

Oct. 30, 1951

R. F. WANDELT

2,573,121

RADIANT HEATING AND DRYING DEVICE

Filed April 20, 1950

9 Sheets-Sheet 1

Fig. 1.

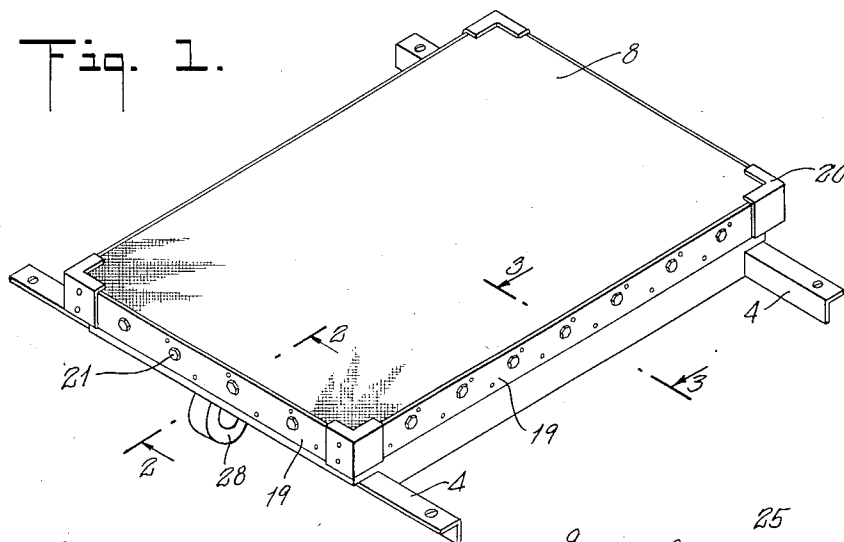
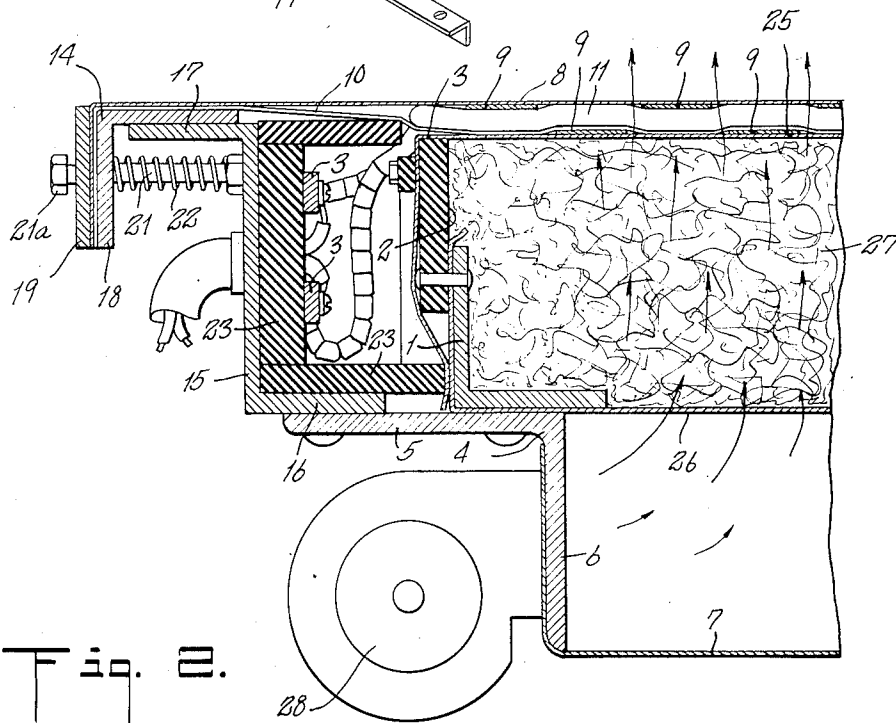


Fig. 2.



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9 Sheets-Sheet 2

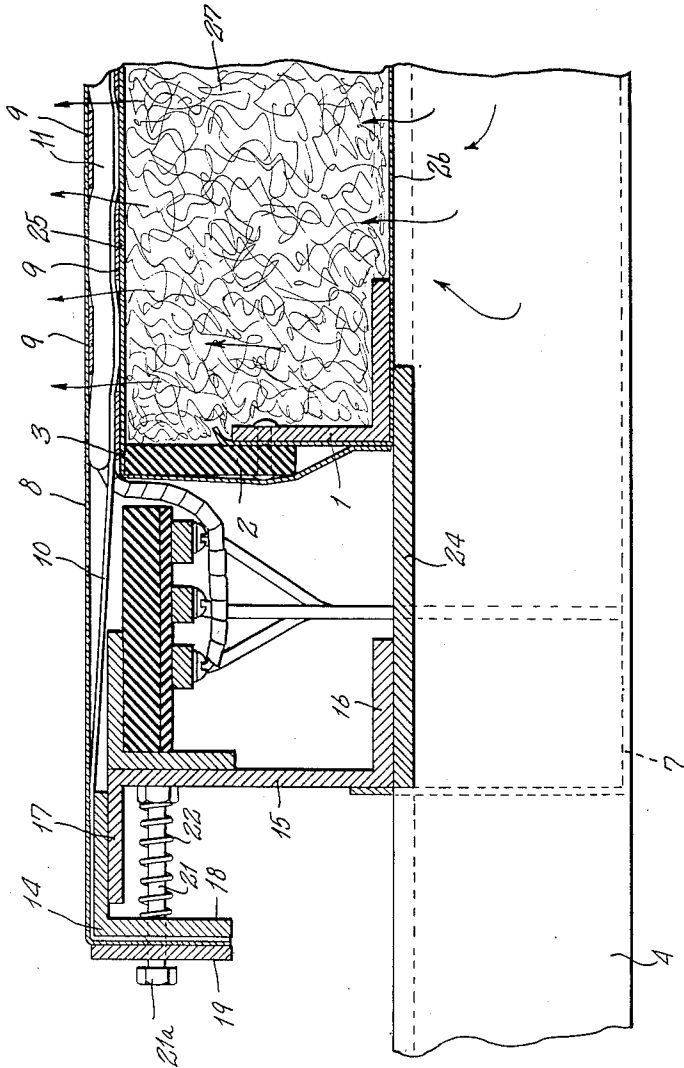


Fig. 3.

