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Nichols

[11] **3,744,146**

[45] **July 10, 1973**

[54] **SHRINK TUNNEL**

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[73] Assignee: **Mill Engineers, Inc.,** Shrereport, La.

[22] Filed: **June 2, 1970**

[21] Appl. No.: **42,747**

[52] **U.S. Cl.** ..... **34/212,** 34/216, 34/224, 34/236, 53/184 X

[51] **Int. Cl.** **F26b 19/00**

[58] **Field of Search** 34/225, 233, 242; 53/30, 42, 184; 98/36

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Assistant Examiner—James C. Yeung
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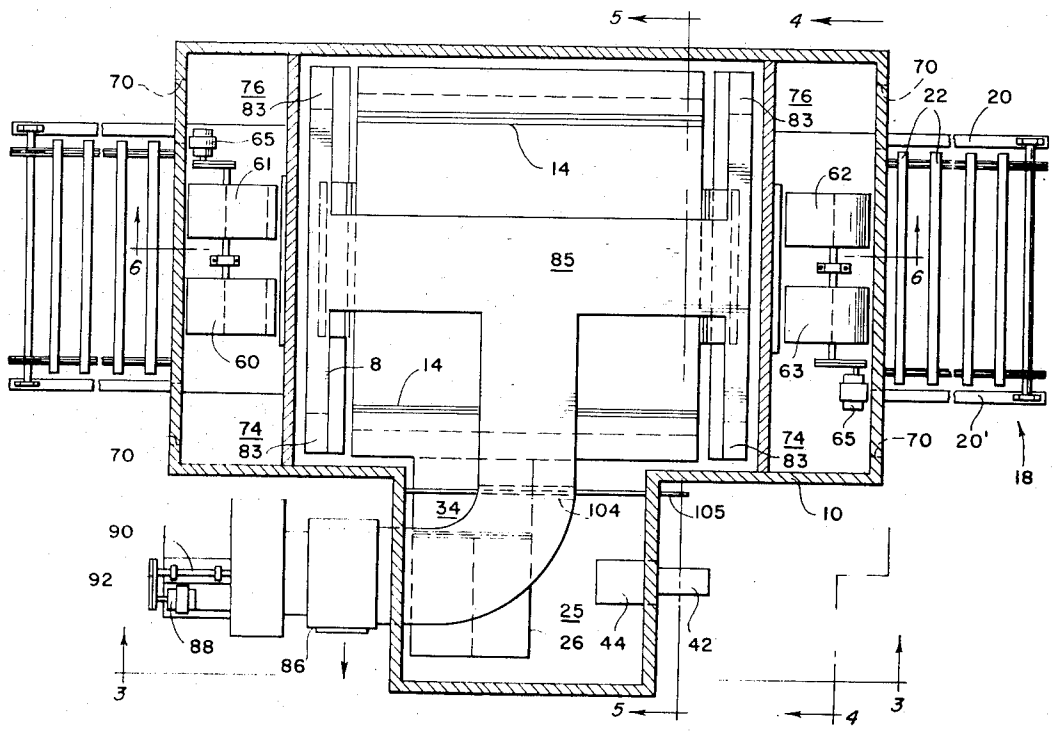
[57] **ABSTRACT**

A shrink tunnel for heat shrinking plastic film about pelletized articles wherein the tunnel has continuously open ends and a conveyor for transporting the articles through the tunnel. Heated air is evenly applied to the top and sides of the film surfaces through apertured side and top walls and to the ends of the film surfaces through a first nozzle that extends across the top of the opening at each end of the tunnel and directs heated air downwardly and inwardly of the tunnel ends. A second nozzle is mounted adjacent to and outwardly from each of the first hot air nozzles and directs relatively cooler air downwardly and inwardly of the tunnel ends and preferably in a direction parallel to the heated air, to provide air curtains on both ends of the tunnel. Slots are further provided along the bottom of the side walls of the tunnel for directing heated air inwardly and downwardly against the lower portions of the palletized articles to shrink wrap the plastic around the pallet as well as the articles on the pallet.

