sectional elevation, and Fig. 14 is a cross-section of a modification of a furnace extension, as hereinafter fully described.

In Fig. 1 I have shown a longitudinal sectional elevation of a complete apparatus constructed according to one style covered by this application, and showing some features common to all the styles and modifications and variations thereof. Thus, I have the revolving drying-cylinder A, inclosed about its side and top by wall B and at its rear by wall C, and the plates or their equivalent D, immediately at the rear of the cylinder and about the spindle thereof. The said cylinder is supported at its ends by extended trunnions or spindles 2 and 3, projecting from the spiders 4 and 5 at the respective ends of the cylinder, and each working in a set of bearings 7 and 8 wholly outside the inclosures or walls of the drier. It will be noticed that the cylinder A is set slightly at an inclination downward from front to rear, as seen clearly in Fig. 1, and the degree of inclination may be varied according to the nature of the material to be dried and the duration of exposure and treatment it may require. This arrangement, however, is not new in this application, and is not claimed herein.

In the pending application above referred to and in the invention prior to this improvement, no provision was made for admitting heated air or the products of combustion from the furnace E into cylinder A, except through the rear end of said cylinder, nor were there any means for modifying, tempering, or regulating the degree of heat along the bottom of said cylinder, except as the large area or space beneath said cylinder in said old construction afforded room for expansion of the heat, or the admission of cool air into said space gave a measure of change or relief. Experience has shown me that the apparatus really is incomplete in structure and imperfect and unsatisfactory in operation, as to many of the materials to be dried, without means interposed between the direct heat from the furnace and the surface of the cylinder to limit and regulate the flow of heat to each and every part of the cylinder, and especially to the front part thereof, where the raw and cold and frequently very wet and pasty and contrary material is first dealt with, and where excessive heat would be liable to incrust or bake the material on the inner surface of the cylinder. These and other considerations which may be obvious have led to the changes and improvements embodied in the present case to overcome these difficulties, and which very materially enhance the efficiency of the apparatus as to certain materials, and broaden its utility so as to adapt it to many others, thereby enabling me to put materials through this drier which no one ever before saw going successfully through a mechanical drier or drying-machine of any kind. Specifically, therefore, the improvements referred to embrace an arch G, Figs. 1 and 8, which extends from side to side of the inclosing wall of cylinder A, beneath the same, relatively, about the depth shown, and runs from the arch or dome 10 of the furnace proper to near the rear end of said cylinder. The arch G is numerously perforated with openings 12, scattered from end to end and side to side thereof, and these openings are of a size which will permit a certain limited quantity of heat to pass through to the cylinder or heating-chamber 14 immediately over the arch. Now, having reached the space or chamber 14, over arch G and beneath and about the drying-cylinder, the heat envelopes the said cylinder and naturally seeks such outlets as may be available. This brings us to another novel and valuable feature of my improvement. It has been found highly desirable, if not absolutely necessary, in the treatment of many materials to introduce heat more or less directly from the furnace into the drying-cylinder between its ends, instead of taking all the products of combustion or heated air through the rear end of the cylinder, as formerly.