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9 Sheets-Sheet 3

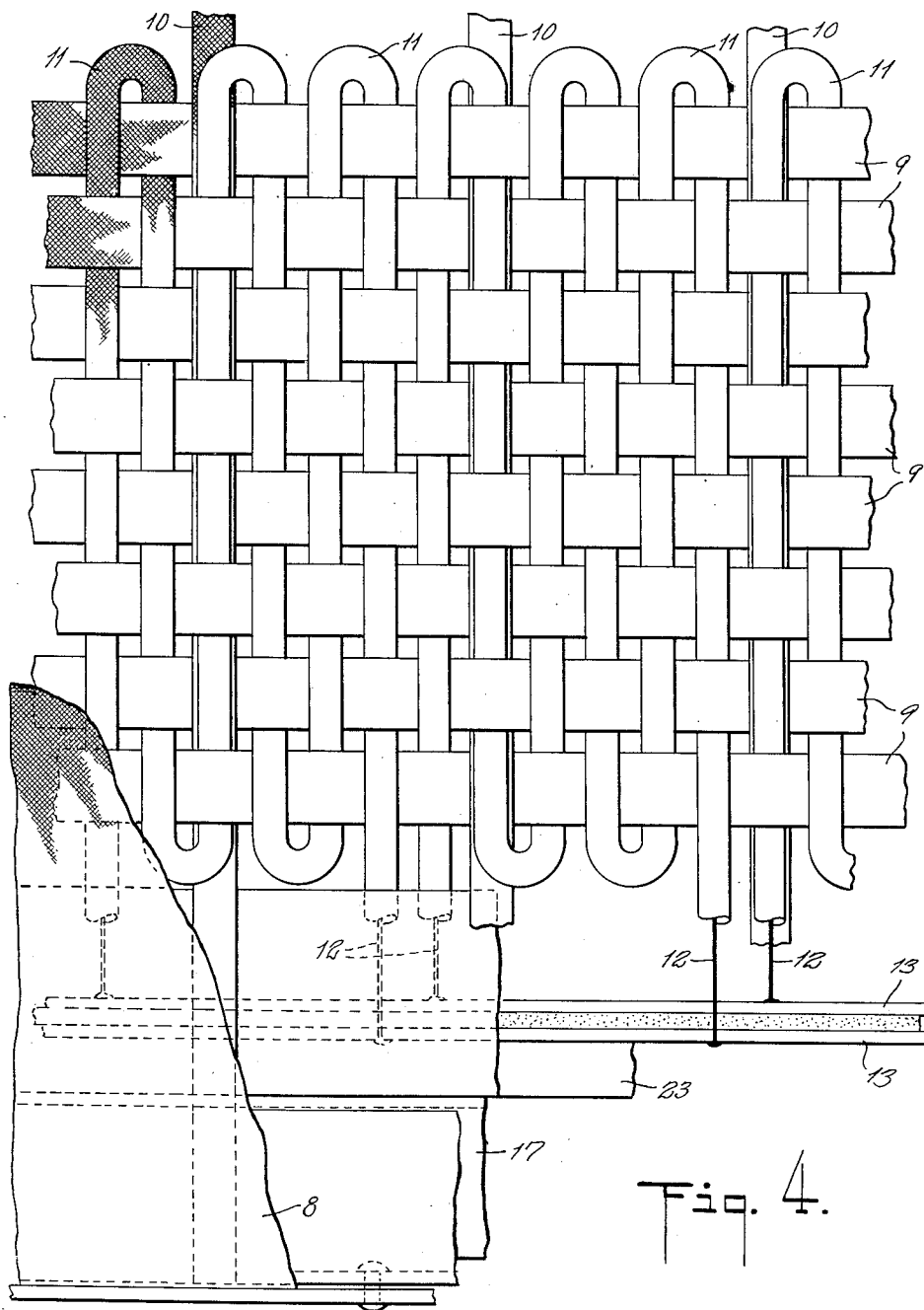


Fig. 4.

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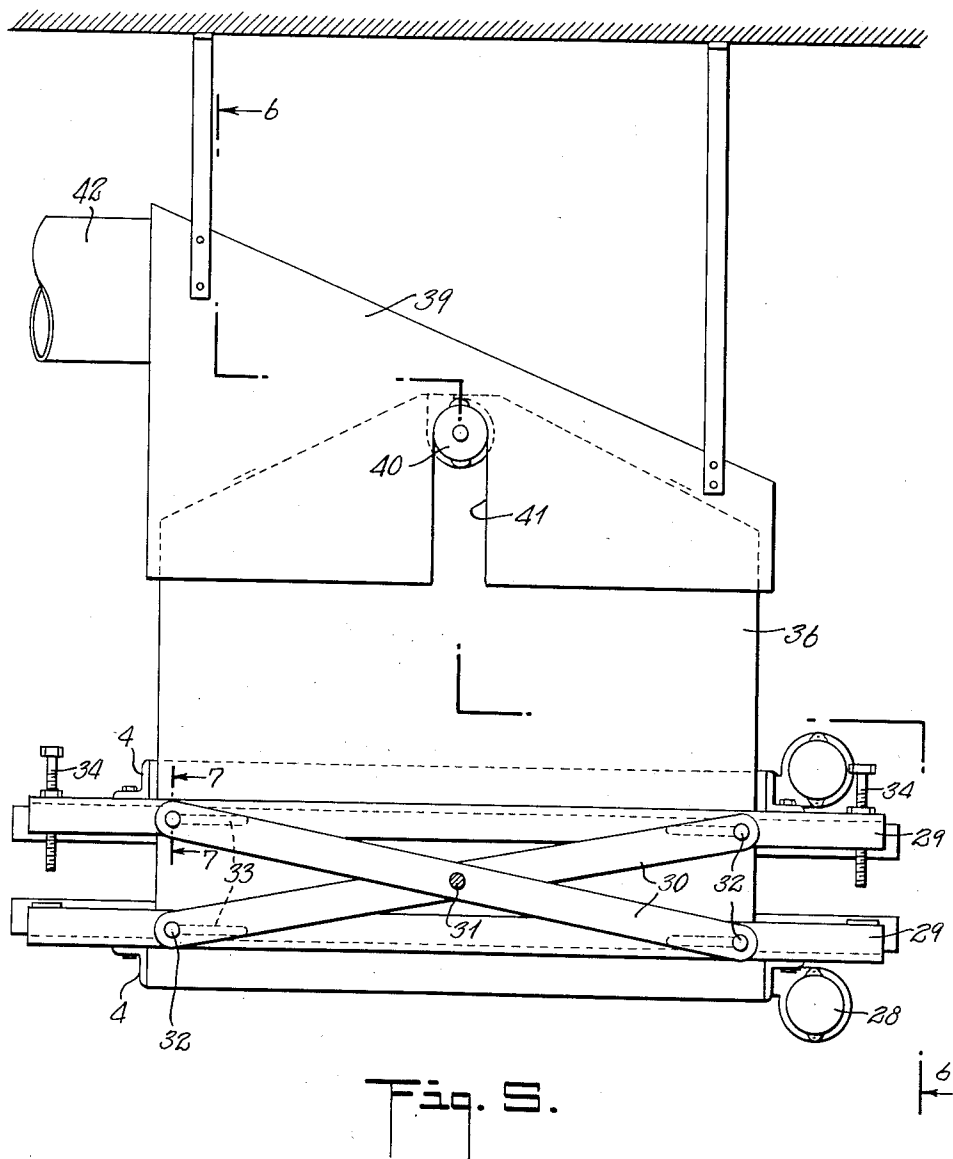
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RADIANT HEATING AND DRYING DEVICE

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Fig. 6.

