April 4, 1967 F. G. SHANKLIN 3,312,811

SHRINK TUNNEL

Filed Feb. 4, 1964 6 Sheets-Sheet 1

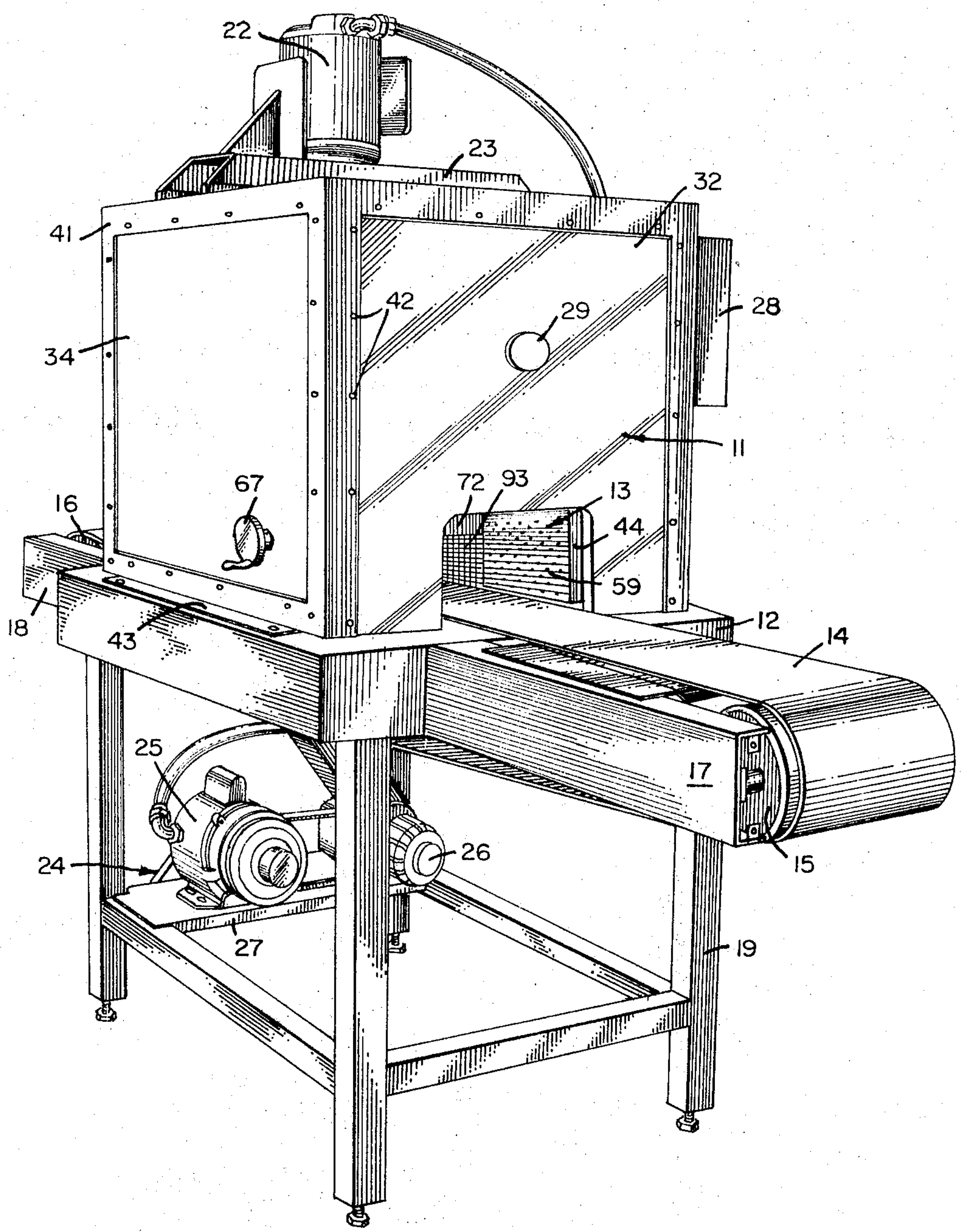

FIG.1

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