

Nov. 5, 1963

J. S. TAYLOR

3,109,637

TOBACCO CURING APPARATUS

Filed July 17, 1963

11 Sheets-Sheet 1

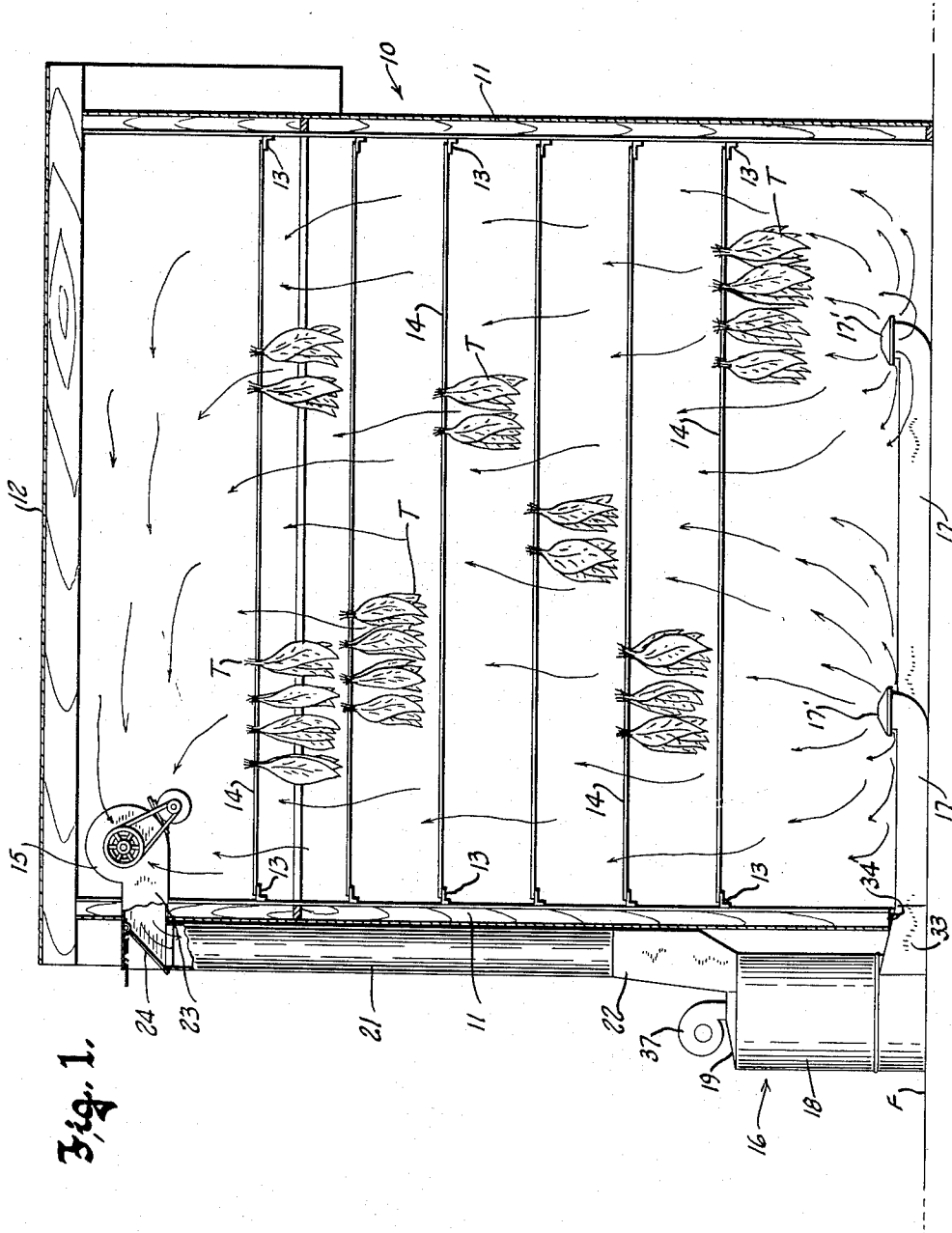


Fig. 1.

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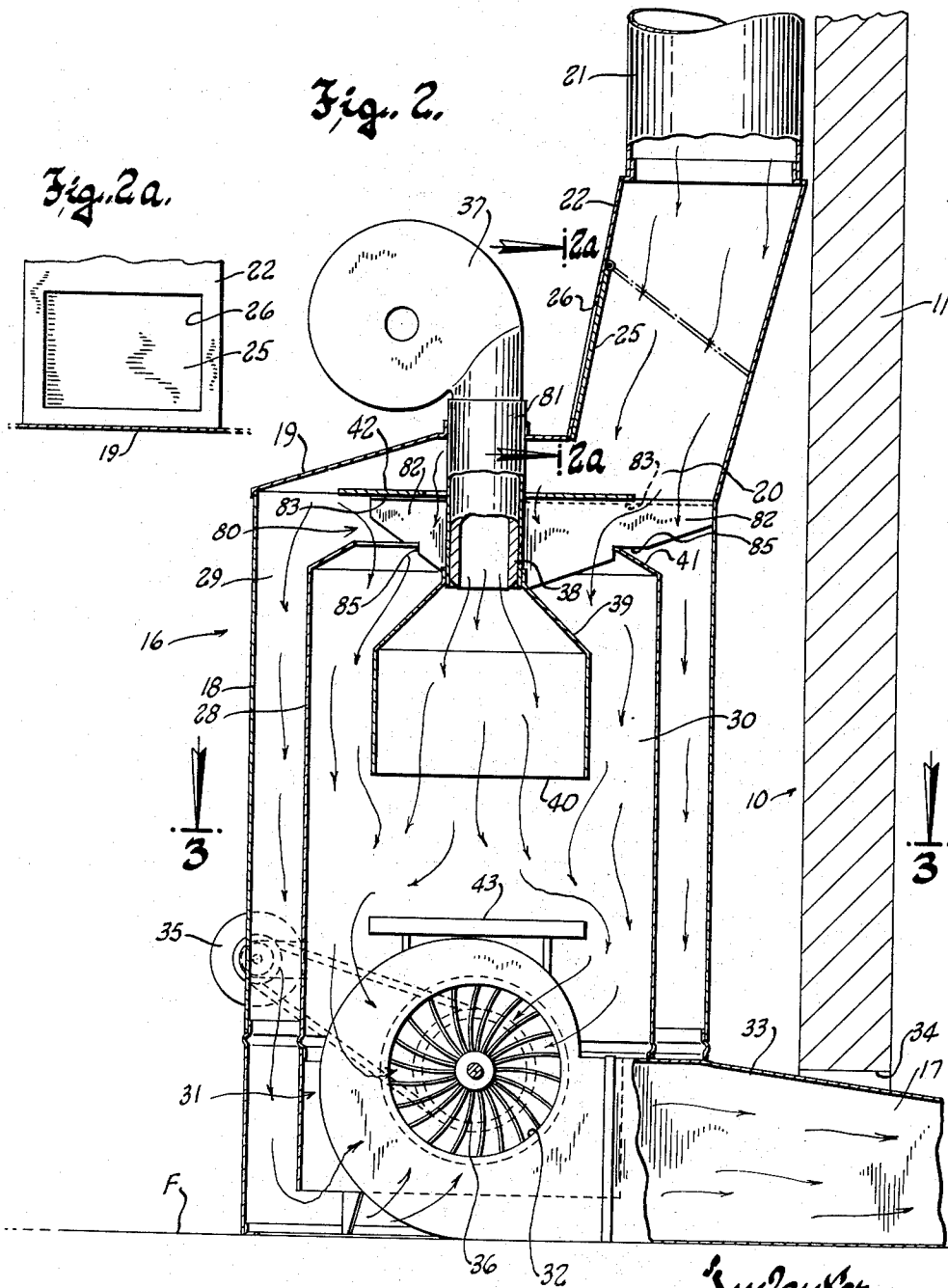
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11 Sheets-Sheet 2