17 Claims, 7 Drawing Figures



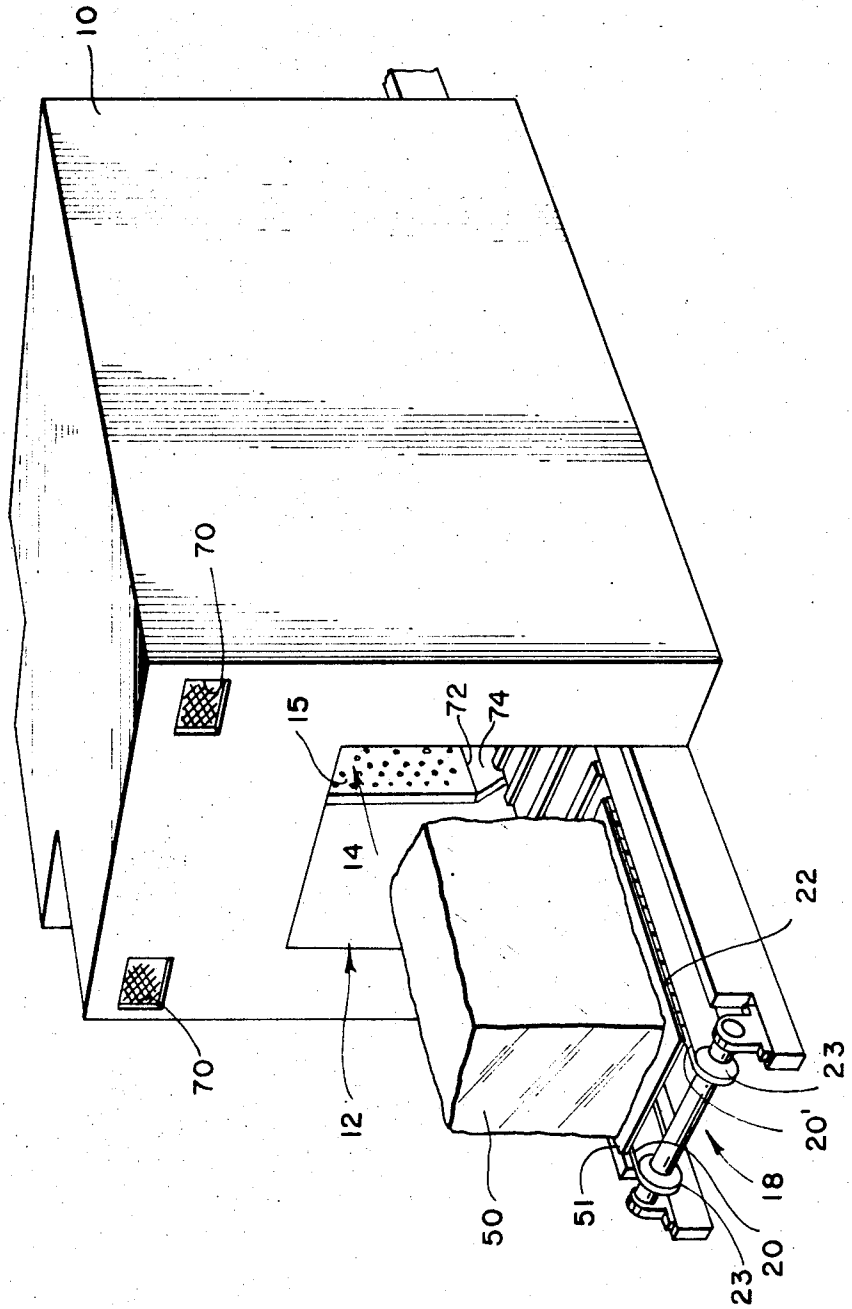


FIG. 1

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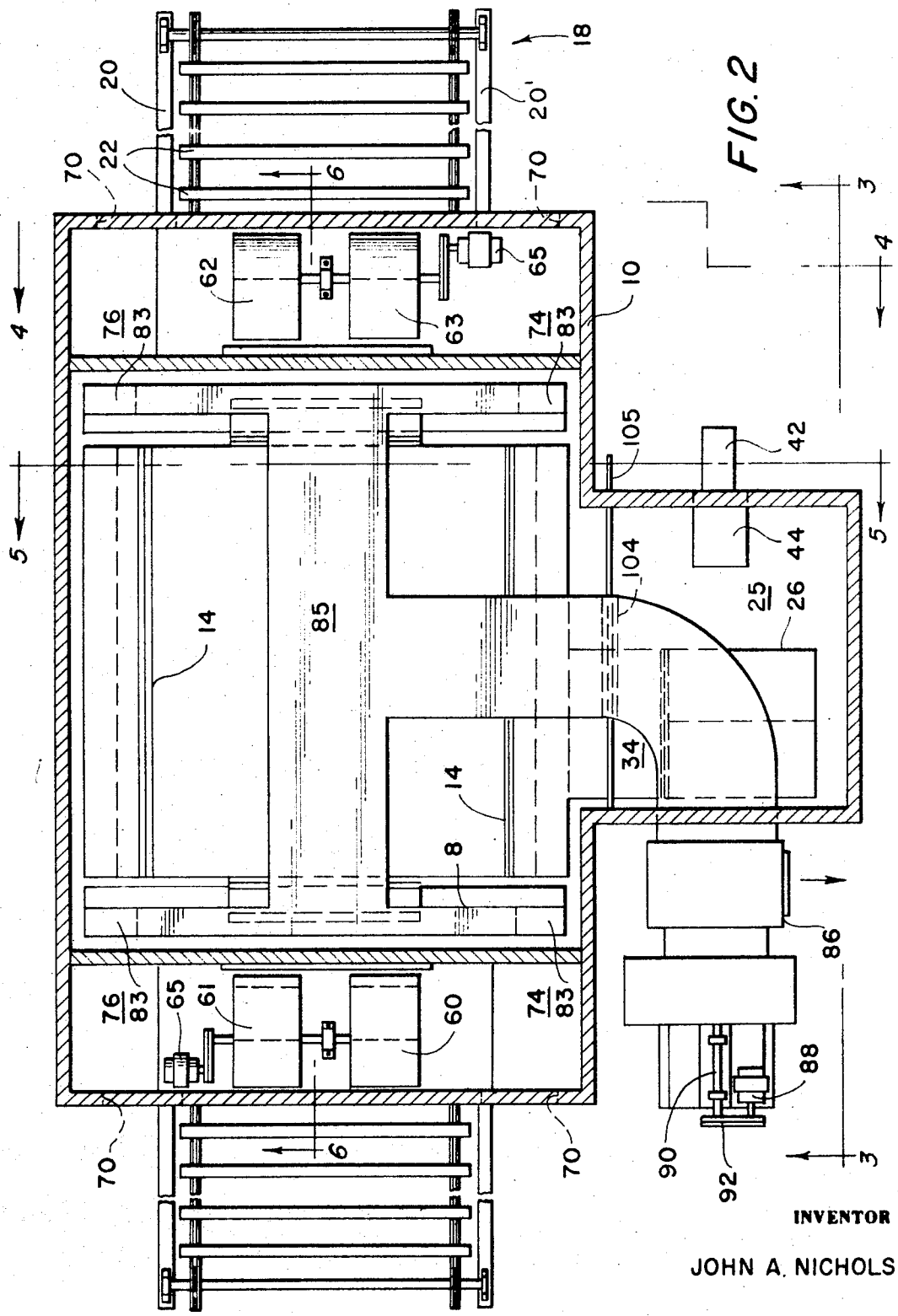

FIG. 2

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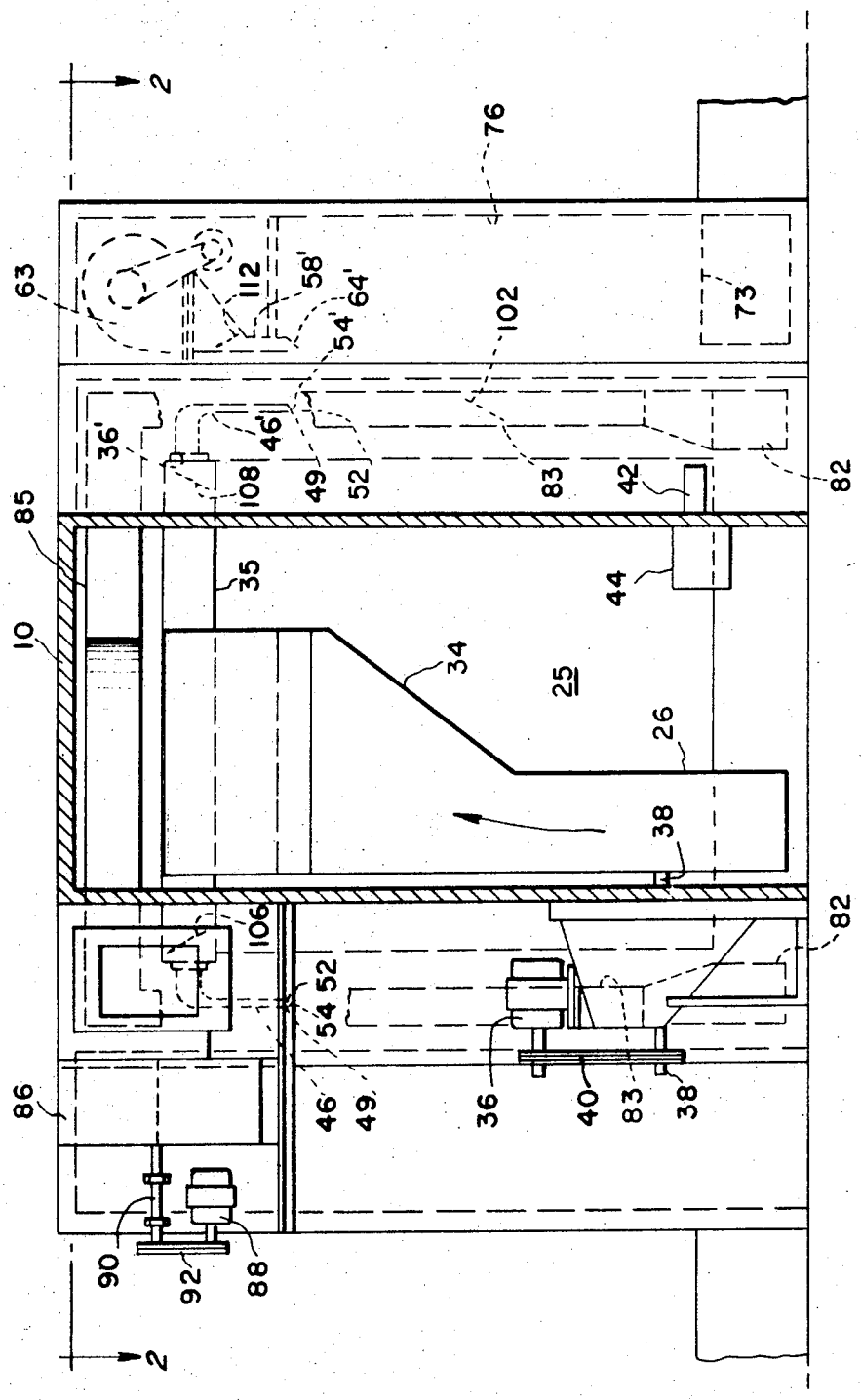

