Aug. 23, 1960 R. J. RUFF 2,950,098

COATING OVEN

Filed April 22, 1958 5 Sheets-Sheet 1

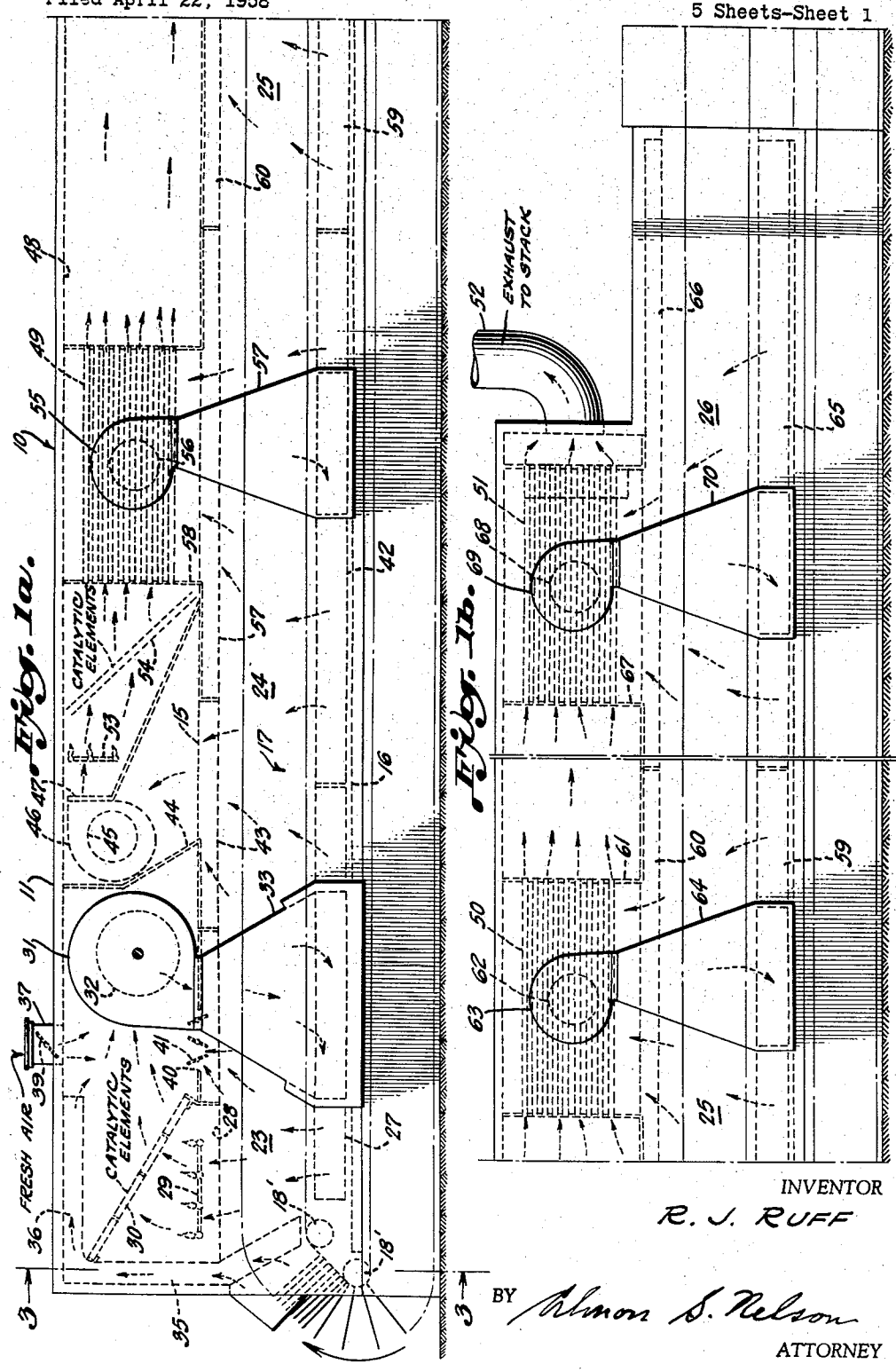


Fig. 1a.

Fig. 1b.

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COATING OVEN

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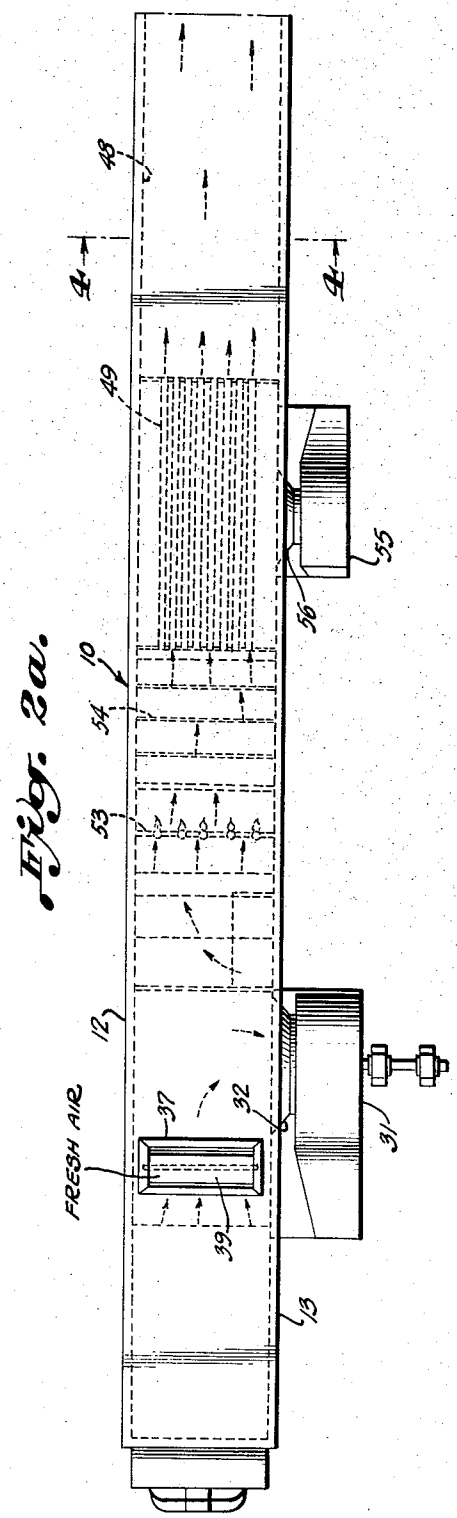


Fig. 2a.