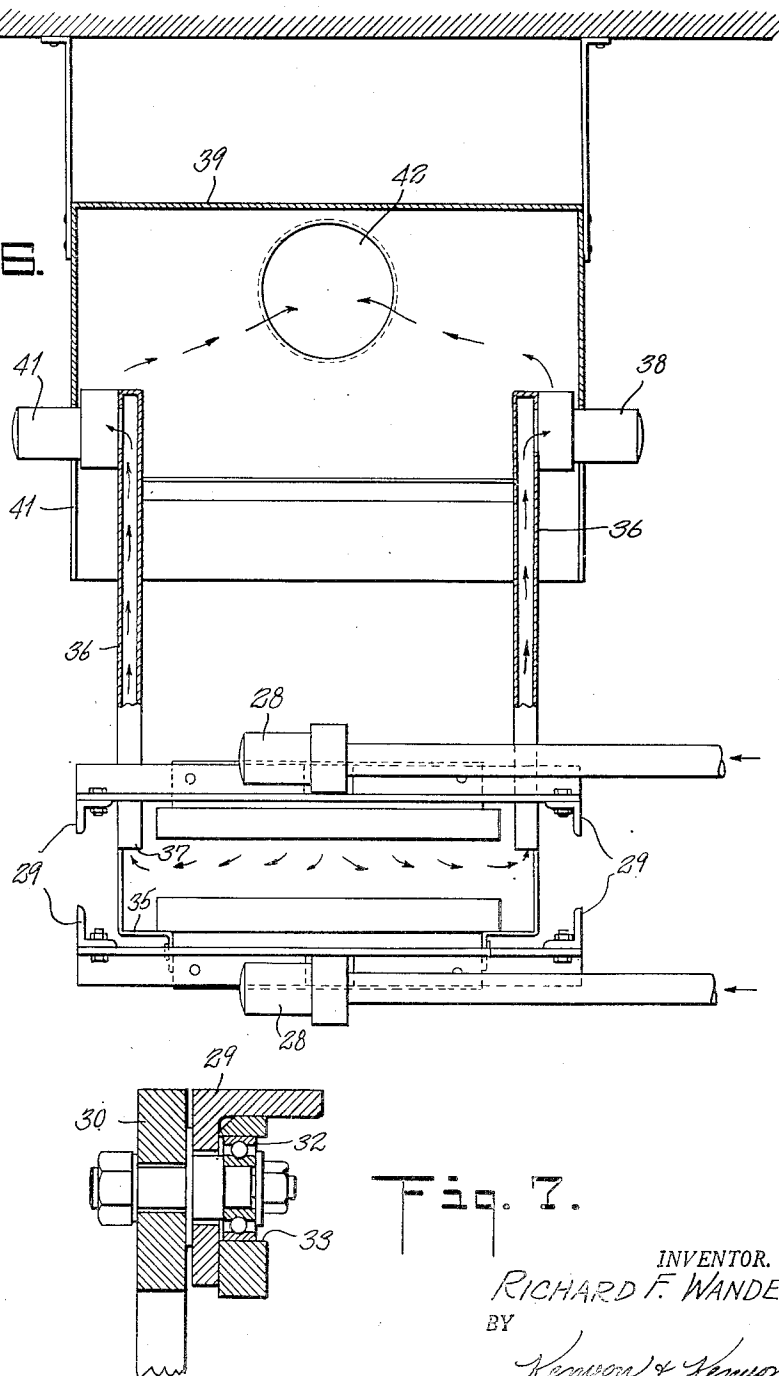


Fig. 7.

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RADIANT HEATING AND DRYING DEVICE

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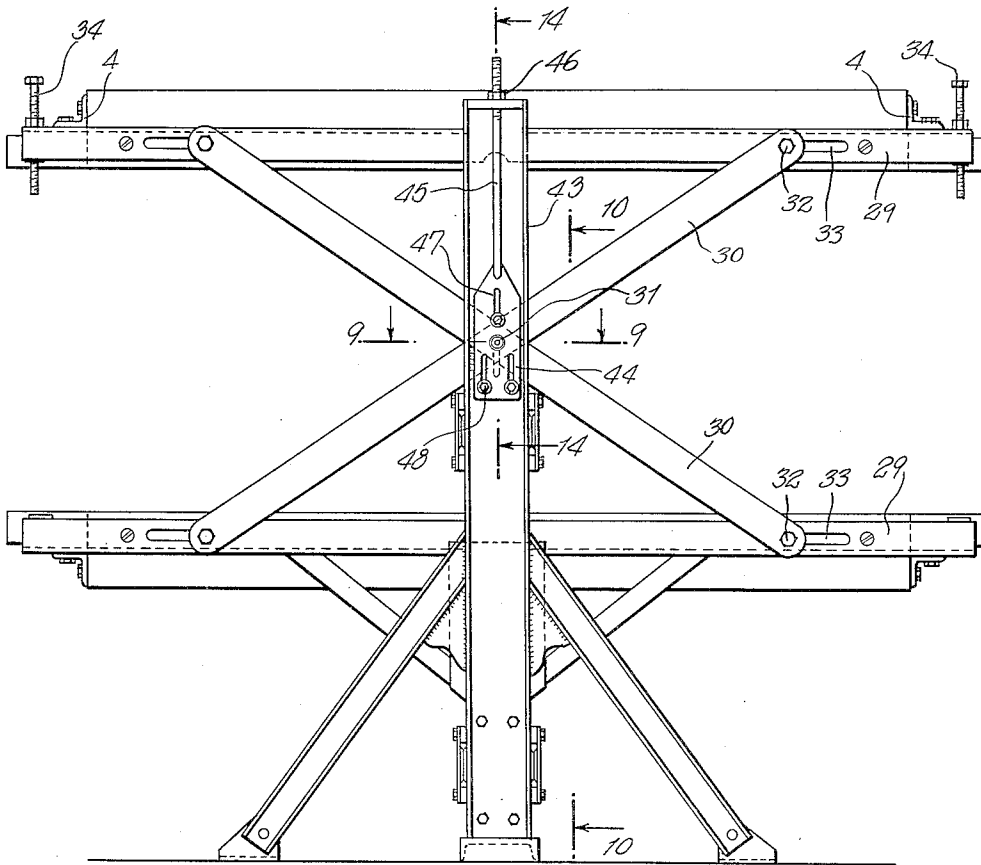


Fig. 8.

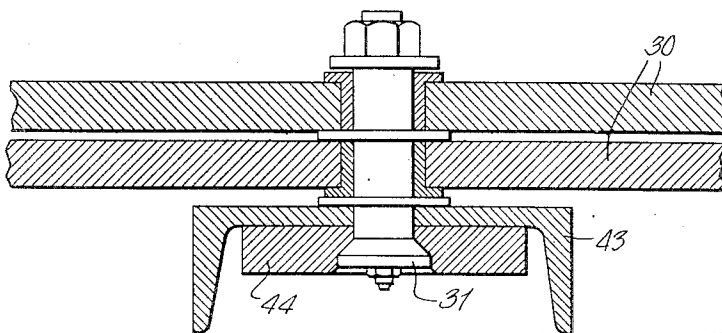


Fig. 9.

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RADIANT HEATING AND DRYING DEVICE