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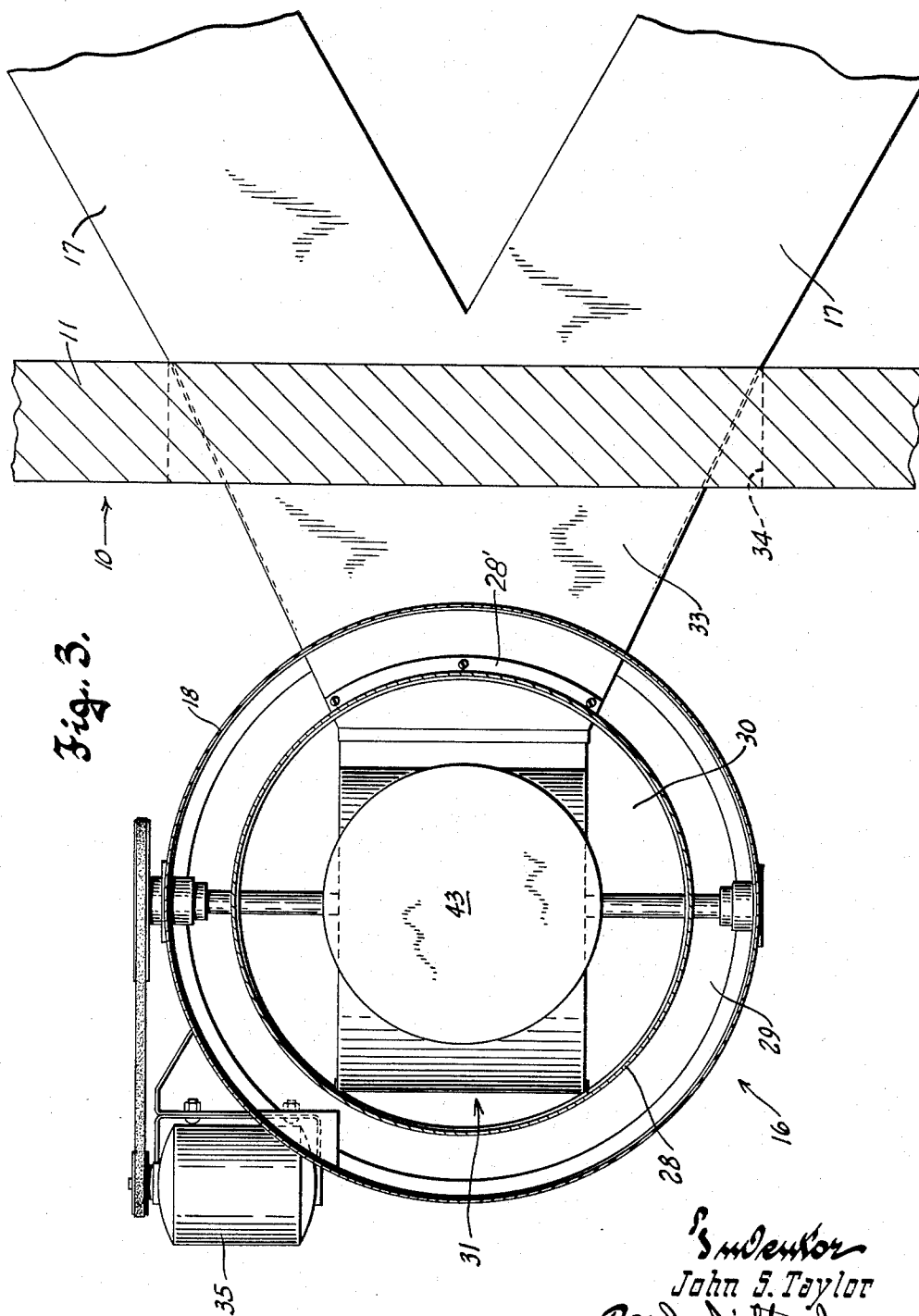
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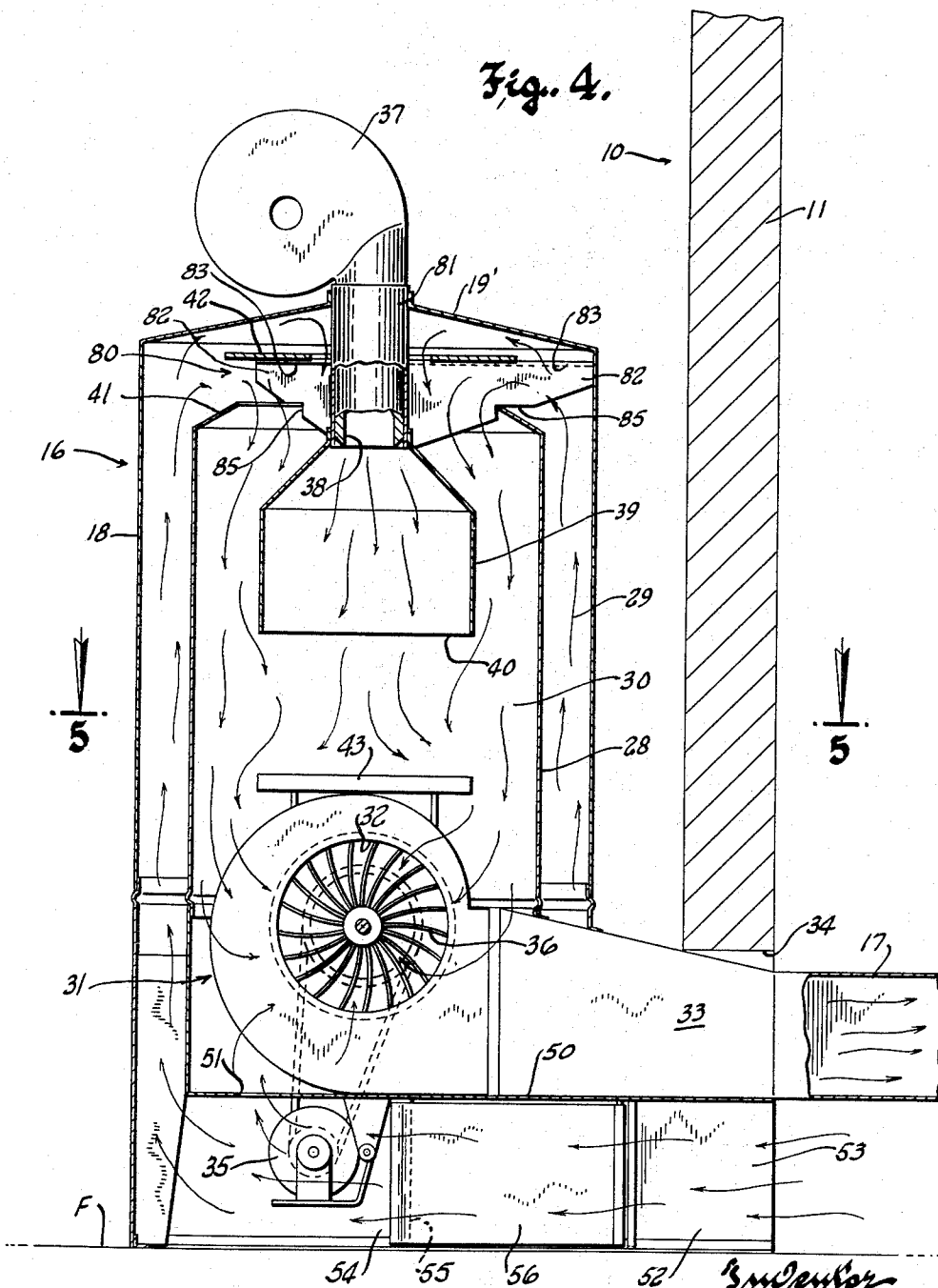
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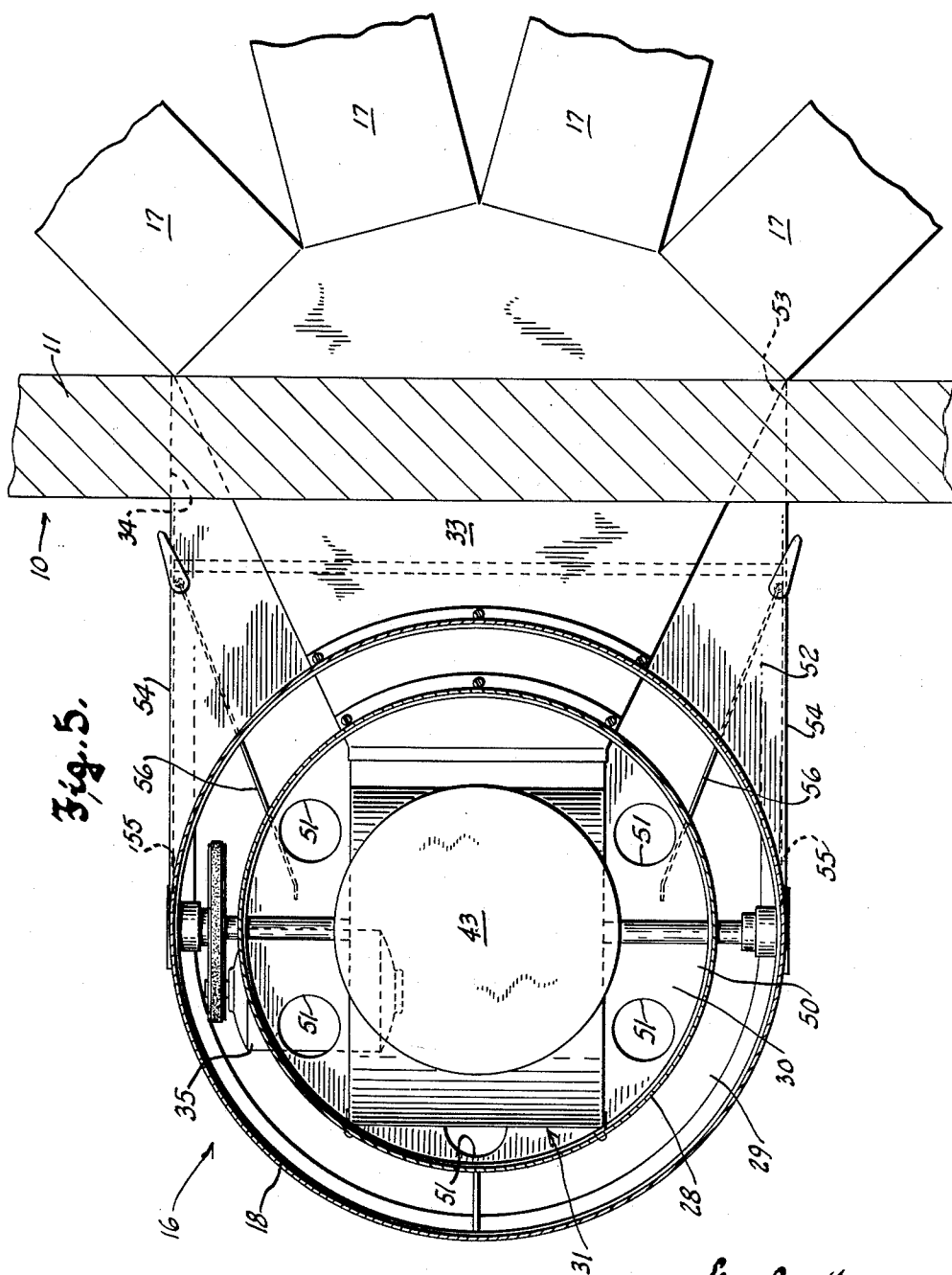
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11 Sheets-Sheet 5