It may be stated for information and illustration that the drying-cylinder generally is thirty feet in length or thereabout, and hence there is a travel of sixty feet from the furnace-grates through to the rear of the cylinder and thence to the discharge end thereof. Obviously there are varying conditions in degree and effect of the heat between the terminals of this travel, and in the old construction there were no means for varying, controlling, or changing these conditions as different materials, or the same material at different points in its treatment might require. I have, therefore, introduced the arch G and the perforated air-inlet arch H beneath, as hereinafter described, and the hooded inlets or openings into the cylinder, as plainly shown in several of the figures. These inlets consist in this instance, Figs. 1 and 6, in a series of preferably spirally-arranged openings 15 at suitable intervals in the cylinder between its ends and between the lifting-blades of the cylinder, and over these inlets on the inside of the cylinder are the substantially elbow-shaped hoods or guards L, Fig. 5. These hoods are designed as coverings and heat-conductors for the openings 15, so that the heat or heated air may have a free and unobstructed flow through them, notwithstanding the presence in the cylinder of a mass of tossed and traveling material, which, without such hoods or guards, would unavoidably sift out through the openings 15 and be lost, hence, also, the peculiar shape of the hoods with the elbow turned preferably toward the front of the cylinder in the direction of the draft and the flaring mouth and shield 18. With this construction the material dropping onto the hoods at the bottom of the cylinder is shed or thrown off, and as a further safeguard at the base of this flaring shield or mouth there is a fine-wire webbing, gauze, or other suitable openwork diaphragm 20, which prevents the longer material which may happen to come within shield 18 from passing through the hood into the heating-chamber. Of course, the heavy draft or suction through the hoods is directly opposed to any such tendency, but still the precaution of the diaphragm is deemed necessary. The hood L may be cast or otherwise formed, substantially as shown, and is bolted firmly to the cylinder over the openings 15. In this instance the flaring shield 18 is shown as made in a separate piece, bolted to the hood, and the diaphragm 20 is secured between said parts. These details may, of course, be varied without departing from the spirit of the invention.

Now as a further feature of my improvement and auxiliary to the arch G and the inlets through hoods L and to control temperatures here and there according to the many varying needs of materials dried or the volume of heat at command, I provide for the introduction of cool or fresh air, usually beneath the arch G, into the direct draft 25 for the heat or products of combustion from the furnace. This passage-way or flue 25 is formed by the side walls of the furnace and the perforated arches G and H at top and bottom, respectively, and the said arch H forms the covering for the series of fresh-air chambers *a*, *b*, *c*, *d*, and *e*, Fig. 1, beneath said arch. Division-walls 27 separate these chambers, and each chamber has its own air-inlet 28, controlled by a suitable gate or other device to regulate the volume of air admitted or to entirely cut off the air, if necessary. One or more such chambers with one or more air-inlets each may be used, as needed. This enables me to throw more or less fresh air into the products of combustion or volume of heat from the furnace all along the line of travel or at different points therein, as the needs of the work for the time being may demand, and gives me complete mastery over the heat whatever the immediate or prospective conditions or requirements may be. I can temper the heat at the front, at the middle, or at the rear of the cylinder, and may have, say, 2,500° at the furnace and not exceeding 150° or less entering the cylinder at the rear. The possibilities of variation are at least within these widely-separated limits, and the products of combustion as they approach and enter the rear of the cylinder may, indeed, be almost whatever I choose to have them. This comes, of course, from the admission of fresh air, as described, and the gradual drawing off of the hottest gases or greatest heat through arch G and the hooded openings 15 in the cylinder and incidental conditions and results flowing from or related to these larger actions. Obviously, also, the diffusion of heat and reduction of temperatures by expansion in larger areas here and there after leaving the furnace has to be considered in calculating for effects.

It should be understood that the foregoing description and operation are based on the supposition that the usual fan, blower, or like device O is present in the exhaust flue or passage P at the front end of cylinder A, so that there is constantly present a strong suction or pull in the said cylinder and in the hooded passages leading through said cylinder. Broadly, this arrangement of fan or blower is not new in this case and is disclosed in the application referred to at the beginning of this discription; but it is necessarily present also as a factor in this invention.

The cylinder A for most materials has lifting-blades 30 longitudinally on its inside for lifting and tossing the material, as in said aforementioned application, and sundry other details or features of construction not necessarily developed at length herein. The dried material is discharged at the rear end of the cylinder A into a trough 31, having a worm or the like to convey the material out through one of the side walls. This, too, is in the other application.