FIG. 3

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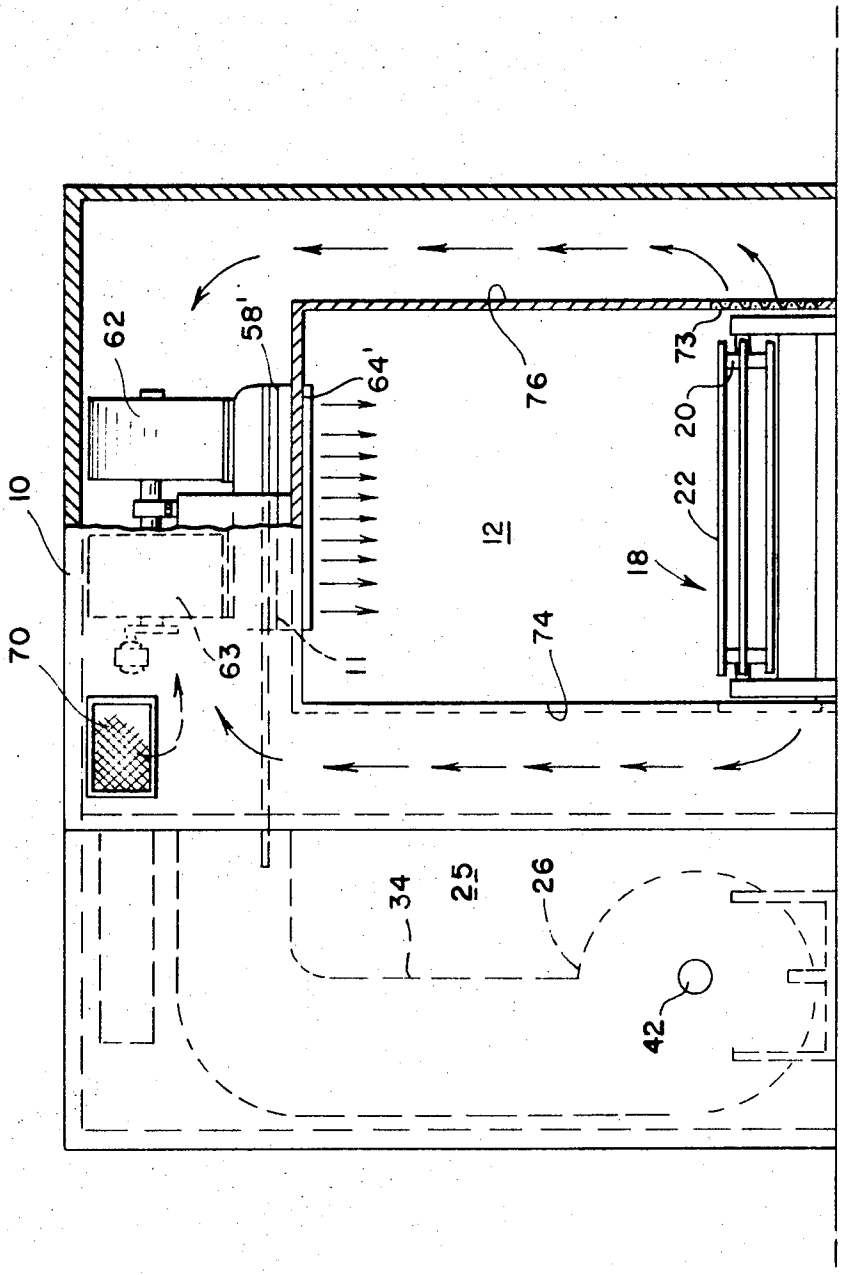

FIG. 4

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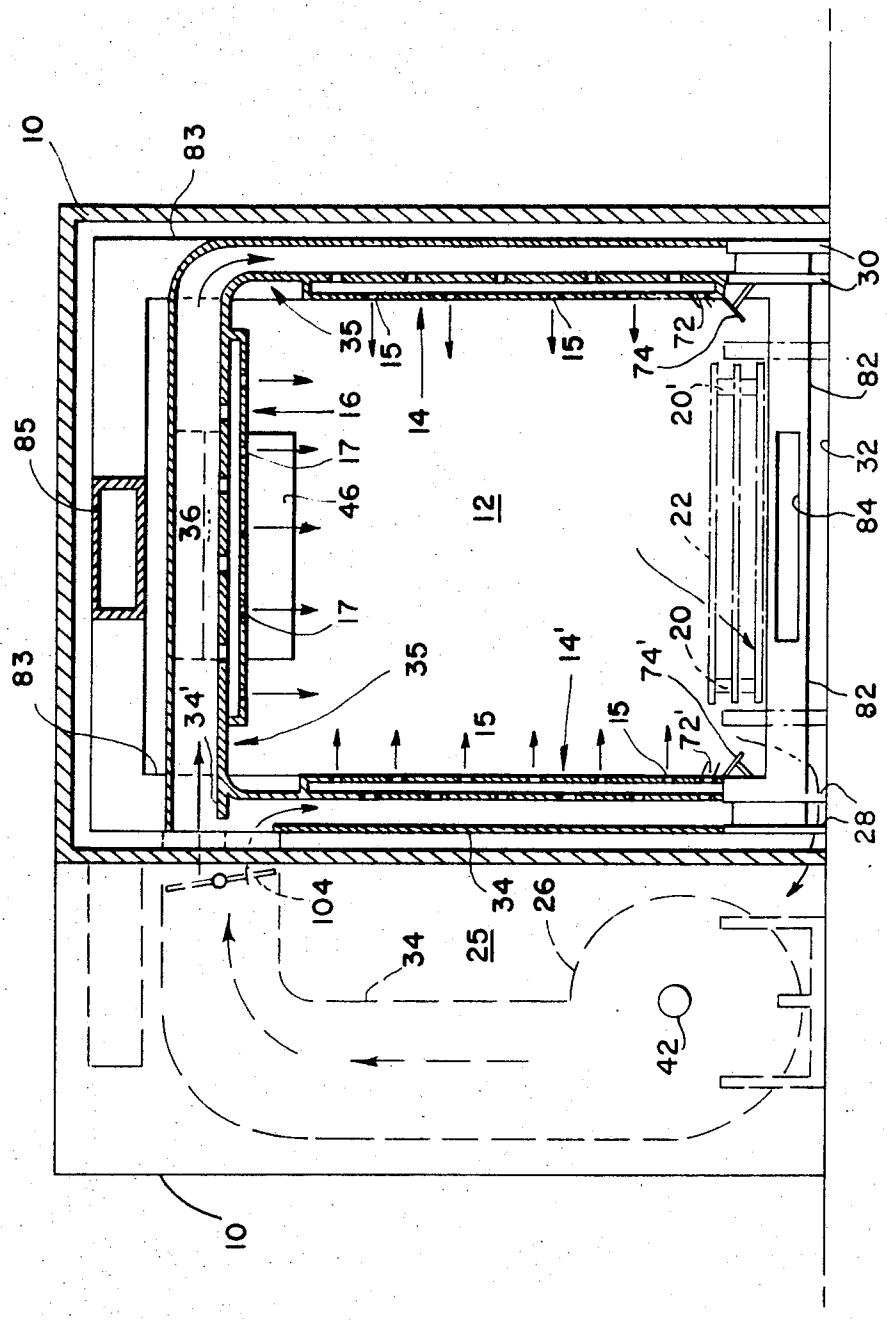

