Nov. 9, 1965 R. J. RUFF 3,216,127

COATING OVEN WITH CATALYTIC INCINERATION OF VOLATILES

Filed Feb. 9, 1962 3 Sheets-Sheet 1

Figure 1

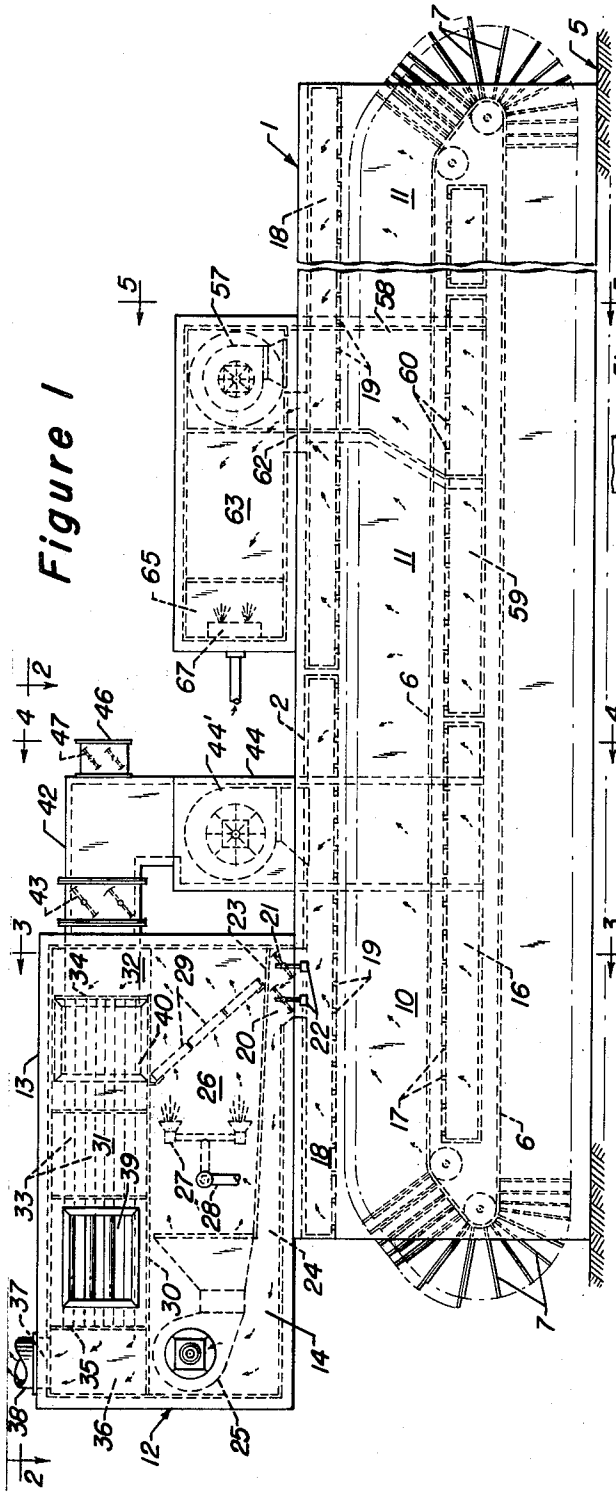
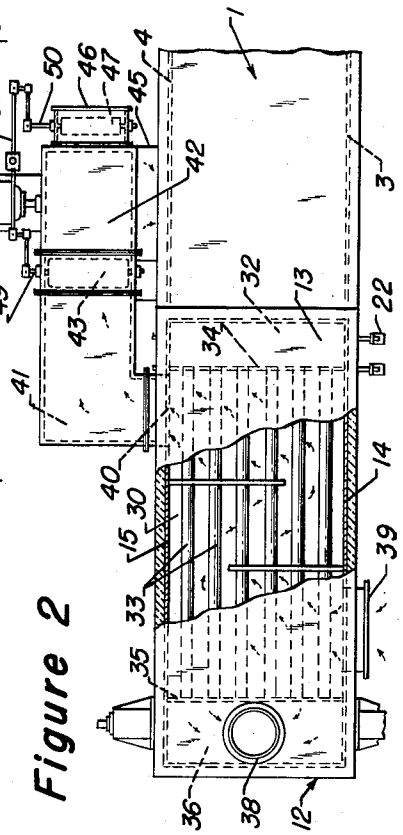