Two leading modifications of the apparatus are shown. The first is disclosed in Fig. 6, and comprises the power mechanism, which in this figure is located at the front of cylinder A instead of the rear, as in Fig. 1. Having reference, first, to the construction involved in this change, we see at the rear of the cylinder, Fig. 2, a tubular trunnion or spindle 32, having a plain interior and resting in a sleeve-bearing 33, having trunnions on its sides supported on the bearing-posts 35, as in the above-mentioned application. This construction of spindle 32 compensates for any expansion or contraction in cylinder A and by reason of the length thereof enables me to locate the bearing outside the inclosing-wall of the apparatus and away from the heat. Integral with the spindle 32 is the spider R, which supports the rear end of the cylinder A and has a series of tubular or hollow arms 36, which open into the heating-chamber about the cylinder and admit air, which comes in through the hollow spindle 32, and an annular rim or band 37 unites the ends of said arms. The arms 36 project slightly beyond the band 37, so as to have a free discharge outside. The cylinder A and spider R are fastened together by means of a flanged ring S, riveted or bolted to the cylinder, and which is of such diameter as to just overlap the band 37, and straps 39, fixed at one end to cylinder A and at the other to side of arms 36, firmly unite all said parts. A sleeve 40 incloses said spindle 32 within the furnace and affords a housing therefor.

At the front, Figs. 2 and 6, an elongated spindle 41 is used, and two bearings having sleeves 42 and 43, resting on posts 44 and 45, respectively; but since the power connections are at this end the spindle 41 should not be permitted to slide in its bearings, and to prevent such movement, as well as to prevent sliding of the cylinder, I have put the bearing 42 between shoulders 46 and 47, or their equivalent, on the spindle. In this case, also, the spindle 41 is formed separately from spider T, but is made rigid therewith and operates as if said parts were in one piece. The spider T has arms 48, and rim 49 about the ends of said arms and integral therewith. This rim fits snugly within cylinder A and is fixed thereto by straps 50 and rivets 51 or some equivalent means. For convenience, I so construct this band or rim 49 as to make a close union with the annular base of the supply-hood V, and to this end the said rim is contracted about its outer edge to provide an inclined portion 52 and a flange 53 outside thereof, and this flange overlaps a corresponding flange 55 on the hood V. This or some other substantially equal construction may be used to effect so close a joint at this point that the material fed into the cylinder will not leak or work out at this point. Power is applied through the large gear-wheel 56 on spindle 41, pinion 57, shaft 58, and bevel-gears 59 and 60, or other sufficient power connections.

In Fig. 10 I show a modification of the rear spindle and spider for the cylinder, which may be considered an extension of the principle shown in Fig. 2, for securely and firmly connecting spindle and cylinder. In this latter form the tubular or hollow spindle 62 has a sleeve-bearing 63, as in the other case, but is extended inward some distance beyond spider 64 and has an auxiliary or supplementary spider 65 integral therewith. Connection is made between the cylinder A and spider 64 by angle ring or band 66, as in Fig. 2, and the hollow arms 67 of spider 65 through holes in the cylinder and about which they are firmly secured by rivets. This makes an exceedingly firm connection of the parts.

Referring now to Fig. 9, I have a modification of a still different character. In this case the inclosing wall of the drying-cylinder is set back from the front end of the cylinder some distance, amounting to several feet in a full-sized machine, and the front of the cylinder is therefore exposed to the open air, or at least removed from outside heat, where it thus projects beyond said wall. The object of this arrangement is to adapt the apparatus to be used in drying materials which otherwise, possibly, could not be handled at all, and which are of a pasty character and would adhere to the surface of the cylinder and parch and form a crust thereon if exposed at once to so hot a surface as the cylinder has at the front—in Figs. 1 and 6, for example. But by first introducing the material to a comparatively cool surface and subjecting it to the volume of heat passing through the cylinder, it becomes prepared to enter upon the hot surface with much less liability to adhere, or in fact none at all in many materials, and which could not be handled in this way without the initial and preparatory treatment or surface digging this construction affords. The said cylinder A′ is supported on spindle and bearings and is provided with gear connections, as in Fig. 1, except that in this case the rear spindle 68 is tubular and has hollow arms 69, as in Fig. 6. Otherwise the cylinder has the same equipments as shown in Fig. 1, but the furnace-arch 70, corresponding to 10 in Fig. 1, is extended back to a point perpendicular with the front end 71 of the cylinder inclosing wall B, instead of stopping at the front end of the cylinder. A suitable ring 72 and certain other inclosing mechanism (indicated by 73) serve to bridge the otherwise open space about the cylinder where the wall terminates at 71, and any means that would make a close joint and prevent the escape of heat may be adopted. In this case, however, the exposed front portion 75 of the cylinder has a series of hooded openings 80, as many as may be needed, and these have slides 81, Fig. 9ª, to close them when fresh air is not wanted at this point. The ventilating-hoods L are located between the elevating-blades 30, as plainly seen in Figs. 3 and 4, and between the angle 76 in the elbow, Fig. 5, and the bottom 77 of the elbow there is the relative depth shown in said figure and which is intended to correspond somewhat to the possible depth of the material at the bottom of the cylinder, it being desirable that, in any event, the outlet of the hoods should be unobstructed as the said hoods come to the bottom, where, if anywhere, obstruction might otherwise occur. I have herein referred to both the parts G and H as arches, and so they are, as here shown. Obviously, however, they may be made perfectly flat instead of convex and still serve the same purpose, but in that case would require other means of support. Other forms of construction also might be adopted.