FIG. 5

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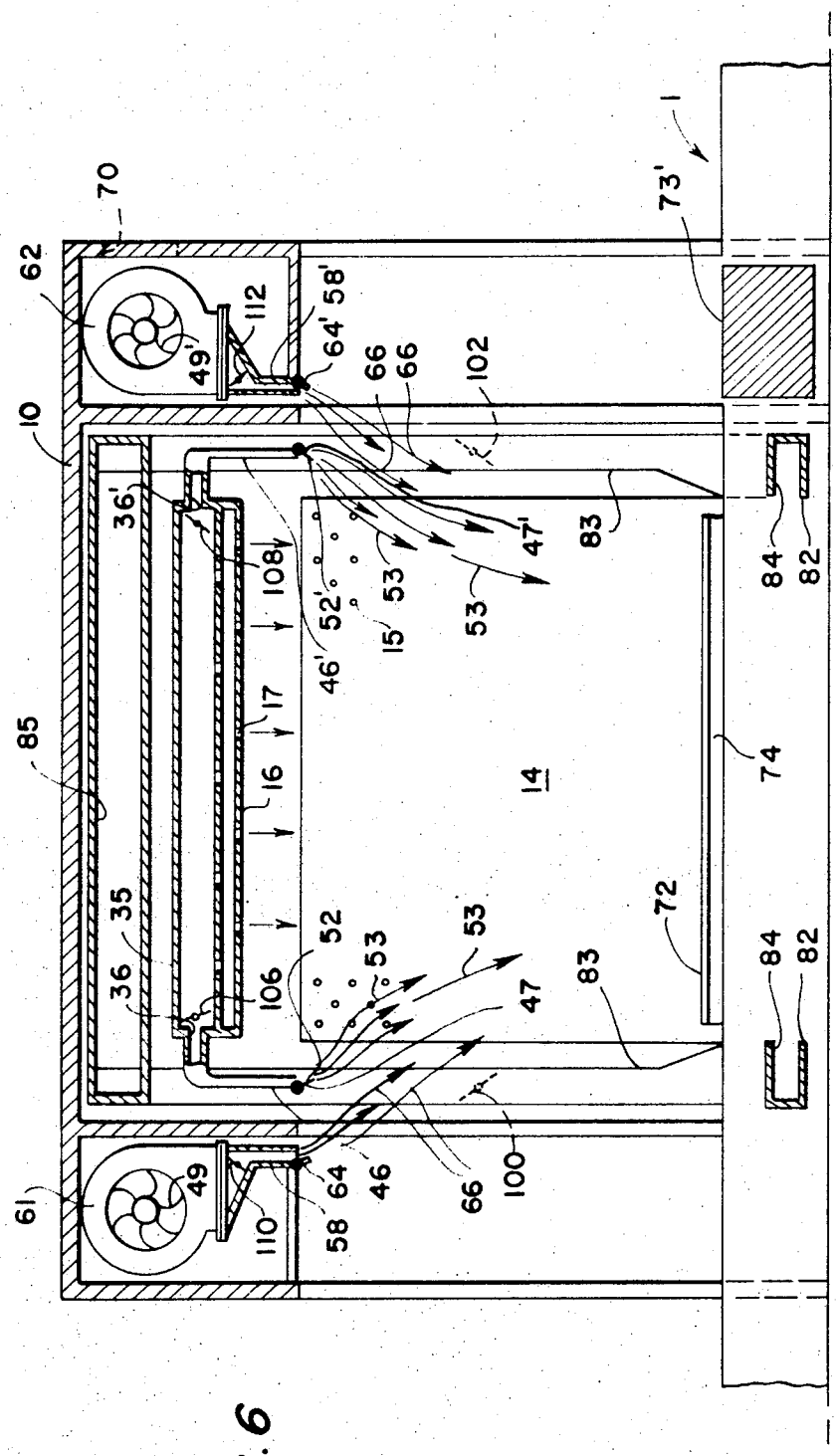

FIG. 6

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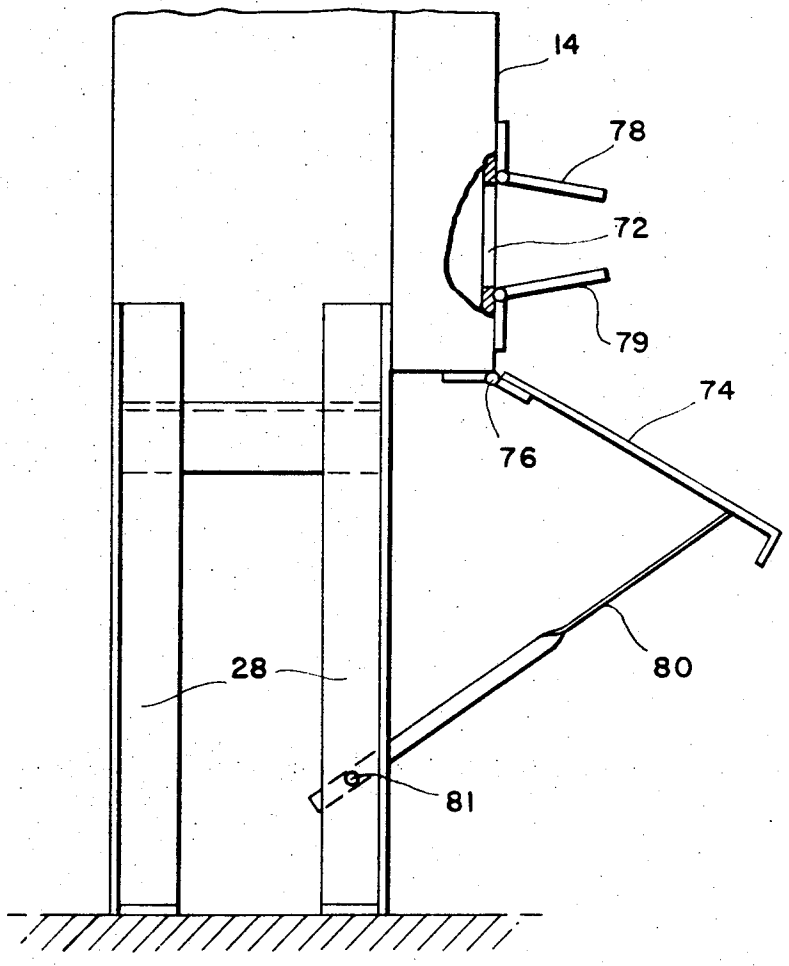