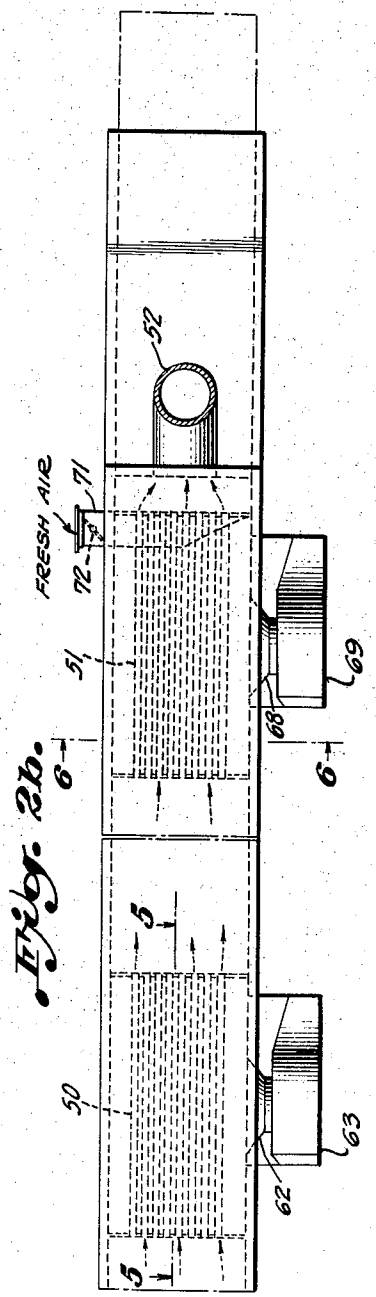


Fig. 2b.

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COATING OVEN

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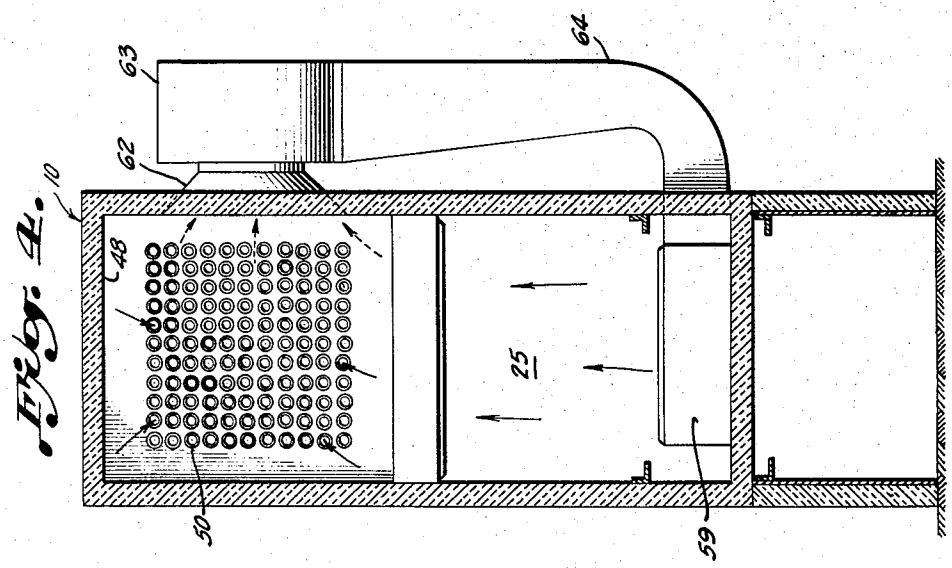


Fig. 4.

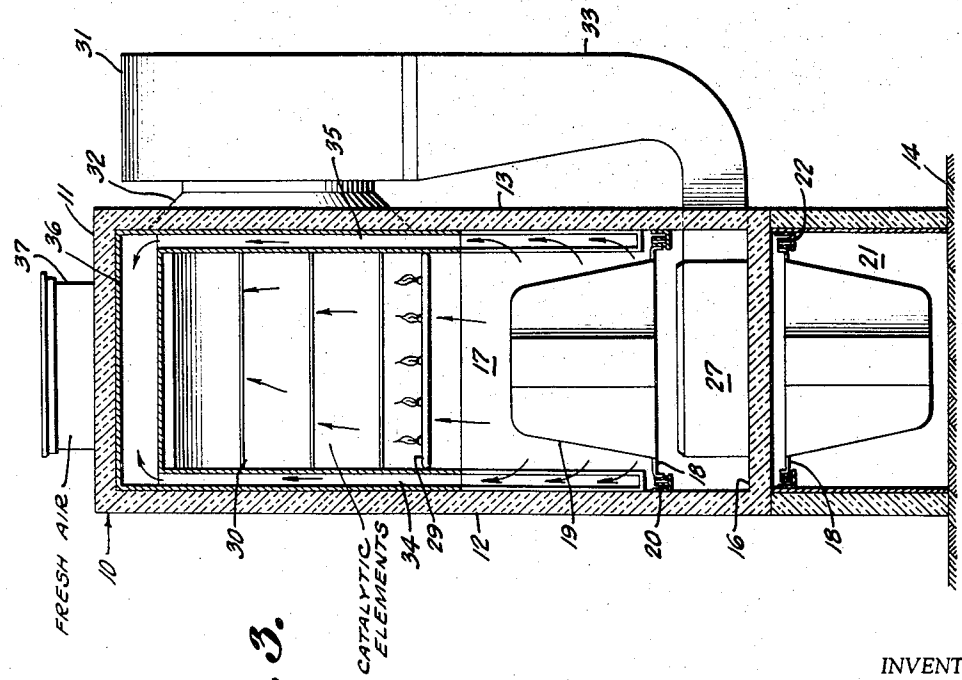


Fig. 3.

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COATING OVEN

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Fig. 6.