In Figs. 13 and 14 I show enlarged openings 85, corresponding to opening 12 in Fig. 9, and an asbestos or like non-combustible board 86, with passages 87, arranged to register with openings 85. A rod 88 at the rear serves to adjust the board or cover 86, and thus control the flow of heat through the arch G^2. The said board 86 operates as a valve, and any means which will serve the same purpose may be employed. So, also, may any suitable means be employed to adjust the part 86.

A further modification in Figs. 13 and 14 is the air-inlet through the openings 90 into the cylinder-chamber above the arch G^2. This is intended to occur only when for any reason it becomes desirable to reduce the temperature in said chamber more or less, and is supplied to said openings through the passages 92 in the furnace-wall having openings 94 to the outside air. A brick or any other means for temporarily closing openings 94 will suffice for this purpose, or an adjusting mechanism of some kind can be employed.

I have mentioned 2,500° Fahrenheit as a common temperature at the furnace, and the heat may run from that to 3,000° as a regular temperature, and yet not exceed 100° where the apparatus discharges into the open air. In fact, by my improved construction I can make the temperature here and there almost anything I desire it to be, assuming that I start with the degree high enough at the furnace. Now, in order that the wide range of uses to which my improved apparatus is adapted may be fully understood I may mention some of the materials it is now successfully drying and the varying conditions under which it is doing the work. Thus take distillers' slops, for example. When these slops come from a mash that is largely rye, it is very wet and adhesive and viscous, and the same may be said of gluten and other materials of this character. Hence in the early stages of drying it is desirable that this material should not be brought in contact with the walls of the cylinder when the cylinder is in a heated condition, and therefore these and similar materials should be surface dried, if possible, before being brought in contact with any heated surface in the drying-cylinder. While these materials are in a wet condition, large volumes of heat may be poured in among them as they are agitated, because the heat is taken up by the moisture as it is evaporated and the materials are not injured by the high temperature of the gases and heated air that are poured in among them; but as they become drier and drier they are the more easily injured by high temperatures. Consequently it is desirable and necessary that as they become more dry they should be brought in contact with lower temperatures.

In drying sulphate of soda, alum, and similar substances the material should be exposed to very low temperatures at first, because the sulphate of soda, according to the amount of moisture that it carries, will melt at about 90° to 113° Fahrenheit. The alum crystals become viscous and sticky at about 100° Fahrenheit, and in a very short time will paste up the walls of any rotating cylinder. Therefore in drying these materials, as stated before, they should not be brought in contact with anything excepting very low temperatures; but they differ in their nature from distillers' grains, gluten, brewers' grains, and like substances in this respect—viz, that as the alum and the sulphate of soda become more dry they will resist higher temperatures without melting or becoming viscous or sticky, and, finally, in their dried condition may be heated to very high temperatures without any injury whatever. Nitrate of soda and carbonate of soda crystals do not melt at such low temperatures, but correspond with the alum and sulphate of soda in this respect—viz., that as they become drier they will resist high temperatures without melting and can be heated to high temperatures without injury.