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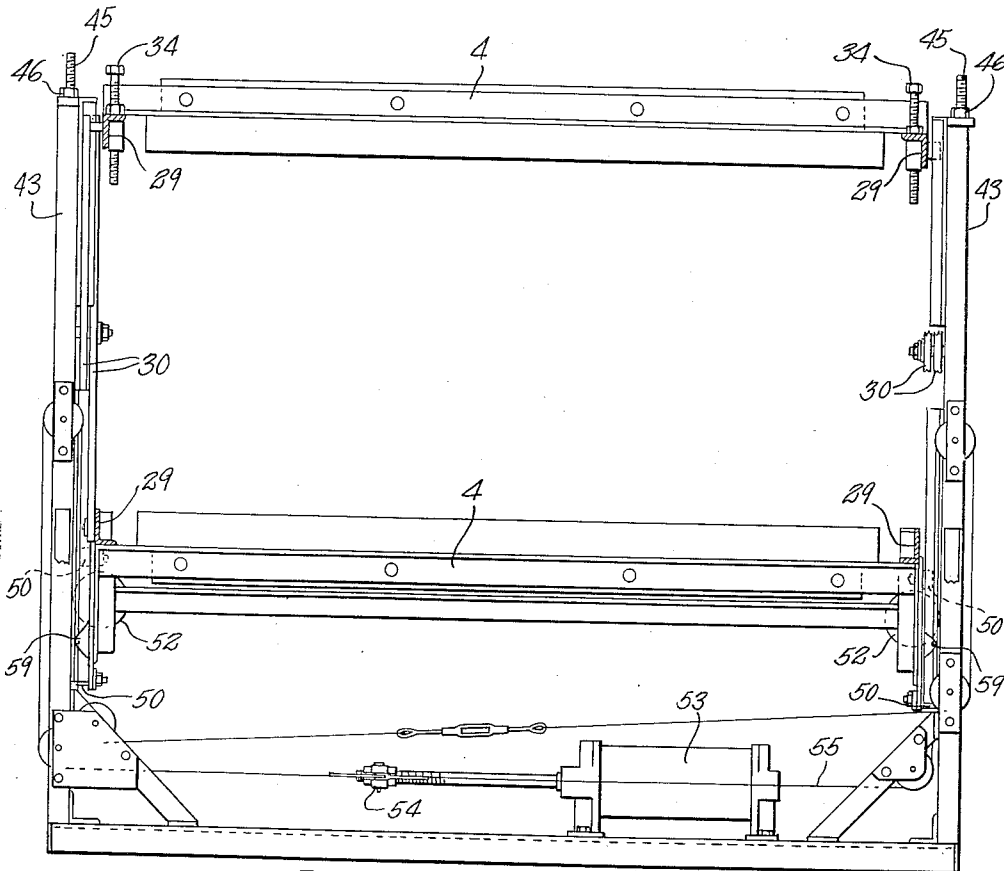


Fig. 13.

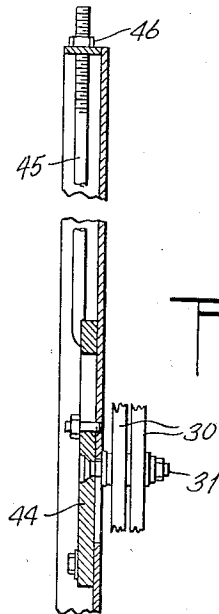


Fig. 14.

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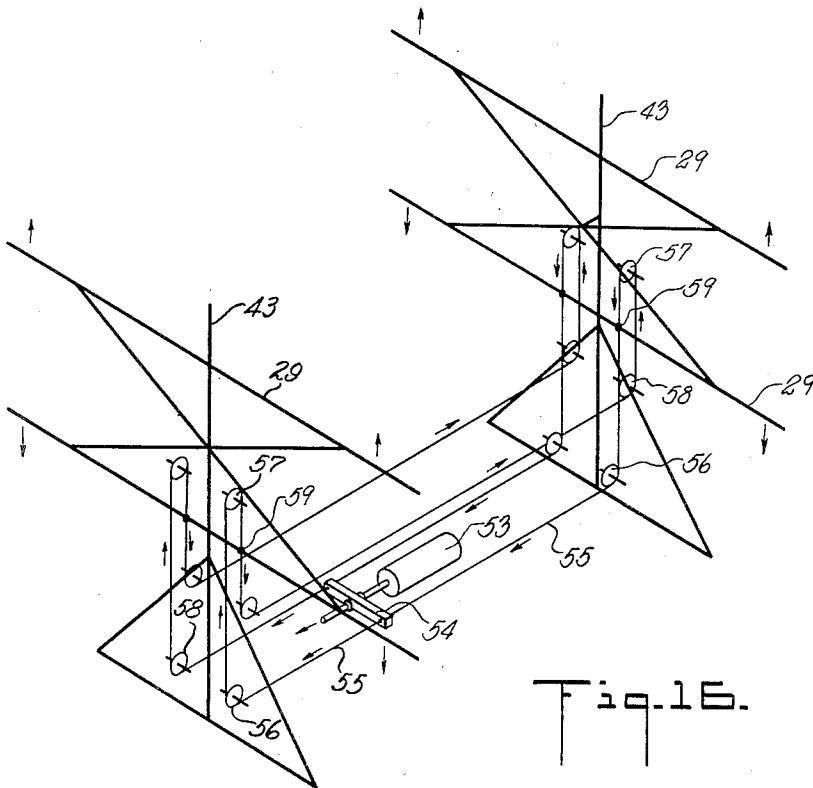
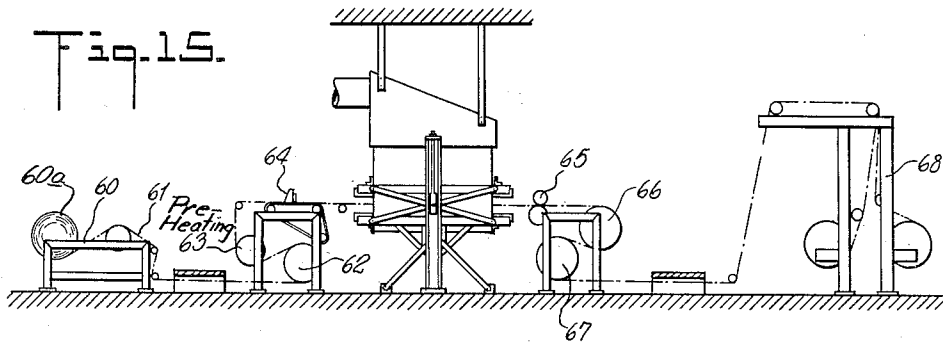
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RADIANT HEATING AND DRYING DEVICE

Filed April 20, 1950

9 Sheets-Sheet 9



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UNITED STATES PATENT OFFICE

2,573,121

RADIANT HEATING AND DRYING DEVICE

Richard F. Wandell, Gladstone, N. J.

Application April 20, 1950, Serial No. 156,957

16 Claims. (Cl. 34—155)

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This invention relates to devices for radiating heat uniformly to flat work. Such devices are useful for drying or curing coatings or saturants carried by paper or fabric, as well as other types of work requiring the use of heat.

One of the objects is to provide a flat heat radiating surface of large or small area and which may be positioned parallel to a sheet or web of material and which will operate at high efficiency to radiate heat uniformly to the material to raise its temperature evenly. Another object is to provide for the safe and satisfactory use of such a surface in connection with materials which give off volatile matter or gases when heated. Other objects may be inferred from the following:

A specific example of the invention is disclosed by the following description with the aid of the accompanying drawings. This is for the purpose of disclosing the principles and operation of the invention. Those skilled in the art may incorporate these principles and operation in other forms and by using other details than are involved by this specific example.

This specific example is in the form of a continuous web heating machine which may be used for thermally processing webs of paper, cloth, or the like, which are coated or impregnated with compositions requiring processing by heating. Such processing may involve the softening of the web material to permit embossing. The machine may be used for setting the threads of nylon fabric webs, in the general drying or curing of various paper or textile webs, or other uses.

This example is illustrated by the accompanying drawings.

Fig. 1 is a simulated perspective of a novel heat radiating panel used by the machine.

Fig. 2 is a section from Fig. 1 taken on the line 2—2.

Fig. 3 is a similar section but taken on the line 3—3 in Fig. 1.

Fig. 4 is a broken-away view showing somewhat diagrammatically some of the components of the heat radiating surface of the panel shown generally by Fig. 1.

Fig. 5 is a side elevation showing certain major elements of the machine, using two of the panels and embodying an enclosure and exhaust system.

Fig. 6 is a section taken from Fig. 5 on the line 6—6.

Fig. 7 is a section taken on the line 7—7 in Fig. 5.

Fig. 8 is a side view of a supporting arrangement used to mount the arrangements and particularly the panels shown by Fig. 5.

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Fig. 9 is a section taken from Fig. 8 on the line 9—9.