Figure 2



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Filed Feb. 9, 1962 3 Sheets-Sheet 2

Figure 4

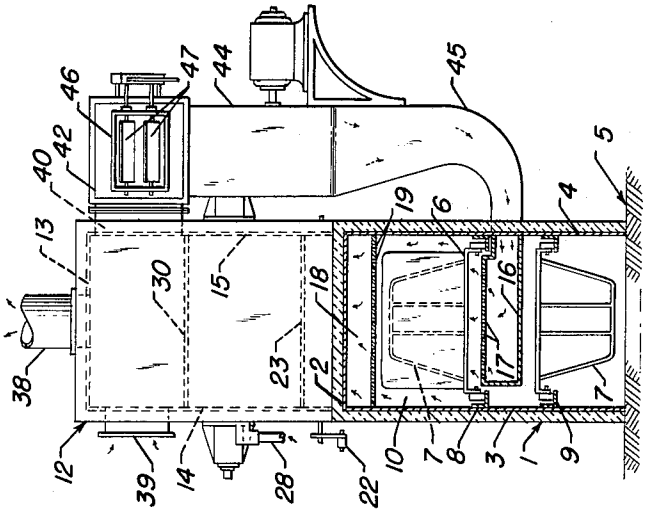
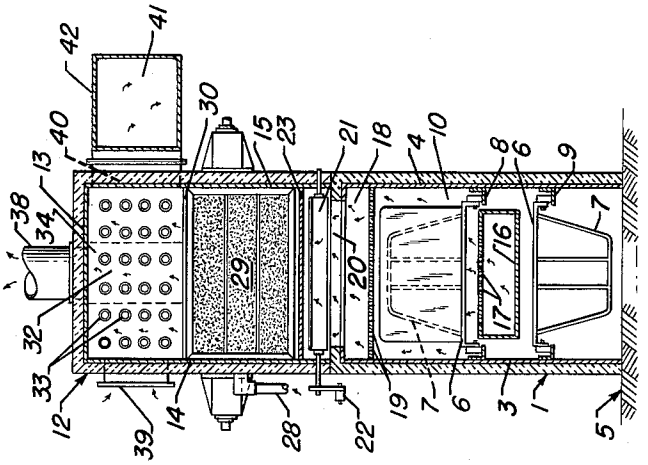


Figure 3



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COATING OVEN WITH CATALYTIC INCINERATION OF VOLATILES

Filed Feb. 9, 1962 3 Sheets-Sheet 3

Figure 6

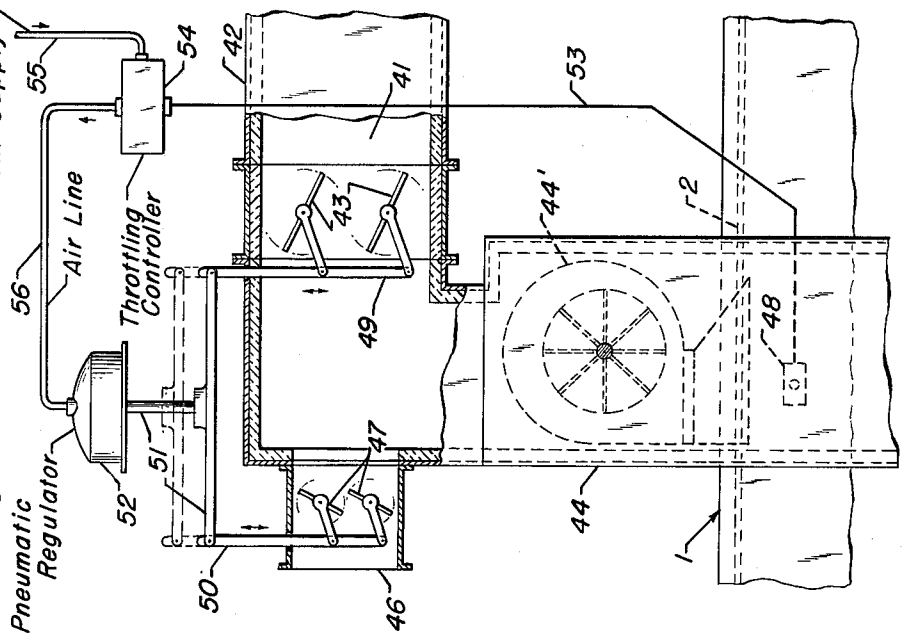
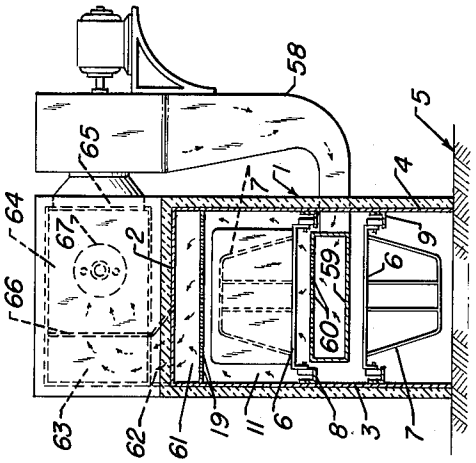


Figure 5



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3,216,127

COATING OVEN WITH CATALYTIC INCINERATION OF VOLATILES

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3 Claims. (Cl. 34—54)

This invention relates to improved apparatus for effecting the heat treating of coated articles and more specifically to an improved coating oven construction which has means for catalytically incinerating the volatile components entrained in the treating air stream.

The treating apparatus of this invention may be utilized to heat treat many different types of coatings on many different articles and materials, but is primarily designed to heat treat protective coatings or printing applied to sheet metal materials. It should be understood that the drawing and the descriptive material is for illustrative purposes and that the apparatus may be used for other heat treating purposes.

In the manufacture of containers, such as beer cans, coffee cans, containers for fruit juices, etc., decorations are coated and printed on sheet metal plates prior to their being formed into a container. In some instances it is necessary to supply a background coating which is baked onto the sheet metal prior to application of the decorative coating, some of which may be in varying colors. Also in connection with certain types of containers such as beer cans and food containers, there is a protective lacquer coating applied to the inside of the container and this is normally applied to the sheet metal material prior to formation of the container.

Generally heat treating ovens operate at speeds accommodating more than 100 sheets per minute such that the amount of solvent evaporated in the treating and drying process may be as much as 150 gallons per hour, or more. Thus, there is produced a considerable quantity of fumes during the operations of these types of drying ovens which are odorous and obnoxious in character, as well as flammable. In the usual heat treating or coating oven installation, there is a resulting high requirement of fresh air introduction into the oven for diluting the vaporized solvents to a sufficient extent to prevent any danger of fire and at the same time prevent condensation of vaporized solvents which would result in creating a fire hazard and require frequent cleaning of the oven and associated equipment. Also, in connection with prior installations, large quantities of air are required to be passed through coating ovens so that there is oven exhaust ventilation and dilution provided primarily to meet established safety standards, with little or no regard for air pollution that may result. On the other hand, the present improved apparatus provides catalytic incinerating means for insuring a substantially complete oxidation and elimination of obnoxious volatile components such that there is a resulting non-flammable and non-objectionable exhaust stream from the oven. In permitting unoxidized or non-catalytically treated volatiles to escape from a heating treating oven, as by the use of excessive amounts of ventilating and diluting air, there is a definite reduction in the efficiency of the oven, for when operating at reduced material and solvent loadings, the excess fresh air supply results in materially increasing the heat input requirements to the unit and thereby a materially increased cost of operation. Attempts have been made to overcome this inefficiency by utilizing an explosimeter in the unit which operates to vary the supply of fresh air in accordance with the solvent loading to the oven, and such systems have been

utilized with the tacit approval of insurance underwriters; however, it is believed that the practice is somewhat dangerous in that there is an appreciable lag in the operation of the system and it is entirely possible that a sudden full solvent load into the oven will not have a sufficient supply of fresh air to maintain conditions in which no fire hazard is present.

The use of catalytic incineration, as provided in combination with the present heat treating oven design and construction, provides means for rapidly reducing, by oxidation, the solvent loading in the vent gas stream to eliminate odor and fire hazard. It should be pointed out also that insurance underwriter requirements for reducing the fire hazard by diluting volatiles in the air stream to one-fourth of the Lower Explosive Limit (LEL) of the particular type of vapor is a waste of potential energy. For example, an oven vented to provide the 25% LEL carries away energy that is capable of raising its own temperature approximately 660° F., based upon the fact that the B.t.u. release in a cubic foot of dry air (at standard 70° F. density) will raise its temperature approximately 55° F. and that there are 12 B. t.u.'s per standard cubic foot in the diluted air stream. It is thus of definite advantage to provide, in accordance with the present construction, a drying oven or heat treating apparatus which will oxilize through catalytic action the volatiles in the fume laden air and make available the heat from such oxidation to heat the air stream being introduced into the drying zone or zones. The heat available from such oxidation will normally be adequate to supply the total heat requirements of the oven, with auxiliary heat being used primarily for startup purposes.

In the design of drying ovens for certain usages, it is desirable to provide a construction wherein the solvent release is substantially confined to the initial heating zone. Also, in some heat treating operations, it is of advantage to have a once through flow of the drying air stream in order to avoid return of contaminated gas to the oven in the event of any equipment malfunctioning, or to preclude the entry of anything to the oven other than a heated fresh air stream.

It is therefore a principal object of the present invention to provide an improved modified form of heat treating oven which catalytically incinerates all of the combustible components being discharged from the treating chamber.

A further object of the invention is to provide a modified construction and arrangement effecting the automatic control of the fresh air stream to the coating oven and a channeling of all of the fresh air intake flow to the initial treating zone of the unit, whereby to effect the venting of the vapor and fume-containing gas stream through a catalytic incineration zone operating in conjunction with only the initial heat treating zone of the unit.

A still further object of the invention is to provide a heat exchange arrangement that passes the bulk of the fresh air treating stream in indirect heat exchange relationship with the hot incinerated exhaust stream such that there is a heat recuperative operation to effect improved efficiency and a lowering of heat requirements of the overall operation.

In a broad aspect, the present invention provides an improved coating oven for heat treating coated articles to evaporate and dry coatings and remove combustibles from the vaporized solvents, said oven comprising in combination, an elongated heat treating chamber, means for conveying articles to be heat treated through the chamber from an entrance end to an exit end, a first heating section in the chamber adjacent the article entrance end thereof, at least one additional heat treating section in the chamber, a plenum section within said first heat treating section arranged to direct heated gases over the ar-

ticles passing therethrough, a vapor exhaust duct from said first section, a circulating fan connecting with said exhaust duct, a vapor combustion section connecting to and extending downstream of said circulating fan, heat supplying means within said combustion section, catalytic vapor incinerator means disposed across said combustion section downstream of said heat supplying means, a heat exchange section connecting with said combustion section and having passageway means therein to receive and discharge oxidized exhaust gases from said combustion section, additional passageway means in said heat exchange section extending adjacent to and in heat exchange relationship with first said passageway means that have fresh air inlet means thereto and heated air outlet means therefrom, whereby to pass air in indirect heat exchange relationship with oxidized exhaust gases from said combustion section, a heated air duct extending from said heated air outlet means and said plenum section in said first heat treating section, regulatable damper control means across at least a portion of the heated air duct from said heat exchange section, a recirculating fan in said heated air duct, adjustable air inlet means to said heated air duct upstream of the recirculating fan therein for introducing tempering air thereto, an exhaust gas outlet stack connecting to and extending from the downstream end of said exhaust gas passageway means of said heat exchange section, and means for recirculating drying gases through the additional heat treating of the chamber to continue the drying of the coated articles passing therethrough.

A preferred construction and arrangement interconnects the damper control means regulating the flow of heated fresh air to the oven with damper control means regulating tempering air into the heated air duct and, in turn, automatically regulates and controls the interconnected dampers by means of a throttling controller which operates responsive to temperature sensitive means in the flow path of the heated air stream entering the oven. In other words, where it is desired to reduce the temperature of the air stream, the control means will serve to adjust the dampers in the heated air stream flow path to reduce the volume of air therethrough, while at the same time opening the dampers introducing tempering air into the hot air duct such that there is an overall temperature reduction in the confined stream passing to the heat treating oven. In the reverse situation, where additional heat is required, the dampers in the hot air duct are opened up and the tempering air dampers are closed down to controllably diminish or preclude dilution of the hot air stream.

In the usual heat treating oven construction there are a plurality of heating zones, with hot air being recirculated around the coated sheets or articles to be treated in order to insure complete treating and drying of all coatings prior to the discharge of the articles from the oven zone. It is, however, a feature of the present improved construction and arrangement to permit fresh air introduction into the oven at only the inlet and outlet ends of the conveyor system, together with the heated fresh air stream that is recuperatively heated in the catalytic oxidation-heat exchange zone and then introduced into the initial drying and solvent removal zone of the oven unit. Thus, additional heat treating zones which are positioned downstream from the initial solvent removal zone, with respect to conveyor movement, utilize merely a recirculation of the air stream in the oven, with additional heat being added by means of burners or other heating means associated with the recirculation flow path. Air pressures are balanced throughout the length of the oven unit by the operations of the various air circulating fans, including those feeding the initial heat treating zone and the catalytic combustion zone, together with such other recirculating fans as may be desired for use in connection with subsequent heating zones, such that the fresh air taken into the oven unit at the conveyor discharge end may be continuously moved forwardly to the initial heat treating zone to become mixed with the fresh air introduced thereto. As a result, all of the fresh inlet air to the oven unit is necessarily passed through the catalytic combustion zone and is discharged from a single exhaust stack, after heat exchange passage with the bulk of the fresh air inlet stream to the oven.

Reference to the accompanying drawings and the following description thereof will serve to show further advantages and novel construction features in connection with the modified catalytic oxidation system in accordance with the present invention effecting the elimination of noxious flammable fumes from the heat treating oven.

FIGURE 1 of the drawings is a diagrammatic elevational view of a coating oven having a catalytic fume incinerating section in combination therewith.

FIGURE 2 of the drawings is a partial plan view of the coating oven, as indicated by the line 2—2 in FIGURE 1.

FIGURE 3 of the drawings is a diagrammatic sectional-elevational view, as indicated by the line 3—3 in FIGURE 1.

FIGURE 4 of the drawings is a combination sectional and end view of the initial treating section of the coating oven, as indicated by the line 4—4 in FIGURE 1.

FIGURE 5 of the drawings is a sectional view showing diagrammatically a hot gas recirculating section in connection with the oven unit, as shown by the line 5—5 in FIGURE 1.

FIGURE 6 of the drawings is a partial elevational view of the damper control section as indicated by line 6—6 in FIGURE 2 of the drawings, together with a diagrammatic indication of automatic control means for operating the adjustable dampers associated with the heated air duct.

Referring now to the drawings there is shown an elongated coating oven chamber **1** having a top cover section **2** and side walls **3** and **4** which are supported on a suitable floor or foundation **5**. It will be noted that the upper and side wall portions are indicated diagrammatically as having a suitable insulation to preclude heat loss from the unit, however, it is not intended to limit the present invention to any one type of insulation or to means for attaching the insulation to the walls of the heat treating oven, or to the fume combustion and heat exchange sections.

An endless conveyor **6** having wickets **7**, or other suitable means attached thereto, for receiving and supporting the sheets or articles to be treated, are mounted within the interior of the oven chamber **1** on suitable trackways **8** and **9**. Suitable means, not shown, are provided for introducing or inserting the metal sheets into the wickets **7** at the inlet end of the conveyor system and for subsequently removing the dried and coated metal sheets from the discharge end of the oven unit.

Thus, the wickets carry the sheet metal pieces, or other articles, through the longitudinal upper section of the oven chamber and return empty along the lower half portion of the unit. Generally the oven unit will have an initial or first heat treating zone **10** and one or more additional heat treating zones **11** which are downstream, with respect to conveyor movement, from the inlet end of the oven chamber **1**. The latter will be open only at the two ends thereof such that infiltrated air can only enter from the inlet and discharge ends of the oven, where the conveyor system necessarily emerges therefrom. All additional fresh air intake to the drying system is provided from a heated fresh air system that is in combination with the combustion and heat exchange sections superimposed above the initial heat treating zone **10**.

An enclosed chamber **12**, having a top wall section **13** and side wall sections **14** and **15**, is, as indicated, superimposed above the inlet end of the chamber **1** to effect the desired catalytic combustion of obnoxious volatile components in the discharge gas stream as well as effect

the recuperation of heat therefrom. Heated air is actually distributed to the interior of the initial heat treating zone **10** through a plenum chamber **16** which is positioned longitudinally between the upper and lower sections of the conveyor belt system **6**. The chamber **16** has upper louvers or perforations **17** suitable for discharging heated air through the plurality of wickets and spaced sheet metal pieces to effect the desired drying thereof and the volatilization and entrainment of flammable vapors. The hot air stream with entrained vapors is collected in an upper longitudinal manifold or gas collection section **18** which has the lower face thereof provided with suitable louvers or perforations **19** for admitting the vapor containing stream.

A suitable opening or passageway **20** is provided from the top of the chamber **1** into the lower portion of the upper chamber **12** so as to provide for the flow of the solvent containing air stream into the interior of the combustion section. In the present embodiment, a pair of dampers **21** are shown transversely across the duct or passageway **20** to provide means for adjusting the air flow through said zone where it may be desired to balance flows within the unit. As best shown in FIGURE 3 of the drawings, manually operated positioning means **22** connect with the damper means **21** for adjusting the position of such dampers in the duct **20**. Within the lower portion of the upper chamber **12** is a transverse partitioning member **23** which serves to define a lower gas passageway **24** that extends to the end portion of chamber **12** and feeds into an interiorly positioned fan or blower **25**. The latter serves to insure the withdrawal of the fume laden air stream from the collection duct **18** in the heat treating chamber **10** and the discharge of such stream to a combustion section **26** maintained downstream within the chamber **12**. The actual outlet of fan chamber **25**, within the combustion section **26**, is at the zone of suitable heat supply means such as burners **27** to which a fuel and air are supplied by means of line **28** extending through wall **14** of the chamber **12**.

Fumes in the exhaust gas stream pass from the burner zone uniformly through catalyst units **29** which extend transversely across the combustion section **26** to effectively carry out the catalytic oxidation of all entrained burnable fumes in the discharge gas stream. The catalytic incinerating means **29** may be of the type disclosed in the patent to Suter et al No. 2,658,242, dated November 10, 1953, and covering metal wire or ribbon coated with amorphous platinum and/or palladium, or other noble metals such as osmium, ruthenium, rhodium. Catalytic units are generally formed from flat mats of coated crimped alloy metal ribbon, or from coated metal alloy screens, or from a combination of screens and ribbon cores. The platinum or palladium coating is usually electrodeposited on the ribbon and screens after suitable cleaning and preparation steps insuring a good bond of the plated coating. The finished elements are of such nature that upon heating the same to ignition temperature and supplying suitable mixtures of fuel and air thereto, catalytic oxidation will take place on the surface thereof resulting in the liberation of radiant heat energy. It is understood that any other suitable type of catalytic oxidation element may be employed in the incinerator means. Further detailed description of this incinerating means, however, is believed unnecessary herein, reference being made to the foregoing patent for this purpose.

A substantially horizontal transverse partitioning member **30** extends between side member **14** and **15** to separate the combustion section **26** from the heat exchange section **31** superimposed in the upper portion of chamber **12**. The plate member **30** stops short of the one end of chamber **12** in order to provide for a passageway **32** which receives resulting combustion products passing downstream from catalyst units **29** and to in turn permit their distribution through a plurality of heat exchange tubes **33**. The latter extend longitudinally in a heat exchanger bank through and between end tube sheets **34** and **35**. Thus, the exhaust gases may be passed from the gas passageway **32** through the plurality of tubes **33** to a downstream gas collecting section **36** which in turn communicates through opening **37** to a stack **38**. Generally, after catalytic combustion has been initiated in the catalyst elements **29**, the heat supplied from burners **27** will no longer be necessary, and the heat from the catalytic combustion will sustain the high temperature operation in the initial heat treating zone **10** of the oven **1**.

In order to recuperate heat from the combustion zone of the apparatus, a fresh air intake **39** is provided in the side wall **14** of the chamber **12** permitting air to pass in indirect heat exchange relationship with the hot gas tubes **33** and effect simultaneously the heating of the intake air stream and the cooling of the exhaust gas stream. As is best shown in FIGURES 3 and 4 of the drawings, a heated air discharge opening **40** is provided in the side wall **15** to connect with a heated air outlet duct **41** which in turn communicates with, and discharges into, a mixing chamber **42** through a set of adjustable dampers **43**. The hot air stream then passes through a fan chamber **44** and a transfer duct **45** to the plenum chamber **16**, which in turn effect the longitudinal spreading of the heated air stream and its upward distribution through louvers or perforation **17** to the wickets **7** carrying the coated sheets which are to be dried or heat treated.

In order to provide automatic control of the air temperature, a suitable tempering air inlet opening **46** is provided on the side of the mixing chamber **42** and a set of adjustable dampers **47** are provided therein to control air flow into the interior of the chamber. A recirculating fan or blower **44'** is housed within the chamber or duct work **44** and maintains circulation of the air stream to the plenum section. In FIGURE 6 of the drawings, there is shown diagrammatically an interconnecting linkage between the hot air dampers **43** and the tempering air dampers **47** whereby an automatically operating and throttling control means will effect the adjustment of the damper settings responsive to a temperature sensitive means **48** in the path of the hot air being introduced into the plenum chamber **16** of the heat treating oven. Specifically, there is indicated diagrammatically suitable linkage means **49** connecting with dampers **43** and additional linkage means **50** connecting with dampers **47**, both being connected to a movable arm **51** that in turn is connected to a power operated regulator **52**. The latter may be either electrically or pneumatically operated to effect the desired movement of the linkage means **49** and **50** to in turn effect the adjustment of the dampers. The temperature sensitive element **48** connects through line **53** to a throttling controller **54** that in turn actuates the regulator **52**. Air supply lines **55** and **56** indicate means for pneumatically controlling regulator **52** responsive to the controller **54** and the temperature indicator **48**.

The linkage means **49** and **50** is, of course, merely diagrammatic and may encompass gearing or other suitable mechanisms for connecting to and turning the respective sets of dampers **43** and **47**. In other words, it is not intended to limit the present invention to the use of any one type of linkage means or to any one type of power operating, regulator or controller for carrying out the adjustment of the dampers. It is, however, a feature of the present invention to provide interconnecting linkage between the dampers in order that one set opens in an opposing manner to the other. In other words, when dampers **43** are operated to reduce the quantity of hot air going to the heat treating oven, then the dampers **47** are adjusted to open slightly and introduce a regulated quantity of cooling or tempering air through opening **46**. Conversely when dampers **43** are opened to a maximum extent, then dampers **47** will be maintained substantially closed to preclude the intake of any cooling air into the hot air stream.

As previously set forth above, in providing a long drying oven having an elongated continuous conveyor system, one or more additional heating zones **11** may be incorporated throughout the length of the oven chamber **1**. In FIGURES 1 and 5, there are indicated diagrammatically means for reheating and recirculating a portion of the hot air stream being maintained throughout the longitudinal length of the oven. Hot air is circulated from fan **57** into duct **58** and plenum chamber **59**, which in turn has upper louvers or openings **60** to distribute hot air transversely across the multiplicity of wickets and retained coated sheets. The used and cooled air stream is collected in a manifold duct **61** which extends longitudinally along an upper portion of the chamber **1** and in turn channels the air stream through a passageway **62** into a transverse passageway **63** in a superimposed heating chamber **64**. The end of the chamber is provided with a heat supply burner **65** which adds supplemental heat to the recirculating air stream within chamber **64** permitting reheated air to be discharged through an opening **67** into the fan chamber **57** and thence to the recirculation duct **58**. A suitable vertically positioned partitioning member **66** extends longitudinally within the superimposed chamber **64** to provide the passageway **63**, which in turn channels the recirculated air stream to the burner end of the chamber **64** whereby hot combustion gases may intermingle with the air stream recirculated to the plenum section **59**. Where combustion gases are deemed undesirable to add to the hot air recirculating zones, then electrical heater or indirect heating means may be provided in lieu of burners **65** for adding heat to the air stream being recirculated to the one or more plenum sections **59**.