FIG. 7

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SHRINK TUNNEL

This invention relates to hot air shrink tunnels for shrink film packaging of palletized loads. More particularly, this invention relates to continuous, open ended shrink tunnels having an improved air distribution system for achieving more efficient and uniform shrinking of the film around the pallet load.

Many types of shrink tunnels have been provided in the past to heat shrink plastic films about articles to be packaged. These tunnels include both the relatively faster and more efficient open ended tunnels as well as the relatively slower closed door tunnels that produce a more uniform package but operate on an intermittent basis.

In open ended tunnels more articles can be packaged per unit time because the articles can be passed continuously through the tunnel on a suitable conveyor system. The heated air, however, is directly applied only against the top and sides of the articles and not against its ends causing differential shrinking and wrinkling of the plastic film. As a result, the articles are loose within the film and supplemental heating steps are frequently required to evenly shrink the plastic and provide a uniform and tight package.

In closed door types of shrink tunnels, however, more uniform shrinking of the film can be achieved because the closed doors confine the hot air within the tunnel and permit more uniform distribution of the air around all sides of the package. The speed at which the articles can be packaged, however, is significantly reduced because the conveyor or transporting mechanism must be intermittently stopped each time the doors are closed and the heated air is passed into the tunnel. Thus, although tunnels having doors are generally capable of more uniformly shrinking the plastic films around the articles, they are much slower and more cumbersome in operation than open ended tunnels.

When packaging palletized loads in shrink-film, in particular, a further difficulty has been experienced in making the film shrink around the pallet as well as the articles on the pallet as the film has a tendency to ride up and shrink only around the botton of the articles stacked on the pallet. To firmly hold the articles on the pallet and provide a good palletized package it is necessary that the plastic film shrink around the pallet as well as the articles.

It is, therefore, a primary object of the present invention to provide a new and improved heat shrink tunnel that overcomes these disadvantages in the prior art tunnels and that is convenient, efficient and uniform in operation.

Another object of this invention is to provide an open ended heat shrink tunnel for continuous operation in combination with a new and improved air distribution system that both confines the heated air within the tunnel and achieves uniform shrinking of the plastic film around all sides of the package.

Still another object of one embodiment of this invention is to provide a shrink tunnel for pallet packaging that shrink wraps the plastic film around the pallet as well as the articles on the pallet to provide a tightly wrapped, palletized package.

Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects

and advantages are realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the foregoing objects and as embodied and broadly described the present invention provides apparatus for heat shrinking plastic film package wrappers comprising an open-ended tunnel having a passage formed of at least two apertured side walls and an apertured top wall, means for transporting the articles through the passage and heating means for heating the air within the tunnel.

In accordance with the invention, first hot air distribution means are provided for directing a portion of the heated air into the passage through the apertured top and side walls and against the top and sides of the package, while second hot air distribution means are provided for directing a portion of the heated air downwardly and inwardly from the top of each open end of the passage and against the ends of the package as it passes through the tunnel.

Further, means are provided for withdrawing heated air from the passage and transmitting the air to the heating means for reheating.

Preferably, cool air distribution means are also provided adjacent the open ends of the tunnel and spaced outwardly from the second hot air distribution means for directing a curtain of relatively cooler air downwardly and inwardly of the passage and across the open ends in a direction substantially parallel with the heated air to confine the heated air within the passage.

The second hot air distribution means includes a nozzle that extends along at least part of the distance across the top of each of the open ends of the passage, and directs a curtain of heated air downwardly and inwardly of the passage to impinge upon and shrink the plastic film around the ends of the package. Preferably, each of the nozzles define a continuously open slot and includes a baffle hingedly connected thereto for directing the heated air in the desired direction.

The cool air distribution means also includes a nozzle that extends across the top of the tunnel opening and is mounted adjacent to and outwardly from the hot air nozzle; and a fan for drawing in ambient air and forcing it through the nozzle in a direction substantially parallel to the curtain of heated air emanating from the hot air nozzle.

In accordance with a preferred embodiment of the invention, each of the two apertured side walls have continuous slots that extend substantially along the length of the bottom of the wall to direct a stream of heated air against the lower portions of sides of the package.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory but are not restrictive of the invention.

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate an embodiment of the invention, and together with the description, serve to explain the principles of the invention.

IN THE DRAWINGS

FIG. 1 is a perspective view of a continuous shrink tunnel embodying the principles of the invention;

FIG. 2 is a plan view, partly in section, of the shrink tunnel shown in FIG. 1;

FIG. 3 is a side elevation of the shrink tunnel taken on the line 3—3 of FIG. 2;

FIG. 4 is an end view, partly in section, of the shrink tunnel taken on the line 4—4 of FIG. 2;

FIG. 5 is a partial section of the shrink tunnel taken on the line 5—5 of FIG. 2;

FIG. 6 is a section of the shrink tunnel taken on the line 6—6 of FIG. 2 looking in the direction of the arrows; and

FIG. 7 is a detailed section of a portion of the tunnel as illustrated in FIG. 5.

With reference now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIG. 1 the shrink tunnel of this invention having an outer casing **10**. An open-ended passage **12** is formed within casing **10** by two interior side walls **14** and **14'** having spaced apertures **15** and a top surface or wall **16** also having spaced aperture **17**. Each of the side walls and the top surface are similar in construction and preferably are constructed with double plenums for equal air distribution across all the face of the wall as more fully described in my co-pending application Ser. No. 42,693, for Apparatus for Shrink Packaging, filed June 2, 1970.

In accordance with the invention, means are provided for transporting articles through passage **12**. As embodied, the transporting means comprises a conveyor assembly **18** that includes conventional driving means, such as a motor (not shown), and a pair of endless belts **20** and **20'** between which are mounted spaced supporting bars **22**. Belts **20** and **20'** are mounted around sprockets **23** for translation movement through the tunnel from one end to the other. The conveyor assembly is conventional in construction and forms on part of the present invention.

First hot air distribution means are provided for directing heated air into passage **12** through the apertures in the side and top walls, and against the plastic film surrounding the top and sides of the packaged articles passing through the tunnel. As embodied, this means includes a fan **26** for drawing air into a heating chamber **25** adjacent tunnel passage **12**. Preferably, and as shown in FIG. **5**, support members **28** and **30** support the opposite sides of the tunnel on the floor or ground **32**, and supports **28** are spaced apart from one another along the length of the tunnel so that fan **26** withdraws air from passage **12** for heating in the heating chamber.