The value of ochers, umbers, and other pigments is controlled very largely by their peculiar hues or shades of color and must be dried without being heated to anything but very moderate temperatures; but the nature of these pigments differs from any of the materials that we have described in several respects. First, they will not adhere to a heated shell, while they will adhere and pack and accumulate when being tossed around on the walls of a cold rotating shell. Therefore, it is desirable that as soon as these materials enter the drier they should be brought in contact with hot surfaces, and at no time during the process of the drying must they be heated beyond anything but very moderate temperatures. Many of them must not be heated above 150° to 200° Fahrenheit, while some of them will stand 250° Fahrenheit.

Starch is another material that we dry quite successfully, but owing to its fineness it is very inflammable and explosive in its dried condition, and owing to the fact that at 150° Fahrenheit it is converted into dextrine it must be dried with care. It differs, however, from glutinous substances in not being viscous or adhesive in its wet condition, and it therefore may be brought in contact with hot surfaces as soon as it enters the drier, but, as stated before, it must not be heated above 150° Fahrenheit at any time during the process of drying.

I have now described the nature of a few of the many different materials this apparatus is successfully drying in order to show how necessary it is that a drier should be so constructed that the heat used in connection with it may be so manipulated and applied as to enable the drier to handle the different materials without injuring them and without pasting or sticking up the machine, as well as meeting other conditions not herein enumerated.

It has been the custom to admit all the heat into one end of a rotating drier and discharge the heat and vapor which it liberates at the other end of the drier but in drying materials; which in their dried condition are injured by high temperatures, I would be compelled to generate only a very small amount of heat for the reason that all of the heat enters the drier, such as I have described, at one point. Therefore, in order to increase the capacity of the machine, as well as to be able to handle all of the different materials in a reliable way and modify my method of handling the heated air and gases to conform to the different natures of the materials being dried, I have devised the apparatus herein set forth. By this apparatus or machine, I am enabled to take in the heated air and gases at many different points through the shell as well as into the shell through its open end, and that I may be enabled further to control the heated air and gases so as to increase the capacity of the machine thereby, and also to dry the materials successfully and without injuring them, I have placed the perforated arch under the drier, as shown, and underneath the perforated arch I also show another perforated arch, with the air-space underneath, this latter arch divided by walls or partitions into several chambers, and these chambers have openings for admitting air in a regulated way through registers or valves.

Now, to make clear the advantages that I gain from the different constructions and arrangements illustrated in the drawings and herein described, I will say that in drying materials which in their wet condition would adhere to the inner walls of the drier if they were hot I have a modified construction which allows a portion of the front end of the shell to project outside of the arch or brickwork, as shown in Fig. 9. I find that by feeding these materials into the drier when arranged in this way they do not have any tendency whatever to adhere to the inner walls of the shell, because, although large volumes of heat are passing through the drier at the front end and through the material that is being showered and tossed about in it, still the heat is confined very largely to the center of the drier, so that the moist material, as it is brought in contact with the shell, easily keeps the shell in a cool condition, while the heat which is passing through the shell and being brought in contact with the material that is being showered and tossed about in it is continually drying the material with which it comes in contact, so that by the time the material, as it moves rearward, reaches the warmer parts of the shell, it becomes surface dried, so that it does not adhere to the warm surface. Now, if I was drying distillers' slops, gluten, and similar viscous materials, which as they become drier become less able to resist without injury anything but moderate temperatures, I would so locate the area of the openings in perforated arch G, for example, and so locate the admission of the air into the chamber which exists between the perforated arch G and the shell that the temperature of the hot air and gases as they would enter into the interior of the shell through the hooded openings which are made through the shell would be hotter in the forward end of the shell and would gradually possess less and less heat toward the rear end of the shell. Thus to illustrate I find that in drying such materials as I have described, I can maintain 2,500° to 3,000° Fahrenheit in my furnace, and so manipulate and handle these hot gases by expansion and by mingling them with air, &c., that the expansion-chamber between the perforated arch G and the drier-shell A, at the doorward end of the arch, would be, say, 500° Fahrenheit, while at the same time inside of the shell, at the point where this hot air and gases would be admitted at 500° degrees Fahrenheit the temperature would not be over 200° Fahrenheit, and then by taking the temperature of the hot air and gases in the expansion-chamber between the perforated arch and the drier rearward the temperature would gradually decrease toward the rear end, so that at one point it would be 400°, at another point 300°, at another point 200°, and so on, and although the heat was generated at temperatures approximating 3,000° by this arrangement and by manipulating the hot air and gases and air as described I am able to bring out the dried materials reliably at temperatures ranging at about 100° Fahrenheit, or even less.