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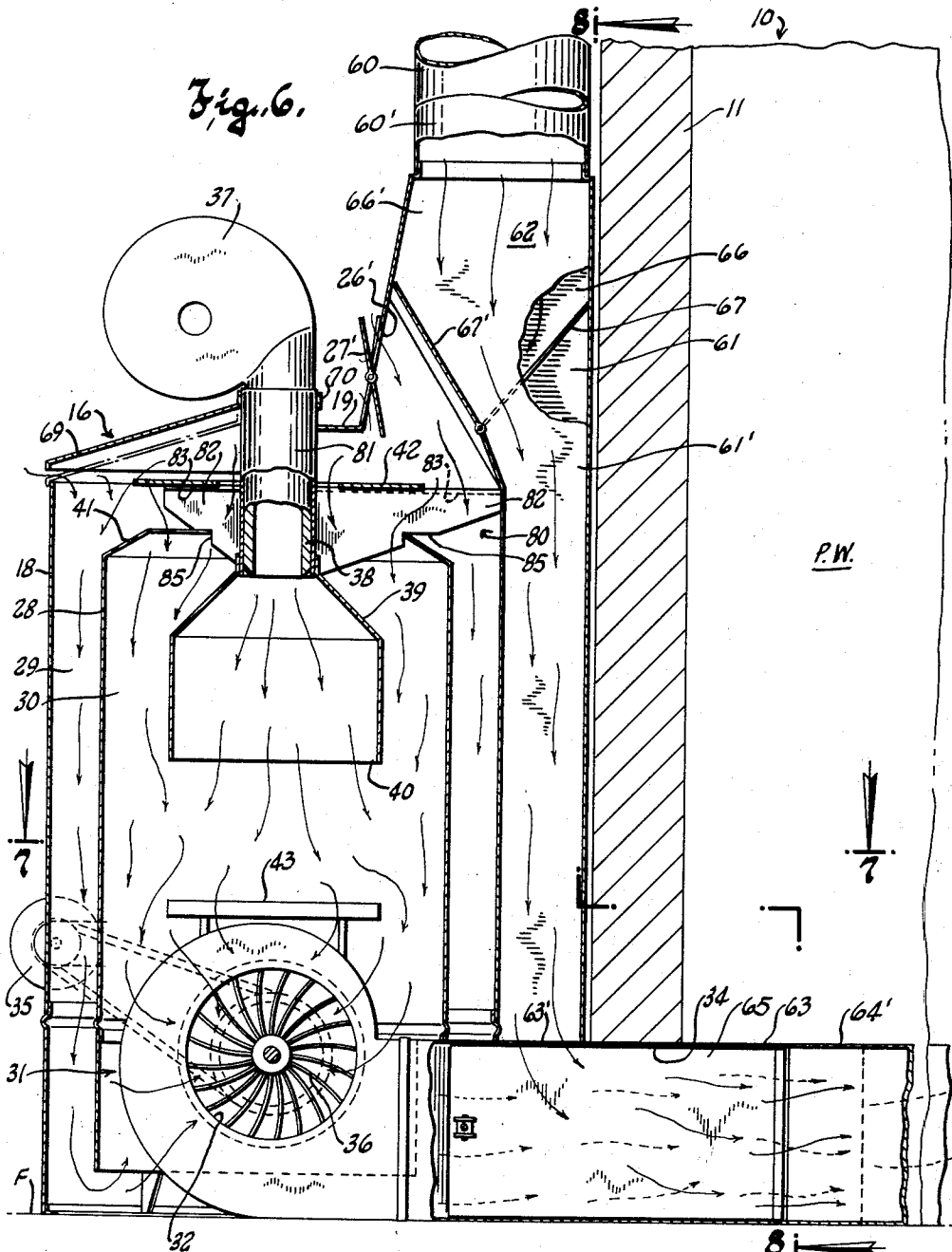
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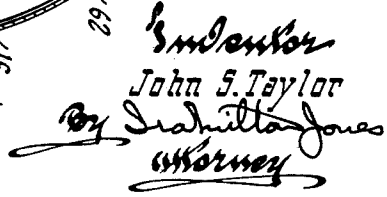
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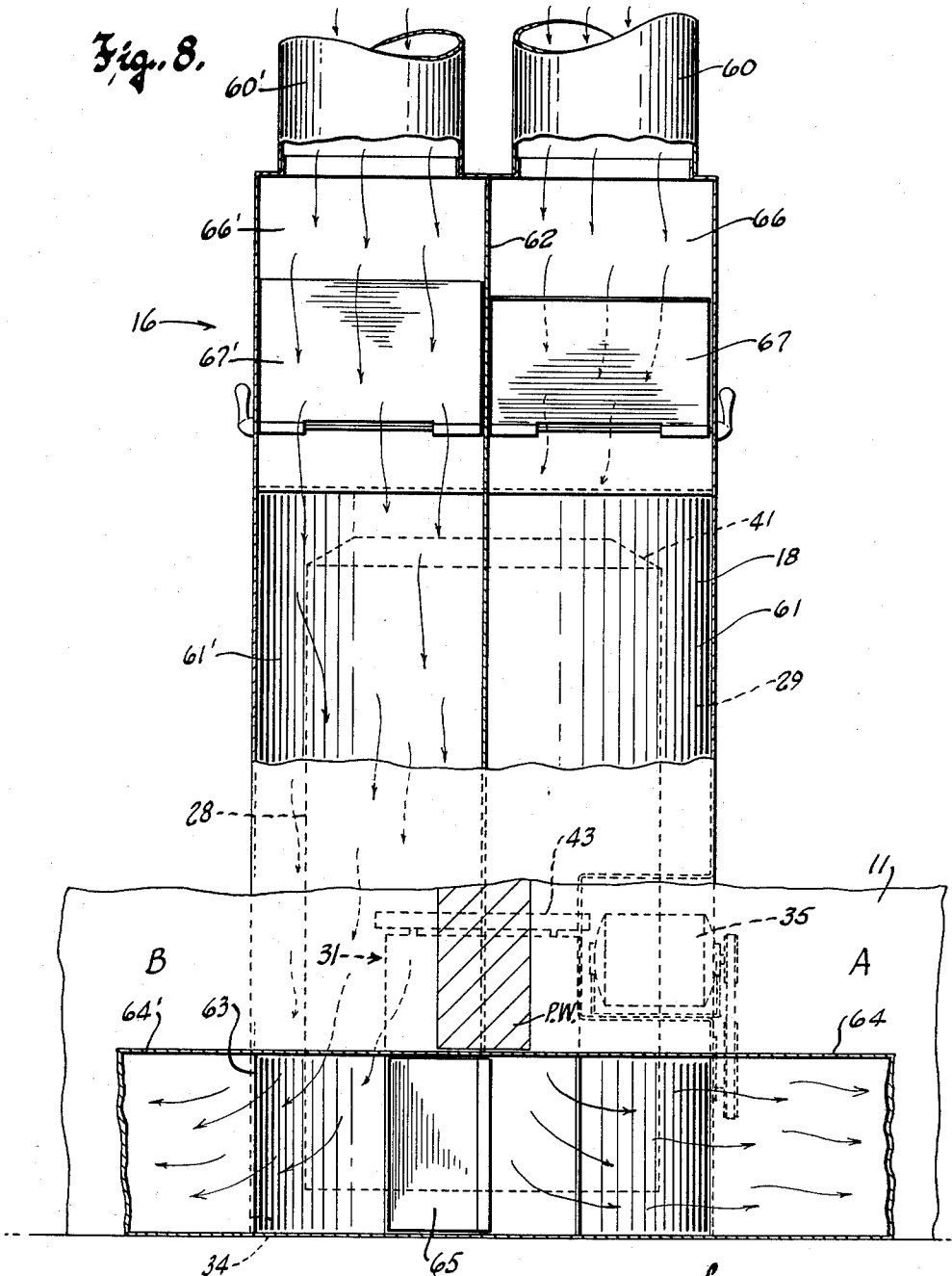
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Fig. 8.



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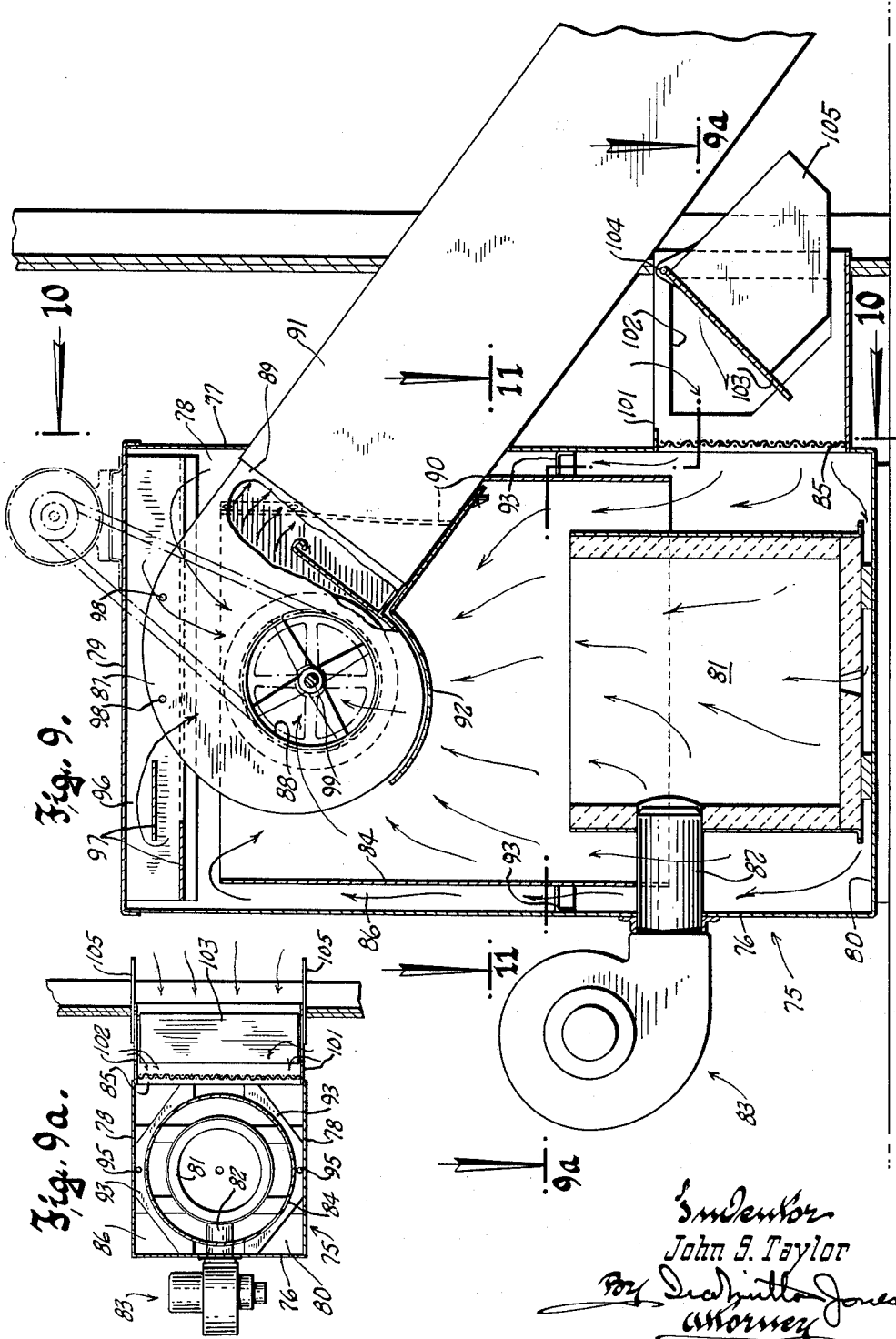
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11 Sheets-Sheet 9