As best shown in FIG. **5**, a vertical duct **34** communicates with fan **26** and with an inverted, U-shaped air plenum generally **35** that feeds a portion of the heated air to side walls **14** and top wall **16**. Fan **26** is driven in a conventional manner by means of a motor **36** (see FIG. 3) that is connected to a fan shaft **38** by conventional belt or gear assembly **40**. A heat source **42**, such as a gas jet, is located adjacent fan **26** for heating the air prior to entry of the air into the fan. If a gas flame is used a flame guard **44** may be provided.

In accordance with the invention, second hot air distribution means are further provided for directing a portion of the heated air downwardly and inwardly from the top of the open ends of the passage and against the plastic film around the ends of the article being packaged. As embodied, this means includes a plurality of nozzles **46** and **46'** (FIGS. 3 and 6) that communicate with U-shaped duct **35** through respective openings **36** and **36'** and which extend at least part of the distance across the top of each of the open ends of passage **12** (see FIG. **5**).

As best shown in FIG. **6**, each of nozzles **46** and **46'** has a continuously open slot **52** and **52'**, respectively, and baffles **47** and **47'** are hingedly connected at **49** and **49'** to each of the nozzles adjacent slots **52** and **52'** for directing heated air inwardly and downwardly of the passage in the direction shown by arrows **53**. Preferably, the baffles are adjusted to direct the heated air at an angle of 30° to 45° with respect to vertical.

As more fully described below in connection with the operation of the tunnel, maximum heating of the ends of the packaged article is achieved, and at the same time maximum retention of heated air within the passage is achieved without leakage of the heated air out through the openings of the passage.

In accordance with this invention cool air distribution means are provided adjacent the open ends of tunnel **12** for directing a curtain of relatively cooler air across the open ends of the passage outwardly from and in a direction substantially parallel with the heated air from nozzles **46** and **46'**. The cooler air curtains substantially confine the heated air within the passage and eliminate the need for any doors on the end of the tunnel. As embodied, the air curtains are provided by a pair of second nozzles **58** and **58'** (FIGS. 3 and 6) mounted adjacent to and outwardly from nozzles **46** and **46'** at either end of the tunnel. As best shown in FIGS. **2** and **6** air curtain fans **60, 61, 62** and **63** are mounted within the top of the tunnel adjacent nozzles **58** and **58'** and driven by a motor **65** for supplying air to the nozzles. As best shown in FIG. **4**, relatively cooler ambient air is drawn in through openings **70** in the upper outside surface of the tunnel by fans **60 – 63** and forced out through nozzles **58** and **58'**. Air curtain baffles **64** and **64'** are hingedly mounted to each nozzle **58** and **58'** to direct the cooler ambient air inwardly and downwardly in the direction shown by arrows **66** (FIG. **6**) and preferably in a stream parallel to hot air streams **53**.

In addition, and to aid in the establishment of a proper air curtain seal, cool air return openings **73** are provided in the botton of the tunnel adjacent the open ends (see FIGS. 4 and 6). Air return ducts **74** and **76** are located on both sides of the open ends of passage **12** and communicate with openings **73** and with the air curtain fans for pulling cool air out of the bottom of the tunnel and back up to the fans.

In accordance with a preferred embodiment, means are provided for directing a steam of heated air inwardly and downwardly from the bottom of side walls **14** and against the bottom edges of the plastic film wrapper to blow it down against the pallet and to shrink the film around the pallet as well as the articles stacked on the pallet. As embodied, and as best shown in FIGS. **6** and **7**, this means cmprises a pair of longitudinal slots **72** that extend along the bottom of the entire length of each side wall **14** in a substantially horizontal direction. Adjustable, continuous baffles **74** (FIG. **5**) are hingedly affixed to each of side walls **14** and below their respective slots **72**. As better shown in FIG. **7** baffle **74** is hingedly affixed at **76** to side wall **14** and the baffle extends substantially along and underneath the entire length of slot **72**. Each baffle **74** is also adjustable by a strap handle **80** to locate the baffle at different angles with respect to vertical side walls **14**.

Adjustable nozzle means are associated with each of the side walls adjacent their respective slots for controlling the direction of heated air passing through these slots as more fully described below. As best shown in FIG. 7, the adjustable nozzle means include a pair of continuous direction plates 78 and 79 that extend substantially along the upper and lower length of each slot 72 and are hingedly affixed to side wall 14.

In accordance with this invention means are provided for withdrawing at least a portion of the heated air from passage 12 and exhausting it to the atmosphere. As here embodied, this means include a pair of transverse exhaust ducts 82 (FIGS. 2, 5, and 6) located transversely of and at each end of passage 12 below the upper part of the conveyor assembly. Each duct 82 has an opening 84 (FIGS. 5 and 6) on the inner side thereof that is in communicating relationship with the passage. A pair of vertical ducts 83 are connected to the ends of each transverse duct 82 and to an upper exhaust air plenum 83, FIG. 2. An exhaust fan 86 is provided in communicating relationship with exhaust air plenum 85 for exhausting a portion of the heated air withdrawn from the passage through openings 84, and ducts 82 and 83. The exhaust fan is driven in a conventional manner by motor 88 and fan shaft 90 that is driven from the motor by means of belts or gearing 92.

In operation, article or articles 50 (FIG. 1) are placed on conveyor assembly 18 and are preferably located on a pallet 51 that rests on support members 22 of the conveyor assembly. Dampers 100 and 102 (FIG. 6) are set to the desired positions in exhaust ducts 83, and damper 104 (FIG. 2) controlled by damper rod 105 is set to a desired position within main heat air supply duct 34. Similarly, dampers 106 and 108 (FIG. 6) are adjusted to provide the desired air flow from chambers 35 through openings 36 and 36' to nozzles 46 and 46', and dampers 110 and 112 (FIGS. 4 and 6) are adjusted to provide the desired air flow from the air curtain fans through nozzles 58 and 58'. Other dampers (not shown) may be used throughout the system at various points to control the volume and velocity of air flow into and out of the tunnel passage.

Supply fan 26 (FIGS. 3–5) is energized by means of motor 36 and shaft 38. As best seen in FIG. 5, air from within the passage is drawn through spaced supports 28 and into chamber 25 where fan 26 in located. The air is then heated by a gas flame, for example, emanating from flame source 42 and shielded by flame guard 44 (FIGS. 2 and 3). The heated air is drawn into fan 26 and is forced through main hot air duct 34 by the action of the fan. The air flow is divided by divider 34' (FIG. 5) so that it flows evenly into U-shaped chamber 35 and to the double plenum arrangement of side walls 14 and top wall 16. The hot air eventually passes out through apertures 15 in side walls 14 in a horizontal direction and through apertures 17 in top wall 16 in a downward direction.