I have carefully tested this machine and method of handling hot air and the products of the furnace for several days, taking the temperatures at different points each hour, and have found that the dried material on leaving the drier did not vary more than 10° in ten hours' time. In drying glutinous meal the lowest temperature in a ten hours' run as it left the drier was 90° Fahrenheit and the highest temperature as it left the drier was 100° Fahrenheit.

In drying sulphate of soda, alum, and similar materials—that is, in driving off the water by crystallization—I use the same style of setting that I have just described and allow the forward end of the shell to project outside of the setting and be uncovered. Then I manipulate the hot gases or heat from the furnace mingled with air, so that these materials, when entering the drier, meet with hot air at such temperatures as will not melt the material being dried, and further manipulate the hot air and gases that as the material is gradually working rearward and becoming more and more dry it will meet higher temperatures. At last, then, the gases and hot air inside of the boiler-setting would be manipulated so as to give a result exactly the reverse of what is wanted in drying glutinous meal, distillers' slops, and similar materials. Thus, instead of aiming to admit heated air and gases through the forward portion of the drier-shell and into its interior at the highest temperatures and gradually have the temperatures lower toward the rear end, I aim to admit the hot air and gases into the interior of the shell through the forward portion of it at lower temperatures and have these temperatures increase as the hot air and gases are admitted through the more rearward portions of the shell. Thus from the time that the material in its raw condition is delivered into the drier it at first meets with very low temperatures, and as it becomes more dry it is brought constantly in contact with higher temperatures as it travels slowly toward the rear or discharging end of the shell.

In drying ochers, umbers, and material of that character, I admit them into a shell that is heated its entire length and which is entirely inclosed, because, as stated before, these materials have no tendency to adhere to hot surfaces. Now as these materials must not be heated as a rule above 225° Fahrenheit I admit the gases through the walls of the front end of the shell or cylinder at the highest temperatures, and as the material passes rearward in the shell I bring it in contact with hot air and gases at constantly decreasing temperatures, so that the temperature of the hot air and gases between the perforated arch G and the drier-shell are less and less toward the rear end of the shell and are admitted through the shell at constantly decreasing temperatures, so that at the rear end of the shell, where the material is finally dropped out of the machine in a dried condition, the dried material meets with the mingled air and gases at such temperatures, owing to the expansion of the gases, as do not injure the material in the slightest degree.

There is another great advantage following from this peculiar construction of the drier and of the brickwork which incloses it, including the perforated arch, &c., which may be described as follows: Many materials when in a wet condition can be showered and tossed about and brought in contact with very rapid currents of air and vapor without being carried away, but these same materials when thoroughly dried become very light and are floated off and carried away by very moderate currents. It may be easily understood that in the front end of the shell a current would be established and maintained that would be due to the cross-sectioned area of the shell and to the volume of hot air and gases and freed vapors that would be passing through the front end of the shell, because at the front end all the gases and vapor and air pass outward toward the fan and atmosphere, but as the dried material passes rearward and becomes more dry it is being brought in contact with currents of less velocity, for the reason that only a small percentage of the heated air and gases reach the rear end of the shell where the material has become thoroughly dried, so as a result of the construction of this drier and the arrangement of the brickwork which incloses it as these very fine and light materials become more dry they are brought in contact with currents which move at slower and slower velocities, and for this reason I am able to use much greater volumes of heated air successfully than I would be able to use successfully providing that all of the heat and all of the air and gases were admitted into the rear or discharging end of the drier-shell at the point where the dried and light materials are delivered. Another advantage following from this arrangement is that in proportion as I am able to use larger volumes of air commingled with the heat of the furnace I am able to do my drying more economically, because the vapors as they are freed are absorbed by the heat and expanded air and carried off mechanically.