Fig. 10 is a section taken on the line 10—10 in Fig. 8.

Fig. 11 is a section taken on the line 11—11 in Fig. 10.

Fig. 12 is a section taken on the line 12—12 in Fig. 10.

Fig. 13 is an end view of the arrangement shown by Fig. 8.

Fig. 14 is a section taken on the line 14—14 in Fig. 8.

Fig. 15 is a side view of the machine showing the general association of the arrangements of Figures 5 and 8 and other details.

Fig. 16 schematically shows a rope system interconnecting the elements of Figures 5 and 8 for synchronized operation.

The radiant heating panel, illustrated in detail by Figures 1 through 4, includes a casing of rectangular contour and which is relatively shallow in depth as compared to its lateral dimensions. This casing is formed by a rectangular frame of angle bars 1 having upstanding legs which connect with a rectangular frame of structurally strong and stiff thermally insulating and refractory strips 2 extending upwardly from the angle bars. These strips 2 are arranged to form a rectangular wall, projecting upwardly from the upstanding legs of the angle bars 1, having top edges 3 arranged to form a flat open front for the casing. The other legs of the angle bars 1 project horizontally inwardly.

The casing is completed by the horizontal legs of the angle bars 1 being superimposed on and connected with transversely extending angle bars 4 arranged at the opposite ends of the panel or unit transversely thereof and projecting laterally therefrom to provide mounting bars for the panel. These angle bars 4 are arranged with one of their legs 5 projecting horizontally outwardly respecting the panel, these legs being fastened to the horizontal legs of the angle bars 1. The other legs 6, of the angle bars 4, vertically depend, and a sheet metal box 7 fully encloses all of the space between the interfacing sides of these legs 6 and between their bottom edges. This box forms a manifold chamber for reasons subsequently apparent.

A porous cloth diaphragm assembly, which is elastically flexible in all directions, is tautly stretched, across the casing's flat front, into a flat plane. This diaphragm is continuously maintained under tension directed throughout the diaphragm in a plurality of mutually transverse

directions lying in the mentioned flat plane. The fibrous material actually used, and preferred unless other similar material is developed, is fiber glass.

This diaphragm is heated so that it functions as the heat radiating surface. Since it is stretched like a drumhead and is elastically flexible in all directions, this surface remains flat at all times over a wide range of operating temperatures, as exemplified by a range of from 120° to 700° F.

This diaphragm is formed by a front or outside sheet 8 of refractory cloth that is woven as an integral unit from threads spun from the refractory fibers, which, as previously indicated, are glass fibers commonly called fiber glass. The fiber glass used in this example, is uncolored, and the cloth sheet is free from impregnation of any kind which is not adequately stable at high operating temperatures and which might clog or close the pores of the cloth.

Such fiber glass cloth is commercially available. It is elastically flexible in all directions and is capable of being stretched like a drumhead.

The sheet 8 is free from discontinuities in the sense of the discontinuities that would result from interweaving strips or large strands of cloth. Its weave, thread fineness and continuity are in the nature of a sheet of sail cloth.

Beneath this sheet 8 is a layer of interwoven warp tapes 9 and woof tapes 10. Each of these tapes is made from interwoven threads of fiber glass or glass fibers although other material of similar physical properties may be used if available. The tapes are relatively wide as exemplified by some ½ to 1½ inch widths. As illustrated, the warp tapes have the wider widths while the woof tapes have the narrower widths.

A tube 11 is interwoven with these tapes along with the woof tapes. This tube is also made from interwoven threads of refractory fibers, of the character described, and it may be made by braiding. This tube 11 contains electric resistance heating wire 12 which is threaded through the tube and which is longer than the tube, and is sinuously arranged therein.

The tapes 9 and 10 and the tube 11 are commercially available. In all cases they are formed by interwoven threads spun from fiber glass or glass fiber or the like. The tube 11 may be braided, and in the case of the illustrated example has an inside diameter of ¼ inch.

The strips 9 and 10 are termed warp and woof strips entirely as a matter of convenience. This fabricated layer of tapes and tube is, at present, made by hand weaving methods. The weavers follow substantially the same practice as making cane-bottom chairs. The strips 9 and 10 are made to project considerably beyond the tube 11 so as to form a kind of fringe around the layer. A plurality of lengths of the tube 11 may be incorporated, in the case of areas of large area, with corresponding lengths or sections of the resistance wire 12 being used and with its ends connected with bus bars 13 so that the various lengths of wire are in parallel with each other. This circuit arrangement is used to permit the heating of the layer to high temperatures.

As in the case of the sheet 8, the pores of the tapes and of the tube are left open, and no impregnating material is used which is unstable at the high temperatures previously mentioned, or which may interfere with the elastic flexibility inherently possessed by fiber glass cloth products.

In this example, uncolored fiber glass is used throughout for these tapes and tube.

This diaphragm assembly, comprising the two layers described, is stretched tautly over the casing front, formed by the edges 3, by extending the warp and woof tapes 9 and 10 outwardly beyond the edges 3, and also the peripheral portion of sheet 8, to transversely movable clamping bars 14 which clamp these extended parts. The proportions are such that the periphery of the portion carrying the tube 11 substantially coincides with the edge 3 of the casing.

A mounting for the clamping bars 14 is provided by a rectangular frame surrounding the frame formed by the angle bars 1 and refractory strips 2. This outer frame is formed by Z bars 15 which may be formed by appropriately arranging two separate angle bars. These Z bars have their webs vertical, and have their bottom legs 16 extending horizontally inwardly and fastened to the tops of the legs 5 of the panel-mounting angle bars 4. These bars 15 have their top legs 17 projecting horizontally outwardly a little above the level of the edges 3. The clamping bars 14 ride on the top surfaces of these legs 17.

The clamping bars 14 are angle bars having horizontal legs riding on the legs 17 and over which the sheet 8 and tapes 10 extend. These diaphragm parts bend down around the outer corners of the angle bars and extend downwardly along vertically depending legs 18. Outer bars 19 clamp the textile elements to the legs 18 of the clamping bars 14.

There is one of these clamping bars extending along each of the four sides of the heat radiating panel. Corner housings 20 are used at the corners in the interest of providing an attractive appearance. These corner housings must, in each instance, be connected to only one of the bars, and there must be room for play between the other bar and the corner members in each instance. The clamping bars are each capable of individual movement transversely to the parts clamped thereby.

A plurality of clamping-bar guide rods 21 extend outwardly from the webs of the Z bars 15 and through holes formed in the legs 18 and outer bars 19 of the clamping bars 14. These rods 21 function as guides mounting the various bars 14 for transverse reciprocation respecting the diaphragm and the sides of the casing. A compression spring 22 surrounds each guide bar 21 so as to continuously bias outwardly the clamping bars 14, heads 21a on the bars keeping the clamping bars from disengaging. These springs 22 are powerful, although not so powerful as to rupture the fabric components placed in tension by these springs.

The various bus bars 13 extend peripherally around the panel in the space between the described inner and outer frames, this space is more or less enclosed by strips of refractory thermal insulation 23. The long open bottoms of these spaces, extending longitudinally between the panel mounting bars 4, are closed by appropriately dimensioned flat strips 24 of the described thermal insulation. These strips 24 complete the enclosure of the casing provided by the bottom box 7 and the legs 1 and strips 2. The front of this casing is closed by the diaphragm assembly forming a tautly stretched and completely flat porous diaphragm or front wall. When the resistance wire 12 is energized, this wall functions as the heat radiating surface.