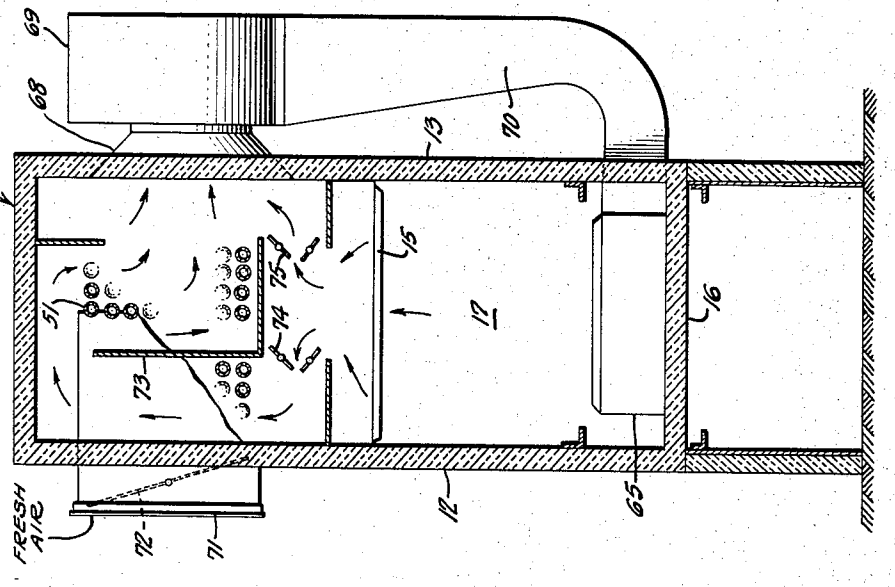
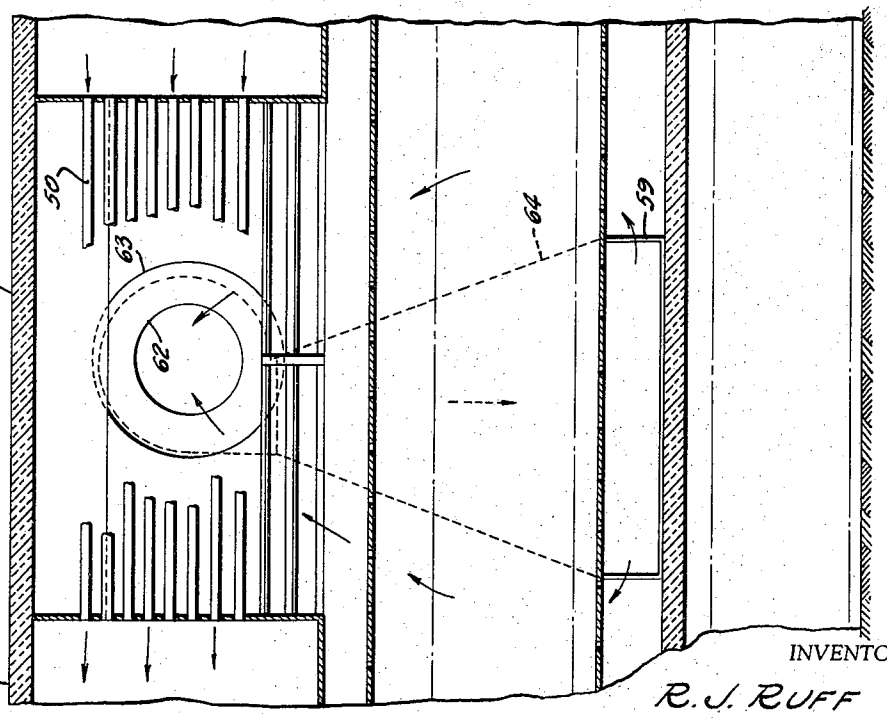


Fig. 5.



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COATING OVEN

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Fig. 9.

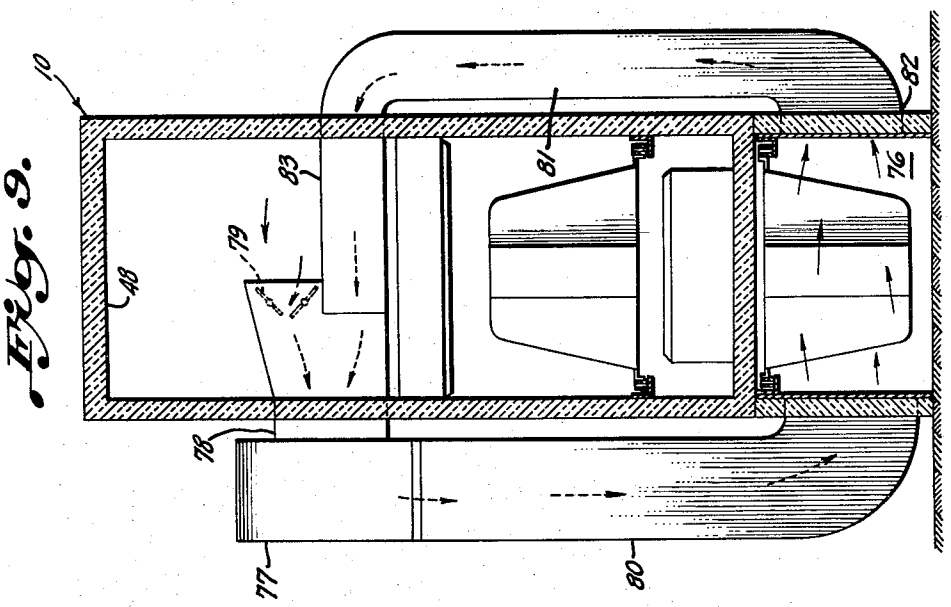


Fig. 7.

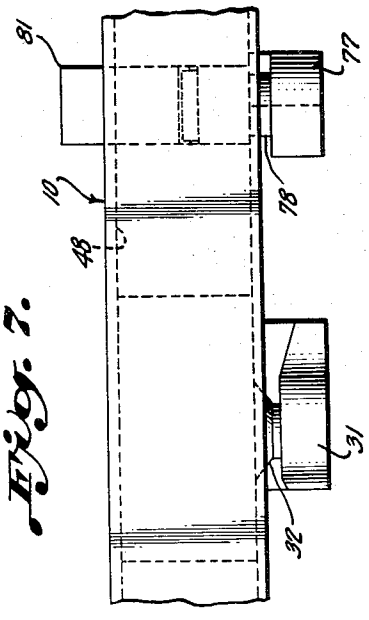
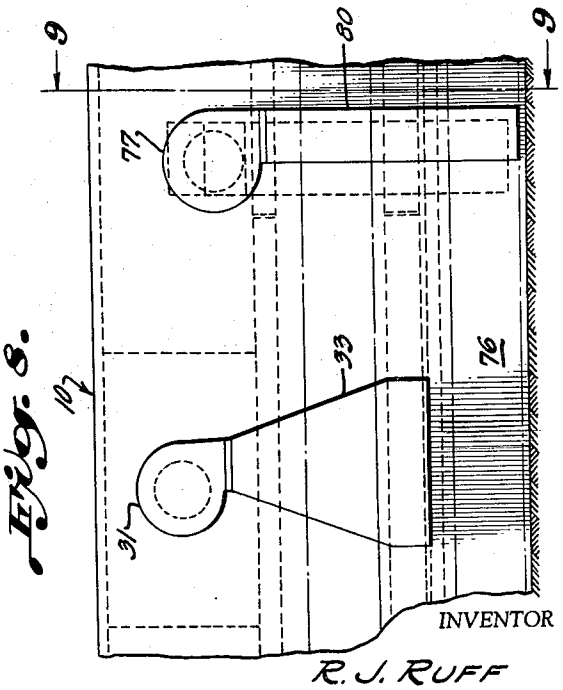


Fig. 8.