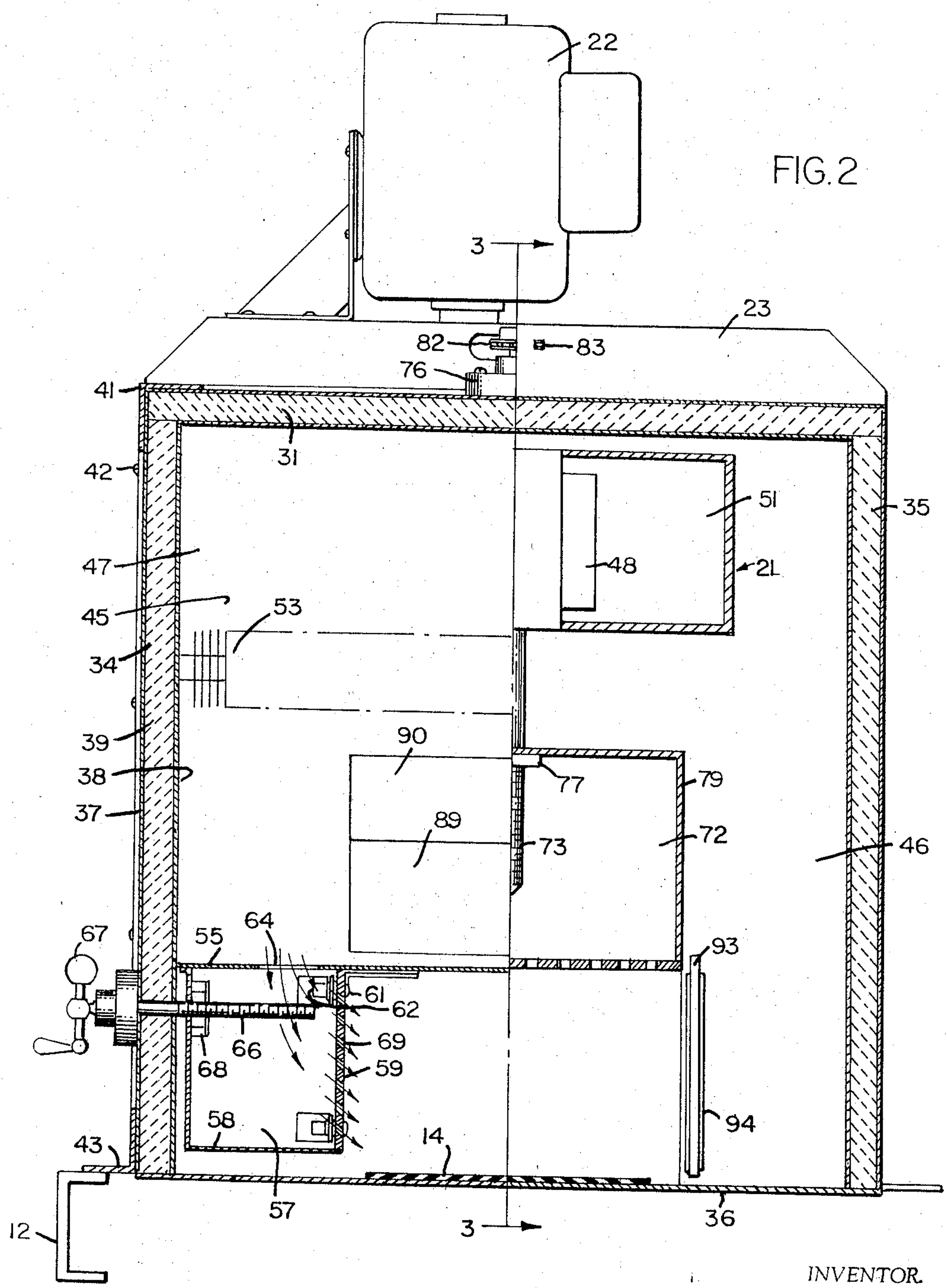
FIG. 2



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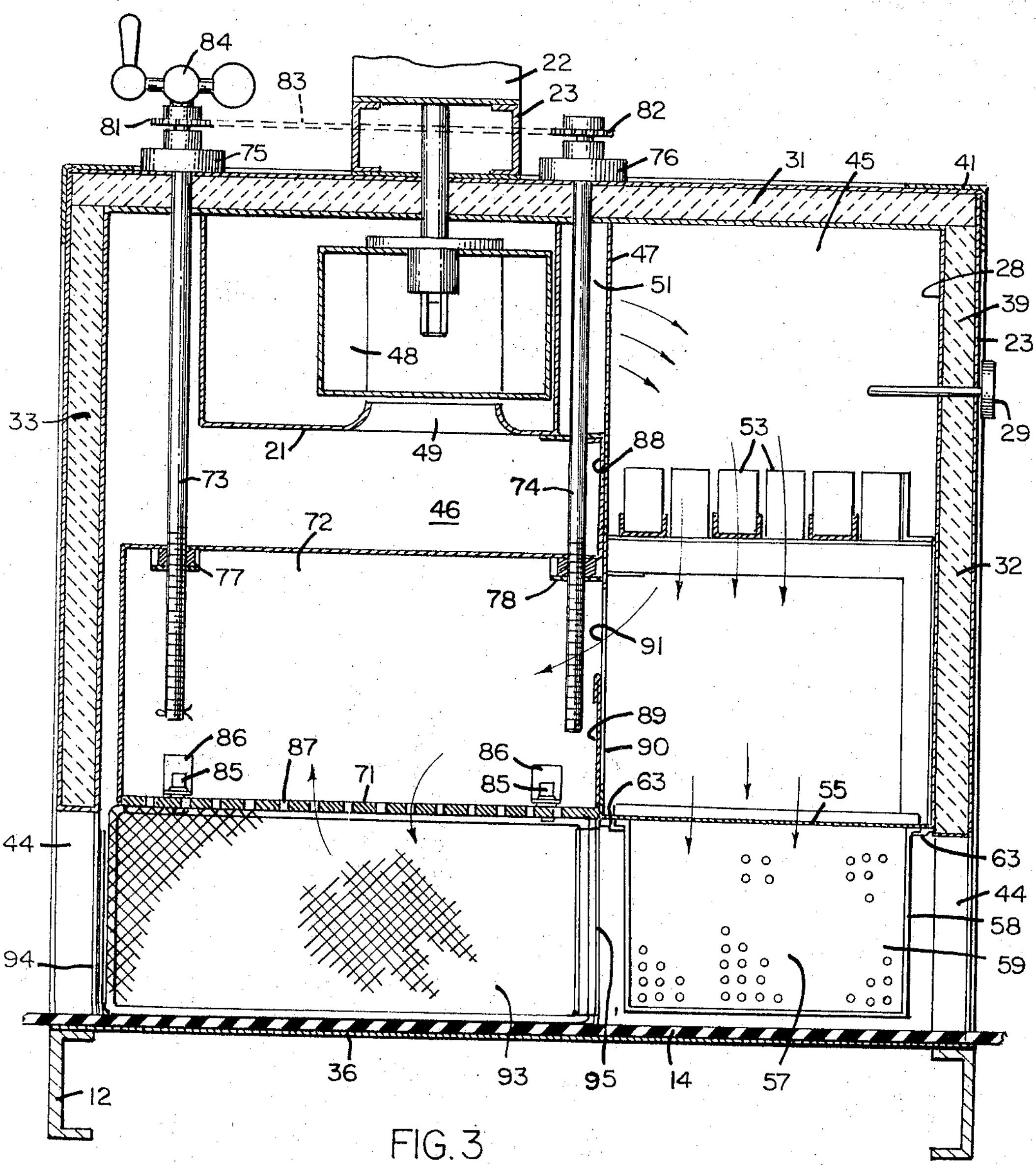

FIG. 3

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SHRINK TUNNEL

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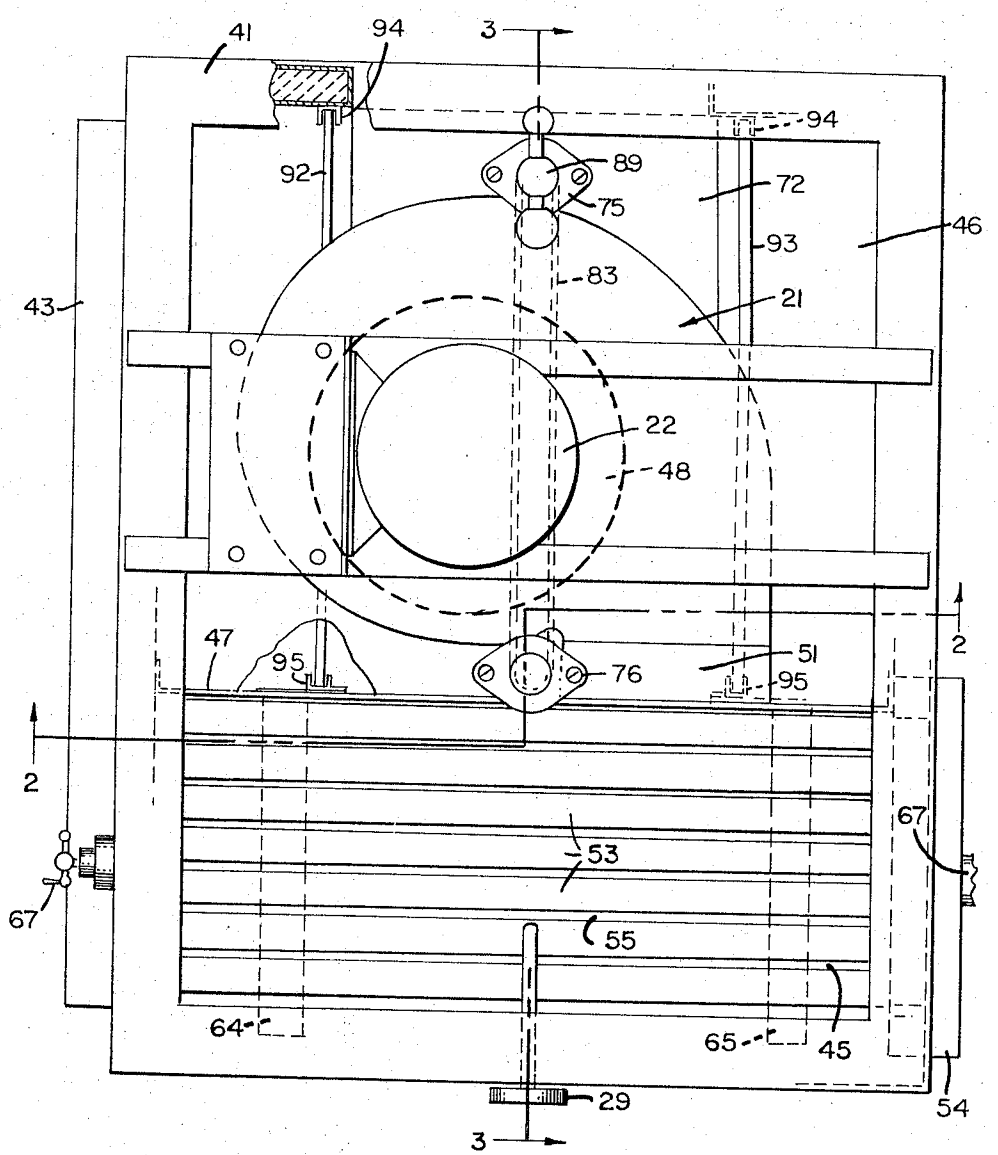

FIG. 4

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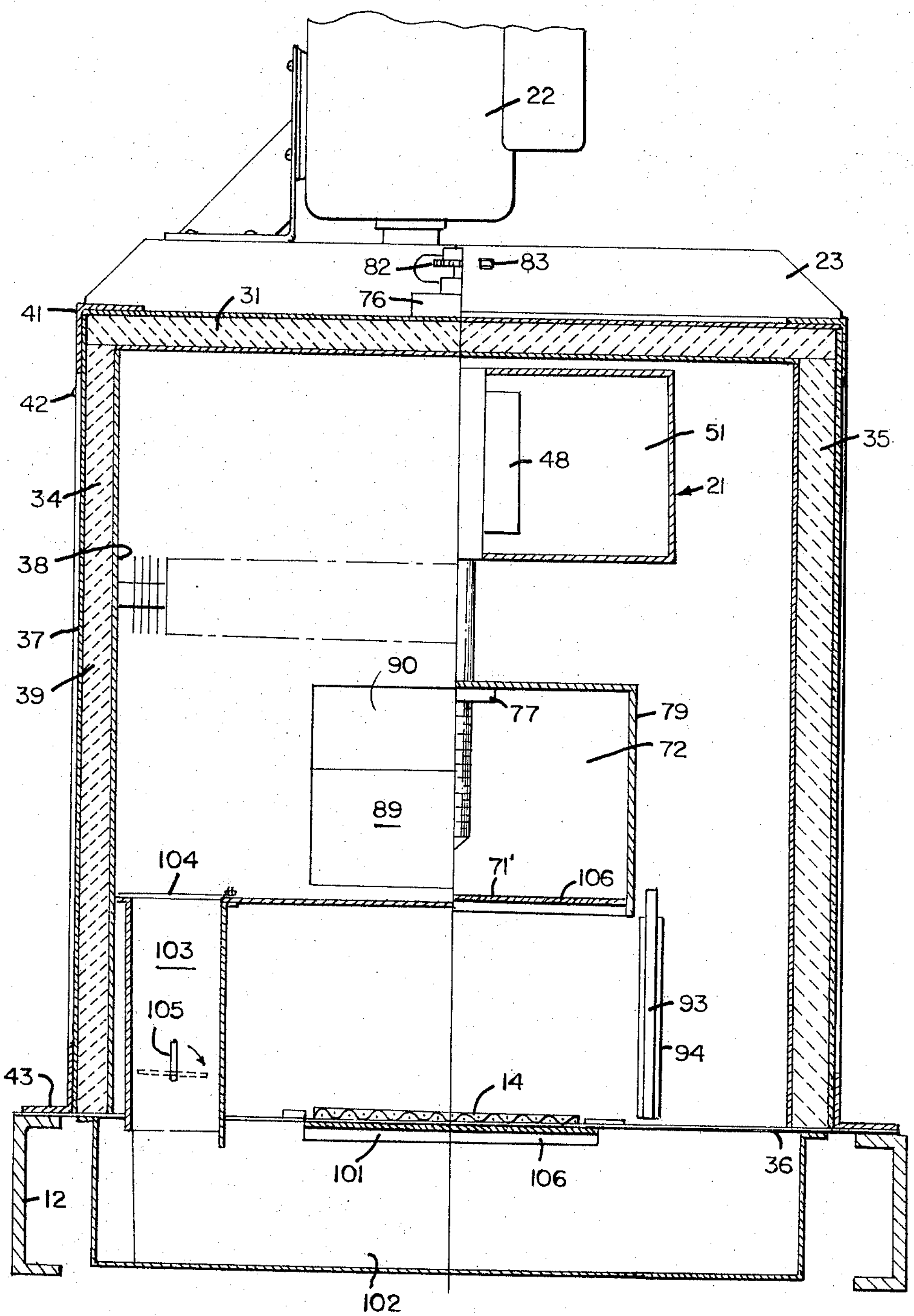

FIG. 5

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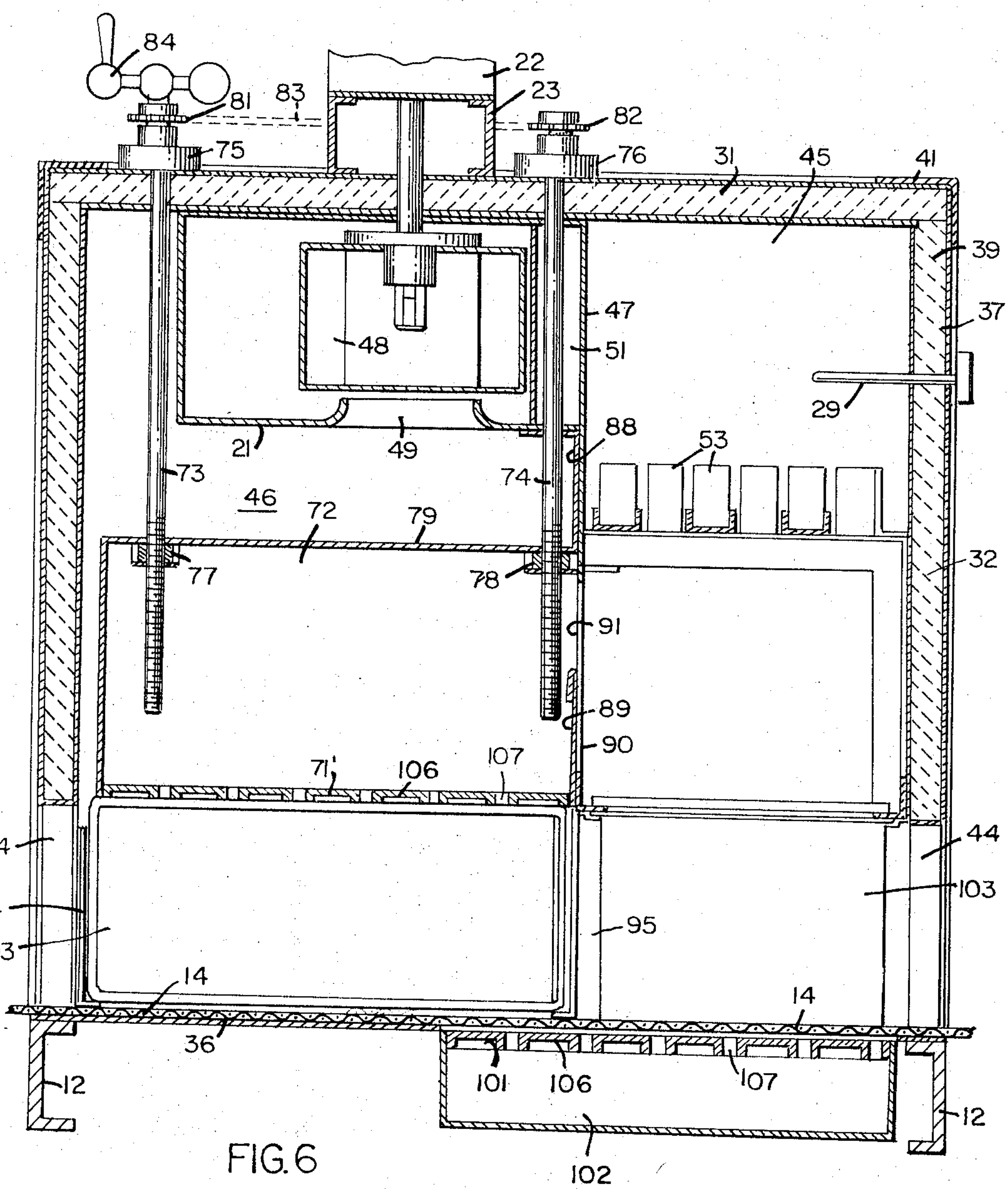

FIG. 6

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SHRINK TUNNEL

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8 Claims. (Cl. 219—388)

This invention relates to a hot air shrink tunnel for shrinking packages formed from heat shrinkable plastic films about articles contained therein. More especially it relates to a shrink tunnel adapted to direct to a flow of hot air at a relatively high velocity directly against the surface of a package formed of heat shrinkable film in such manner that the film shrinks uniformly without any local overheating.

The shrink packaging technique has become an important factor in the flexible packaging art in recent years. In this technique the article to be packaged is placed in a loosely fitting bag or overwrap of a flexible plastic material in film form capable when heated to an elevated temperature below its melting point of substantially reducing its area (i.e. shrinking). Thereupon the film is heated to its shrinking temperature and the loosely fitting bag or overwrap shrinks into a tight attractive conforming fit with the contents of the package. Unless for some particular reason some special effect is desired the shrinkage of the film is carried out ideally under conditions wherein all portions of the film are heated uniformly to the shrinking temperature and wherein little, if any, heat is transferred to the contents.

When the shrink packaging art was first developed the film then in common use had a shrink temperature below the boiling point of water. Under these circumstances shrinking could be conveniently carried merely by dunking the package into a pot of boiling water, or by passing the package through a deluge of boiling water. Because of the high heat capacity of water, and because of the excellent contact between the water and the film, shrinking could be carried out under these circumstances substantially uniformly in a very short period of time, and if the package was removed from contact with the water soon enough with very little heating of the contents. On the other hand even with these early films which had a low shrinking temperature the hot water technique could not be used unless the package was tightly sealed before shrinking, and unless the film was free of pin holes or other defects. Indeed in most instances it was necessary to evacuate the package before sealing and before shrinking. With the passage of time new films were developed having better physical characteristic than those originally used. But these new films for the most part had a shrinking temperature above the boiling point of water. In a few instances where this temperature was not too much in excess of the boiling point of water solutions such as ethylene glycol solutions having an elevated boiling point where used in place of water. The use of such solutions however, increased the cost of shrinking and increased the possibility of contaminating of the contents of the packages in the event of a leak in the seal or a hole in the film.

To overcome these difficulties and to permit the use of the shrink packaging technique with unsealed packages, hot air shrink tunnels were developed. Such tunnels generally consists of little more than an enclosed box provided with a conveyor belt for carrying the wrapped articles therethrough and with means usually one or more fans adapted to blow air over heated resistance wires (not unlike portable hair driers) for heating the air contained therein. In all of the conventional hot air shrink tunnels the velocity of the air in the region of the packages passing therethrough is relatively low. When used with films that are relatively easy to shrink, acceptable, though not ideal results, may be obtained in such tunnels using air

heated to a moderate temperature. Frequently however, since the rate of heat transfer from the air to the film is relatively low the product within the film takes heat out of the film faster than it can be put into the film from the air, and as a result the product at least where it is in contact with the film heats excessively and the film shrinks unevenly with wrinkles being produced where the product touches the film.

The only way in a conventional low velocity oven to increase the rate of heat transfer from the air to the film is to increase the air temperature. While such a measure may improve the shrink where the film comes into contact with the product it creates serious difficulties where the film is out of contact with the product. In such areas the film tends to be overheated resulting in a degradation of physical properties, or even in the melting of the film. Thus a conventional low velocity hot air shrink tunnel is of limited usefulness with many films. If the air is hot enough to heat the film which is in contact with the product to the shrinking temperature the film out of contact with the product may be degraded or even destroyed. On the other hand, if the temperature is maintained at a moderate enough level not to excessively degrade or destroy the film out of contact with the product the shrinkage of the film where it is in contact with the product may be incomplete. In general the more narrow the range of temperature at which the film will shrink without melting, the more serious this dilemma becomes and this problem has become particularly serious with polypropylene for example, which must be heated to 300° F. to obtain a 40% shrink but which melts at 340° F. approximately.

In order to overcome the difficulties inherent in the conventional prior art hot air shrink tunnels I have developed a hot air shrink tunnel that incorporates several desirable features. In order to increase the quantity of heat available for transfer to the film a large volume of air is directed against the surface of the package. This air is recirculated in a closed system in order to conserve the heat content thereof. In order to break up and blast away the dead laminar layer of air which surrounds any solid object such as a package, and to allow the heated air to come into intimate contact with the film thus transferring its heat to the film very rapidly these large volumes of heated air are impinged directly on the package in the form of jets or cascades having a velocity of 1500 to 2000 and preferably 3000, or even more feet per minute.

I have found that with the use of large volumes of air directed against the package in the form of high velocity jets or cascades the film in the package is uniformly heated to shrink temperature very rapidly even when the temperature is maintained at a level which is little, if any, higher than the desired shrink temperature. The rapid heating means that the package can be passed through the shrink tunnel very rapidly and the shrink can be accomplished with very little warming of the product within the film. The uniform heating of the film to the shrink temperature produces packages of outstanding attractiveness.

My improved shrink tunnel is adapted to direct the high velocity jets of hot air directly against the top and both sides of the package; directly against the top and the bottom of the package or both. In addition, since jets or cascades of high velocity air tend to diffuse and lose their velocity rapidly as they pass through regions of relatively calm air, means are provided for adjusting the location of the source of such jets or cascades easily and rapidly from the outside of the tunnel even while the tunnel is in full operation. Because of its compact and efficient design my new tunnel can be produced and sold competitively with conventional shrink tunnels.

These and other features of my new shrink tunnel can be best understood by reference to the description which follows taken in connection with the drawings, in which:

FIG. 1 is an overall view in perspective elevation of the shrink tunnel of the present invention.

FIG. 2 is a front elevation in cross section on lines 2—2 of FIG. 4.

FIG. 3 is a side elevation in cross section along line 3—3 of FIG. 4.

FIG. 4 is a top view with the covering layer of insulation removed.

FIG. 5 is a front elevation in cross section along line 2—2 but showing a modification of the shrink tunnel.

FIG. 6 is a side elevation in cross section along line 3—3 showing the same modification as shown in FIG. 5.

The shrink tunnel of the present invention generally comprises an oven indicated generally in FIG. 1 at **11** which is mounted on a base **12** and is provided with a tunnel **13** for the passage of articles therethrough. A conveyor belt **14** is provided to carry packaged articles through tunnel **13**. Conveyor belt **14** may either be a part of a packaging line or as shown a separate conveyor belt **14** mounted on pulleys **15** and **16** which pulleys are mounted on braces **17** and **18** mounted on base **12** may be provided. The return run of belt **14** passes beneath base **12**. Base **12** is mounted at the desired height on some convenient support such as leg structure **19**.

Oven **11** is provided internally with a blower **21** powered by blower motor **22** which is mounted externally of oven **11** on the top thereof on blower support brace members **23**. Conveyor belt **14** may be driven by conveyor drive unit **24** which preferably consists of motor **25** and reduction gear **26** mounted on conveyor drive base member **27** supported on leg member **19**. A junction box **28** containing the blower motor control, the drive motor control, and the thermostatic control for the heaters may be mounted on the side of oven **11**. A thermometer **29** may be provided to give visual indication of the air temperature within oven **11**.

Oven **11** is a totally enclosed box-like structure provided with a top wall **31**, two end walls **32** and **33**, two side walls **34** and **35** and a bottom **36**. Walls **31, 32, 33, 34** and **35** are provided with a layer of insulating material to prevent or at least to minimize heat transfer from within the oven to the outside, and the walls may conveniently be formed from a sandwich comprising an inner and an outer sheet metal skin (indicated generally at **37** and **38**) with a layer of insulating material (indicated at **39**) therebetween. Oven **11** may be conveniently assembled using an external frame indicated generally at **41** formed of angle irons to which the walls are fastened as indicated generally by fasteners **42**. Base **12** is formed of assembled channel irons of substantial depth fastened together in a suitable manner. Oven **11** is fastened to base **12** by means of angles **43** which extend along the base of side walls **34** and **35**. Entrance to tunnel **13** is provided by an opening **44** of convenient height and width formed adjacent base **12** in each end wall **32** and **33** at a point midway between side walls **34** and **35**. Openings **44** may be provided with a flexible curtain (not shown) if desired to close off the entrance and to reduce the loss of heated air from the interior of oven **11**. Conveyor **14** is arranged to pass through openings **44** in contact with bottom **36** of oven **11** or a suitable slide member arranged thereon. In the version shown in FIGS. 1, 2, 3 and 4 where the air flow is directed at the packages entirely from the top and the sides belt **14** may be a conventional temperature resistant conveyor belt. In the modification shown in FIGS. 5 and 6 where the air is directed onto the packages from underneath an apertured belt, such as a wire mesh belt, must be used.

The upper portion of oven **11** is divided into two chambers, air feed chamber **45** and air return chamber **46**, by means of a partitioning wall **47** which extends vertically between side wall **34** and side wall **35** from top wall **31** to a point about level with the top of openings **44**. The bottom of air feed chamber **45** is defined by floor member **55** which extends horizontally between side walls **34** and **35** and between end wall **32** and vertical wall **47** at substantially the height of opening **44** of tunnel **13**. Blower **21** which is located in the upper end of air return chamber **46** is a conventional centrifugal blower with a rotor indicated at **48**, an air intake indicated at **49**, and an air outlet indicated at **51**. Outlet **51** fits closely into a matching aperture formed in vertical wall **47** so that all of the air passing through blower **21** is forced into the top of air feed chamber **45**. Blower **21** is of such capacity that the total volume of air contained within oven **11** is circulated many times a minute. Typically blower **21** has a rate of capacity in cubic feet per minute 40, 80 or even more times the volume of oven **11** in cubic feet. The air flow is generally downward in air feed chamber **45** and upward in air return chamber **46**.

Air feed chamber **45** is provided at a midpoint with a plurality of heater elements **53** so arranged that all of the air passing through chamber **45** comes into close association with the heated surface associated with heater elements **53**. Preferably heater elements **53** may be electrical fin-strip type resistance heaters arranged side by side horizontally between side wall **24** and side wall **25**. An arrangement of six 1500 watt heaters has proven to be satisfactory for a structure 2′ wide, 2′ high and 2½′ long. It will be noted that because of the substantially complete recirculation of the air within oven **11** once the air within oven **11** is brought up to temperature relatively little additional heat is required to maintain the air at the higher temperature. As the result all of the air within oven **11** remains once it is brought to temperature at essentially the desired temperature. Heater elements **53** are connected to the electrical input for the shrink tunnel through heat insulated junction box **54** located on the outside of side wall **35**. Junction box **54** may be included within junction box **28** or may be mounted separately therefrom. Conventional thermostatic controls (not shown) with the sensing element thereof located in the lower portion of air feed chamber **45** are provided to control the electrical input into heater element **53**. The electrical input to heater elements **53** may be so arranged that a number of these heater elements are disconnected from the power source once the air comes to temperature, and the remaining heaters may be operated under modulated control to avoid excessive temperature variation.

On either side of belt **14** there is provided on the underside of floor member **55** a side air box **57**. Both side air boxes **57** are substantially identical and each comprises a totally enclosed structure indicated generally at **58** having an open top and a removable face plate **59**. Face plate **59** is attached to box **57** by means of bolts **61** associated with brackets **62** mounted on the side walls of box **57**. Each side air box **57** is mounted for laterally reciprocal travel toward or away from the center line of belt **14** on rails **63** mounted on the underside of floor member **55**. The top portion of the side walls of box **57** and of face plate **59** are all located in close association with the bottom of floor member **55** thus making floor member **55** effectively the top of box **57**. An aperture **64, 65** is provided in floor member **55** to permit the passage of air through floor member **55** into each side air box **57**. Apertures **64** and **65** are so positioned that all portions of each such aperture opens only to the interior of the associated side air box **57** independent of the lateral position of that air box. A screw member **66** pivotally mounted on side walls **34, 35** and provided with an external crank **67** passes into each said box **57** through the rear wall thereof and cooperates with a threaded member **68** affixed thereto provided to adjust the lateral position of each said box **57** independently. Thus the position of each side air box **57** may be adjusted laterally and independently merely by rotating the appropriate crank 67 located outside of oven 11.

Face plate 59 is a plate of substantial thickness and is provided with a plurality of spaced apertures 69 each acting as a nozzle directing the flow of air passing therethrough. Apertures 69 may be directed horizontally or may be directed at an angle for instance, downwardly as indicated. Since side air boxes 57 fit closely against the bottom of floor member 55 substantially all of the air passing from air feed chamber 45 through either aperture 64 or 65 must pass through apertures 69 in face plate 59 of the appropriate box 57, and is directed against the appropriate side of packages passing along belt 14. In use boxes 57 which are adapted to pass above belt 14, are adjusted to a position where face plates 59 are in close proximity to the side of the packages passing along belt 14. The adjustability afforded by crank 67 and screw member 66 permits ready relocation of boxes 57 from outside oven 11 in order to accommodate packages of varying width.

Air is directed onto the top of packages passing along belt 14 from face plate 71 on the bottom of top air box 72. Top air box 72 is suspended from top 31 of oven 11 by means of screw members 73 and 74 pivotally mounted at 75 and 76 to top 31 and passing through threaded members 77 and 78 affixed to the top of body 79 of top air box 72. Screw members 73 and 74 are interconnected by drive means including sprockets 81, 82 and chain 83 and are driven simultaneously by crank 84. The vertical position of box 72 is adjusted by turning crank 84. Face plate 71 is fastened to body 79 of air box 72 by means of bolts 85 and brackets 86 and similar to face plates 59 is provided with a plurality of air directing apertures 87.

One end of top air box 72 fits closely against vertical wall 47 and air is admitted into air box 72 through apertures 90 formed in wall 47 above floor member 55. In order to insure that the effective aperture will remain constant in area the end of air box 72 adjacent wall 47 is provided with two vertical baffles 88 and 89. Baffle 88 extends vertically from the top surface of box 72 adjacent wall 47 and baffle 89 extends vertically from the bottom of box 72 adjacent wall 47. Baffle 89 terminates short of the top of air box 72 forming aperture 91. Aperture 91 registers with aperture 87 in every position of top air box 72. Baffle 88 prevents leakage of air from the top portion of aperture 90 when top air box 72 is in a lowered position. As a result the effective aperture leading into air box 72 remains substantially constant no matter what position air box 72 may be adjusted to. Face plate 71 of top air box 72 forms the top of tunnel 13 in air return chamber 46.

The sides of tunnel 13 in air return chamber 46 are formed by screens 92 and 93 which extend upwardly from bottom 36 between wall 47 and end wall 33 immediately adjacent the sides of top air box 72. The air forced in to tunnel 13 passes through either screen 92 or screen 93 and to return air chamber 46 where it is drawn into the intake 49 of blower 21. Screens 92 and 93 are mounted for easy removal in vertical channels 94 affixed to the surface of wall 33 and channels 95 depending from wall 47. The function of screens 92 and 93 is to prevent the introduction of foreign material into the air stream.

The velocity of the air passing through air directing apertures 87 and face plate 71, or air directing apertures 69 of face plate 59 is determined primarily as a matter of simple design, the velocity in each case being the function of the volume of air passing through the particular air box in a unit of time divided by the effective total area of the apertures. Where the relative total area of the apertures is small thus giving a relatively high air velocity a substantial back pressure develops in each of the air boxes and in air feed chamber 45 tending to equalize the proportional flow through each of the air boxes and through each of the apertures in the face plate of each. Dampers may be provided in association with each of the apertures leading to an air box, or in association with each of the face plates to further control relative air velocities.

It has been found that with an apertured plate the high velocity air dissipates after a distance which is dependent upon the open area of the apertures and the proximity of surrounding apertures. For ¼″ diameter holes located ¾″ on centers the high velocity air persists about 2 inches of travel away from the face plate. Therefore, to obtain the full beneficial effect of the high velocity jet these face plates should be adjusted to within 2 inches of the side or the top as the case may be of the packages passing along belt 14. It has been found that to obtain the maximum distance of persistence of the jet the thickness of the face plate in the region of the aperture must be equal to or greater than the diameter of the individual apertures.

The modification shown in FIGS. 5 and 6 varies in two respects from that version of the shrink tunnel of the present invention shown in FIGS. 1 through 4. One such variation lies in the fact that the face plates of the air boxes or plenum chambers are provided iwth channeled slots instead of perforations. A second variation is that means are provided for directing high velocity air against the bottom of the packaged articles from beneath conveyor 14. It is obvious that the slotted face plates may be substituted for the apertured face plates as shown in FIGS. 1 through 4 and that a shrink tunnel may be provided in which air is directed against the packaged article from the top, the sides and the bottom, as well as either the top and the sides or the top and the bottom.

In providing the shink tunnel with means for directing air onto the packaged articles from beneath, an elongated aperture into which is inserted face plate 101 is provided in bottom 36 beneath belt 14. A bottom air box or plenum chamber 102 is provided fastened to the underneath of bottom 36. Air is supplied to bottom air box 102 on either side of tunnel 13 by means of passages 103 which lead from apertures 104 provided in floor member 55 of air feed chamber 45 through cooperating apertures provided in bottom 36 to bottom air box 102. A damper 105 may be provided in passage 103 to adjust the proportional air flow through face plate 101 as compared to the air flow through face plate 71′ of top air box 72. Since bottom air box 102 is located beneath the level of bottom 36 it may extend as far along the path of belt 14 as may be desired without alteration of the basic structure of the shrink tunnel. Face plate 101 throughout its length extends substantially the full width of belt 14, which belt as mentioned above, is provided with suitable apertures to permit a substantially unimpeded flow of high velocity air therethrough.

In the slotted face plate structure as shown in face plate 71′ and face plate 101 in FIGS. 5 and 6, air passages are provided by mounting channel elements 106 on a frame (not shown) with gaps or passages 107 between adjoining channel elements. In the slotted face plate as in the case of the face plate provided with apertures, a desirable well directed blast of air is achieved when the height of the wall in the gap is equal to or greater than the width of the gap. Thus in a typical slotted face plate the channel elements are approximately 3⅜ inches wide; the gap between adjoining elements is approximately ⅜ inch and the height of the wall in the gap is approximately ½ inch. It has been found that such a face plate works almost equally effectively in creating well directed high velocity blasts of air independent of the direction of the air flow therethrough. In order to obtain uniform shrink however the gaps should be arranged transversely to the direction of travel of the packages through the tunnel so that all portions of the package pass through the same curtain of air. One particular advantage of the slotted face plate structure over the apertured face plate structure shown in FIGS. 1 through 4 lies in the fact that the high velocity of the jets or cascades of air emitted through the slots persists under operating conditions for approximately 4 inches as compared to the two inch persistence of the jets created by the apertured face plates. This difference is presumably due to the reduced interference between adjoining air streams in the slotted face plate as compared to the apertured face plate.

It will be noted that the modifications to the basic shrink tunnel shown in FIGS. 1–4 to equip such a tunnel for a bottom air flow as shown in FIGS. 5 and 6 are relatively minor. For this reason the common elements in both showings have been given the same reference number. It will be further noted that passages **103** which feed air to bottom air box **102** have been placed adjacent to side walls **34** and **35** to permit the addition of side air box structures similar to side air boxes **57** as shown in FIGS. 2 and 3. It is contemplated that in the event that both a bottom air box and side air boxes are provided separate apertures feeding such air boxes would be provided in floor **55**.

A particular advantage of the shrink tunnel shown lies in the fact that substantially full recirculation of the air is achieved. This is accomplished by the fact that the return air passage through the tunnel **13** and return chamber **46** is completely free and unimpeded and that all portions of air feed chamber and the respective air feed boxes where the air is under pressure are completely sealed from the outside. This permits very large volumes of air as compared to the volume of the shrink tunnel itself to be recirculated at a relatively low cost for the energy required to heat the air. A large volume of recirculated air effectively prevents the creation of any hot spots but rather permits all of the air within the shrink tunnel to be maintained at substantially a uniform temperature. The use of apertured face plates to restrict the large volume flow of air causes an appreciable static pressure to be built up behind the face plate. When the air escapes through an aperture in the face plate, it is driven at high velocity. Thus the large volume of recirculated air, together with the pressure build up behind the face plates, permits the establishment of high velocity air jets or cascades which effectively scour the surface of the packages as explained above. This scouring increases the rate of heat transfer very drastically and the large volume of air involved has a sufficient capacity to heat the film to the shrinking temperature very rapidly (without cooling the air appreciably) thus achieving a very rapid and uniform shrinkage of the film using air which is heated only to the desired shrink temperature. The relatively low temperature of the air as compared to the conventional shrink tunnel and the rapid passage of the package through the tunnel permitted by the high rate of shrink practically eliminates any possibility of the contents of the package being heated or the wrapping film being damaged.

I claim:

1. In a shrink tunnel for shrinking heat shrinkable film into close contact with the contents of a package formed at least in part therefrom, said tunnel including a box-like structure having a passage permitting transport of packages therethrough, means for transporting packages in a predetermined path through said passage, circulating means for circulating the air contained therein, heating means for heating the air contained therein, said circulating means having a circulating capacity expressed in terms of volume of air circulated per minute substantially in excess of the cubic capacity of said structure, a first duct means for directing the air from the circulating means to

the vicinity of said passage, and a second duct means for directing the air from said passage to said circulated means, said first duct means including a stationary enclosed air feed chamber and at least one movable enclosed air feed box, one side of said box arranged parallel to and contiguous to one side of said chamber, said air feed box having an apertured baffle plate in one wall thereof, the wall of said box including said baffle plate forming a wall of said passage, the adjacent contiguous sides of said chamber and said box being provided with mating apertures for the passage of air therethrough, the effective area of said apertures being substantially greater than the total area of the apertures in said baffle plate whereby air is maintained under a substantial pressure within said chamber and said box and is forced through the apertures in said baffle plate at a high velocity, and baffle plate positioning means for adjusting the position of said box toward and away from the predetermined path whereby the clearance between the baffle plate and the packages being treated may be adjusted and the air may be directed directly onto the surface of the packages.

2. A shrink tunnel as claimed in claim **1** wherein the baffle plate positioning means are actuatable externally of said box-like structure whereby the location of said baffle plate may be adjusted while said tunnel is in use.

3. A shrink tunnel as claimed in claim **2** wherein the velocity of the air emitted from said apertured baffle plate is at least 1500′ per minute.

4. A shrink tunnel as claimed in claim **2** wherein said apertured baffle plate has a substantial thickness and the apertures therein comprise a plurality of spaced holes passing therethrough.

5. A shrink tunnel as claimed in claim **2** wherein said apertured baffle plate comprises a plurality of spaced parallel channel members, the space between adjoining said members forming a restricted channel for the passage of air therethrough.

6. A shrink tunnel as claimed in claim **2** wherein an adjustable apertured baffle plate is provided in the top and along at least one side of said passage.

7. A shrink tunnel as claimed in claim **2** wherein an adjustable apertured baffle plate is provided in the top of said passage, a fixed apertured baffle plate is provided in the bottom of said passage, and said package transport means includes an apertured conveyor means.

8. A shrink tunnel as claimed in claim **2**, wherein all the air passing from said first duct means to said second duct means passes through said passage, and wherein, in a portion of said passage, screen members are provided, said screen members forming the entrance to said second duct means from said passage.

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