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A sheet of fiber glass cloth 25 covers the inside of the diaphragm assembly. This sheet need not be tensioned to any great degree and hence is not connected with the clamping bars 24. Another sheet 26 of fiber glass cloth is stretched across the space between the bottom of the frame of angle bars 1 and top of the box 7. This sheet, also, does not need to be tensioned to any great degree. These two sheets 25 and 26 provide a space that is relatively thick, as compared to the diaphragm assembly, and in which fiber glass fibers, in the form of a loosely compacted felt or mat, are packed to form a refractory heat absorbing and thermal insulation layer 27.

The fiber glass cloth sheets 25 and 26 and the fiber glass mat or layer 27 do not contain impregnating material which might cause troubles at high temperatures or which might clog the pores of these various layers. The mat 27 functions as a porous layer or mat.

The angle bar legs 6 and the box 7, aided by the strips 24, form a manifold below the layer 27. An electric blower 28 is connected to an inlet hole, formed in one of the angle bar legs 6, so as to blow into this manifold. The air moving capacity of this blower is such as to cause an appreciable but just about discernible flow of air through the porous layer 27 and the porous diaphragm assembly forming the front wall of the heat radiating panel. The idea is to provide a very slow moving draft, moving through the porous layer 27 towards the diaphragm assembly and through the porous diaphragm assembly and out through the front surface of the latter.

The new heat radiator panel is adapted for many uses under conditions which cannot be met by any other known kind of heat radiator. When the resistance wire 12 is energized to heat the diaphragm assembly to high temperatures, such as up to 700° F. or higher, and even though the panel may have a radiant heating surface area of much more than a few square feet, the diaphragm assembly remains flat at all times. The tube 11 is carried as an idle wool that is free from tension. Tension is transmitted through the diaphragm assembly in at least two mutually transverse directions which in all cases lie in the same flat plane because the clamping bars 14 all work in a single flat plane.

Any tendency for localized overheating of the diaphragm, such as might occur due to uneven heat absorption by the work, cannot result in buckling or loss of flatness by the radiating surface. Since it is elastically flexible in all directions, the tension applied by the springs 22 keeps the surface completely flat, in the manner of a drumhead. Localized portions may stretch, relative to other portions, without locally affecting flatness.

This flatness characteristic is of importance in connection with the uniform heating of flat webs of material positioned adjacently parallel to the heat radiating surface, as must be done in many types of work.

The actual heat radiating surface is formed by the sheet 8 which is free from any discontinuities other than the very minute thread interstices; for practical purposes the sheet 8 forms an integral surface. This sheet is heated very uniformly by conduction and radiation from the layer underneath.

Obviously, a heat radiator is ordinarily required to direct the heat primarily in one direction. In the described device the heat radiated backwardly from the diaphragm assembly into the casing

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over the front of which it is stretched, is absorbed by the refractory thermal insulation layer 27. This layer receives this heat both through radiation and by conduction. Although fiber glass wool, or any refractory fibrous or porous material, is a good thermal insulator, it naturally absorbs heat in performing this function. If heated through to its back surface, heat is lost by radiation from this surface.

The heat absorbed by the thermal insulation 27 is not lost in the case of the present device. The gentle draft of air constantly moving through this insulation layer, from its back to its front, resulting from the operation of the blower 28, wipes the heat from the layer 27 and returns this heat to the diaphragm assembly as the air passes therethrough. This effect adds to the efficiency of the device. When in actual operation, at high temperatures of around 700° F., it is possible to place the hand comfortably on the box 7, the outside of this box being only warm at the most. As made commercially, the bottom of this box is only about one foot from the front of the sheet 8, yet when this sheet 8 is operating at the higher temperature mentioned it is still comfortable to touch the back of the box 7.

The usual operating practice is to adjust the amount of air blown into the manifold box 7, by the blower 28, by maintaining it at a rate which increases the temperature of the diaphragm assembly to a maximum. If the air is blown too fast, it will cause cooling of the diaphragm assembly, and if the air is not moved fast enough it will not so fully perform its function of returning the heat to the diaphragm assembly. If the air moves too slowly, the temperature of the diaphragm assembly drops, due to the heat lost, and there is a corresponding increase in the temperature of the box 7. The amount of air forced into the manifold box, per unit of time, may be varied by changing the blower's motor speed, or by any other appropriate arrangement.

Although the heating panel has been referred to as having top and bottom parts, this has been done for convenience only. Frequently the device is used in an inverted position, with the diaphragm assembly pointing downwardly on the work.

Sometimes, work being thermally treated by the radiated heat, drives off volatile vapors or other materials which might adversely affect or clog the diaphragm assembly so as to interfere with its heat radiating efficiencies and its general heat radiation characteristics. Any such trouble is prevented by the draft of air through the diaphragm assembly. This slow moving but constantly progressing barrier of air, forms a protective pneumatic wall or covering extending throughout the entire front of the diaphragm assembly. This shields the heat radiating surface from the usual contamination resulting from volatile solvents, gases, impregnating materials and the like, which may be driven off in gas or vapor phase from the work. Thus the described blower arrangement provides a second important operating advantage.

Referring now to Figures 5 through 7, in the illustrated machine, a pair of mutually opposed, upper and lower, rectangular frames 29 are arranged parallel to each other and so they can reciprocate simultaneously to and from a common central plane. This is accomplished by interconnecting the frames by pantograph arms 30, centrally interconnected by a pivot 31 and having their ends connected with bearings 32

running in raceways 33 provided on each of the side bars of the frames 29 parallel therewith. With the pivots 31 fixedly positioned, as subsequently described, and with one of the frames 29 restrained against tilting, this arrangement causes the frames to synchronously move oppositely to and from a horizontal plane intersected by the pivot pins 31. One of the frames is provided with adjustable abutment screws 34 which engage the other frame so as to limit the approach of the frames towards each other to a definite separation distance, fixed by adjustment of the screws.

The upper one of the frames 29 is in the form of a rectangle that is substantially wider than the heat radiating panel and which is also somewhat longer than this panel. Both frames may be of the same dimensions and are so proportioned in the illustrated example.

A pair of the panels are arranged, with their heat radiating sheets 8 interfacing and oppositely positioned, by the panels' respective angle mounting bars 4 being fastened to the side or longitudinally extending bars of the frames 29. With this arrangement, when the frames are reciprocated together, to the limit set by the screws 34, the machine is provided with a pair of mutually opposed, porous, heated, refractory cloth diaphragms. Also, each diaphragm is stretched across its back casing, as previously described.

With this arrangement, using the mutually opposed radiant heating panels, a high degree of heating efficiency is effected. Assuming each of the radiating heating panels is provided with a suitable temperature control device, relatively little electric power is needed to obtain a high operating temperature. Each sheet 8 radiates heat to the other sheet. Relatively little heat is lost backwardly because of the air flow through each of the diaphragms towards and into the space therebetween. Each diaphragm acts as an insulator for the opposite side of the web being heated by the other diaphragm. Neither diaphragm can lose much heat because the heat absorbed by the respective layers 27 is convectionally returned, by the moving air currents, to the adjacent diaphragm.

The pneumatic screen action, previously described, raises the pressure slightly between the interfaces of the two radiant heating panels. Many volatile and gaseous matters, thrown off when heating work of the character to which this invention is particularly adapted, are of an explosive, nauseating or poisonous nature. It is important that such vapors and gases be restrained from contaminating the atmosphere of the room where the thermal processing is being carried out.