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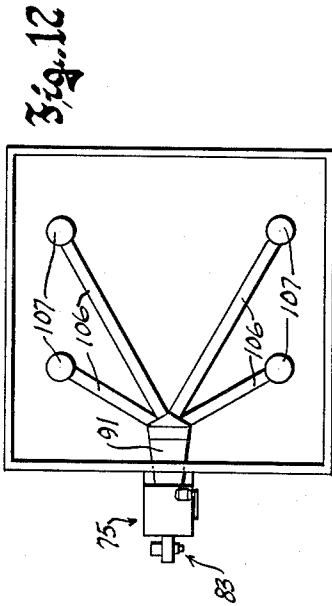
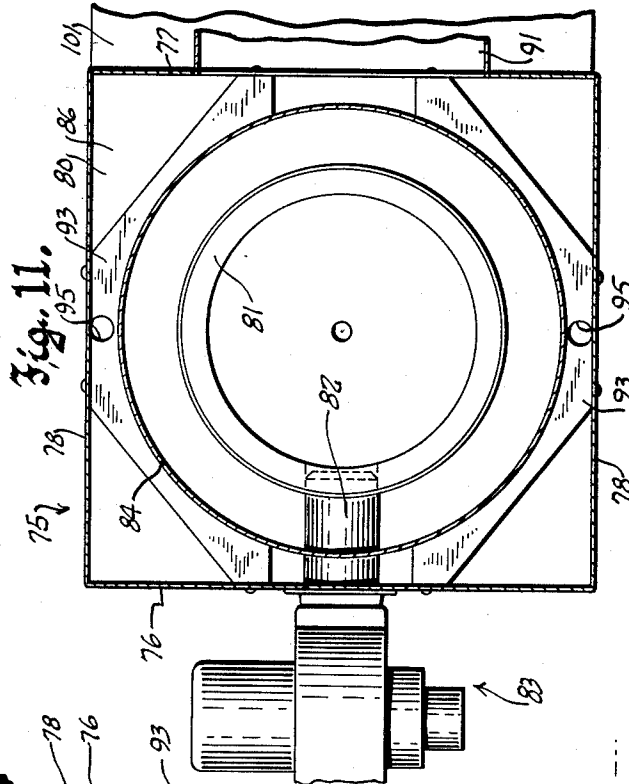
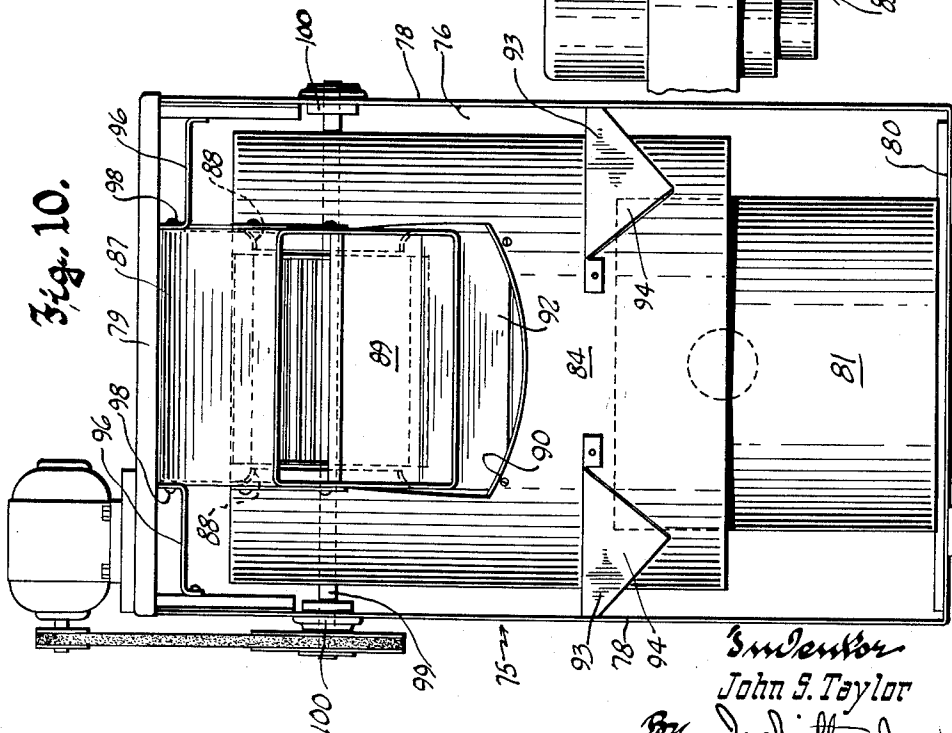
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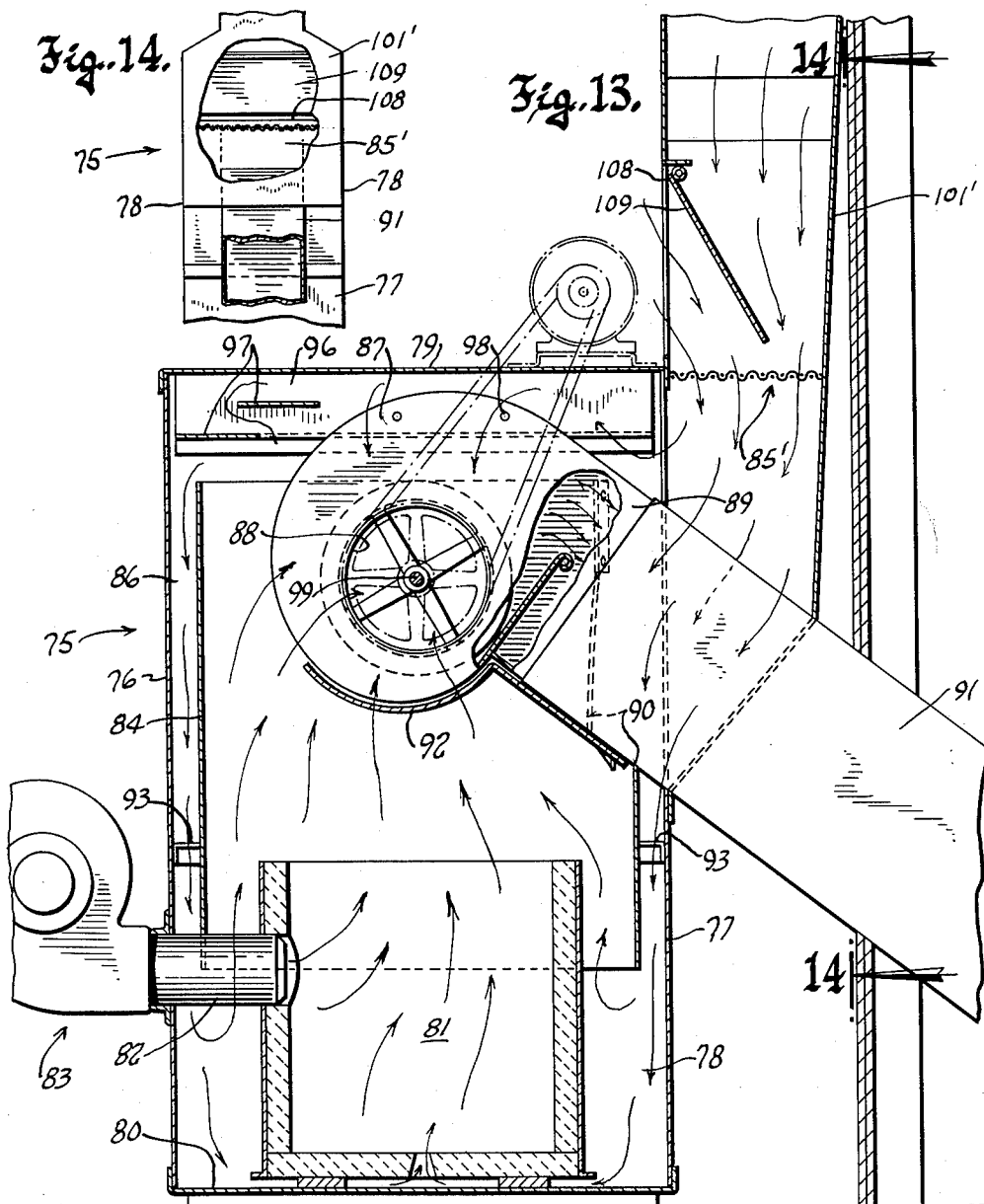
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TOBACCO CURING APPARATUS

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23 Claims. (Cl. 263—19)

This application is a continuation-in-part of my pending application Serial No. 288,854, filed June 11, 1963, now abandoned, which in turn was a continuation-in-part of my pending application Serial No. 179,601, filed March 14, 1962, now abandoned. Hence, the invention here presented concerns tobacco curing apparatus used to cure the type of tobacco grown in many localities including the southeastern area of the United States, commonly known as "flue cured" or "yellow leaf" tobacco.

Although the art of curing tobacco is quite old, and supposedly well understood by tobacco growers, it has been recently discovered that time-honored curing methods and equipment are not capable of producing the desired results when the curing barns are heavily loaded.

By improved growing methods, tobacco growers have been able to double their yield per acre in the past few years, and will no doubt continue to improve it. However, the increased production and labor costs make it economically unfeasible for the farmers to duplicate their curing facilities. Instead, they crowd much more tobacco into the curing barns. In fact, twice as much tobacco is now being put into the same old barn.

Because of this greatly increased loading of the curing barns, the tobacco curing apparatus heretofore available, even that of the Jones Patent No. 2,841,381, which, until, the advent of this invention, probably was the best available, was incapable of producing the desired results. This follows from the fact that prior curing methods and apparatus depended on natural convection to effect the needed circulation of air during the yellowing phase, and the discharge of moisture laden air from the upper reaches of the barn during the leaf-drying period. With the barns densely packed with tobacco, natural convection all but disappeared. Thus, as heat was introduced into the barn below the racked tobacco, and moisture was released from the lower tiers, the temperature did not increase correspondingly higher up in the barn, but instead a strata of very humid, relatively cool air was formed. At best, this resulted in a poor compromise between too rapid drying of the lower tiers of tobacco and too slow drying higher up, and often led to ruined tobacco.

With a view toward obviating this objectionable situation, the present invention has as its general purpose to provide an improved curing apparatus by which positive circulation of air throughout the entire barn can be produced in all phases of the cure, despite the present day heavy loading of the barn and the adverse weather conditions which are apt to be encountered and which heretofore made it difficult to do good curing even with a lightly loaded barn.

More specifically, it is an object of this invention to provide a tobacco curing apparatus by which the air in the curing barn is positively drawn from the top thereof, and then either recirculated as in the yellowing stage, or replaced with a controlled amount of outside air as needed during the drying state.

Another object of this invention is to provide a tobacco curer which does not depend upon natural convection currents within the barn.

Another object of this invention is to provide a tobacco curing apparatus, which is capable of serving two separate adjacent barns in such a way that yellowing of the

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tobacco leaf may take place in one of the barns while drying of the tobacco leaf occurs in the other, and vice versa.

With the increased loading of the curing barns, it was found that more and more air had to be moved through the barn and, in apparatus heretofore available, this was impossible. Also, with existing tobacco curing apparatus it was impossible to prevent overheating of the apparatus unless substantial amounts of outside air were continually drawn into it and recirculated along with the air being delivered to the barn. During yellowing this is very objectionable. Proper yellowing cannot be done unless the amount of outside air allowed to enter the barn is held to the barest minimum. Ideally no outside air should be admitted at this time.

It is thus another object of the present invention to provide a tobacco curing apparatus which is capable of delivering all the air needed to effect proper curing even at maximum loading of the barn, and wherein a large volume of the recirculated air continually sweeps across the inner surfaces of the outer walls of the unit to keep the same from overheating without having to introduce outside air for this purpose.

Finally, it is another object of this invention to provide a tobacco curing apparatus of the character described, by which any desired proportioning of recirculated and outside air may be obtained and maintained, and by which unprecedentedly good results are accomplished in less time than was heretofore required to effect a good cure.

With these and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiments of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of the physical embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIGURE 1 is a cross sectional view through a curing barn equipped with one form of the tobacco curing apparatus of this invention;

FIGURE 2 is a vertical sectional view through the curing apparatus per se;

FIGURE 2a is a detail sectional view through FIGURE 2 on the plane of the line 2a—2a;

FIGURE 3 is a cross sectional view through FIGURE 2 on the plane of the line 3—3;

FIGURE 4 is a view similar to FIGURE 2, but illustrating a slightly modified embodiment of the invention, which differs from that of FIGURE 2 primarily in that the air from the barn enters the unit at the bottom, rather than at the top thereof, as it does in the unit of FIGURE 2;

FIGURE 5 is a cross sectional view through FIGURE 4 on the plane of the line 5—5;

FIGURE 6 is a view which is again similar to FIGURE 2, but illustrating still another modified embodiment of the invention, especially adapted for simultaneously servicing two adjacent barns, said view being taken on the plane of the line 6—6 in FIGURE 7;

FIGURE 7 is a cross sectional view through FIGURE 6 on the plane of the line 7—7;

FIGURE 8 is a vertical sectional view through FIGURE 6 on the plane of the line 8—8;

FIGURE 9 is a vertical sectional view through a tobacco curing apparatus of the type shown in FIGURE 4, wherein the air enters the unit at the bottom rather

than at the top, but illustrating a modified embodiment of this form of the invention;

FIGURE 9A is a cross sectional view through FIGURE 9 on the plane of line 9a—9a, illustrating particularly the manner in which the air enters the apparatus either from the barn for recirculation, or from the outside;

FIGURE 10 is a rear view of the apparatus shown in FIGURE 9, but with the rear panel and the air inlet and outlet ducts removed;

FIGURE 11 is a cross sectional view through FIGURE 9 on the plane of the line 11—11;

FIGURE 12 is a plan view more or less diagrammatically illustrating the installation of the curing apparatus of FIGURE 9 in a conventional tobacco curing barn.

FIGURE 13 is a view similar to FIGURE 9, but showing this form of the curing apparatus adapted for top return of the air; and

FIGURE 14 is a fragmentary rear view of the apparatus shown in FIGURE 13.

Referring now particularly to the accompanying drawings, and more specifically to FIGURES 1, 2 and 3 thereof, the numeral 10 designates generally a curing barn which may be of any desired type or construction, having upright walls 11 and a roof 12, which is preferably pitched so as to localize the upper portion thereof.

As is customary, the barn is equipped with poles 14 or the like, secured to opposite walls as at 13, and from which the tobacco leaves T are hung in the customary manner. As will readily be understood, a fully loaded curing barn, contains a vast amount of tobacco leaves, especially now that the farmers' yields are so much larger than before, and the farmer finds it necessary to pack more and more tobacco into the curing barn. This makes circulation of air in the barn rather difficult, but despite this difficulty, if the tobacco is to be properly cured there must be a positive circulation of the air in all portions of the barn so that moisture is uniformly abstracted from all of the tobacco and the drying of the tobacco progresses uniformly whether it happens to be located in one of the lower tiers or in one of the upper tiers.

To assure such positive circulation of the air within the curing barn, the curing apparatus of this invention preferably employs an exhaust fan or blower 15 mounted in the upper portion of the barn to draw the air therefrom and then discharge it either into the atmosphere or down into the heating unit of the curing apparatus indicated generally by the numeral 16. It should be understood, however, that the fan or blower need not be used in all stages of the cure and normally is used only during the leaf drying phase. At other times, and especially during recirculating when less air is required, the blower 31 with which the heating unit 16 is equipped can meet the requirements.

The heating unit of the apparatus is located exteriorly of the barn, preferably adjacent to one of its walls 11, and discharges into the lower portion of the barn through a plurality of distributor ducts 17 which lead to diffusing heads 17', strategically located on the floor of the barn, or in any other suitable manner to effect uniform distribution of the air entering the barn.

Although one of the aspects of this invention resides in the concept of positively withdrawing the air from the upper portion of the barn and either discharging it to the atmosphere or directing it down into the heating unit of the apparatus for recirculation, the invention resides primarily in the novel construction of the heating unit 16. By virtue of its improved construction and design, the heating unit 16 accommodates this desirable overhead return arrangement, and does so without precluding the adaptation of the unit to the more conventional bottom-return arrangement shown in FIGURE 4.

The heating unit 16 comprises an upright casing 18

which is preferably round, as illustrated in the accompanying drawings, though it may be square or rectangular in horizontal cross section. The casing is adapted to set upon a suitable foundation or base F alongside the barn. Since the bottom of the casing 18 is closed by the base F, it need not have a bottom wall, though, if desired, this may be provided so that the bottom of the casing will be closed independently of the base or other supporting structure upon which it sets.

At its top, the casing 18 is closed by a top wall 19 which, in the case of the overhead return embodiment of the invention shown in FIGURE 2, has an air inlet opening 20 with which the lower end of the return or recirculation duct 21 is connected by means of a flat-walled valve housing 22.

The upper end of the duct 21 which may extend vertically alongside the adjacent wall of the barn, is connected with a duct 23 which leads from the outlet or discharge of the blower 15 and also opens to the atmosphere. A damper 24 mounted in the duct 23 is movable between a closed position, shown in full lines in FIGURE 1, in which it directs all air issuing from the blower down into the duct 21, and an open position, shown in broken lines, allowing the air drawn from the interior of the barn by the blower 15 to be discharged directly to the atmosphere.

A damper 25 mounted in the valve housing 22 controls the admission of air from the duct 21 into the casing 18. This damper also controls the admission of outside air through an air inlet port 26 in one wall of the housing 22. In one of its extreme positions, shown in full lines in FIGURE 2, the damper 25 closes the port 26 and directs any air moving down through the return or recirculation duct 21 into the casing 18. In its other extreme position (shown in broken lines in FIGURE 2) the damper 25 disconnects the duct 21 from the interior of the casing 18, making recirculation of the air in the barn impossible, but allowing outside air to be supplied to the heating unit, through the air inlet port 26. Obviously, of course, the damper 25 can occupy any desired intermediate position to effect both recirculation and the admission of outside air in any desired proportion.

Air entering the top of the casing 18 either from the recirculation duct 21 or the air inlet port 26, flows downwardly around and through an inner casing 28. The inner casing 28 may be an open-ended cylindrical shell mounted in spaced and preferably equispaced relation to the walls of the outer casing 18, so as to provide an annular chamber 29 surrounding the inner casing, and an inner hot air chamber 30. The shell which forms the inner casing 28 is open at its top and bottom ends, and is spaced from the top and bottom of the outer casing so that the interiors of the two casings are in open communication at their opposite ends.

The blower 31, hereinbefore referred to, is located in the bottom portion of the unit and, more specifically, within the bottom portion of the inner casing 28. The inlet 32 of this blower thus is in open communication with the lower portion of the inner hot air chamber 30, and also with the lower portion of the annular chamber 29, so that all air moving downwardly through either of these chambers reaches the blower, to be discharged thereby into a discharge duct 33 which extends laterally from the outer casing and through a hole 34 in the adjacent wall of the barn, to deliver conditioned air thereto through the ducts 17.

As will be seen in FIGURES 2 and 3, the discharge duct 33 passes through appropriately located openings in the walls of both casings 18 and 28. These views also show that the top and side walls of the duct are directly contiguous to the adjacent edges of the openings in the casing walls through which the duct passes, and that the casing walls may have flanges such as the flange 28' in FIGURE 3, at the edges of these openings, which flanges may be secured to the duct by sheet metal screws.

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It follows, therefore, that the only way air which enters the annular chamber 29 can reach the inlet of the blower 31 is by flowing around the bottom edge of the casing 28, since the wall of this casing, except where it is cut out to accommodate the duct 33 is imperforate.

An electric motor 35, suitably mounted on the exterior of the unit, drives the rotor 36 of the blower, it being understood that the shaft of the rotor projects to the exterior of the outer casing, as clearly shown in FIGURE 3.

The heating unit is, of course, provided with a heat source 37 which is preferably an injection type oil burner, though it may be a gas-fired unit. In any event, the heat source is mounted on top of the unit, with its nozzle 38 projecting down through the top wall 19 thereof, and debouching into the upper portion of the inner hot air chamber 30. To prevent interference with proper combustion by the air entering the top of the chamber 30, the nozzle opens into a shroud 39 which has a downwardly opening mouth 40 considerably larger than the mouth of the burner nozzle. The shroud provides an expansion chamber for the flame and combustion gases, and being interposed between the flame and the open top end of the chamber 30 protects the flame from being objectionably cooled by the air entering the chamber 30.

Since the walls of the shroud are a source of significant radiant heat, heat shielding means is interposed between this radiant heat source and the top wall 19. This heat shielding means comprises an inwardly directed flange 41 on the upper end of the inner casing 28 and a centrally apertured baffle 42 mounted above the entrance to the chamber 30. The heat shield also proportions the air flowing into the inner chamber 30 and the outer annular chamber 29.

The heat source 37, the shroud 39 and the heat shield and baffle 42 are all supported by a spider 80 which is secured in the upper end portion of the outer casing 18. This spider comprises a central tube 81 of a diameter to snugly receive the burner nozzle 38 and a length to extend from the mouth of the nozzle all the way through the top wall 19, and three arms 82 which radiate from the tube and have their ends secured to the upper end of the casing 18. The top edges of these arms are bent at right angles to provide flanges 83 upon which the heat shield and baffle 42 rests and is secured. The arms 82 also serve to hold the upper end of the shell 28 centered with respect to the outer casing, for which purpose the bottom edges of the arms are notched as at 85 to provide radially outwardly facing shoulders which engage the inner edge of the inturned flange 41.

Any suitable way of securing the nozzle 38 in the tube 81 may be employed, and to support the shroud 39 in proper position, its small diameter upper end may be telescoped over and secured to the lower end of the tube.

To protect the housing of the blower 31 from the flame and products of combustion issuing from the burner nozzle 38, a shield 43 is provided. This shield may be of refractory material or of metal capable of withstanding the direct impingement of flame thereon.

In use of the apparatus for the curing of tobacco, the tobacco, of course, is first racked in the barn. Then, with the doors leading into the barn and any other openings therein closed, the heating unit is turned on. The heat source 37 is controlled by a thermostat (not shown) located within the barn and preset to provide a predetermined temperature in the barn. Another control suitably interlocked with the thermostat governs operation of the blower 31.

With the damper 25 in its position shown in full lines in FIGURE 2, and the damper 24 closed, the air drawn from the top of the barn by the blower 31 passes down through the recirculation duct 21 into the top of the heating unit to flow simultaneously into the annular chamber 29 which

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surrounds the inner casing 28, and the inner chamber 30. The air flowing through the annular chamber keeps the outer walls of the casing 18 cool and abstracts heat energy from the walls of the inner casing as it flows thereover in its passage to the inlet of the blower 31. The air which enters the top of the inner chamber 30 is, of course, also heated and, in fact, to a higher temperature than that flowing through the chamber 29.

Thus, all the air which enters the top of the heating unit, as well as the products of combustion issuing from the burner nozzle 38 pass on out of the unit through the duct 33 and into the branch ducts 17 for entry into the bottom of the barn.

By virtue of the fact that the air in the barn is drawn from the top thereof, and because the diffusing heads 17' are located to distribute the heated air and products of combustion entering the barn substantially uniformly over its entire floor area, all of the tobacco racked in the barn will be subjected to substantially the same curing atmosphere, so that the yellowing phase of the cure proceeds as uniformly as possible throughout the entire mass of the tobacco.

After yellowing has been completed the tobacco must be dried. At the start of the drying phase it is preferable that there be no recirculation of the air in the barn but instead the moisture-laden air should be replaced with outside air. Accordingly, the damper 24 is opened, the blower 15 is turned on, and the damper 25 is closed, i.e. moved to its dotted line position. Also, the thermostat is reset to effect a rise in temperature in the barn.

As the leaf drying phase progresses and the moisture content of the air in the barn approaches that of the outside atmosphere, the amount of outside air drawn into the barn is reduced by appropriate adjustment of the dampers until, at the completion of the leaf drying period, no outside air enters the barn. With the apparatus thus set, the next stage or phase of the cure can take place. This is the drying or "killing" of the stems of the leaves.

The stem drying or "killing" stage is followed by the so-called "ordering" of the tobacco, during which time the leaves are allowed to absorb moisture and regain pliability. Ordering may be hastened by positively circulating outside unheated air through the barn.

The specific procedure followed in the curing of the tobacco is no part of this invention and will depend, to a large degree, upon local conditions and the convictions of the grower using the equipment. The important thing is that this invention provides an apparatus by which the grower or farmer can produce and maintain the desired conditions in the curing barn—despite bad weather conditions and the fact that he has loaded more than twice the amount of tobacco into his barn than he ever did; and also that, with the apparatus of this invention, it is possible to exclude outside air from the barn during the yellowing stage of the cure (other than that which may enter through the fuel burner) without the disadvantage of having the apparatus overheat.

Although it has been fairly well established that it is definitely more efficacious—especially where the barn is densely packed—to positively withdraw the air to be recirculated from the upper portion of the barn above the uppermost tiers of tobacco racked therein, the apparatus of this invention nevertheless is also adaptable to use with the more conventional bottom return system; and FIGURES 4 and 5 illustrate the modifications necessary to adapt the heating unit to such bottom return arrangement.

In this embodiment of the invention (FIGURES 4 and 5) a wall 50 extends across the bottom of the inner chamber 30, and except for a plurality of holes 51 therein, closes the same.

The blower 31 and its discharge duct 33 are directly above the wall 50, and beneath it is an inlet duct 52. The mouth 53 of the inlet duct opens to the interior of the

barn below the discharge duct 33, to communicate the interior of the barn with the interior of the heating unit at the lowest portion thereof. The side walls 54 of the inlet duct have large outside air admission ports 55 therein, which are controlled by dampers 56. When these dampers are in their closed positions only air from the interior of the barn reaches the heating unit and, when the dampers 56 are fully open, only outside air is drawn into to unit. At any intermediate position of the dampers 56 outside air will be drawn into the unit along with air from the barn, in a proportion depending upon the setting of the dampers.

Because of the presence of the wall 50 across the bottom of the inner chamber 30, the bulk of the air entering the inlet duct flows upwardly through the annular chamber 29 to the top of the heating unit and, from there, moves downwardly within the inner chamber 30 to reach the inlet of the blower 31. Obviously, the air flowing upwardly through the outer annular chamber 29 keeps the outer casing walls from overheating in the same way that the downward flow of air does in the structure previously described and specifically illustrated in FIGURE 2.

In this modified embodiment of the invention, the top of the outer casing is completely closed by the top wall 19' through which the nozzle of the blower extends, as it does in the FIGURE 2 construction. Also, as in the structure shown in FIGURE 2, the burner 37 with its downwardly facing nozzle 38, the shroud 39 and the heat shield and baffle 42 are supported in the upper end of the outer casing by a spider 30.

Some of the air entering the heating unit through its inlet duct 53 reaches the blower 31 through the holes 51. Thus, because of the presence of the holes 51, the lower end of the inner casing, like its upper end, is communicated with the interior of the outer casing and, by the number and size of these holes, it is possible to proportion the heated and unheated air reaching the blower inlet, it being understood that the air which reaches the blower 31 through the holes 51 does not pass across the hot surfaces of the heating unit.

To those skilled in the art it is of course understood that when the bottom return method of curing (FIGURES 4 and 5) is employed, some means of exhausting the air from the top of the barn must be provided. This may be done with conventional top vents or by an exhaust fan mounted in the upper reaches of the barn.

Another possible variation or modification of the disclosed structure contemplates the omission of the blower 31. While such omission might entail a sacrifice in the adaptability of the invention to different uses, for some purposes satisfactory results would be obtained by using only the blower or fan 15 to effect the needed movement of air. In this case, the blower or fan 15 would be in operation during the entire cure, not only during drying. During yellowing when the air in the enclosed space is recirculated, the damper 24 would have to be left closed, and the damper 25 would have to be in its closed position shown in solid lines in FIGURE 2; and for drying when outside air is needed, both these dampers would be adjusted to their open positions shown in dotted lines in FIGURES 1 and 2, so that the air discharged to the atmosphere because of the open damper 24 could be replaced by outside air drawn through the port 26.

As noted hereinbefore, this invention has as one of its purposes to provide a tobacco curing apparatus, not only adapted for use with a single curing barn, but also with two separate barns, and in a way which enables yellowing to be done in one barn while drying takes place in the other, and to enable one barn to be loaded while tobacco in the other is undergoing part of its cure.

For this purpose, the heating unit is essentially the same as it is in the embodiment of the invention shown in FIGURE 2, but the manner in which air is fed to and delivered from the unit is different. Thus, instead of a single recirculation duct delivering air to the top of the

heating unit, there are two side-by-side ducts 60 and 60', the former leading from the top of one barn, and the latter from the top of the other barn, which, for purposes of illustration, are designated by the letters A and B in FIGURE 7. The two barns may be simply the two halves of a single barn divided by a partition wall P.W. In any event, the two barns or enclosed spaces preferably are adjacent to one another.

Each of the two ducts 60—60' connects with one of a pair of side-by-side plenum chambers 61—61' which extend down alongside the outer casing. These plenum chambers are separated from one another by a common wall 62 that projects radially from the outer casing, and from the interior of the outer casing only by the wall of this casing. Hence the plenum chambers and the interior of the outer casing, and more especially the annular chamber 29 are in fairly good indirect heat exchange relation with one another. The significance of this observation will become apparent as the description proceeds.

At their bottoms, the plenum chambers 61—61' open to an outlet duct 63 which projects laterally from the outer casing and enters both barns straddling the partition wall P.W. between them. At this point the duct 63 is bifurcated to provide two discharge branches 64 and 64', the former opening to the barn A and the latter to the barn B.

The mouth of the discharge duct 33 which leads from the blower 31 also opens into the outlet duct 63 directly below a horizontal wall 63' which is at least as wide as the mouth of the duct 33 and is contiguous to the upper edge thereof. It should also be noted that the wall 63' connects with the common wall 62 between the two plenum chambers and that it bridges the space between the wall of the outer casing 18 and the opposite walls of the plenum chambers.

A damper 65 which is hinged to the junction of the two discharge branches 64—64' and projects into the mouth of the duct 33 with its top and bottom edges in sliding engagement respectively with the wall 63' and the bottom wall of the outlet duct 63, enables the discharge of the blower 31 to be directed alternatively into one or the other of the two barns. In the position this damper is shown in FIGURE 7, the blower 31 discharges only into the discharge branch 64 which leads to the barn A. In this position the damper 65 also shuts off communication between the plenum chamber 61' and the branch 64', so that air moving through this plenum chamber can be delivered only to the barn B. Any suitable means such as a handle 65' may be provided for adjusting the damper.

The upper ends of the plenum chambers project above the top of the outer casing to provide side-by-side flat-walled valve housings 66—66' in which dampers 67—67' swing between positions either connecting or disconnecting the recirculating ducts 60—60' with their respective plenum chambers. As shown in the drawings (FIGURE 6) the damper 67' is set to connect the recirculation duct 60' which leads from the blower in the top of the barn B with its plenum chamber 61'. Accordingly, the air drawn from the top of barn B (by the blower in the top thereof) flows downwardly through the plenum chamber 61' in indirect heat exchange relation with the hot air in the chamber 29 to be heated thereby, and then returned to the barn B through the duct 63 and its discharge branch 64'. Recirculation of the air in the barn B is thus effected by the blower in the upper portion of the barn, to produce the desired yellowing of the tobacco in barn B.

Since the temperature to which the air in the chamber 29 is heated is not under the control of the thermostat in barn B, but instead depends upon the demand for heat in barn A where drying of the leaves is taking place, it is possible that the air passing through the plenum chamber 61' on its way to the barn B might become too hot for proper yellowing unless some control is maintained over the amount of heat imparted to the recirculated air. Such

control is obtained by admitting a regulated amount of outside air into the chamber 29 through an air inlet port 26', the regulation being effected by a damper 27'. The outside air thus admitted flows over the wall of the outer casing which separates the chamber 29 from the plenum chamber 61' and abstracts some of the heat from this wall.

It should be noted that although the port 26' is in a wall which defines part of both valve housings 66—66', it is below the adjacent edge of the dividing wall 62 so that the air entering the port 26' serves as a temperature modifier for the recirculated air, regardless of which of the barns is in the yellowing phase.

While the tobacco in barn B is being yellowed, the tobacco in barn A is being dried—in the situation depicted in the drawings. To this end, the damper controlling the discharge from the blower in the upper portion of the barn A is open to allow the air exhausted from the upper portion of this barn to be discharged to the atmosphere. Also, damper 67 is set to close off communication between the plenum chamber 61, in which a positive pressure obtains due to its connection with the discharge of the blower 31, from the recirculation duct 60. This prevents loss of heated air delivered by the blower 31, through the recirculation duct 60, and assures that all of this heated air will be delivered to the barn A to effect the drying of the tobacco therein.

It is, of course, understood that the heated air delivered to the barn A for leaf drying must enter the unit from the outside, and while at the start of the drying phase the temperature in the barn should be increased as rapidly as possible, the volume of dry air entering the barn must be proportionally increased. If this does not occur, i.e. if not enough air is moved through the barn to carry off the moisture released from the tobacco leaves by the rising temperature, the barns sweat, and if this condition is allowed to continue unchecked the tobacco is soon ruined.

Some outside air, of course, can enter the unit through the inlet port 26', if it is open, but this does not suffice. Moreover, to admit all of the air needed for proper leaf drying in the barn A, through the port 26' would vitiate the temperature control which the regulated admission of outside air through this port has upon the air being recirculated through the barn B. Hence, the outside air required for leaf drying in the barn A must be admitted through another entrance into the top of the unit, and in a manner which will not unduly cool the wall separating the chamber 29 from the plenum chambers 61—61'.

This objective is conveniently met by forming the top wall 19 of the outer casing in two sections, one of which is stationary and has the valve housings 66—66' connected thereto and the other, designated by the numeral 69, is movable between a closed position closing the top of the unit and a lifted or open position admitting outside air into the upper portion of the unit, as shown in FIGURE 6. Any suitable structure may be employed to mount the movable section 69 of the top wall, as for instance a collar 70 slidably mounted on the tube 81 and having the movable top wall section fixed thereto.

It should be observed that the air admitted into the top of the unit when the top wall section 69 is lifted, does not flow directly to the rear portion of the casing wall which separates the chamber 29 from the plenum chambers 61—61', but sweeps over hot surfaces before it reaches that portion of the casing wall.

Overheating of the heating unit in this double barn arrangement is no problem since at all times either outside air or recirculated air flows through the outer annular chamber 29. But the important advantage of the double barn arrangement is that, with a single heating unit, two separate barns may be served, so that while yellowing takes place in one barn, drying may proceed in the other, it being simply a matter of properly adjusting the various control dampers. Nor are the operations that can take

place simultaneously in the two barns limited to yellowing and drying, for by simply making the necessary adjustments of the controls, loading or unloading could take place in one of the barns while one of the phases of the cure proceeds in the other barn.

Also the number of barns served by the unit might be multiplied beyond the two shown and described, by simply increasing the number of plenum chambers and making other appropriate additions to the ducting.

In FIGURES 9—12, inclusive, another embodiment of the bottom-return form of the invention is illustrated. In this structure there is an upright outer casing or cabinet 75 which is square in cross section so that it has front and rear walls 76 and 77, respectively, and side walls 78. The top of the casing is closed by a flat wall 79 and its bottom is closed by a wall 80.

Seated in the bottom portion of the outer casing or casing 75 is a refractory lined combustion chamber or pot 81 into which the nozzle 82 of an oil burner, indicated generally by the numeral 83, debouches. A round open-ended inner casing 84 is mounted inside the outer casing with its lower end portion embracing the top of the combustion chamber or pot 81 in spaced relation thereto. Thus, air introduced into the interior of the outer casing or cabinet through an air inlet opening 85 in the lower portion of the rear wall 77, may flow upwardly into the interior of the inner casing 84 to be heated and admixed with the products of combustion rising from the combustion chamber or pot 81. Air entering the inlet opening 85 may also flow into and upwardly through the chamber 86 formed by the space between the inner and outer casings.

In the upper portion of the inner casing is a blower 87, the inlets 88 of which—one at each side of the blower—are just below the top edge of the inner casing and well spaced from the adjacent sides of the inner casing so that all air which enters the interior of the inner casing will be freely drawn into the blower.

The outlet 89 of the blower passes through the wall of the inner casing 84 which is cut out as at 90 to accommodate the same, and connects with a discharge duct 91 that passes through an appropriate opening in the rear wall 77 of the outer casing or cabinet. The edges of the cutout 90 are contiguous to the adjacent walls of the outlet 89 so that air which flows upwardly through the chamber 86 between the inner and outer casings is substantially constrained to travel the full length of the inner casing in order to reach the inlets of the blower. This assures against localized hot spots on the walls of the outer casing or cabinet, since it forces the cooling air rising in the chamber 86 to sweep substantially uniformly across all portions of these walls that are most apt to become hot.

While it is desirable to have the edges of the cutout 90 as close as possible to the adjacent walls of the blower outlet, for convenience in production more or less clearance space may be left therebetween, and this condition is contemplated in the choice of the word "contiguous" in defining the relationship between the edges of the cutout and the adjacent walls of the blower.

Preferably a heat shield 92 is mounted beneath the blower and the adjacent portion of its discharge duct to protect the same against radiant heat from the combustion chamber or pot.

The chamber 86 between the inner and outer casings should be as free from obstructions as possible, but some means must be provided to hold the inner casing 84 properly spaced with respect to the outer casing, and in the present structure this is accomplished by two sheet metal spacers 93 which embrace diametrically opposite portions of the inner casing near its bottom end and are secured to the front, side and rear walls of the outer casing or cabinet by sheet metal screws or the like. As clearly seen in FIGURE 11, the spacers 93 are so shaped that they leave large areas of the corner portions of the outer casing or cabinet wholly unobstructed, and to secure

stiffness for the spacers 93 their outer edges are turned down to form flanges 94 which may be of uniform width or triangular, as would be the case if the spacers were formed of pieces of sheet metal having two square corners and the corner portions were simply turned down. Also, to minimize the obstruction to flow of air which the spacers 93 might impose, holes 95 are formed in their medial portions.