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United States Patent Office

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COATING OVEN

Richard J. Ruff, Detroit, Mich., assignor to Catalytic Combustion Corporation, Detroit, Mich., a corporation of Michigan

Filed Apr. 22, 1958, Ser. No. 730,176

11 Claims. (Cl. 263—8)

This invention relates to the heat treatment of coated articles or materials and more particularly to an apparatus for heat treating such coated articles or materials to evaporate the solvents or other volatile components in the coatings to dry and bake such coatings on the articles or materials to which they are applied.

The apparatus of this invention may be utilized to heat treat many different types of coatings on many different articles or materials, but is primarily intended to heat treat the printing or other coatings applied to sheet metal materials for decorative or protective purposes and accordingly the invention will be described in connection with the printing or coating of such sheet metal materials or articles, but it is to be understood that this is for illustrative purposes only and that the apparatus is in no way limited to such use.

In the manufacture of containers, such as coffee cans, beer cans, containers for frozen fruit juices, oil cans and other similar containers, decoration is coated and printed on sheet metal plates prior to forming the same into such containers. In some instances, it is necessary to apply a background coating which is baked prior to application of other decorative coatings, some of which may be in varying colors. Certain types of containers, such as beer cans and sardine cans, have a protective lacquer coating applied to the inside of the container and this is also normally applied to the sheet material prior to formation of the container.

This invention is primarily concerned with an oven for heat treating the coated metal sheet prior to forming the same into containers.

This art has progressed from ovens which would operate at sheet speeds of approximately sixty per minute with a maximum sheet size of approximately twenty-nine by thirty-six inches and in which only approximately ten to fifteen gallons per hour of solvents were liberated or vaporized whereas present day ovens are capable of operating at speeds of one hundred to one hundred fifty sheets per minute of an approximate size of thirty-four by forty-four inches and where the amount of solvent evaporated during the baking process may be as much as fifty to one hundred twenty gallons per hour. Obviously, this high speed operation places an appreciable load on the oven insofar as heat requirements are concerned and also since the fumes created during operation of an oven of this type are odorous and noxious in character, as well as inflammable, it can well be recognized that the problems in heat treating articles or materials of the type under consideration in order to eliminate prior hazards and also to render the fumes or vapors suitable for discharge to the atmosphere are very considerable. Furthermore, the loads imposed on an oven of this type will vary considerably depending upon the specific type of coating being applied, as well as the speed of operation and consequently ovens which are designed for maximum capacity may very well operate at an extremely low efficiency when running at less than maximum capacity. This factor is of a particular importance in connection with

the supply of fresh air provided to 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 the vaporized solvents which would result in creating a fire hazard and also requiring frequent cleaning of the oven and associated equipment. Fire insurance underwriters specify certain standards for ventilation of ovens of this type in order to eliminate fire hazards and normally it has been required that maximum ventilation specified be utilized regardless of the load to which the oven is subjected at a particular time. This, of course, resulted in further reducing the efficiency of the oven, since when operating at reduced load, the excess fresh air supply would result in materially increasing the heat input requirements thereby materially increasing the cost of operation.

Attempts have been made to overcome this difficulty by utilizing an explosimeter which operates to vary the supply of fresh air in accordance with the solvent load on the oven and while such systems have been utilized with the tacit approval of the insurance underwriters, nevertheless, it is considered that the practice is somewhat dangerous in that, there is an appreciable time lag in operation of the system and it may be entirely possible that upon the imposition of a sudden full solvent load on the oven, that the system will not sense the change in time to increase the supply of fresh air sufficiently to maintain conditions in which no fire hazard is present.

Furthermore, with prior ovens of the type under consideration there has always been the problem of infiltration air at the entrance end of the oven and heretofore this air has been allowed to mix indiscriminately with the vaporized solvent in the first portion of the oven which resulted in materially increasing the heat input requirements and also this infiltration air was introduced in such a way that it could not be considered as part of the fresh air utilized to ventilate the system and dilute the vapors to a point where fire hazard ceased to exist. Accordingly, an oven of the type under consideration which is designed to treat the vaporized solvents in such a manner that the oven may be exhausted to the atmosphere without undue polution of the same and also an oven in which the infiltrated fresh air at the entrance end of the oven may be utilized as part of the ventilating or diluting air and without materially increasing the input requirements of the oven represents a very material step forward in the art. It will, therefore, be seen that it is extremely desirable to provide a heat treating apparatus of the character under consideration which will eliminate all discharge of vapor or fume laden air and furthermore, since the fumes or vapors from the solvents of the coatings may be oxidized through catalytic action, the heat available from such oxidation can be utilized and will normally be adequate to supply the total heat requirement of the oven and the apparatus of the instant invention is designed to accomplish this result.

It is accordingly an object of the invention to provide a coating oven for heat treating coated articles or materials to evaporate coating solvents and in which one or more catalytic vapor incinerators may be utilized to oxidize the combustibles in the vaporized solvents to thereby remove noxious fumes and at the same time, provide all or part of the heat necessary to operate the oven.

A further object of the invention is the provision of a coating oven for heat treating coated articles or materials to evaporate coating solvents and remove combustibles therefrom in which the coated articles or materials are conveyed through an elongated heat treating chamber having a plurality of treating zones in which the coatings are progressively treated and the vaporized solvents utilized to supply heat for operating the oven and in

which all noxious fumes are removed from the vaporized solvents to permit exhaust to the atmosphere.

A still further object of the invention is the provision of a coating oven for heat treated coated articles or materials to evaporate coating solvents and remove combustibles from the vaporized solvents and including an elongated heat treating chamber having a plurality of heat treating zones, the vaporized solvents from the first zone being directed through a heating burner and a catalytic vapor incinerator and including means for permitting a portion of the vaporized solvents to by-pass the burners and incinerator.

Another object of the invention is the provision of a coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents including an elongated heat treating chamber having a plurality of heat treating zones with the vaporized solvents in the first zone being directed through heating burners and a catalytic vapor incinerator and including means for by-passing infiltration fresh air at the entrance end of the first zone by the burners and incinerator to prevent dilution of the vaporized solvents prior to treatment by the incinerator.

A further object of the invention is the provision of a coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents including an elongated heat treating oven having a plurality of heat treating zones, the vaporized solvents from the first and second zones being treated by catalytic vapor incinerators with the exhaust from the incinerator for the second zone being directed through a plurality of heat exchangers to provide heat for treating articles in the zones following the second zone, as well as in the second zone.

A still further object of the invention is the provision of a coating oven for heat treating coated articles to evaporate coated solvents and remove combustibles from the vaporized solvents including an elongated heat treating chamber having a plurality of heat treating zones and in which catalytic vapor incinerators are utilized to remove the combustibles from the vaporized solvents, the exhaust from one incinerator being directed through a plurality of heat exchangers and re-circulating fans for certain of the zones connected to the heat exchangers for circulating heated air through the zones and exchangers, together with means for controlling proportionately the air passing through the exchanger and being by-passed direct to the fan inlet.

Another object of the invention is the provision of a coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents including an elongated heat treating chamber having a plurality of heat treating zones and in which means is provided for introducing fresh air to the first zone and also for introducing fresh air to the last zone.

A further object of the invention is the provision of a coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, including an elongated heat treating chamber and an endless conveyor to convey articles or materials through the chamber, together with means for pre-heating the conveyor prior to the feeding of articles thereto and introduction of such articles into the treating chamber, the heat for pre-heating such conveyor being obtained from one of the heat treating zones in the heat treating chamber.

Further objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawings wherein:

Fig. 1*a* is a side elevational view of a coating oven constructed in accordance with this invention;

Fig. 1*b* a side elevational view constituting a continuation of Fig. 1*a* and showing the remainder of the heat treating oven for coated articles constructed in accordance with this invention;

Fig. 2*a* a top plan view of the portion of the coating oven shown in Fig. 1*a*;

Fig. 2*b* a top plan view constituting a continuation of Fig. 2*a* and showing the portion of the coating oven shown in Fig. 1*b*;

Fig. 3 a sectional view taken substantially on the line 3—3 of Fig. 1*a* and showing the arrangement of the infiltration air by-pass ducts at the entrance to the heat treating chamber and the first heat treating zone;

Fig. 4 a sectional view taken substantially on the line 4—4 of Fig. 2*a* and showing the arrangement of one of the heat exchangers, circulating fan and associated heat treating zone;

Fig. 5 a fragmentary sectional view taken substantially on the line 5—5 of Fig. 2*b* and showing the structure of one of the heat exchangers, as well as the relationship of the air passages and the inlet to the circulating fan for the associated heat treating chamber;

Fig. 6 a sectional view taken substantially on the line 6—6 of Fig. 2*b* and showing a damper arrangement for controlling the flow of air over the surfaces of the heat exchanger, as well as for by-passing air directly to the inlet of the circulating fan and also showing the fresh air inlet for the last treating zone of the apparatus;

Fig. 7 a top plan view showing the manner in which a conveyor pre-heater, as well as the heat supply for such pre-heater may be incorporated in the coating oven of this invention;

Fig. 8 a fragmentary side elevational view of the apparatus shown in Fig. 7 and showing the arrangement of the conveyor pre-heating system; and

Fig. 9 a sectional view taken substantially on the line 9—9 of Fig. 8 and showing the conveyor pre-heating chamber, as well as the manner of supplying heated air thereto and returning air from the pre-heating chamber to be re-heated and re-circulated.

With continued reference to the drawing, there is shown a coating oven constructed in accordance with this invention and which may well comprise an elongated housing 10 composed of a top wall 11, sidewalls 12 and 13 and a bottom wall provided by a supporting surface 14, such as the floor of a building or other surface. Of course, if desired, a separate bottom wall may be provided and form an integral part of the housing 10. Also provided in the housing 10 is a longitudinally extending partition 15 and a second longitudinally extending partition 16 disposed below the partition 15 and providing an elongated heat treating chamber 17. An endless conveyor 18 having wickets 19 or other suitable means thereon for receiving and supporting sheets or articles to be treated is mounted to pass through the chamber 17 on suitable trackways or the like 20 and the lower flight of the conveyor 18 passes through a chamber 21 below the partition 16 and may be supported on suitable trackways or the like 22. The conveyor 18 may be mounted adjacent the ends of the heat treating chamber 17 on pulleys or other suitable means 18'.

The heat treating chamber 17 may be divided into a first heat treating zone 23, a second heat treating zone 24, subsequent heat treating zones 25 and a last heat treating zone 26. Only one subsequent heat treating zone 25 is shown in the drawing for the purpose of simplicity, but it is to be understood, that any number of such zones which are considered necessary may be incorporated between the second heat treating zone 24 and the last heat treating zone 26. Since the structure of any additional subsequent heat treating zones will be identical with the zone 25 it is considered that a description of the structure of zone 25 is all that is necessary to provide an accurate understanding of the structure and operation of the invention.

A plenum chamber 27 may be disposed below the con-

veyor 18 in the first zone 23 in order to direct heated gases through the articles or materials carried by the conveyor 18 and a vapor exhaust duct 28 may be provided above the first zone 23 for conducting vaporized solvents therefrom. Disposed in the exhaust duct 28 are heating burners 29 to which gas or other fuel may be supplied and also disposed in the exhaust duct following the burners 29 is a catalytic vapor incinerator 30. The catalytic vapor or fume incinerator 30 may be of the type disclosed in patent to Suter et al., No. 2,658,742, dated November 10, 1953, or may be of any other suitable type and no detailed description of this incinerator is believed necessary or desirable, reference being made to the above patent for this purpose. Since the incinerator 30 is located directly in the flow of vapor or fume laden air from the burners 29 there is no dilution thereof prior to contact with the catalyst and consequently, such catalyst may operate at peak efficiency. A circulating fan 31 is provided with an inlet 32 connected to the duct 28 following the incinerator 30 and the outlet 33 of the circulating fan 31 is connected to the plenum chamber 27. It will thus be seen, that gases heated by the burners 29 and by the catalytic incinerator 30 will pass to the inlet 32 of the fan 31 and thereafter be re-circulated through the plenum chamber 27 and the first heat treating zone 23.

Since a certain amount of fresh air will infiltrate into the first heat treating zone 23 through the entrance end thereof because the same cannot be sealed, it is desirable to prevent direct mixing of such infiltrated air with the vapor laden fumes in the first treating zone 23, because dilution of such air prior to passing through the catalytic incinerator 30 is undesirable. Consequently, infiltration air conduits 34 and 35 are provided on each side of the entrance end of the heat treating zone 23 and such conduits connect with a common conduit 36 which by-passes the burners 29 and catalytic incinerator 30 and discharges directly into the duct 28 between the incinerator 30 and the inlet 32 of the fan 31. Consequently, infiltrated air will be collected in the by-pass ducts 34 and 35 and will be discharged through the inlet of the fan 31 and mixed with the air flowing from the incinerator 30 to be re-circulated through the plenum chamber 27 and first treating zone 23.

When first starting the coating oven of this invention, the fume or vapor laden air passing from the first treating zone 23 will be heated by the burners 29 to a sufficient temperature to activate the catalytic incinerator 30, but thereafter, depending upon the quanttiy of solvents present in the air flowing thereto, the incinerator 30 will provide all of the heat necessary to treat the articles passing through the first treating zone 23 and consequently, the flow of fuel to the burners 29 may be reduced by suitable control means thereby reducing the cost of operation of the apparatus.

Since it is sometimes desirable to introduce additional fresh air to the first treating zone 23, for this purpose there may be provided a fresh air inlet 37 communicating with the duct 28 between the incinerator 30 and the inlet 32 of the fan 31 and a suitable damper 39 may be provided for controlling the flow of fresh air through the inlet 37.

Since it is also sometimes desirable to by-pass a portion of the fume or solvent laden air by the burners 29 and incinerator 30, there may be provided a vapor passage 40 between the first treating zone 23 and the duct 28 between the incinerator 30 and the inlet 32 of the fan 31 and this passage 40 may be controlled by suitable dampers o rother means 41 which may be automatically or manually controlled in order to vary the flow through the passage 40.

A second plenium chamber 42 may be disposed below the conveyor in the second zone 24 for directing heated gases over articles carried by the conveyor through zone 24 and a vapor collecting hood or other suitable means 43 may be disposed above the second zone 24 and a portion of the first zone 23. A vapor exhaust duct 44 is connected to the hood 43 and to the inlet 45 of a blower 46 with the outlet 47 of the blower 46 being connected to a conduit 48 disposed above the heat treating chamber 17 and in which may be located a series of heat exchangers 49, 50 and 51. It is to be noted, that heat exchanger 49 is located adjacent the second heat treating zone 24, heat exchanger 50 adjacent the subsequent heat treating zone 25 and heat exchanger 51 adjacent the last heat treating zone 26. The heated gases after passing through the last heat exchanger 51 are discharged to the atmosphere through a suitable stack or other means 52.

Disposed in the conduit 48 between the blower 46 and the first heat exchanger 49 is a heating burner 53 and disposed in the conduit 48 between the burner 53 and the first heat exchanger 49 is a second catalytic vapor or fume incinerator 54. Consequently it will be seen that gases passing from the second heat treating zone 24 and also from the first heat treating zone 23 will be drawn into the hood 43 and through the exhaust duct 44 into the inlet 45 of the blower 46 and thereafter through the heating burners 53 and incinerator 54 to be forced through the heat exchangers 49, 50 and 51 to the stack 52.

The gases passing from the second incinerator 54 through the heat exchangers 49, 50 and 51 will supply heat for treating the articles in the second zone 24, as well as the subsequent zone 25 and last zone 26 and for this purpose there may be provided a circulating fan 55 having an inlet 56 connected to the heat exchanger 49 and an outlet 57 connected to the second plenum chamber 42. A second hood 57 may be disposed above the second treating zone 24 and gases passing from such zone will be collected by the hood 57 which communicates through an opening 58 with the heat exchanger 49 and consequently, such gases will pass through the heat exchanger 49 and through the inlet 56 into the fan 55 to be re-circulated through the plenum chamber 42 and the second heat treating zone 24.

In a similar manner, a plenum chamber 59 may be disposed below the subsequent heat treating zone 25 and a hood 60 may be disposed above such zone and communicate through an opening 61 with the heat exchanger 50 which in turn is connected through an inlet 62 with a circulating fan 63, the outlet 64 of which is connected to the plenum chamber 59. Consequently operation of the fan 63 will result in circulating air heated by the heat exchanger 50 through the plenum chamber 59 and the subsequent heat treating zone 25.

A last plenum chamber 65 may be disposed below the last heat treating zone 26 and a hood 66 may be provided above the heat treating zone 26 and communicate through an opening 67 with the last heat exchanger 51 which in turn is connected to the inlet 68 of a circulating fan 69, the outlet 70 of which is connected to the plenum chamber 65. Consequently, operation of the fan 69 will serve to circulate air heated by the last heat exchanger 51 through the plenum chamber 65 and the last heat treating zone 26.

Since it is desirable to provide fresh air for the last heat treating zone 26, there may be provided a fresh air inlet 71 connected to the last heat exchanger 51 and a suitable damper or other control means 72 may be provided in the fresh air inlet 71 to control the amount of air introduced therethrough to the last heat exchanger 51 and the treating zone 26.

It will thus be seen that the heat necessary for treating the articles and materials in the first and second zones 23 and 24 may be provided in the first instance, by the burners 29 and 53 and thereafter by the catalytic incinerators 30 and 54 and also that the entire heat requirements of the subsequent zones 25 and last zone 26, as well as the requirements of the second zone 24 may be provided by the incinerator 54 in conjunction with the

heat exchangers 49, 50 and 51. Also the fresh air introduced into the heat treating chamber 17 through the fresh air inlet 71 may be controlled as desired, as well as any fresh air which may be introduced through the inlet 37 and, furthermore, infiltrating fresh air from the entrance end of the treating chamber 17 will not operate to dilute the vapors or fumes passing through the first catalytic incinerator 30, but will be introduced into the airflow thereafter and such infiltrated air may, consequently, be considered as a part of the fresh air introduced into the system to maintain solvent concentration at such a point that no fire hazard exists. Furthermore, the infiltrated air at the entrance end of the oven does not operate to cool the vapor or fume laden air and consequently, condensation is reduced to a minimum with the result that fire hazard is reduced and also the necessity for frequent cleaning of the apparatus.

The heat exchangers 49, 50 and 51 for convenience are shown as conventional tubular heat exchangers, but it is to be understood that this is for illustrative purposes only and that any suitable type of heat exchanger may be employed and that the principle of operation will be the same in any case.

Since it is frequently desirable to control the temperature in individual treating zones, there may be provided means for such control which is particularly shown in Fig. 6 and, of course, such means may be incorporated in any or all of the heat treating zones. As shown in Fig. 6, there may be provided a suitable baffle 73 for dividing the flow of gas from the treating chamber 17 with the flow in one direction passing through the associated heat exchanger and with flow in the opposite direction passing directly to the inlet 68 of the circulating fan 69. In order to control the flow of gas through the heat exchanger 51 or directly to the inlet 68 of the fan 69, there may be provided a system of dampers 74 and 75 which may be manually actuated or actuated by a proportionate controller in order to direct the gas flowing from the treating chamber 17, either to the heat exchanger 51 or to the inlet 68 of the fan 69 or the dampers 74 and 75 may be so controlled that part of the gas will pass through the heat exchanger 51 and part directly to the inlet 68 of the fan 69. In this manner, the temperature in each of the treating zones may be conveniently controlled.

Since the conveyor 18 absorbs a significant portion of the heat input to the oven of this invention and since the lower flight of such conveyor passes through a relatively cool atmosphere, it may well be found desirable to preheat such conveyor in order to minimize cooling of the articles or materials deposited on the conveyor and also to maintain the efficiency of the oven at a higher point. With particular reference to Figs. 7, 8 and 9, there is shown a structure for pre-heating the conveyor 18 and which may well comprise a pre-heating chamber 76 disposed below the heat treating chamber 17 and through which the lower flight of the conveyor 18 passes. A circulating fan 77 may have an inlet 78 connected to the conduit 48 between the second incinerator 54 and the first heat exchanger 49 and the inlet 78 may if desired, be controlled by suitable dampers or other means 79. The outlet 80 of the fan 77 is connected to the pre-heating chamber 76 and will supply heated air thereto to properly pre-heat the conveyor 18. In order that the air supplied to the pre-heating chamber 76 may be re-circulated a return duct 81 may be connected at 82 to the pre-heating chamber 76 and an outlet 83 of the return duct 81 may be connected to the inlet 78 of the circulating fan 77. Thus with the dampers 79 closed the air is recirculated or the dampers 79 may be adjusted to mix air, from the conduit 48 with the recirculated air.

It will thus be seen that by the above described invention there has been provided an oven for suitably heat treating coated articles to evaporate coating solvents and remove combustibles therefrom and in which catalytic vapor or fume incinerators are utilized to remove such combustibles and also at the same time, to provide heat for operating the oven. Furthermore, the infiltration of fresh air at the entrance end of the oven is diverted and directed in such a manner, that the same will not operate to cause undue condensation or dilution of vapor or fume laden air with the result that the oven operates at a higher efficiency than would be the case if the infiltrated air mixed directly with the vapor or fume laden air in the treating chamber and also adequate control is provided to control the temperature throughout the treating process and also to pre-heat the conveyor utilized to convey articles or materials through the treating chamber in order to maintain such efficiency at a maximum.

It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is shown in the drawings and described in the specification, but only as indicated in the appended claims.

What is claimed is:

1. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from tht vaporized solvents, said oven comprising an elongated heat treating chamber, having an entrance at one end and an exit at the other, an endless conveyor for conveying coated articles to be heated through said chamber from the entrance end to the exit end, a conveyor preheating chamber below said heat treating chamber, means for supplying heat to said pre-htating chamber, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber disposed below said conveyor in said first zone for directing heated gases over coated articles carried by said conveyor, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a damper controlled fresh air inlet connected to said duct between said incinerator and said fan inlet, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber disposed below said conveyor in said second zone for directing heated gases over the coated articles carried by said conveyor, a vapor collecting hood disposed over said second zone and a portion of said first zone, a second open vapor txhaust duct connected to said hood, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to said series of heat exchangers adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a second hood disposed above said second zone and connected to the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers disposed in subsequent zones and a last plenum chamber disposed below said conveyor in said last zone, subsequent hoods disposed above said subsequent zones and a last hood disposed above said last zone, said subsequent and last hoods being connected to the heat-exchangers adjacent

said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones, a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone and damper controlled means associated with said second hood, said subsequent hoods and said last hood for proportionately directing air flow from the associated hood through the associated heat exchanger and directly to the inlet of the associated circulating fan.

2. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber, having an entrance at one end and an exit at the other, an endless conveyor for conveying coated articles to be heat treated through chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber disposed below said conveyor in said first zone for directing heated gases over coated articles carried by said conveyor, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a damper controlled fresh air inlet connected to said duct between said incinerator and said fan inlet, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber disposed below said conveyor in said second zone for directing heated gases over coated articles carried by said conveyor, a vapor collecting hood disposed above said second zone and a portion of said first zone, a second open vapor exhaust duct connected to said hood, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to said series of heat exchangers adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a second hood disposed above said second zone and connected to the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers disposed below said conveyor in said subsequent zones and a last plenum chamber disposed below said conveyor in said last zone, subsequent hoods disposed above said subsequent zones and a last hood disposed above said last zone, said subsequent and last hoods being connected to the heat exchangers adjacent said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlet connected to the plenum chambers in said subsequent and last zones, a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone and damper control means associated with said second hood, said subsequent hoods and said last hood for proportionately directing air flow from the associated hood through the associated heat exchanger and directly to the inlet of the associated circulating fan.

3. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, an endless conveyor for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber disposed below said conveyor in said first zone for directing heated gases over coated articles carried by said conveyor, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a damper controlled fresh air inlet connected to said duct between said incinerator and said fan inlet, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber disposed below said conveyor in said second zone for directing heated gases over coated articles as carried by said conveyor, a second open vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to said series of said heat exchangers adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a second hood disposed above said second zone and connected to the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers disposed below said conveyor in said subsequent zones and a last plenum chamber disposed below said conveyor in said last zone, subsequent hoods disposed above said subsequent zones and a last hood disposed above said last zone, said subsequent and last hoods being connected with the heat exchangers adjacent said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlets connected to the plenum chambers connected to said subsequent and last zones, a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone and damper control means associated with said second exhaust duct, said subsequent hoods and said last hood for proportionately directing air flow from the associated hood through the associated heat exchanger and directly to the inlet of the associated circulating fan.

4. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, an endless conveyor for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zones with a last

zone adjacent said exit ends, a plenum chamber disposed below said conveyor in said first zone for directing heated gases over coated articles carried by said conveyor, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a damper controlled fresh air inlet connected to said duct between said incinerator and said fan inlet connected to said duct between said incinerator and said fan inlet, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber disposed below said conveyor in said second zone by directing heated gases over coated articles carried by said conveyor, a second open vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to said series of heat exchangers adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a third duct connecting said second zone and the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers disposed below said conveyor in said subsequent zone and a last plenum chamber disposed below said conveyor in said last zone, said subsequent and last zones being connected through subsequent and last ducts to the heat exchangers adjacent said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the inlets adjacent said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones, a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone and damper control means associated with said second exhaust duct, said third duct and said subsequent and last ducts for proportionately directing air flow from the associated heat exchanger and directly to the inlet of the associated circulating fan.

5. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, an endless conveyor for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber disposed below said conveyor in said first zone for directing heated gases over coated articles carried by said conveyor, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a damper controlled fresh air inlet connected to said duct between said incinerator and said fan inlet, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber disposed below said conveyor in said second zone for directing heated gases over coated articles carried by said conveyor, a second open exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to a said series of heat exchangers adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a third duct connecting said second zone and the first heat exchanger, a second circulating fan having an inlet connected to said second plenum chamber, subsequent plenum chambers disposed below said conveyor in said subsequent zones and said last plenum chamber disposed below said conveyor in said last zone, said subsequent and last zones being connected through subsequent and last ducts to the heat exchangers adjacent said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones and a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone.

6. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, means for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber disposed below said first zone for directing heated gases over coated articles, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough for said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and said fan inlet, a damper controlled fresh air inlet connected to said duct between said incinerator and said fan inlet, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber disposed below said conveyor in said second zone for directing heated gases over coated articles, a second open vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to said series of heat exchanges adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and said first heat exchanger, a third duct connecting said second zone and the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and

an outlet connected to said second plenum chamber, subsequent plenum chambers disposed below said subsequent zones and a last plenum chamber disposed below said last zone, said subsequent and last zones being connected through subsequent and last ducts to the heat exchangers adjacent said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones and a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone.

7. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, means for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with said last zone adjacent said exit end, a plenum chamber communicating with said first zone for directing heated gases over coated articles, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a damper controlled fresh air inlet connected to said duct between said incinerator and said fan inlet, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber communicating with said second zone for directing heated gases over coated articles, a second open vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connecting with said second exhaust duct and an outlet connected to said series of heat exchangers adjacent said second zone, said second zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a third duct connecting said second zone and the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers communicating with said subsequent zones, and a last plenum chamber communicating with said last zone, said subsequent and last zones being connected to subsequent and last ducts to the heat exchangers adjacent said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones and a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone.

8. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, means for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber communicating with said first zone for directing heated gases over coated articles, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said ducts for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a damper controlled vapor passage connecting said first zone and said duct between said incinerator and said fan inlet, a second plenum chamber communicating with said second zone for directing heated gases over coated articles, a second open vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to said series of heat exchangers adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a third duct connecting said second zone and said first heat exchanger, a second circulating fan having an inlet connected to said first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers communicating with said subsequent zones and a last plenum chamber communicating with said last zone, said subsequent and last zones being connected through subsequent and last ducts to the heat exchangers adjacent to said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlet connected to the plenum chambers in said subsequent and last zones and a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone.

9. A coating oven for heat treating coated articles to evaporate coating solvent and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, means for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber communicating with said first zone for directing heated gases over coated articles, an open vapor exhaust duct in said first zone spaced inwardly of said entrance end, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following the burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, and an infiltration air by-pass conduit having an inlet opening adjacent the entrance end of said heat treating chamber and a discharge opening into said duct between said incinerator and the inlet to said fan, a second plenum chamber communicating with said second zone for directing heated gases over coated articles, a second open vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet

connected to said series of heat exchangers adjacent said second zone, said subsequent zone and said last zone discharging to the atmosphere, heating burners disposed in said outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a third duct connecting said second zone and the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers communicating with said subsequent zones and a last plenum chamber communicating with said last zone, said subsequent and last zones being connected through said subsequent and last ducts to the heat exchangers adjacent said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones and a damper controlled fresh air inlet connected to the heat exchanger adjacent said last zone.

10. A coating oven for heat treating coated articles to evaporate coating solvents and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber, having an entrance at one end and an exit at the other, means for conveying coated articles to be heat treated through said chamber from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber communicating with said first zone for directing heated gases over coated articles, a vapor exhaust duct in said first zone, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said phenum chamber, a second plenum chamber communicating with said second zone for directing heated gases over coated articles, a second vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connected to said second exhaust duct and an outlet connected to said series of heat exchangers adjacent said second zone, said subsequent zones and said last zone and discharging to the atmosphere, heating burners disposed in said last named duct between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a third duct connecting said second zone and the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers commuicating with said subsequent zones and a last plenum chamber communicating with said last zone, said subsequent and last zones being connected through subsequent and last ducts through the heat exchangers adjacent subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers adjacent said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones and a fresh air inlet connected to the heat exchanger adjacent said last zone.

11. A coating oven for heat treating articles to evaporate coating solvent and remove combustibles from the vaporized solvents, said oven comprising an elongated heat treating chamber having an entrance at one end and an exit at the other, means for conveying coated articles to be heat treated through said chamber and from the entrance end to the exit end, a plurality of heat treating zones spaced longitudinally of said heat treating chamber including a first zone adjacent said entrance end, a second zone following said first zone, subsequent zones following said second zone with a last zone adjacent said exit end, a plenum chamber communicating with said first zone for directing heated gases over coated articles, a vapor exhaust duct in said first zone, heating burners in said duct for heating gases passing therethrough from said first zone, a catalytic vapor incinerator disposed in said duct following said burners, a circulating fan having an inlet connected to said duct following said incinerator and an outlet connected to said plenum chamber, a second plenum chamber communicating with said second zone for directing heated gases over coated articles, a second vapor exhaust duct communicating with said second zone, a series of heat exchangers, a blower having an inlet connecting with said second exhaust duct and an outlet connected to said series of heat exchangers and discharging to the atmosphere heating burners disposed in said last named outlet between said blower and the first heat exchanger, a second catalytic vapor incinerator disposed in said last named outlet between said last named burners and the first heat exchanger, a third duct connecting said second zone and the first heat exchanger, a second circulating fan having an inlet connected to the first heat exchanger and an outlet connected to said second plenum chamber, subsequent plenum chambers communicating with said subsequent zones and a last plenum chamber communicating with said last zone, said subsequent and last zones being connected through subsequent and last ducts through the heat exchangers associated with said subsequent and last zones, circulating fans for said subsequent and last zones having inlets connected to the heat exchangers associated with said subsequent and last zones and outlets connected to the plenum chambers in said subsequent and last zones and a fresh air inlet connected to the heat exchanger associated with said last zone.

References Cited in the file of this patent

UNITED STATES PATENTS

2,230,800	Hormel	Feb. 4, 1941
2,658,742	Suter et al.	Nov. 10, 1953