With the large-sized machines I find that I am able to vaporize fifteen pounds of moisture with one pound of combustible. Owing to the fact that rapid currents with this machine and furnace construction are brought into contact with the wet materials only, I am able to successfully dry not only starch, but very finely ground wood pulp, such as is used for making paper and as an absorbent for nitro-glycerine. In short, this construction of apparatus enables me to dry in a straightforward economical manner many materials which before could not be successfully dried mechanically, and owing to the fact that the machines have such a large capacity as a result of their construction and the manner in which the heated air and gases can be brought in contact with the material I am enabled to do a very large amount of drying in a very small space, so that in the large paper-mills and starch and glucose works, where room is very valuable, my machines may be employed, whereas if they only had a moderate capacity and if they required a very large amount of space to do the required work they, for this reason alone, even if they did the work economically, could not be successfully employed.

The peculiar arrangement of the furnace and construction of the machine enable me to do three or four times as much drying in a given space as formerly, and I am enabled to do even as high as ten times as much work in a given space as many machines are able to do which are being employed where room is not so valuable as to prohibit their use.

I claim—

1. In an apparatus as described, the drying cylinder open at both ends for the passage of the material and the products of combustion in opposite directions, inlet openings at intervals through the side of said cylinder and hoods or guards over said openings on the inside of the cylinder, substantially as set forth.

2. The drying cylinder having an inlet for the material at one end and an outlet for the material at the other end and inlet openings through its side, and hoods over said openings on the inside of the said cylinder having their direction of discharge substantially parallel with the axis of the cylinder, substantially as set forth.

3. The drying cylinder described, having a series of inlet openings through its side, elbow-shaped hoods over said openings on the inside of the cylinder, and lifting blades constructed to toss the material over the hoods, substantially as set forth.

4. The cylinder described, having inlet openings at intervals about its side and hoods over said openings of substantially elbow-shape, and open work shields or diaphragms in said hoods to prevent escape of material through them, substantially as set forth.

5. The cylinder described, having a series of openings through its side, and elbow-shaped hoods over said openings on the inside of the cylinder and having flaring discharges, substantially as set forth.

6. The cylinder described, having longitudinally arranged lifting blades on its inside, and a series of inlet openings over its surface between said blades and hoods over said openings having necks to raise the discharge above the floor of the cylinder and curved at their top to discharge in the direction of the end of the cylinder, substantially as set forth.

7. The drying cylinder open at both ends for the passage of the material and the products of combustion in opposite directions, and having inlet openings through the side of the cylinder, substantially as set forth.

8. The combined furnace and walled chamber for the drying cylinder, and the drying cylinder therein open at both ends and arranged in the line of draft and having covered inlet openings between its ends and a device at the front of the said cylinder to stimulate or augment the natural draft through said cylinder, substantially as set forth.

9. The apparatus described, comprising a furnace and a drying cylinder set into the line of draft from the furnace and open at its ends, and a perforated arch between the said cylinder and the line of draft from the furnace to the rear of the cylinder, substantially as set forth.

10. The furnace and the perforated arch forming a continuation of the furnace arch, and a revolving drying cylinder above said perforated arch and open at its ends to allow draft through the same, substantially as set forth.

11. The furnace and the perforated arch beyond the furnace over the line of draft, and a drying cylinder set into the line of draft above said perforated arch and provided with

covered openings to admit heat into the cylinder about its side, substantially as set forth.

12. The furnace and the drying cylinder set into the line of draft therein, and provided with a series of hooded inlet openings between its ends, and a perforated arch extending substantially parallel to said cylinder beneath the same and separating the cylinder from the direct draft from the furnace, substantially as set forth.

13. The furnace, and the perforated arch forming an extension substantially of the arch of the furnace, in combination with the open ended revolving drying cylinder set into the line of draft and having its side provided with a series of inlet openings, and elbow shaped hoods over said openings, substantially as set forth.

14. The furnace and the perforated arch extending beyond the same toward the rear and forming the covering of the line of draft and a perforated air inlet arch beneath said line of draft, substantially as set forth.

15. The furnace constructed for a drying apparatus, the drying cylinder therein and an air inlet arch beneath said cylinder perforated at intervals for the passage of air, whereby the temperature of the products of combustion is reduced as air is admitted, substantially as set forth.

16. The construction described, consisting of the furnace proper, the parallel perforated arches forming the draft passage from the furnace between them, and the revolving drying cylinder set into the line of draft above said arches, substantially as set forth.

17. The furnace and the two perforated arches, one above the other, and having the draft passage between them, and mechanism to regulate the flow of air through the lower arch, substantially as set forth.

18. The furnace described, the parallel perforated arches and air inlets to the lower of said arches in combination with the open ended drier cylinder above said arches in the line of draft and having hooded inlet openings about its side, substantially as set forth.

19. The furnace and the two perforated arches, the drying cylinder set into the line of draft above said arches and having openings about its side, and hoods over said openings having their discharge directed toward the front of the cylinder, substantially as set forth.

20. The furnace proper and the draft passage from said furnace having perforated arches above and below the same, a cylinder in the line of draft above said arches and open throughout its length, hooded inlet openings in said cylinder and a device to produce artificial, draft through said cylinder, substantially as set forth.

21. The furnace and the revolving drying cylinder set into the line of draft therefrom and having inlet openings about its side and hoods over said openings, means at the front of said cylinder through which the material to be dried is fed thereto and means to produce an artificial draft through the cylinder and said hoods, substantially as set forth.

22. The apparatus described, comprising the furnace and expansion chamber, the drying cylinder in said chamber and having its front end exposed outside said chamber and hooded openings in the portion of the cylinder within said chamber, substantially as set forth.

23. The construction described, consisting of the furnace and the expansion chamber and a perforated arch beneath said chamber, and a cylinder having its front end projecting outside of said chamber and means to feed the material to be dried to said cylinder, substantially as set forth.

24. In a cylinder of the kind described, a tubular spindle or trunnion and tubular arms radiating from said spindle and an open passage through spindle and arms to admit air, substantially as set forth.

25. The cylinder in combination with the combined tubular spindle and arms and the band integral with said arms, said parts connected, substantially as set forth.

26. The furnace and the arch over the passage way therefrom provided with openings, and means to control said openings, substantially as set forth.

27. The furnace and the perforated arch to the rear thereof over the passage way, and a sliding part of non-combustible material to control the said perforations, substantially as set forth.

28. The furnace having a perforated arch at its rear and a chamber over said arch having air inlets at its side, substantially as set forth.

Witness my hand to the foregoing specification this 26th day of February, 1895.

FRANKLIN DAVID CUMMER.

Witnesses:

RICHARD J. GOREY,
H. T. FISHER.

Disclaimer in Letters Patent No. 545,120.

DISCLAIMER.

545,120.—*Franklin David Cummer*, Cleveland, Ohio. DRYING APPARATUS. Patent dated August 27, 1895. Disclaimer filed February 9, 1912, by the assignee, *The F. D. Cummer & Son Company.*

Enters this disclaimer—

"To that part of the claim in said specification which is in the following words, to wit:

"7. The drying cylinder open at both ends for the passage of the material and the products of combustion in opposite directions, and having inlet openings through the side of the cylinder, substantially as set forth.

"8. The combined furnace and walled chamber for the drying cylinder, and the drying cylinder therein open at both ends and arranged in the line of draft and having covered inlet openings between its ends and a device at the front of the said cylinder to stimulate or augment the natural draft through said cylinder, substantially as set forth.

"9. The apparatus described, comprising a furnace and a drying cylinder set into the line of draft from the furnace and open at its ends, and a perforated arch between the said cylinder and the line of draft from the furnace to the rear of the cylinder, substantially as set forth.

"10. The furnace and the perforated arch forming a continuation of the furnace arch, and a revolving drying cylinder above said perforated arch and open at its ends to allow draft through the same, substantially as set forth."

[OFFICIAL GAZETTE, *February 20, 1912.*]