Free communication exists between the upper end of the chamber 86 and the adjacent end of the inner casing so that the air flowing upwardly through the chamber 86 freely enters the upper end of the inner casing for passage to the blower. It is desirable, however, that the top wall 79 of the cabinet be protected against radiant heat and, for this purpose, heat shields 96 and 97 are provided, the former also serving to mount the blower, as shown at 98 in FIGURE 10.

As in the other embodiments of the invention, the shaft 99 of the blower rotor is journaled in bearings 100 mounted on the side walls of the outer casing or cabinet, and at one of its ends the shaft 99 mounts a drive pulley by which the rotor is drivingly connected with its drive motor, the motor being conveniently mounted on the top wall of the apparatus.

The inlet opening 85 is preferably screened to keep rodents from entering the unit, and is connected with the interior of the barn by means of a recirculation duct 101. The duct 101 opens unrestrictedly to the interior of the barn and has outside air inlet openings 102 in its opposite sides. A damper 103 hinged as at 104 to be movable between a vertical position closing the mouth of the duct and a horizontal position leaving the mouth wide open, controls communication between the interior of the barn and the apparatus, and dampers 105 which may be mounted to swing in unison with the damper 103 to and from positions closing the openings 102 controls the admission of outside air.

The discharge duct 91 is downwardly inclined to meet the floor of the barn where it opens into branch ducts 106, each leading to a diffuser head 107.

FIGURES 13 and 14 illustrate the embodiment of the invention just described, modified to adapt the same to introduction of the air into the top of the curing apparatus. Thus, in this case, the inlet opening 85' into the outer casing is in the upper portion of its rear wall 77, and in fact provides the opening through which the discharge duct 91 passes. The duct 91 is narrower than the opening 85' which extends across the full width of the outer casing or cabinet. Hence the recirculation duct 101' which extends upwardly from the opening 85' embraces the discharge duct with sufficient space at the sides thereof to permit air to flow around the sides of the discharge duct and into the chamber 86 between the inner and outer casings. Some of the air from the duct 101' also flows across the top of the blower 87 into the upper end of the inner casing, and, in so doing, sweeps the underside of the top wall 79 to cool the same.

Extending upwardly from the apparatus as it does, the recirculation duct 101' is connectable with the interior of the barn or other enclosed space near the top thereof, and to enable controlled amounts of outside air to be introduced, the duct has an air admission port or opening 108 in one of its walls, and a hinged damper 109, the position of which proportions the amount of recirculated and outside air entering the apparatus.

From the foregoing description, taken in connection with the accompanying drawings, it will be apparent to those skilled in this art that this invention provides a significant improvement in tobacco curing apparatus.

It should also be apparent that, while the problem or need which motivated this invention arose in the curing of tobacco, and the physical embodiments of the invention illustrated and described are primarily tobacco curers, the apparatus of this invention can be used to advantage for the curing or drying of other crops—notably, peanuts,

sweet potatoes and corn. Another use to which the invention lends itself is the drying of lumber. In fact, it would be advantageous in any situation where the humidity and temperature in an enclosed space are to be maintained at predetermined levels, and where the introduction of products of combustion into the enclosure is not objectionable. The invention, therefore, should be construed in this broader light.

Finally, it should be understood that while the upright disposition of the heating unit shown and described is most practicable, the unit could be disposed horizontally, i.e. laid on its side so to speak. In this case that end of the outer casing which in the illustrated structure is bottom-most, would have to be closed by a wall forming part of the unit rather than some extraneous wall such as the foundation upon which the unit stands when in its upright posture.

What is claimed as my invention is:

1. Apparatus for heating an enclosed spaced, comprising:

(A) an outer casing having opposite closed end and side wall means;

(B) an open ended inner casing within said outer casing and having side wall means spaced from the side wall means of the outer casing and coacting therewith to define

(1) a chamber between said inner and outer casings, extending lengthwise from end-to-end of the inner casing and having open communication with the opposite end portions of the interior of the outer casing,

(2) the opposite ends of the inner casing by virtue of their open ended condition being in open communication with the end portions of the interior of the outer casing;

(C) means adjacent to one end of the inner casing providing an air inlet into the outer casing to admit air into the inner casing at said end thereof and also into the adjacent end of said chamber between the inner and outer casings to travel through it toward and into the opposite end of the inner casing;

(D) a recirculation duct connected with the outer casing at said air inlet means and connectable with the interior of the enclosed space to convey air from said space to said inlet means;

(E) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the inner casing;

(F) a blower in the apparatus, said blower having

(1) an inlet in open communication with the interior of the inner casing near one end thereof and at a zone remote from the point at which the burner nozzle discharges into the inner casing to receive said products of combustion and the air which enters the inner casing and is heated therein; and

(G) a discharge duct leading from the outlet of the blower and to the exterior of the inner casing and passing through an opening in the side wall means of the outer casing to be connectable with the interior of the enclosed space,

(1) the side wall means of the inner casing being uninterrupted, of substantially uniform length and substantially imperforate at least for the length thereof which extends from a point substantially in line with the inlet of the blower to the remote end of the inner casing so that the air which enters said chamber at the end thereof remote from the blower cannot reach the interior of the inner casing and the inlet of the blower except by traveling the full length of said uninterrupted and substantially imperforate portion of the side wall means of the inner casing.

2. Apparatus for heating an enclosed space, comprising:

- (A) an outer upright casing having closed top and bottom ends and upright side wall means;
 - (B) an open ended inner casing within said outer casing, having upright side wall means spaced from the side wall means of the outer casing and coacting therewith to define
 - (1) an upright chamber between said inner and outer casings extending from end-to-end of the inner casing and in open communication with the interior of the outer casing at its top and bottom;
 - (2) the top and bottom ends of the inner casing by virtue of their open ended condition being in open communication with the interior of the outer casing at its top and bottom;
 - (C) means adjacent to one end of the inner casing providing an air inlet into the outer casing to admit air into the inner casing at said end thereof and also into the adjacent end of said chamber between the inner and outer casings to travel through it toward and into the opposite end of the inner casing;
 - (D) a recirculation duct connected with the outer casing at said air inlet means and connectable with the interior of the enclosed space to convey air from said space to said air inlet means;
 - (E) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the inner casing;
 - (F) a blower in the apparatus, said blower having
 - (1) an inlet in open communication with the interior of the inner casing at a level near one end thereof and remote from the point at which the burner discharges into the inner casing to receive said products of combustion and the air which enters the inner casing and is heated therein; and
 - (2) a discharge duct leading from the outlet of the blower and to the exterior of the inner casing and passing through an opening in the side wall means of the outer casing to be connectable with the interior of the enclosed space,
 - (1) the side wall means of the inner casing being uninterrupted, of substantially uniform length and substantially imperforate at least for the length thereof which extends from substantially the level of the inlet of the blower to the remote end of the inner casing so that the air which enters said chamber is remote from the blower and cannot reach the interior of the inner casing and the inlet of the blower except by traveling the full length of said uninterrupted and substantially imperforate portion of the side wall means of the inner casing.
3. The apparatus of claim 1, wherein
- (A) the nozzle of the fuel burner is located to discharge into the inner casing through one end thereof; and wherein
 - (B) the outer casing has an end wall adjacent to said end of the inner casing; and further characterized by
 - (C) radiant heat-shielding means in the outer casing between said end of the inner casing and said end wall of the outer casing, to shield said wall from the heat in the inner casing.
4. The apparatus of claim 1, wherein
- (A) the nozzle of the fuel burner has its mouth in the end of the inner casing at which the air inlet means is located; and further characterized by
 - (B) a shroud at the mouth of the burner nozzle and into which the burner discharges, said shroud being located within the inner casing, and being coaxial with the burner nozzle, the shroud having
 - (1) a mouth considerably larger than the mouth of the nozzle,

(2) walls extending from the mouth of the nozzle to the mouth of the shroud, and

(3) said shroud providing an expansion chamber for the flame and combustion gases issuing from the nozzle, and being interposed between the mouth of the nozzle and said end of the inner casing, through which air enters the inner casing to protect the flame and burning gases against being excessively cooled by the air which enters the inner casing.

5. The apparatus of claim 2, further characterized by the following:

(A) the fuel burner is located at the top of the outer casing and has its nozzle pointing downwardly through the top wall of the outer casing to debouch into the upper portion of the inner casing, and

(B) the blower is located in the lower portion of the inner casing to receive the products of combustion and air which flows downwardly through the inner casing and is heated by the flame and products of combustion issuing from the burner nozzle, as well as air which enters the inner casing from the chamber which surrounds the inner casing.

6. The apparatus of claim 5, further characterized by the fact that the air inlet means into the outer casing is at the top thereof, so that air enters both the inner casing and the chamber surrounding it, at the top, to in each case flow downwardly in traveling to the inlet of the blower.

7. The apparatus of claim 6, further characterized by:

(A) means providing a second air inlet into the outer casing; and

(B) damper means to control the admission of air into the outer casing through said second air inlet.

8. The apparatus of claim 7, wherein the damper means comprises:

(A) a single damper mounted adjacent to said second air inlet means and movable between

(1) a position closing the second air inlet means and allowing unrestricted communication between the recirculation duct and the outer casing through the first air inlet means, and

(2) another position closing off communication between the recirculation duct and the outer casing and allowing free flow of outside air through the second air inlet means and into the outer casing.

9. The apparatus of claim 6, further characterized by:

(A) means providing a second air inlet means into the outer casing;

(B) a damper mounted adjacent to said second air inlet means to control said second air inlet means, and which, when open admits outside air into the outer casing; and

(C) a damper between said recirculation duct and its connection with the outer casing, which in one position does not interfere with communication between the two, but in another position disconnects the same.

10. The apparatus of claim 2, wherein

(A) the air inlet is at the bottom end of the outer casing, and has direct communication with the chamber surrounding the inner casing at the lower end thereof, and further characterized by

(B) means restricting communication between the air inlet and the lower end of the inner casing, so that air passing through the air inlet means flows upwardly through the chamber surrounding the inner casing to and into the top of the inner casing, and also flows into the lower end of the inner casing.

11. The apparatus of claim 2, wherein

(A) the discharge duct leads from the bottom portion of the outer casing and is bifurcated to provide two branches adapted to discharge into two separate enclosed spaces, and wherein

- (B) there are two recirculation ducts, each of which communicates with the interior of the outer casing at the upper end thereof, and also with the discharge duct, said recirculation ducts extending upwardly beyond the top of the outer casing for connection with the upper portions of said two enclosed spaces, and further characterized by the following:
- (C) a damper in the discharge duct to direct the discharge of the blower into one or the other of said two branches; and
- (D) a damper for each of the recirculation ducts to close off communication thereof with the discharge duct, so that by proper positioning of the several dampers the single apparatus may be used to simultaneously maintain different humidity and temperature conditions in said two enclosed spaces.
12. Apparatus for simultaneously establishing different temperature and humidity condition in a plurality of separated enclosed spaces containing material to be dried, comprising:
- (A) an outer casing having opposite closed end and side wall means;
- (B) an inner open-ended casing with the outer casing spaced from the side wall means thereof and coacting with said side wall means to define
- (1) a chamber surrounding the inner casing, extending from end-to-end of the inner casing and having open communication with the interior of the outer casing at its opposite ends;
 - (2) the opposite ends of the inner casing being in open communication with the interior of the outer casing;
- (C) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the inner casing;
- (D) a blower in the apparatus having
- (1) an inlet in open communication with the interior of the inner casing to receive the products of combustion discharged into the inner casing by the burner nozzle along with the air which enters the inner casing and is heated therein;
- (E) an outlet duct having a plurality of discharge branches, one for each enclosed space and connectable therewith;
- (F) a discharge duct leading from the outlet of the blower and having walls defining a mouth opening into the the outlet duct;
- (G) damper means in the outlet duct coacting with the walls thereof which define its mouth to selectively connect the mouth of the discharge duct with any of the discharge branches;
- (H) a plurality of plenum chambers, one for each enclosed space, contiguous to a portion of the side wall means of the outer casing so that air moving through the plenum chambers is in indirect heat exchange relation with heated air in the outer casing,
- (1) each of said plenum chambers opening to the outlet duct;
- (I) a plurality of recirculation ducts, one for each enclosed space and connectable therewith,
- (1) each of said recirculation ducts being connected with the interior of the outer casing and with one of the plenum chambers,
- (J) a damper for each recirculation duct movable between a first position shutting off communication between the recirculation duct and its plenum chamber, and a second position communicating the recirculation duct with its plenum chamber, so that
- (1) an enclosed space into which the blower delivers the products of combustion along with heated air through one of the discharge branches of the outlet duct may be shut off from its recirculation duct, while
 - (2) another enclosed space to which another of said discharge passages leads may be connected

- through its respective recirculation duct and plenum chamber with the outlet duct, to allow recirculation and heating of the air in said space, by air moving means other than the blower; and
- (K) means providing a controlled outside air inlet into the outer casing, through which air may be drawn by the blower for delivery, after being heated, into an enclosed space with which the discharge of the blower is connected.
13. The apparatus of claim 12, further characterized by:
- (A) structure within the outer casing between its air inlet and said portion of the side wall means to which the plenum chambers are contiguous, to prevent direct flow of outside air to said portion of the side wall means, said structure including
- (B) radiant heat shielding surfaces positioned to be heated when the fuel burner is in operation and lying in the path of the air entering said outside air inlet means and over which said air must flow before it reaches said portion of the side wall means.
14. The structure of claim 13, further characterized by:
- (A) means providing a second outside air inlet into the outer casing adjacent to said portion of the side wall means so that outside air entering therethrough may flow substantially directly to said portion of the side wall means; and
- (B) valve means operatively associated with the means providing said second outside air inlet to control the admission of outside air therethrough,
- (1) whereby the temperature of said portion of the side wall means may be regulated.
15. Apparatus for simultaneously establishing different temperature and humidity conditions in two separate enclosed spaces containing material to be dried or cured, comprising:
- (A) a heating unit having
- (1) an outer casing having an inlet through which air to be heated may be drawn, and
 - (2) an outer wall which becomes hot when the heating unit is in operation;
- (B) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the interior of the unit to co-mingle with the air drawn into the unit;
- (C) a blower in the heating unit having
- (1) an inlet in open communication with the interior of the outer casing to receive the products of combustion issuing from the burner nozzle and the air which enters the casing and is heated therein, and
 - (2) an outlet exterior to said casing;
- (D) an outlet duct into which the outlet of the blower opens, said outlet duct being
- (1) bifurcated to provide two discharge passages, one for each enclosed space;
- (E) means defining a pair of separate plenum chambers alongside the outer casing of the heating unit and separated from the interior of the outer casing by said wall thereof which becomes hot when the heating unit is in operation, so that air moving through the plenum chambers will abstract heat from said wall
- (1) both of said plenum chambers opening to the outlet duct;
- (F) a pair of recirculation ducts, one for each enclosed space and connectable therewith to receive air exhausted therefrom, each recirculation duct leading to one of the plenum chambers;
- (G) damper means in the outlet duct to selectively connect the outlet of the blower with one or the other of the two discharge branches and at the same time connect the other discharge branch with only one of the plenum chambers, so that one of the en-

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closed spaces can have the air exhausted therefrom heated by passage through its respective plenum chamber, and then returned thereto without admixture of outside air therewith, while the other enclosed space can have outside air which is drawn into the heating unit by the blower delivered to it along with the products of combustion to replace air that has been discharged to the atmosphere; and

(H) damper means to selectively close off either recirculation duct from its plenum chamber so that the discharge branch into which the blower delivers heated air and products of combustion may be disconnected from its respective recirculation duct to preclude loss of heated air.

16. The apparatus of claim 15, further characterized by:

(A) structure within the outer casing between its air inlet and the outer casing wall which separates the interior of the casing from the plenum chambers, to prevent direct flow of air from the inlet to said wall, said structure including

(B) radiant heat shielding surfaces in juxtaposition to the fuel burner so as to be heated when the fuel burner is in operation and located between said air inlet and said wall so as to lie in the path of the air entering said inlet and flowing to said wall.

17. The structure of claim 16, further characterized by:

(A) means providing a second air inlet into the outer casing adjacent to said wall so that air entering therethrough flows substantially directly to said wall; and

(B) valve means operatively associated with the means providing the second air inlet to control the admission of air through said second air inlet,

(1) whereby the temperature of the air returned to said first designated enclosed space may be regulated.

18. Apparatus for heating an enclosed space comprising:

(A) an outer casing having opposite closed ends and side walls;

(B) an inner casing within said outer casing spaced from the side walls of the outer casing and coacting therewith to define

(1) a chamber surrounding the inner casing extending from end-to-end of the inner casing and having open communication with the opposite end portions of the outer casing;

(2) the opposite ends of the inner casing being in open communication with the end portions of the outer casing;

(C) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the inner casing;

(D) means providing an air inlet into the outer casing adjacent to one end of the inner casing so that air entering said inlet may flow into the inner casing at said end thereof for admixture with the products of combustion, and also into the chamber which surrounds the inner casing to travel through it toward and into the opposite end of the inner casing;

(E) a recirculation duct having a discharge end connected with the outer casing at the air inlet thereof and having an intake end connectable with the enclosed space, to convey air from said space into said air inlet when the intake end of the recirculation duct is connected with the enclosed space,

(F) a discharge duct having its receiving end connected only with the interior of the inner casing near said opposite end thereof and leading to the exterior of the outer casing for connection of its discharge end with the enclosed space to deliver heater air and products of combustion to said space; and

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(G) air moving means to effect a positive circulation of air through said chambers and through the discharge duct into the enclosed space to which the discharge duct is connected, whether or not the intake end of the recirculation duct is connected to said space.

19. The apparatus of claim 18, wherein the air moving means is adjacent to the intake end of the recirculation duct.

20. Apparatus for simultaneously establishing different temperature and humidity conditions in a plurality of separated enclosed spaces containing material to be dried, comprising:

(A) an outer casing;

(B) an inner open-ended casing within the outer casing spaced from the walls thereof and coacting therewith to define

(1) a chamber surrounding the inner casing, extending from end-to-end of the inner casing and having open communication with the interior of the outer casing at its opposite ends;

(2) the opposite ends of the inner casing being in open communication with the interior of the outer casing;

(C) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the inner casing;

(D) an outlet duct having a plurality of discharge branches, one for each enclosed space;

(E) a discharge duct in open communication with the interior of the inner casing to receive the products of combustion discharged into the inner casing by the burner nozzle along with the air which enters the inner casing and is heated therein, said discharge duct opening into the outlet duct;

(F) damper means in the outlet duct to selectively connect the mouth of the discharge duct with any of the discharge branches;

(G) a plurality of plenum chambers, one for each enclosed space, contiguous to the outer casing so that air moving through the plenum chambers is in indirect heat exchange relation with heated air in the outer casing,

(1) each of said plenum chambers opening to the outlet duct;

(H) a plurality of recirculation ducts, one for each enclosed space and connectable therewith,

(1) each of said recirculation ducts being connected with the interior of the outer casing and with one of the plenum chambers,

(I) a damper for each recirculation duct at the junction thereof with the interior of the outer casing and its plenum chamber, and movable between a first position shutting off communication between the recirculation duct and its plenum chamber, and a second position communicating the recirculation duct with its plenum chamber, so that

(1) an enclosed space into which products of combustion and heated air are delivered by one of the discharge branches of the outlet duct may be shut off from its recirculation duct, while

(2) another enclosed space may be connected through its respective recirculation duct and plenum chamber with the outlet duct, to allow recirculation and heating of the air in said space; and

(J) air moving means to effect a positive circulation of air through the discharge duct and into each enclosed space whether or not it is shut off from its recirculation duct.

21. Apparatus for heating an enclosed space comprising:

(A) an outer upright casing having closed top and bottom ends and upright side wall means;

- (B) an open-ended inner casing within said outer casing, having upright side wall means spaced from the side wall means of the outer casing and coacting therewith to define
- (1) an upright chamber between said inner and outer casings extending from end-to-end of the inner casing and in open communication with the interior of the outer casing at its top and bottom,
 - (2) the top and bottom ends of the inner casing by virtue of their open-ended condition being in open communication with the interior of the outer casing at its top and bottom;
- (C) means adjacent to the bottom end of the inner casing providing an air inlet into the outer casing to admit air into the lower portion of the inner casing and also into the bottom end of the chamber between said inner and outer casings, to travel through said chamber toward and into the upper end of the inner casing;
- (D) a recirculation duct connected with the outer casing at said air inlet means and connectable with the interior of the enclosed space to convey air from said space to said air inlet means;
- (E) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the inner casing;
- (F) a blower in the apparatus, said blower having
- (1) an inlet in open communication with the interior of the inner casing at a level near one end thereof and remote from the point at which the burner discharges into the inner casing to receive said products of combustion and the air which enters the inner casing and is heated therein; and
- (G) a discharge duct leading from the outlet of the blower and to the exterior of the inner casing and passing through an opening in the side wall means of the outer casing, to be connectable with the interior of the enclosed space,
- (1) the side wall means of the inner casing being cut out to accommodate the discharge duct and the edges of said cutout being contiguous to the adjacent walls of the discharge duct so as to minimize the possibility of air which enters said chamber at the end thereof remote from the blower, reaching the interior of the inner casing and the inlet of the blower, except by traveling the full length of the side wall means of the inner casing.
22. The apparatus of claim 21, wherein said means providing the air inlet and the opening in the side wall means of the outer casing through which the discharge duct passes are at the same side of the outer casing, with said opening for the discharge duct being above and in vertical alignment with the air inlet means.
23. Apparatus for heating an enclosed space comprising:

- (A) an outer upright casing having closed top and bottom ends and upright side wall means;
- (B) an open-ended inner casing within said outer casing, having upright side wall means spaced from the side wall means of the outer casing and coacting therewith to define
- (1) an upright chamber between said inner and outer casings extending from end-to-end of the inner casing and in open communication with the interior of the outer casing at its top and bottom,
 - (2) the top and bottom ends of the inner casing by virtue of their open-ended condition being in open communication with the interior of the outer casing at its top and bottom;
- (C) means adjacent to the top end of the inner casing providing an air inlet into the outer casing to admit air into the upper portion of the inner casing and also into the upper end of the chamber between said inner and outer casings, to travel through said chamber toward and into the lower end of the inner casing;
- (D) a recirculation duct connected with the outer casing at said air inlet means and connectable with the interior of the enclosed space to convey air from said space to said air inlet means;
- (E) a fuel burner having a nozzle arranged to discharge its flame and products of combustion into the inner casing;
- (F) a blower in the apparatus, said blower having
- (1) an inlet in open communication with the interior of the inner casing at a level near one end thereof and remote from the point at which the burner discharges into the inner casing to receive said products of combustion and the air which enters the inner casing and is heated therein; and
- (G) a discharge duct leading from the outlet of the blower and to the exterior of the inner casing and passing through an opening in the side wall means of the outer casing, to be connectable with the interior of the enclosed space,
- (1) the side wall means of the inner casing being cut out to accommodate the discharge duct and the edges of said cutout being close enough to the adjacent walls of the discharge duct to minimize the possibility of air which enters said chamber reaching the interior of the inner casing and the inlet of the blower, except by flowing around the ends of the inner casing.

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