It will be obvious that various changes or modifications may be made in the design or configuration of the passageways or treating zones within the scope of the present invention without departing from the scope or spirit thereof. Also, it may be noted that the conveyor **6** and wickets **7** will absorb a significant portion of the heat input to the heat oven and the lower flight of the conveyor in the present embodiment passes through a relatively cool zone, so that, if desired, in a modified embodiment, it may be found advantageous to channel a portion of the hot air stream passing to the initial heating zone, or a recirculated air stream, to a preheating section which will serve to preheat the wickets prior to their entry into the upper heat treating section **10** at the inlet end of the oven chamber **1**.

I claim as my invention:

1. A coating oven for heat treating articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising in combination:

(a) an elongated heat treating chamber,

(b) means for conveying articles to be heat treated through said chamber from an entrance end to an exit end,

(c) a first heat treating section in said chamber adjacent the article entrance end thereof,

(d) at least one additional heat treating section in said chamber,

(e) a plenum section in said first heat treating section for directing heated gases over the articles passing therethrough,

(f) a vapor exhaust duct from said first heating section,

(g) a circulating fan in said exhaust duct,

(h) a vapor combustion section connection to and extending downstream of said circulating fan,

(i) heat supplying means in said combustion section,

(j) catalytic vapor incinerator means disposed across said combustion section downstream of said heat supplying means,

(k) a heat exchange section connecting with said combustion section, said heat exchange section having passageway means therein to receive and discharge oxidized exhaust gases from said combustion section,

(l) a fresh air inlet means connected to an additional passageway means in said heat exchange section to receive and to pass fresh air in indirect heat exchange relationship with the oxidized exhaust gases and a heated air outlet means connected to said heat exchanger to receive heated fresh air,

(m) a double ended heated air duct connected to said heated air outlet means at one end of said heated air duct and connected directly to said plenum section at the other end of said heated air duct thereby to pass only fresh heated air to said plenum section,

(n) regulatable damper control means across at least a portion of said heated air duct from said heat exchange section,

(o) a recirculating fan in said heated air duct,

(p) an adjustable cool air inlet means to said heated air duct upstream of said recirculating fan therein for introducing tempering air thereto,

(q) an exhaust gas outlet stack connecting to and extending from the downstream end of said heat exchange passageway means, and

(r) means for recirculating drying gases through said additional heat treating section of said chamber to continue the drying of the coated articles passing therethrough.

2. The coating oven of claim **1** further characterized in that interconnecting linkage means connects between said damper control means in said heated air duct and the adjustable air inlet means to said heated air duct for tempering air, a temperature sensitive means is positioned in said heated air duct downstream of said recirculating fan, with said temperature sensitive means connecting to power operated control means which in turn connects with said interconnecting linkage means, whereby said regulatable damper means and said adjustable air inlet means may be opened and closed responsive to changes in temperature noted by said temperature sensitive means.

3. A coating oven for heat treating articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising in combination:

(a) an elongated heat treating chamber,

(b) means for conveying articles to be heat treated through said chamber from an entrance end to an exit end,

(c) a plenum section within said chamber and having openings in a wall thereof for directing heated gases over the articles passing through the chamber,

(d) a vapor combustion chamber having heat supply means and a catalytic vapor incinerator disposed therein,

(e) a vapor exhaust duct connecting said treating chamber with said combustion chamber,

(f) a circulating fan in said exhaust duct,

(g) a heat exchanger connected to said combustion chamber,

(h) means for passing air through said heat exchanger in indirect heat exchange relationship with hot gases from said combustion chamber,

(i) a double ended heated air duct connected to said heated air outlet means at one end of said heated air duct and connected directly to said plenum section at the other end of said heated air duct thereby to pass only fresh heated air to said plenum section,

(j) damper control means and a recirculating fan in said heated air duct, and

(k) adjustable cool air inlet means to said heated air duct between said damper control means and said recirculating fan for introducing tempering air to the heated air duct.

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