The heated air within chamber 35 is also caused to pass through openings 36 and out through nozzles 46 and 46'. Adjustable baffles 47 and 47' are hingedly attached to the ends of the respective nozzles by hinges 49 and 49' so that the baffles can be adjusted to direct the heated air downwardly and inwardly of the passage in a predetermined direction.

Simultaneously, relatively cooler ambient air is drawn through openings 70 by the air curtain fans at both ends of the tunnel and is directed downwardly through nozzle 58 and 58'. Air curtain baffles 64 and 64' adjacent nozzles 58 and 58' respectively are adjusted to direct the cool air curtain stream substantially parallel with the direction of the heated air streams emanating from nozzles 46 and 46'. Tests have shown that the air emanating from nozzles 46 and 46' and from nozzles 58 and 58' should preferably be directed inwardly of the passage at an angle of 30° to 45° with respect to vertical. In this way, maximum retention of heated air within the passage is accomplished by the air curtain, and the direction of the heated air from nozzles 46 and 46' against the ends of the articles 50 efficiently heats the plastic along the ends so that the desired uniform shrinkage of the plastic around all sides of the package is accomplished.

Heated air emanating from side walls 14, in addition to being forced through the apertures therein, is also forced through continuous slots 72 (FIGS. 6 and 7). The adjustable nozzles formed by continuous direction plates 78 and 79 direct the heated air against the lower portions of the articles 50 and beneath pallet 51 to cause the plastic to wrap around at least a portion of the bottom of the pallet and to cause the plastic to shrink in the wrapped around position. In this way, the articles are firmly held in position on the pallet and a tight, moisture-proof, soil-proof seal is created between the articles and the pallet as they move through the passage.

A portion of the heated air within the passage is withdrawn by supply fan 26. The air passes down and between vertical supports 28 and into contact with the gas flame where the air is reheated in chamber 25 and it is then drawn into the fan for recycling. The remaining portion of the heated air is exhausted from the passage through openings 84 in transverse exhaust ducts 82 (FIG. 6). These ducts are located so that a large portion of the heated air emanating from nozzles 46 and 46' is drawn downwardly and directly into openings 84 to be ultimately exhausted by fan 86. This arrangement together with the cooler air curtain effectively prevents escape of heated air from the passage out through the open ends thereof. Undesirable heating of the room within which the tunnel is located is avoided.

The suction created by exhaust fan 86 draws air through openings 84 and up through ducts 83 to exhaust air plenum 85 that is in communication with the ducts 83 and with exhaust fan 86. The air is then exhausted to the atmosphere by fan 86. Thus, a certain portion of the heated air within the passage is constantly being exhausted and a fresh supply of air is drawn in to replace the exhausted air.

When it is desired to heat shrink plastic about articles in accordance with this invention, the articles are placed on pallet 51, for example, and are loosely covered by plastic material in the form of a bag as illustrated in FIG. 1. Conveyor assembly 18 is activated in a conventional manner and articles 50 are caused to pass into and through passage 12. As the articles move into the passage heated air from side walls 14 and from top wall 16 is forced against the sides and top of the plastic covered articles so as to heat the plastic. This heating of the plastic causes it to shrink in a known manner and to tightly surround the articles.

However, the heated air forced from the sides and the top of the passage does not adequately impinge upon the ends of the plastic covered articles so as to result in the proper shrinking of the plastic along the

ends. This is accomplished in a unique way in accordance with this invention by nozzles **46** and **46'** that direct heated air at an angle downwardly and inwardly of the passage to directly impinge upon the leading and trailing ends of the plastic covered articles as they pass through the tunnel.

As the articles first enter the passage the heated air from nozzle **46'** directly impinges upon the upper portion of the trailing end of the articles. As the articles progress through the tunnel and move further away from nozzle **46'**, heated air from the nozzle **46'** is directed against successively lower portions of the trailing end of the articles until the entire film surface covering the trailing end has been directly contacted with forced heated air so as to efficiently shrink the plastic over the trailing end.

At the same time and as shown in FIG. **6** relatively cool ambient air is forced from nozzle **58'** in a direction substantially parallel to the direction of air emanating from nozzle **46'**. This cooler ambient air has no effect on the plastic at this stage of the operation as it is outside of the heated air environment, but it does act as an air curtain to prevent the heated air from escaping from passage **12** via the open end.

As the articles pass through the tunnel and approach the exit opening of the passage, heated air from nozzle **46** is directed downwardly and inwardly to contact the leading end of the plastic covered articles. Heated air initially impinges upon the lower portion of the leading end of the articles, and as the articles approach more closely towards the opening, the heated air from nozzle **46** directly impinges upon successively higher portions of the leading end. This continues until the entire leading end has been directly contacted by forced heated air from nozzle **46,** and this end of the plastic covering is caused to shrink to the same degree as the side and top portions so that an evenly and tightly wrapped package is provided.

As with the entrance opening of the passage, the exit opening is provided with an air curtain nozzle **48,** and a stream of relatively cooler ambient air is directed downwardly and inwardly of the passage in a direction substantially parallel to the heated air emanating from nozzle **46.** The purpose of this air curtain is also to retain the heated air within the passage and to prevent escape thereof through the exit opening. However, the air curtain adjacent the exit opening of the passage has the additional function of quickly cooling the plastic that surrounds the articles so that the shrink cycle is more rapidly completed and the package emerges from the tunnel with the plastic completely solidified and ready for immediate handling.

Another important feature of the invention is provided by slots **72** in conjunction with adjustable baffles **74** and the adjustable nozzles for the slots. The adjustable nozzle associated with one of the slots is shown in FIG. **7** and is formed by continuous direction plates **78** and **79.**

The plates are preferably oriented with respect to slot **72,** for example, so that heated air from side wall **14** is directed at the bottom of articles **50** and beneath the underside of pallet **51.** The force of the air from slots **72** as directed by the nozzles against the lower portions of the plastic covering along the sides thereof causes the plastic to wrap around beneath the pallet. In addition, the heat of the air emanating from slots **72** causes the lower portions of the plastic material to shrink so that the plastic shrinks in the wrapped around position and engages the pallet to tightly hold the articles onto the pallet in a moisture-proof and soil-proof manner.

Baffles **74** (FIGS. **1, 6,** and **7**) assist in directing the heated air in the desired directions. In addition, the baffles are hingedly attached to the side walls **14.** As shown in detail in FIG. **7,** baffle **74** also performs the important function of preventing the so-called short circuiting of heated air directly from slot **72'** and wall **14** to the intake of fan **26** without contacting the plastic material in the tunnel. The location of baffle **74'** requires that air emanating from slot **72'** pass around baffle **74'** before it can be affected by the suction of fan **26.**

This invention provides a unique heat shrink tunnel that is capable of efficiently heat shrinking a large number of articles per unit time while at the same time evenly wrapping the articles by directing heated air not only against the sides and tops of the articles but also against the ends thereof. This is accomplished by the use of nozzles that direct heated air inwardly and downwardly of the tunnel passage to impinge upon the ends of the articles as they pass through the open ended tunnel. Air curtains are also provided in a unique manner to direct cooler ambient air inwardly and downwardly of the passage in a direction substantially parallel to the direction of heated air impinging upon the ends of the articles whereby the heated air is effectively retained within the passage without escaping through the open ends. The use of heavy and cumbersome doors is eliminated so that the number of articles capable of being wrapped per unit time is markedly increased over tunnels which utilize such doors. In addition, the present invention incorporates longitudinal slots along the bottom portions of the side walls together with adjustable baffles and adjustable nozzles for directing the heated air against the bottom portions of the articles and below the pallets upon which the articles are located. This quickly and efficiently shrinks the plastic in the wrapped around position to tightly affix the articles in place on the pallet and to provide a moisture-proof and soil-proof seal so that the articles can be shipped or stored under relatively adverse conditions.

