

July 21, 1925.

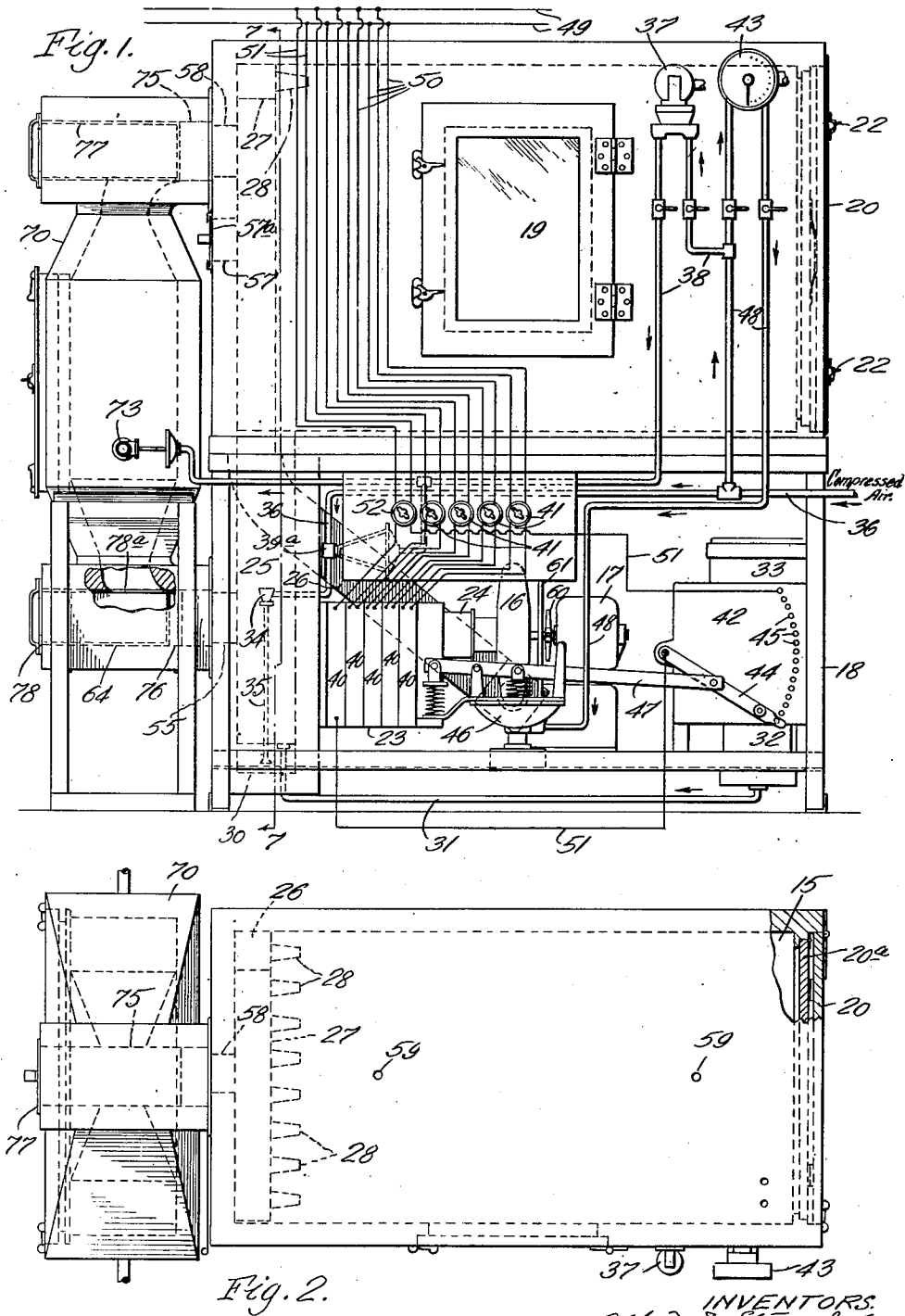
1,546,415

A. E. STACEY, JR., ET AL

APPARATUS FOR DRYING MATERIALS AND FOR OTHER PURPOSES

Filed March 23, 1923

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

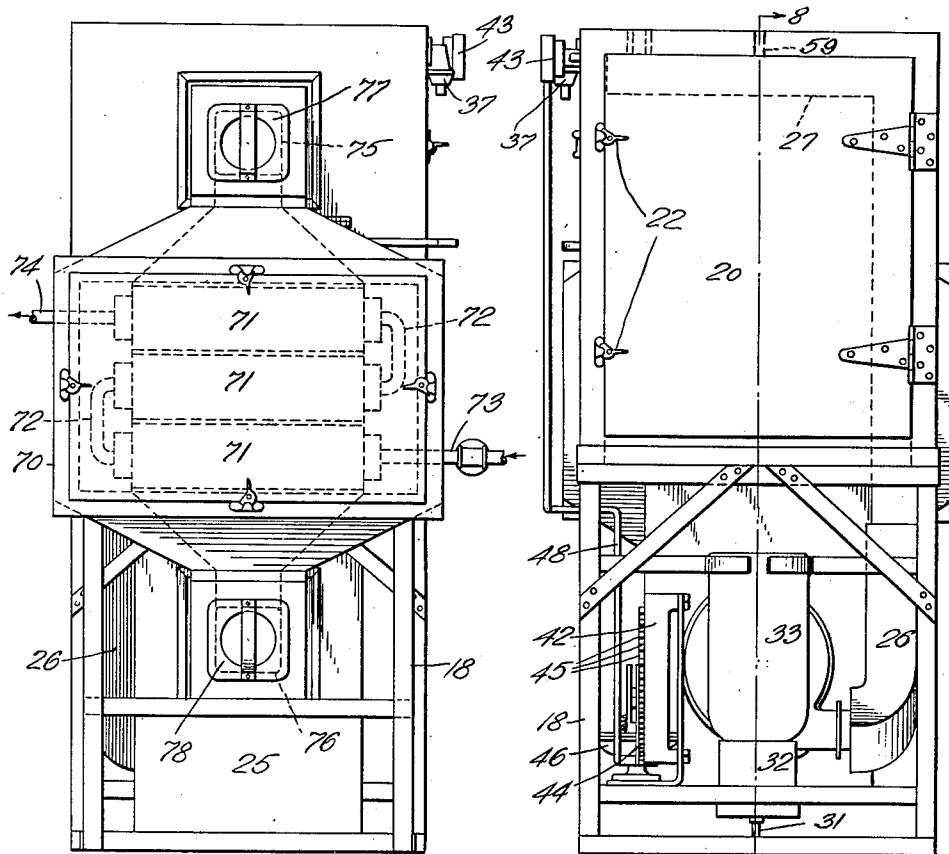


Fig. 3.

Fig. 4.

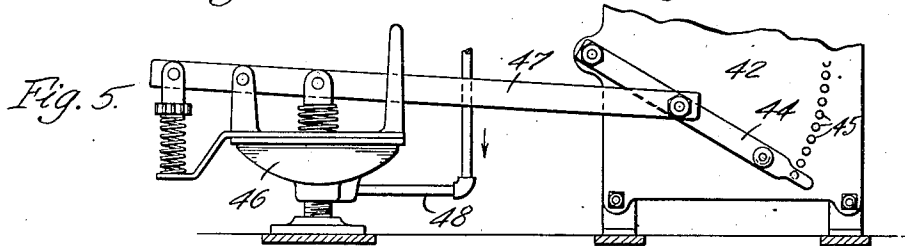


Fig. 5.

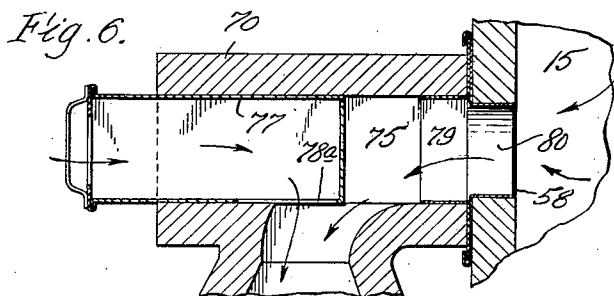


Fig. 6.

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4 Sheets-Sheet 3

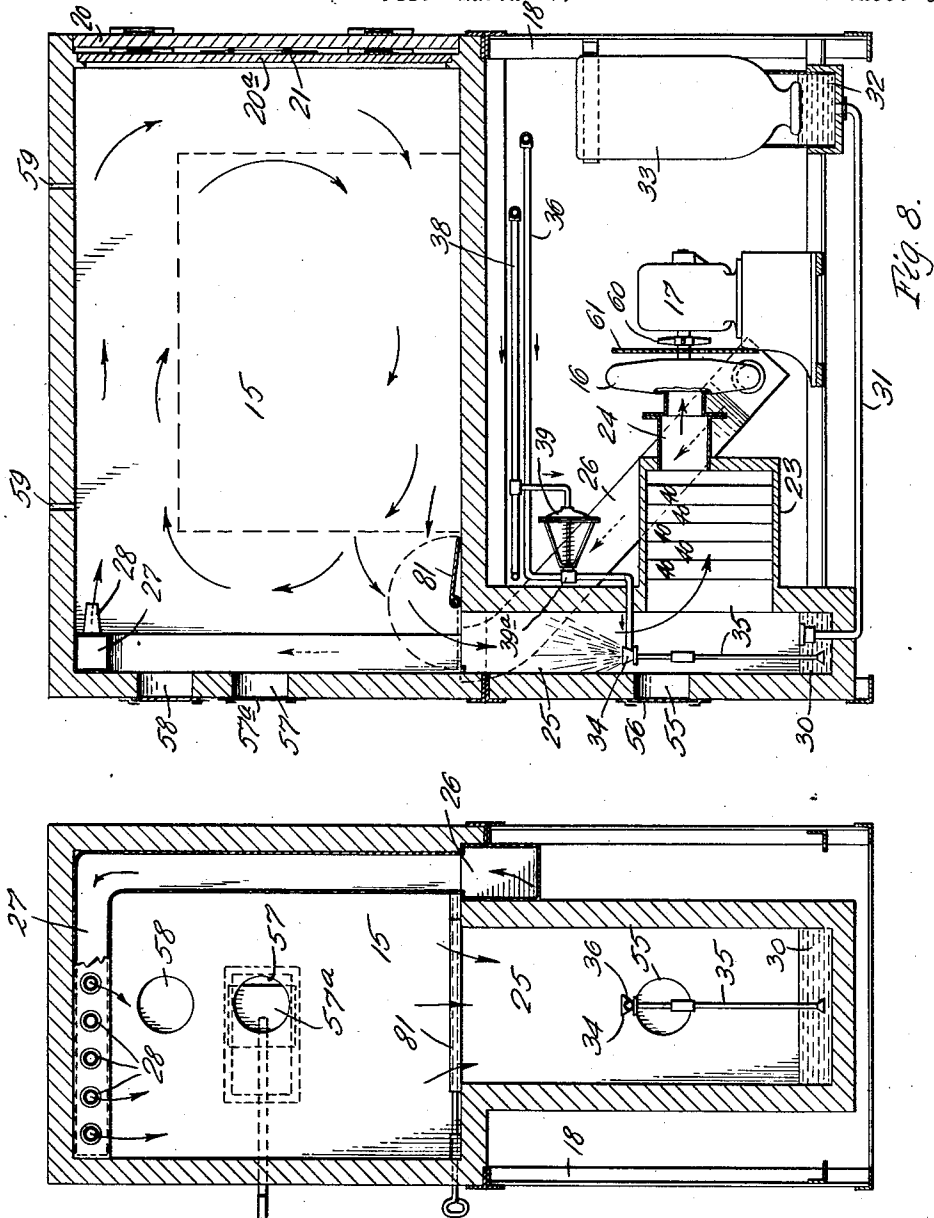


Fig. 7

Fig. 8.

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR DRYING MATERIALS AND FOR OTHER PURPOSES.

Application filed March 23, 1923. Serial No. 627,102.

To all whom it may concern:

Be it known that we, ALFRED E. STACEY, Jr., and MILTON S. SMITH, citizens of the United States, residing at Essex Fells and Maplewood, respectively, in the county of Essex and State of New Jersey, have invented a new and useful Improvement in Apparatus for Drying Materials and for Other Purposes, of which the following is a specification.

This invention relates to a cabinet or apparatus comprising a chamber or compartment in which materials can be dried, processed or treated or experiments performed under various atmospheric conditions, and instrumentalities for causing a vigorous, uniform circulation of air in the chamber or compartment, and for controlling the atmospheric conditions in said chamber, whereby any required conditions of temperature and humidity can be produced or maintained in the chamber, depending upon the material being treated or the desired results to be obtained.

One object of the invention is to produce an efficient, practical and desirable apparatus of the nature stated, which is provided with air conditioning means and regulating means therefor, whereby definite, desired atmospheric conditions can be maintained in the processing chamber, or different conditions produced as may be required with great accuracy and reliability. Another and important object of the invention is to provide a small unit processing cabinet so arranged that it is complete in itself, occupies a minimum amount of floor space, is portable, and affords a suitable means for exposing small quantities of materials to various conditions of temperature, humidity and air circulation under accurate automatic control. Other objects of the invention are to design and arrange the air circulating, conditioning and regulating means so that it is only necessary to condition a relatively small quantity of air, which can be quickly and easily changed from one to another required condition, while nevertheless a vigorous circulation of a much larger volume of air in the drying or processing chamber is produced and uniform conditions are obtained throughout the processing portion of the chamber; also to provide an electric heater

for the air supplied to the drying or processing chamber, the heating effect of which heater is regulated by a rheostat actuated by a fluid pressure motor under the control of a thermostat which is responsive to temperature changes in the drying or processing chamber, whereby any required temperature in the chamber can be quickly and accurately secured or maintained; also to provide the apparatus with air dehumidifying means whereby the air delivered to the drying or processing chamber can be dehumidified or cooled as may be required; also to construct the apparatus so that the dehumidifying means are arranged as a separate attachment or unit, whereby when the apparatus is to be used only for purposes which do not require dehumidification or cooling of the air, the dehumidifying unit can be omitted, thus decreasing the cost of the apparatus, whereas, if it is desired to afterwards equip the apparatus with the dehumidifying attachment, the latter can be readily installed and operatively connected with the cabinet to enable the performance of work requiring air cooling or dehumidification; also to provide the apparatus with air humidifying means of a novel construction, whereby the air can be humidified to give or maintain an accurate humidity condition with the minimum use of water and power, and which is susceptible of very accurate regulation; also to provide means of very simple construction to prevent the driving motor for the air circulating fan from becoming heated by the warm or heated air passing through the fan; and also to improve apparatus of the character mentioned in the other respects hereinafter described and set forth in the claims.

In the accompanying drawings:

Fig. 1 is a front elevation of an apparatus embodying our invention showing the same equipped with the air dehumidifying attachment.

Fig. 2 is a plan view thereof, partly in horizontal section, to show the door construction for the processing chamber.

Fig. 3 is an elevation of that end of the apparatus where the air dehumidifying attachment is located.

Fig. 4 is an elevation of the opposite end of the apparatus.

Fig. 5 is an elevation, on an enlarged scale, of the heat regulating rheostat and the actuating motor therefor.

Fig. 6 is an enlarged, sectional elevation, showing one of the air connections and valves between the processing chamber and the dehumidifying attachment.

Fig. 7 is a transverse sectional elevation of the apparatus on line 7—7, Fig. 1.

Fig. 8 is a longitudinal sectional elevation thereof on line 8—8, Fig. 4, omitting the dehumidifying attachment.

Fig. 9 is a transverse sectional elevation of the air cooling or dehumidifying attachment.

Fig. 10 is an elevation, partly in section, on an enlarged scale, of the fan, its driving motor and associated parts.

Fig. 11 is a section of the cooling device for the motor shaft, on an enlarged scale, on line 11—11, Fig. 10.

Fig. 12 is an enlarged, transverse sectional elevation of one of the connections between the processing chamber and the dehumidifying attachment.

Fig. 13 is a longitudinal section thereof on line 13—13, Fig. 12.

15 represents the processing chamber or compartment in which the temperature and humidity are controlled for drying or otherwise processing or treating materials in the chamber or performing any other required work or experiments. 16 is a fan for supplying air to and causing the circulation of air in said chamber, and 17 is a motor for driving said fan, said fan and said motor being of any suitable kind. The processing chamber 15 is preferably of rectangular shape and is made with walls of heat insulating or non-conduction construction adapted to insure the proper insulation of the interior of the chamber from the external atmosphere so that the conditions within the chamber will not be appreciably affected by the external conditions. The apparatus as shown in the drawings is designed for laboratory or experimental work and the chamber 15 is supported at a convenient height on a frame or stand 18 of any suitable construction, on which the fan and its motor and other parts hereinafter described are preferably mounted beneath the chamber 15, the whole apparatus being small enough to be readily transported or moved from place to place. The chamber 15 is provided, preferably at one end, with a large door through which access is had to the chamber for placing material in and removing it from the chamber, and the front wall of the chamber is also preferably provided with a suitable glazed door or window 19 through which the operations within the chamber can be observed and which can be opened if desired to give access to the chamber. To insure a tight closure of

the chamber and more perfect insulation, the door at the end of the chamber is preferably made double, consisting of outer and inner hinged doors 20 and 20^a which are connected so as to open and close simultaneously, but are separately hinged and fitted so that each door is adapted to seat independently of the other to better insure a tight closure of the chamber. As shown, these doors are separately hinged at the same side of the door opening and are connected by a chain or loose connection (not shown) so that when the outer door is opened it will pull open the inner door also. Suitable leaf springs 21 secured on the inner side of the outer door, are adapted to bear against the inner door, so that when the outer door is closed and secured by suitable fasteners 22, the springs will press upon and force the inner door tightly to its seat in the door opening.

23 represents the enclosing casing of a suitable heater for heating the air which is supplied to the processing chamber 15. This heater casing is connected at one end by a duct or passage 24 to the inlet of the fan 16 and is connected at its other end by a return flue or passage 25 with the processing chamber, so that the fan is adapted to withdraw air from the processing chamber through the heater and then deliver the heated air again to the processing chamber, as presently explained, whereby the air can be recirculated and repeatedly passed through the processing chamber. Preferably the return passage 25 is made with insulating walls like those of the processing chamber, and forms a downward extension of one end of the processing chamber. The fan 16 discharges into a duct 26 which leads upwardly, preferably in rear of the return flue 25, and extends up in the rear end corner of the processing chamber and has a horizontal portion 27 extending forwardly in the end of the processing chamber near its ceiling. This horizontal extension 27 of the duct is provided with discharge nozzles 28 directed toward the far end of the processing chamber so that the air discharging from the nozzles flows lengthwise along the ceiling of the chamber to the far end thereof, and is thence deflected downwardly and back toward the end where the discharge nozzles are located. The air is discharged under sufficient pressure and velocity from the nozzles to induce a circulation of the other and larger volume of air in the chamber in the direction indicated by the arrows, thus maintaining an active circulation of the air in the chamber around and through the material which is being treated, and which is preferably located at that portion of the chamber below the blasts from the nozzles 28 where the return flow of the air occurs so as to insure a uniform

flow of the air through the material, and uniform treatment of all portions of the material.

The bottom of the return flue 25 below its connection with the heater casing 23, forms a reservoir or well 30 in which water or liquid for humidifying the air, is maintained at a constant level by suitable means. For instance, as shown, the reservoir 30 connects by a pipe 31 with a supply receptacle 32 in which a bottle or container 33 is supported mouth-downward with its mouth depending into the receptacle 32 so that the water in the latter forms a liquid seal for the mouth of the bottle. This apparatus acts in the well known manner of a liquid seal or air displacement reservoir to maintain the liquid at a constant level in the reservoir 30. 34 represents a nozzle or atomizer for spraying water from the reservoir 30 into the return flue 25 for humidifying the air returning through this flue from the processing chamber. This nozzle may be of any suitable type adapted to produce a sufficiently fine spray or atomization of the water to insure the required humidification of the air. As shown, the nozzle has a pipe 35 depending into the water in the reservoir 30 and fluid under pressure for lifting and atomizing the liquid is supplied to the nozzle through a pipe 36 which connects with any suitable source of air or other fluid under pressure. The humidification of the air by the nozzle 34 is preferably regulated under the control of a hygrostat 37 which responds to changes in humidity in the processing chamber and controls the nozzle to increase or decrease the humidity, as may be required, to give the percentage of humidity in the processing chamber for which the hygrostat is set. The hygrostat can control the humidifying nozzle through any suitable instrumentalities. For instance, as shown in Figs. 1 and 8, the hygrostat controls the pressure of compressed air in a pipe 38 connected with the compressed air supply pipe 36 and leading to the actuating diaphragm or motor 39 of a regulating valve 39^a in the air supply pipe 36 for the atomizing nozzle. If the humidity in the processing chamber decreases below that percentage for which the hygrostat is set, the hygrostat will operate through the diaphragm valve 39^a and nozzle 34 to increase the humidity of the air supplied to the chamber, whereas, if the humidity in the chamber rises above the predetermined percentage for which the hygrostat is set, the hygrostat will operate to shut off or reduce the discharge from the atomizing nozzle, and thus reduce the humidity of the air supplied to the chamber.

The electric air heater in the casing 23

may be of any known or suitable construction adapted to impart the desired maximum temperature to the air delivered to the processing chamber and to give different desired temperatures up to the maximum. Preferably this heater is composed of a plurality of independent electric heating elements or units 40 some of which are controlled independently by hand switches 41 only, and one or more of which is or are controlled automatically by a rheostat 42 which is operated automatically under the control of a thermostat 43 responsive to temperature changes in the processing chamber. Thus, one or more of the heating units can be turned on or off by means of the hand switches 41, as may be necessary, to heat the air approximately to the desired temperature, and the exact temperature is controlled automatically by the regulation of the heating unit or units which is or are controlled by the rheostat 42. In this way a very accurate and almost instantaneous control of the temperature is possible. The rheostat may be of ordinary construction having a resistance more or less of which is placed in or cut out of the heater circuit by the movement of a regulating arm or member 44 adapted to engage with one after another of a succession of contacts 45 in the usual manner. As shown in the drawings, the rheostat is connected in circuit with the first heater unit only, the remaining units being controlled only by the hand switches 41. The rheostat arm 44 is actuated by a fluid pressure motor 46, having a movable element or diaphragm which operates a lever 47 connected to the arm 44. Air or other fluid under pressure for actuating the rheostat motor is delivered thereto from the supply pipe 36 through a pipe 48 connecting with the thermostat 43, which controls the pressure in this pipe 48 and in the motor 46, thereby operating the motor to move the rheostat arm and increase or decrease the current to the heater so as to reduce or raise the temperature of the air as necessary to maintain the temperature in the processing chamber 15 for which the rheostat is set. A detailed description of the wiring for the heater and rheostat is unnecessary, it being sufficient to explain that each of the hand-controlled units of the heater can be connected to a main feed line 49, Fig. 1, by separate branch circuits 50, one of the switches 41 being connected in each branch circuit so that each of the hand-controlled heater units can be turned on or off by actuating its switch, while the automatically controlled unit of the heater can be connected to the main feed line through the rheostat by a branch circuit 51 so that the current to the latter unit is regulated by the position of the movable arm 44 of the rheostat. A

hand switch 52 is preferably included in the rheostat circuit so that the heater unit controlled by the rheostat can be turned on or off at will by operating this switch.

5 In the use of the apparatus, air is withdrawn from the processing chamber through the return flue 25 and heater 23 by the fan 16 and is delivered through the duct 26—27 and nozzles 28 under pressure into the processing chamber, the air thus circulating in a substantially closed circuit through the processing chamber and heater. A comparatively small volume of air is thus recirculated by the fan through the heater and
10 processing chamber, the main body of air in the processing chamber being circulated therein by the ejector effect of the air discharging from the nozzles 28. By means of the sectional electric heater described, the temperature of this small volume of air can be very quickly increased or reduced by the described regulation of the heater so as to give and maintain accurately any required temperature within the limits of the apparatus in the processing chamber. As the air passes through the return flue 25 between the processing chamber and the heater 23, it is humidified as may be necessary to give the required humidity in the processing chamber by the spray nozzle 34 under the control of the hygrostat 37. The spray liquid which is not vaporized and carried away by the air falls back to the reservoir 30 in the bottom of the flue 25 over which the air passes in entering the heater 23. The same liquid from the reservoir is thus used over and over again except for the small amount of liquid delivered thereto from the supply receptacle to maintain the level in the reservoir so that the liquid soon takes a temperature nearly that of the air and no additional heating means for the spray liquid is necessary. If it should be necessary to reduce the humidity of the air delivered to the processing chamber, sufficient outside air for this purpose can be admitted through a fresh air inlet opening 55 which is preferably located in the wall of the return flue 25 opposite the heater 23. This fresh air inlet opening is controlled by a hand damper 56 of any suitable kind. When outside air is thus admitted, a corresponding amount of air should be relieved from the processing chamber, for which purpose a relief opening 57 is provided through which the air can escape, this opening being controlled by a hand damper 57^a of any suitable construction. This relief opening is preferably located in the end wall of the processing chamber below the air supply duct 27.

60 A second opening 58 controlled by a damper is shown in the end of the processing chamber above the opening 57 for the passage of air to a dehumidifying or cooling attachment which will be presently de-

scribed. When this dehumidifying or cooling attachment is not used, the opening 58 is not necessary and is kept closed by means of its hand damper, and as hereinafter explained, the air can be relieved through the dehumidifier connection with the opening 58, so that a second opening 57 is not essential and can be omitted.

The material being treated or tested can be supported in the processing chamber on racks, trays or other suitable holders, the material preferably being disposed within that portion of the chamber bounded by the broken lines in Fig. 8, so as to leave unobstructed air flow spaces in the chamber above the material and between the material and each end of the chamber. Holes 59 are shown in the ceiling of the chamber for the passage of wires, whereby material can be suspended within the chamber from a balance placed on top of the chamber, to enable tests with reference to changes in weight in the material.

60, Figs. 1, 10 and 11, represents a cooling fan or device for preventing the heat from the hot air circulated by the fan 16 from being conducted through the fan shaft to the motor and causing objectionable heating of the latter. This cooling device preferably consists of a simple rotor secured to the fan shaft between the fan 16 and the motor and having radial arms. These arms, being connected to the motor shaft, act like radiation projections thereon to conduct heat away from the shaft, and the movement of the air over the faces of the arms produced by their rotation acts by convection to remove the heat from the radiating arms. This simple expedient operates effectually to prevent conduction of heat from the fan 16 to the motor 17. The cooling device is preferably supplemented by a screen or shield 61 which is disposed between the air circulating fan and the cooling device and through which the fan shaft passes, see Figs. 1 and 10.

The air dehumidifying or cooling device is preferably made in the form of a separable attachment or unit, complete in itself, and adapted to be connected to and used with the cabinet hereinbefore described, or not, as required. In its preferred form, shown in the drawings, the dehumidifier comprises a casing 70 having walls of suitable insulating character to insure the requisite insulation of the interior of the casing from the surrounding atmosphere, and a tubular or honeycomb radiator or air cooler located within the casing between the upper and lower ends thereof. The radiator consists of a plurality of separate radiator units or sections 71 each composed of a multiplicity of radiating tubes in an enclosing shell and arranged one above the other with the tubes vertical and the tubes of one section communicating with those of

the next. The air to be cooled or dehumidified is adapted to pass through the tubes of the several radiator sections in succession, and is cooled by water or other suitable cooling medium which is circulated through the spaces in the shells between the radiator tubes. As shown in Fig. 9, the shells of the three sections of the radiator are connected in series by pipes 72 so that the cooling liquid enters the lower section through an inlet pipe 73 and, after passing through this section, passes through the second section and then through the third or uppermost section to the liquid outlet pipe 74, as indicated by the arrows in Fig. 9. The coldest liquid enters the radiator at the bottom, and after abstracting heat from the air which passes downwardly through the radiator, leaves at the upper end of the radiator so that the air to be cooled is first affected by the warmer liquid, and after having its temperature lowered to some extent, is further cooled by the coldest liquid entering at the bottom of the radiator. The dehumidifier casing 70 is provided at its upper end with an air passage 75 adapted to be connected with the hole 58 in the end of the processing chamber 15, and at its lower end with a similar air passage 76 adapted to be connected with the air inlet hole 55 in the return flue 25, so that the fan 16 can draw air from the processing chamber 15 through the dehumidifier casing into the return flue 25, and thence through the heater casing 23 and fan to be again delivered by the fan to the processing chamber. In order to regulate the amount of air passing through the dehumidifier and to cut off the dehumidifier when dehumidification or cooling of the air is not necessary, a tubular slide valve or damper 77 is preferably provided in the upper air passage 75, and a similar valve or damper 78 is provided in the lower air passage 76 of the dehumidifier casing. Each of these valves or dampers has an open outer end and a closed inner end and has a hole 78^a in its tubular wall between its ends. When the dampers are shoved inwardly to the position indicated in Fig. 1, they will shut off communication between the processing chamber and the dehumidifier casing. By pulling the dampers outwardly to their outer position, the processing chamber 15 and the return flue 25 are placed in communication with the radiator chamber of the dehumidifier, thus enabling the air to pass through the dehumidifier. The dehumidifier attachment can be connected with the cabinet or main section of the apparatus with the inlet and outlet passages of the dehumidifier casing connecting respectively with the processing chamber and return flue, by any suitable means. As shown in Figs. 6, 12 and 13, sleeves or thimbles 79 are provided in the upper and lower air passages of the dehumidifier casing and have flanged outer ends which interlock with the bent-over edges of flanges of complementary sleeves or thimbles 80 which are secured in the air inlet and outlet openings 55 and 58 in the end wall of the main section of the apparatus. The flanges of the thimbles 80 are preferably of larger diameter than the flanges of the complementary thimbles so that a limited adjustment of the dehumidifier casing, sufficient to insure registration of its air passages with the holes 55 and 58, is permitted.

When it is desired to dehumidify or cool the air delivered to the processing chamber, the tubular dampers 77 and 78 are pulled outwardly, and the air can then pass from the processing chamber through the dehumidifier and back to the return flue 25, the direct communication of the chamber 15 with the return flue being shut off by closing a suitable damper 81, Fig. 8, at the upper end of the flue 25. If dehumidified room air is needed in the processing chamber to secure a required condition therein, the upper damper 77 is shoved in to close the opening 58 and the lower damper 78 pulled to its outer position. Then the room air will enter through the open outer end and the hole 78^a of the upper damper 77 and pass through the dehumidifier to the return air flue 25. Should air from the room be wanted in the processing chamber without passing through the dehumidifier, the upper damper 77 is placed in its closed inner position and the lower damper 78 placed in a midway position, so that air can enter the return flue 25 through the outer open end and hole 78^a of the lower damper 78 and the inlet opening 55. The resistance of the cooling surface of the dehumidifier will be sufficient to cause the air to be drawn directly through the lower damper. By opening upper damper 77, the passage controlled by the latter can be used as a relief opening for air from the processing chamber. When the apparatus is equipped with the dehumidifying section, and it is not desired to dehumidify or cool the air, the tubular dampers 77 and 78 are pushed in, and the damper 81 opened, thus cutting off the dehumidifier from the processing chamber and return flue. The apparatus can then be operated and controlled, as first explained, to give the desired conditions in the processing chamber without dehumidification.

We claim as our invention:

1. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said cham-

ber, an electric heater for heating the air delivered to the chamber, an electric current controller for regulating the heating effect of said heater, a thermostat responsive to temperature changes in said chamber, and means controlled by said thermostat for operating said current controller to regulate said heater.

2. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, an electric heater for heating the air delivered to the chamber, an electric current controller for regulating the heating effect of said heater, a thermostat responsive to temperature changes in said chamber, and a fluid-pressure-actuated device which operates said current controller to regulate said heater and is controlled by said thermostat.

3. The combination of a chamber adapted to contain material to be treated, and air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, an electric heater for heating the air delivered to the chamber and comprising a plurality of heating elements, means for independently controlling a portion of said heater elements, a current controller for regulating the heating effect of the remaining heater element or elements, a thermostat responsive to temperature changes in said chamber, and means controlled by said thermostat for operating said current controller to regulate said remaining heater element or elements.

4. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, an electric heater for heating the air delivered to the chamber and comprising a plurality of heating elements, means for independently controlling a portion of said heater elements, a rheostat for regulating the heating effect of the remaining heater element or elements, a thermostat responsive to temperature changes in said chamber, and means controlled by said thermostat for operating said rheostat to regulate said remaining heater element or elements.

5. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, an electric heater for heating the air delivered to the chamber and comprising a plurality of heating elements, means for independently controlling a portion of said heater elements, a rheostat for regulating

the heating effect of the remaining heater element or elements, a thermostat responsive to temperature changes in said chamber, and a fluid-pressure-actuated motor controlled by said thermostat for operating said rheostat to regulate said remaining heater element or elements.

6. The combination of a chamber adapted to contain material to be treated, a fan for delivering air to said chamber, an electric heater which heats the air delivered by said fan to said chamber and which comprises a plurality of heating elements, means for independently controlling a portion of said heater elements, a rheostat which regulates the heating effect of the remaining heater element or elements, a thermostat which is responsive to temperature changes in said chamber, and a fluid-pressure-actuated motor which is controlled by said thermostat and operates said rheostat to regulate the heating effect of said heater.

7. The combination of a chamber adapted to contain material to be treated, a fan for delivering air to said chamber, a heater which heats the air delivered to said chamber, a motor connected to said fan for driving the fan, and a cooling device comprising arms projecting from said fan shaft between the fan and said fan-driving motor.

8. The combination of a chamber adapted to contain material to be treated, a fan for delivering air to said chamber, a heater which heats the air delivered to said chamber, a motor connected to said fan for driving the fan, a cooling device comprising arms projecting from said fan shaft between the fan and said fan-driving motor, and a heat screen arranged between the fan and said cooling device.

9. The combination of a chamber adapted to contain material to be treated, a fan for delivering air to said chamber, a heater which heats the air delivered to said chamber, a motor connected directly to said fan shaft for driving the fan, and a cooling device comprising arms secured to and projecting from said fan shaft between the fan and said motor for preventing the conduction of heat by said shaft from said fan to said motor.

10. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, a heater which heats the air delivered to said chamber, a liquid reservoir over which the return air from said chamber flows, an atomizing nozzle arranged to take liquid from said reservoir and discharge the same into said return air for humidifying the latter, and a regulating device which is responsive to humidity changes in said cham-

ber and controls said atomizing nozzle for regulating the humidity of the air delivered to the chamber.

11. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, a heater which heats the air delivered to said chamber, a liquid reservoir over which the return air from said chamber flows, means for maintaining the liquid at a substantially constant level in said reservoir, an atomizing nozzle which takes liquid from said reservoir and discharges the same into said return air for humidifying the latter, and a regulating device which is responsive to humidity changes in said chamber and controls said atomizing nozzle for regulating the humidity of the air delivered to the chamber.

12. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, a heater which heats the air delivered to said chamber, a liquid reservoir in the lower portion of said return passage, means for maintaining the liquid at a substantially constant level in said reservoir, an atomizing nozzle arranged to take liquid from said reservoir and discharge the same into said return air passage for humidifying the return air, and a regulating device which is responsive to humidity changes in said chamber and controls said atomizing nozzle for regulating the humidity of the air delivered to the chamber.

13. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, a heater which heats the air delivered to said chamber, a liquid reservoir over which the return air from said chamber flows, an atomizing nozzle arranged to take liquid from said reservoir and discharge the same into said return air for humidifying the latter, a regulating device which is responsive to humidity changes in said chamber and controls said atomizing nozzle for regulating the humidity of the air delivered to the chamber, a damper-controlled inlet for admitting fresh air to said return air, and a damper-controlled outlet for the relief of air from said chamber.

14. The combination of a chamber adapted to contain material to be treated, a stand on which said chamber is supported, a fan mounted on said stand beneath said chamber and connected to said chamber by supply and return passages for causing the cir-

ulation of air through said chamber, a heater mounted on said stand beneath said chamber for heating the air delivered to the chamber, a thermostat responsive to temperature changes in said chamber, and means controlled by said thermostat for regulating the heating effect of said heater.

15. The combination of a chamber adapted to contain material to be treated, a stand on which said chamber is supported, a fan mounted on said stand beneath said chamber and connected to said chamber by supply and return passages for causing the circulation of air through said chamber, means for humidifying the air delivered to the chamber including a liquid reservoir, liquid supply means for said reservoir mounted on said stand beneath said chamber and constructed to maintain a substantially constant level of liquid in said reservoir, and regulating means responsive to humidity changes in said chamber and controlling said humidifying means for regulating the humidity of the air delivered to the chamber.

16. The combination of a chamber adapted to contain material to be treated, a stand on which said chamber is supported, a fan mounted on said stand beneath said chamber and connected to said chamber by supply and return passages for causing the circulation of air through said chamber, a heater mounted on said stand beneath said chamber for heating the air delivered to the chamber, a thermostat responsive to temperature changes in said chamber, means mounted on said stand beneath said chamber and controlled by said thermostat for regulating the heating effect of said heater, means for humidifying the air delivered to the chamber including a liquid reservoir, liquid supply means mounted on said stand beneath said chamber and constructed to maintain a substantially constant level of the liquid in said reservoir, and a regulating device responsive to humidity changes in said chamber and controlling said humidifying means for regulating the humidity of the air delivered to the chamber.

17. The combination of a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, a dehumidifying attachment comprising a casing connected with said chamber and with said return passage, and air cooling means in said casing for cooling the air passing therethrough, a regulating device which is responsive to humidity changes in said chamber and controls said cooling means, and a valve for controlling the passage of air from said chamber through said dehumidifier casing.

18. The combination of a chamber adapted-

ed to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, a dehumidifying attachment comprising a casing communicating with said chamber and with said return passage by inlet and outlet passages, and air cooling means in said casing, a regulating device which is responsive to humidity changes in said chamber and controls said cooling means, and valves in said inlet and outlet passages of the dehumidifying attachment for regulating the passage of air through said dehumidifier casing.

19. The combination with a chamber adapted to contain material to be treated, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, of a separable dehumidifying attachment comprising a casing, and air cooling means in said casing, connections be-

tween said casing and said chamber and return passage forming air inlet and outlet passages for said casing, and means for controlling the passage of air through said dehumidifier casing.

20. The combination with a portable unit comprising a processing chamber, an air circulating device connected with said chamber by supply and return passages for causing the circulation of air through said chamber, and devices for controlling the temperature and humidity in said chamber, of a separable dehumidifying unit comprising a casing and air cooling means in said casing, said casing having an inlet passage connecting with said chamber and an outlet passage connecting with said return passage, and means for causing the circulating air to pass from said chamber either directly through said return passage or through said dehumidifier casing.

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