The present invention provides for the collection and exhausting of such gases or vapors. This is done by providing the sides of the lower one of the heating panels with walls which extend laterally for a short distance, at 35, and then extend upwardly to provide vertical walls 36. Each of these walls extend the length of the heating panel, and the upwardly extending portions 36 straddle the upper one of the radiant heating panels and extend through the space between its sides and the side bars of the upper one of the frames 29. These walls move up and down with the lower one of the frames and panels, and since the wall portions 36 are free from the upper panel and frame, they do not interfere with vertical reciprocation of these upper parts. The upwardly extending wall portions 36 are made hollow, or in

the form of flat conduits, the bottom ends of these hollow portions opening, at 37, along the entire length of the space between the fronts of the heating panels when the two frames are moved together as far as the screws 34 permit.

An electric blower 38 is carried by the top of each of the walls 36, these two blowers function as suction devices which lower the pressures in the hollow walls 36. These blowers are of the type each having its own electric motor, so as to form a self-contained unit, and these units move up and down with their respective walls. An exhaust hood 39 is positioned above the upper part of the wall portions 36, and therefore, above the heating panels. When the two heating panels are closed together as far as possible, the walls 36 rise up into the inside of the hood 39. The blowers 38 are arranged with their motors 40 projecting outwardly, and the sides of the hood 39 have vertical slots 41 through which the motors 40 project. This puts the motors on the outside where they are free from the vapors and gases. The hood 39 has an exhaust duct 42 which is fastened to an arrangement for sucking through the duct 42.

In operation, the suction through the long openings 37 draws through these openings all of the vapors or gases, produced by the work, carries these fluids up through the hollow walls 36 and exhausts them into the hood 39, which then exhausts them by reason of the suction through the duct 42, the latter carrying the fluids to a safe place of disposal. The electric motor of the blowers 38 are free from such fluids. This is also true respecting the motors 40 of the blowers 38. The air driven by the blowers 28 through the porous diaphragms keeps the possibly offensive fluids away from the diaphragms, and induces outwardly directed currents which are guided by the suction of the openings 37 so that they are thereby collected and carried up through the walls 36 and finally ejected through the duct 42. This method of handling the offensive fluids provides safe operating conditions regardless of the nature of the gases or vapors driven from the work by the heating.

As shown by Figures 8 through 14, upstanding columns 43 mount the pivots 31 of the pantograph arms 30. This is done in an adjustable manner by mounting the pins in vertical sliding carriages 44 adjustably supported from the tops of the columns 43 through tension screws 45 located vertically by nuts 46. Adjustment of these nuts 47 raises and lowers the location of the pivot pins 31.

The columns 43 are shown as comprising outwardly facing channels with the carriages 44 comprising plates riding between the flanges of these channels. The plates are shown with vertical slots 47 and the channels are provided with bolts 48 passing through these slots, whereby tightening of these bolts locks the plates or carriages 44 in any position selected by screwing of the nuts 46.

The lower one of the frames 29 is prevented from tilting by being provided with rigidly depending arms 49 equipped with upper and lower guide rollers 50 which ride in vertical guide ways 51 fastened to the insides of the channels 43. Lateral guidance is provided by wheels 52 journaled to the arms 49 and bearing against the insides of the channels 43.

Simultaneous opposite reciprocation of the frames 29 is effected by a system of sheaves and cables powered by a fluid-operated reciprocating

motor 53 having its plunger connected with a cross head 54 to which the cables are attached to receive reciprocative power therefrom.

This system comprises duplicate halves and, therefore, the description of one half serves to explain both.

References to Fig. 16 facilitates an understanding of this cable and sheave arrangement. Each side of the cross head 54 is connected to an endless cable 55 which extends oppositely therefrom, transversely respecting the frames 29, to fixed position sheaves 56 which bend the cables upwardly so they extend to upper fixed position sheaves 57 around which they wrap and from which they extend downwardly to lower fixed position sheaves 58 from which the cable oppositely extends together so as to complete the endless loop. At 59 cable is connected with the lower one of the frames 29.

In operation, the motor 53, being double acting, is supplied at one end with fluid so as to thrust out the cross head 54. This moves the cable 55 in the directions indicated by the arrows, with the consequent downward movement of the lower one of the frames 29 which, through the pantograph arms 30, moves the upper one of the frames 29. Since the lower one of the frames is restrained against tilting, both frames are held parallel relative to each other at all times. Providing fluid under pressure to the opposite end of the motor 53, draws in the cross head 54 with consequent opposite operation and bringing together of the two frames 29, until the various screws 34 prevent further approach. Maintenance of this fluid under pressure keeps the frames tightly pressed together.

Reference to Fig. 15 shows the remaining elements required to make the machine completely operative. These details are arranged for embossing operations in connection with a web of material coated with a composition suitable for embossing.

This Fig. 15 shows an unreeling stand 60 carrying a roll 60a of the web to be processed. A continuous supply may be provided by attaching the trailing end of an exhausting roll to the advancing end of a fresh roll. The web 61 is fed by suitable guide rollers around a back-tensioning or braked drum 62 from which it extends around a preheating drum 63, and from there, horizontally across a knife coater 64 which applies a coating to carry the embossing.

With the knife coater smoothly spreading on the coating material, the web next travels through the previously described machine which raises its temperature high enough to properly process the coating for embossing. For reasons previously explained, it is immaterial whether explosively volatile or other materials are driven off.

Upon leaving the heating machine, the web material travels through the embosser rolls 65 and around a cooling drum 66, and then another drum 67 which may provide the pulling power required to cause the web to continuously travel. From the drum 67 the embossed web is guided to a double winder 68 where it is rewound as a coil.

The present invention is of particular importance in this kind of work. The web is caused to travel through a relatively flat span. Any uneven heating of the coating material will result in a poor quality of product, or in failure of the process. If the heating is to be done by a small and compact unit, high-temperature radiators are required. Prior art radiators have been un-

satisfactory for this purpose, but the present invention provides the absolutely uniform heating that has been heretofore unobtainable. The electric power required is low because of the efficiency previously noted. Since the coating material is so uniformly heated, a high quality of embossed product results.

It is to be understood that the two heating panels are made to raise and lower relative each other, or separate, so that the machine may be threaded with the web, and so that web breakage trouble may be easily corrected. The horizontal central plane, set by the pivots 31, may be adjusted to coincide with the web traveling plane, established by the web-guiding elements. Once adjusted, the two panels are thereafter maintained, at all times, equidistantly from the web, so there is no chance for heating one side of the web more than the other. However, it may sometimes be desirable to heat one web side more than the other, and this can be uniformly effected by adjustment of the horizontal central plane of the two panels, by adjustment of the pivots 31, as previously described.

I claim:

1. A radiant heater including, in combination, a porous diaphragm woven from refractory fibrous material and which is elastically flexible in all directions, means tautly stretching said diaphragm into a flat plane and continuously maintaining tension directed throughout said diaphragm in a plurality of mutually transverse directions lying in said plane, means heating said diaphragm to cause it to radiate heat therefrom, a porous layer of refractory material substantially covering one side of said diaphragm and positioned adjacently thereto, an enclosure for said layer and said side, and means forcing fluid into said enclosure.

2. A radiant heater including, in combination, a cloth diaphragm assembly which is elastically flexible in all directions and includes a front layer formed by a sheet of cloth woven from threads of refractory fibers and a rear layer formed by fabric woven from threads of refractory fibers and carrying flexible electric heating resistance, means tautly stretching said diaphragm in a flat plane and continuously maintaining tension directed throughout said diaphragm in a plurality of mutually transverse directions lying in said plane, a porous thermal insulation layer of refractory fibrous material substantially covering the rear side of said diaphragm and positioned adjacent thereto, an enclosure for said insulation layer and said rear side, and means forcing fluid into said enclosure.

3. A radiant heater including, in combination, a casing having a flat open front, a porous diaphragm woven from refractory fibrous material and which is elastically flexible in all directions, means tautly stretching said diaphragm in a flat plane across said front to form a front wall therefor and continuously maintaining tension directed throughout said diaphragm in a plurality of mutually transverse directions lying in said plane, means heating said diaphragm to cause it to radiate heat therefrom, a porous layer of refractory material arranged in said casing to form a heat absorbing wall behind said front wall, and a blower connected into said casing to blow thereinto behind said heat-absorbing wall.

4. A radiant heater including, in combination, a casing having a flat open front, a porous cloth diaphragm assembly which is elastically flexible

in all directions and includes a layer of interwoven warp and woof fabric tapes woven from threads of refractory fibers and tube interwoven with said tapes and made from interwoven threads of refractory fibers and electric resistance heating wire threaded through said tube and which is longer than said tube and is sinusously arranged therein, and a front sheet of cloth that is elastically flexible in all directions and is woven as an integral unit from threads of refractory fibers and which is superimposed on said layer in contact therewith, means engaging the periphery of said sheet and the ends of said tapes and tautly stretching said diaphragm assembly in a flat plane across said casing front to form a front wall therefor and continuously maintaining tension directly longitudinally through said warp and woof tapes and throughout said sheet in directions lying in said plane, a porous layer of refractory fibers positioned in said casing behind said diaphragm assembly in the form of a wall therebehind and having a rear surface spaced from the inside of said casing, and a blower connected into said casing to blow therinto behind said rear surface.

5. A radiant heater including, in combination, a porous diaphragm woven from refractory fibrous material and which is elastically flexible in all directions, means tautly stretching said diaphragm into a flat plane and continuously maintaining tension directed throughout said diaphragm in a plurality of mutually transverse directions lying in said plane, means heating said diaphragm to cause it to radiate heat therefrom, an enclosure for one side of said diaphragm, and means forcing fluid to flow into said enclosure.

6. A radiant heater including, in combination, a porous diaphragm woven from refractory fibrous material and which is elastically flexible in all directions, means tautly stretching said diaphragm into a flat plane and continuously maintaining tension directed throughout said diaphragm in a plurality of mutually transverse directions lying in said plane, means heating said diaphragm to cause it to radiate heat therefrom, an enclosure for one side of said diaphragm, and a blower connected into said casing to blow therinto behind said diaphragm.

7. A radiant heater including, in combination, adjacently spaced, mutually opposed porous heated diaphragms, porous heat-absorbing material positioned adjacent the relative outsides of said diaphragms, and means forcing fluid to flow through said material to absorb heat therefrom and then to flow through said diaphragms towards and through their relative insides.

8. A radiant heater including, in combination, adjacently spaced, mutually opposed porous heated diaphragms, porous heat-absorbing material positioned adjacent the relative outsides of said diaphragms, and means forcing fluid to flow through said material to absorb heat therefrom and then to flow through said diaphragms towards and through their relative insides, said diaphragms being woven from refractory fibrous material and being elastically flexible in all directions and each having means tautly stretching it into a flat plane and maintaining tension directed therethrough in a plurality of mutually transverse directions lying in said plane.

9. A radiant heater including, in combination, adjacently spaced, mutually opposed porous heated diaphragms, porous heat-absorbing material positioned adjacent the relative outsides of

said diaphragms, and means forcing fluid to flow through said material to absorb heat therefrom and then to flow through said diaphragms towards and through their relative insides, an exhaust duct extending along at least one side of the space between said diaphragms, and means sucking through said duct to exhaust fluid from said space.

10. A radiant heating device including, in combination, oppositely positioned casings having flat open fronts facing each other in mutually spaced relation and defining a space therebetween, each of said fronts having a porous cloth wall woven from refractory fibrous material and positioned to span the front in a flat plane and forming a front wall therefor, means directing tension through each of said walls in a plurality of mutually transverse directions lying in its said flat plane, electric heating resistance adjacent each of said walls, and fluid inlets opening into each of said casings behind said walls.

11. A radiant heating device including, in combination, oppositely positioned casings having flat open fronts facing each other in mutually spaced relation and defining a space therebetween, each of said fronts having a porous cloth wall woven from refractory fibrous material and positioned to span the front in a flat plane and forming a front wall therefor, means directing tension through each of said walls in a plurality of mutually transverse directions lying in its said flat plane, electric heating resistance adjacent each of said walls, and fluid inlets opening into each of said casings behind said walls, an exhaust duct extending along one side of said walls and opening to the space therebetween, and means for applying suction to said duct to exhaust fluid from said space.

12. A radiant heating device including, in combination, oppositely positioned casings having flat open fronts facing each other in mutually spaced relation and defining a space therebetween, each of said fronts having a porous cloth wall woven from refractory fibrous material and positioned to span the front in a flat plane and forming a front wall therefor, means directing tension through each of said walls in a plurality of mutually transverse directions lying in its said flat plane, electric heating resistance adjacent each of said walls, and fluid inlets opening into each of said casings behind said walls, each of said casings having a layer of porous refractory thermal insulation positioned therein adjacent the inside of its said front wall, and each of said casings having a fluid inlet opening therinto at a location behind said layer.

13. A radiant heating device including, in combination, mutually opposed porous heated diaphragms, means forcing fluid to flow through said diaphragms into the space therebetween, one of said diaphragms being reciprocative to and from the other, hollow walls extending from the opposite sides of one of said diaphragms towards the other and straddling the latter and extending beyond the back thereof, said walls opening to the space between said diaphragms adjacent the front of the diaphragms from which they extend, and means sucking through said hollow walls to exhaust fluid from said space.

14. A radiant heating device including, in combination, mutually opposed porous heated diaphragms, means forcing fluid to flow through said diaphragms into the space therebetween, one of said diaphragms being reciprocative to

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and from the other, hollow walls extending from the opposite sides of one of said diaphragms towards the other and straddling the latter and extending beyond the back thereof, said walls opening to the space between said diaphragms adjacent the front of the diaphragm from which they extend, and means sucking through said hollow walls to exhaust fluid from said space, said walls extending from and moving with the reciprocative one of said diaphragms and said sucking means comprising blowers mounted on said walls and exhausting from their ends opposite to said reciprocative diaphragm behind the back of the other diaphragm, and an exhausting hood into which said wall ends project when said reciprocative diaphragm is moved close to the other diaphragm.

15. A web heating machine including, in combination, means forming the web into a span and causing it to travel therethrough, mutually opposed porous heated diaphragms positioned on opposite sides of said span and movable towards and from the same, means forcing fluid to flow through said diaphragms towards said span, hollow walls extending from the sides of one of said diaphragms and straddling the other thereof and extending to outer ends beyond the back thereof and being free to move relative to this other diaphragm, said walls having inlets opening to the space between said diaphragms and having outlets in their outer ends, means sucking through said inlets and exhausting through said outlets, and an exhaust hood opening towards said diaphragms and into which said wall's outer ends extend.

16. A web heating machine including, in combination, means moving the web flatly through a span, a porous diaphragm woven from refrac-

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tory fibrous material and elastically flexible in all directions, means tautly stretching said diaphragm into a flat plane substantially parallel to and adjacent to said span and continuously maintaining tension directed throughout said diaphragm in a plurality of mutually transverse directions lying in said plane, and means heating said diaphragm to cause it to radiate heat to said span.

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