This invention in its broader aspects is not limited to the specific details shown and described and departures may be made from such details without departing from the principles of the invention and without sacraficing its chief advantages.

What is claimed is:

1. Apparatus for heat shrinking plastic film wrappers about articles stacked on a pallet comprising:

an open-ended tunnel having a passage formed of at least two apertured side walls and an apertured top wall;

means for transporting the pallet through said passage;

means for heating the air within the tunnel;

hot air distribution means for directing heated air into the passage through said apertured top and side walls and against the plastic film surrounding the top and sides of the articles stacked on the pallet; and

means for directing a stream of heated air inwardly and downwardly from the bottom of each wall of the passage said means comprising:

continuous slots extending substantially along the length of the bottom of each side wall in a substantially horizontal direction;

adjustable nozzle means affixed to each of said side walls and adjacent said slots for adjusting the amount and direction of flow of heated air passing through the slot; and

said nozzle means directing the heated air passing through the slots against the lower portions of the palletized articles to cause the plastic film wrapper to wrap around a portion of the bottom of said pallet and to shrink in the wrapped-around position, whereby the articles are firmly held in position on the pallet.

2. Apparatus as in claim **1**, wherein said adjustable nozzle means include:

upper and lower direction plates that extend substantially along the length of each slot, said plates being hingedly affixed to the side wall above and below the slot.

3. Apparatus of claim **1**, including an adjustable continuous baffle hingedly affixed to each side wall below each slot for further directing the flow of air against the lower portions of the palletized package.

4. Apparatus for heat shrinking plastic film wrappers about articles, to form a package comprising:

an open-ended tunnel having a passage formed of at least two apertured side walls and an apertured top wall;

means for transporting the articles and wrapper through said passage;

means for heating the air within the tunnel;

first hot air distribution means for directing a portion of the heated air into the passage through said apertured top and side walls and against the plastic film surrounding the top and sides of the package;

second hot air distribution means for directing a portion of the heated air downwardly and inwardly from the top of each open end of the passage and against the plastic film adjacent the ends of the package as it passes through the tunnel;

first and second ducts located transversely of and within said passage and below at least a portion of said transporting means;

said first and second ducts having openings on the inner sides thereof and in communicating relationship with said passage; and

an exhaust fan in communicating relationship with said first and second ducts for exhausting a portion of said heated air from said passage.

5. Apparatus for heat shrinking plastic film wrappers about articles to form a package comprising:

an open-ended tunnel having a passage formed of at least two apertured side walls and an apertured top wall;

means for transporting the articles and wrapper through said passage;

means for heating the air within the tunnel;

first hot air distribution means for directing a portion of the heated air into the passage through said aperture top and side walls and against the plastic film wrapper surrounding the top and sides of the package;

second hot air distribution means for directing a portion of the heated air in the form of a curtain downwardly and inwardly from the top of each open end of the passage and against the plastic film wrapper adjacent the ends of the package as it passes through the tunnel; and

cool air distribution means for directing a curtain of relative cooler air downwardly and inwardly from the top of each open end of the passage and adjacent to and outwardly from the heated air curtain to substantially confine all the heated air within the passage.

6. Apparatus as in claim **5**, including a fan for withdrawing heated air from the passage to the heating means for reheating air.

7. Apparatus as in claim **5**, wherein said second hot air distribution means and cool air distribution means each includes a nozzle extending across the top of each open end of the tunnel, said hot air nozzles being located adjacent to and inwardly of the ends of the tunnel from the cool air nozzles and said nozzles directing their respective curtains of air downwardly and inwardly from the ends of the tunnel and in a substantially parallel direction.

8. Apparatus as in claim **7**, whrein each cool air nozzle defines a continuously open slot and an adjustable baffle is located adjacent each of said cool air nozzles for adjusting the direction of flow of the cool air curtains.

9. Apparatus as in claim **7**, wherein each hot air nozzle defines a continuously open slot and an adjustable baffle is located adjacent each of said hot air nozzles for adjusting the direction of flow of the hot air curtains.

10. Apparatus as in claim **5**, wherein hot and cool air curtains are directed downwardly and inwardly of said passage at an angle about 30° to 45° with respect to vertical.

11. Apparatus as in claim **5**, including a fan for drawing in ambient air and supplying the ambient air to the cool air distribution means.

12. Apparatus as in claim **11**, wherein the cool air distribution means includes:

means for withdrawing cool air from the bottom of each open end of the tunnel; and

supplying the air to the air curtain fan.

13. Apparatus for heat shrinking plastic film wrappers about articles stacked on a pallet comprising:

an open-ended tunnel having a passage formed of at least two apertured side walls and an apertured top wall;

means for transporting the pallet through said passage;

means for heating the air within the tunnel;

hot air distribution means for directing heated air into the passage through said apertured top and side walls and against the plastic film surrounding the top and sides of the articles stacked on the pallet;

means for directing a stream of heated air inwardly and downwardly from the bottom of each wall of the passage, said means comprising:

continuous slots extending substantially along the length of the bottom of each side wall in a substantially horizontal direction,

adjustable nozzle means affixed to each of said side walls and adjacent said slots for adjusting the amount and direction of flow of heated air passing through the slot, and

said nozzle means directing the heated air passing through the slots against the lower portions of the

palletized articles to cause the plastic film wrapper to wrap around a portion of the bottom of said pallet and to shrink in the wrapped-around position whereby the articles are firmly held in position on the pallet; and

cool air distribution means for directing a curtain of relatively cooler air downwardly and inwardly from the top of each open end of the tunnel to substantially confine all the heated air within the passage.

14. The apparatus of claim **13,** wherein said cool air distribution means includes a nozzle extending across the top of each open end of the tunnel for directing the cool air curtain downwardly and inwardly from the top of each open end of the tunnel.

15. The apparatus of claim **14,** including adjustable baffles located adjacent each of said cool air nozzles for adjusting the direction of flow of said cooler air.

16. The apparatus of claim **15,** wherein each nozzle defines a continuously open slot and wherein said adjustable baffle is hingedly connected adjacent the slot for adjusting the direction of flow of the cooler air.

17. Apparatus as in claim **13,** wherein said adjustable nozzle means includes upper and lower direction plates that extend along the length of each slot, said plates being hingedly affixed to the side wall above and below the slot.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,744,146 Dated July 10, 1973

Inventor(s) John A. Nichols

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading, after "Assignee:", change "Mill Engineers, Inc., Shrereport, La." to --Mill Industries, Inc., Shreveport, La.--

Signed and sealed this 6th day of August 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents