

March 22, 1938.

H. H. ROBSON

2,111,938

AIR CIRCULATING METHOD AND APPARATUS

Filed May 24, 1933

4 Sheets-Sheet 1

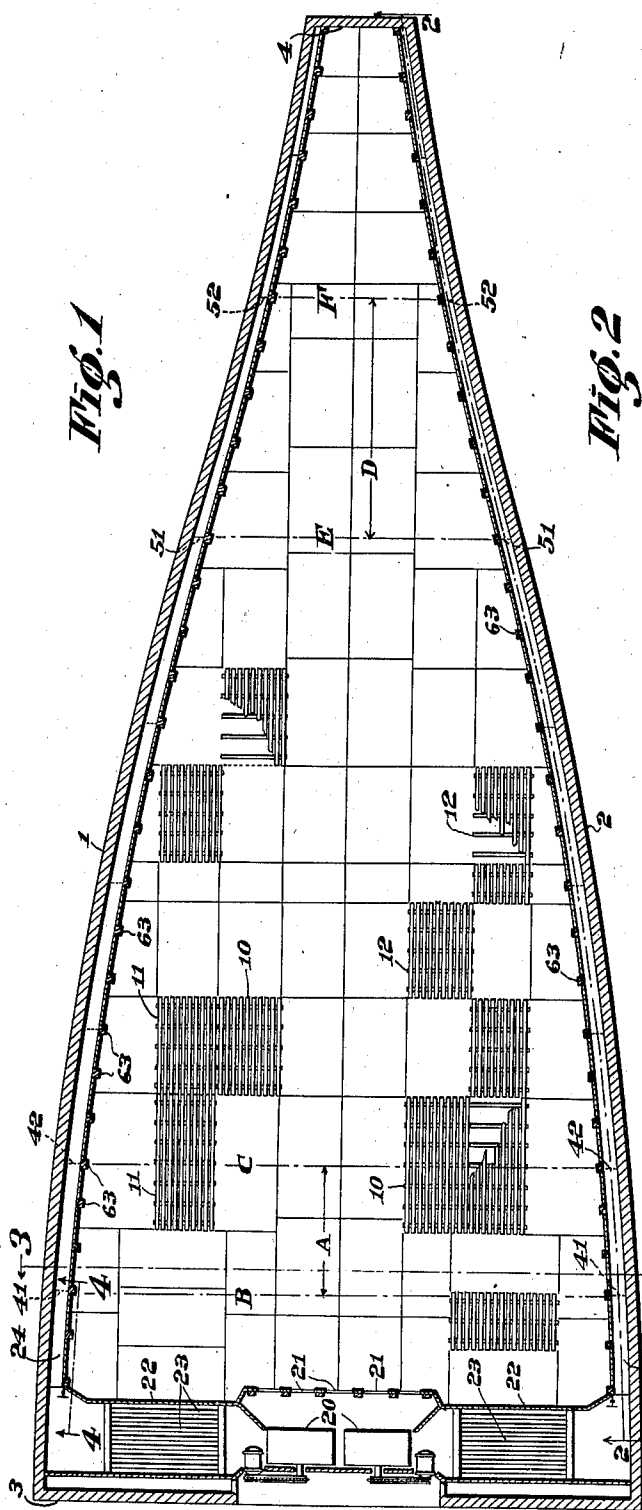
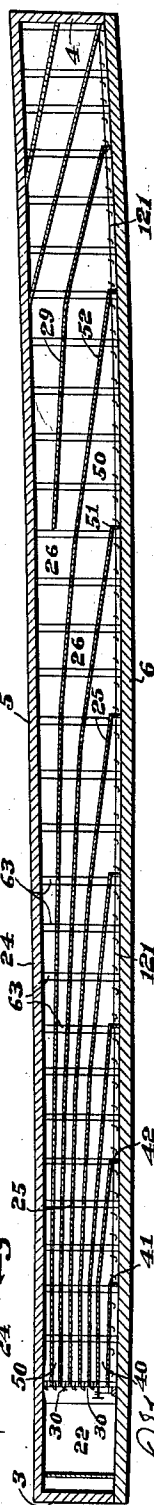
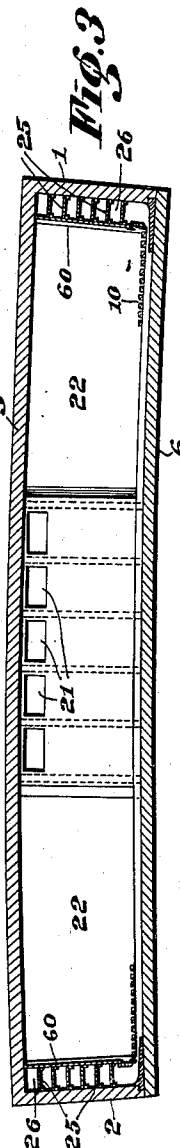


Fig. 2



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4 Sheets-Sheet 2

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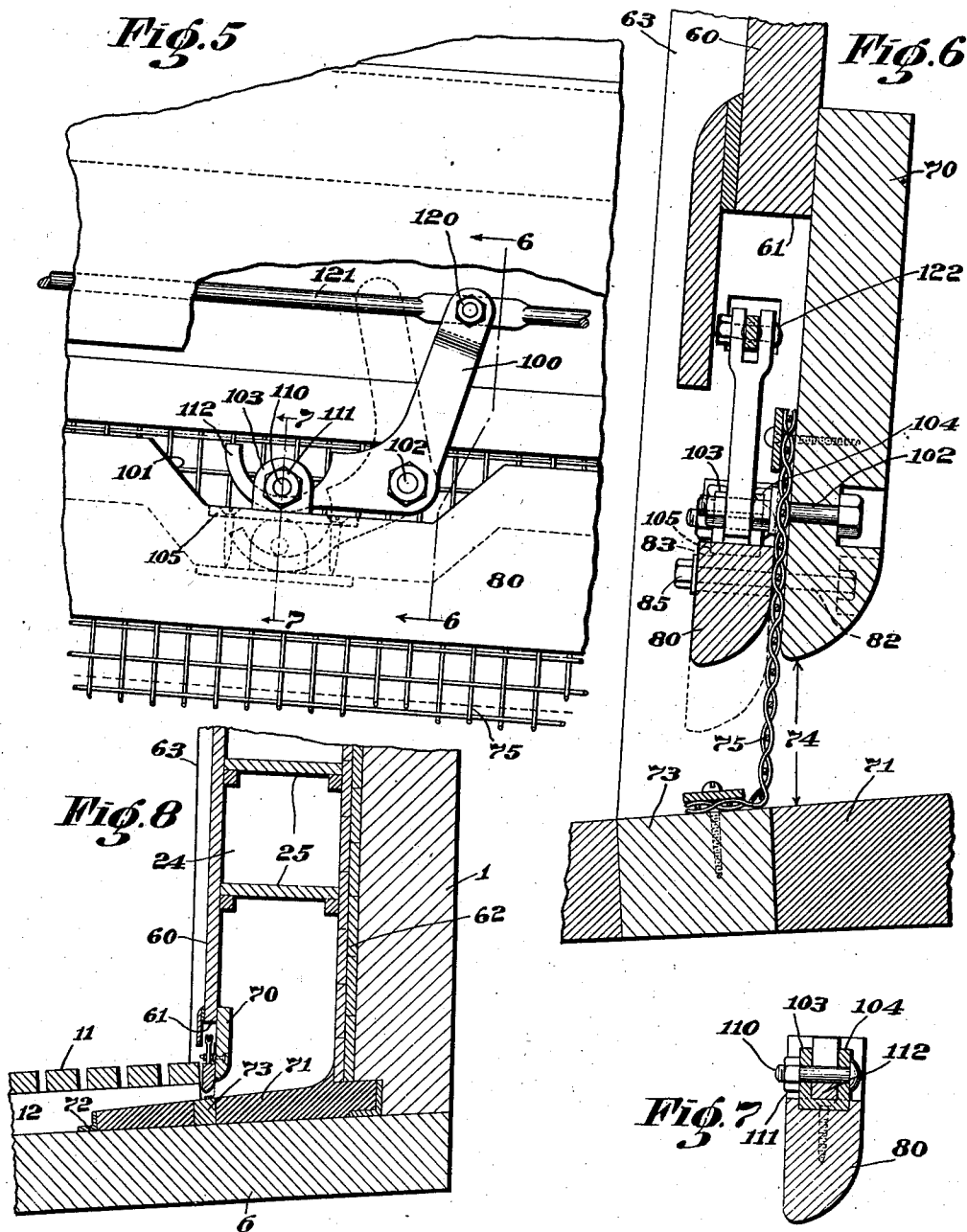
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AIR CIRCULATING METHOD AND APPARATUS

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4 Sheets-Sheet 3



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March 22, 1938.

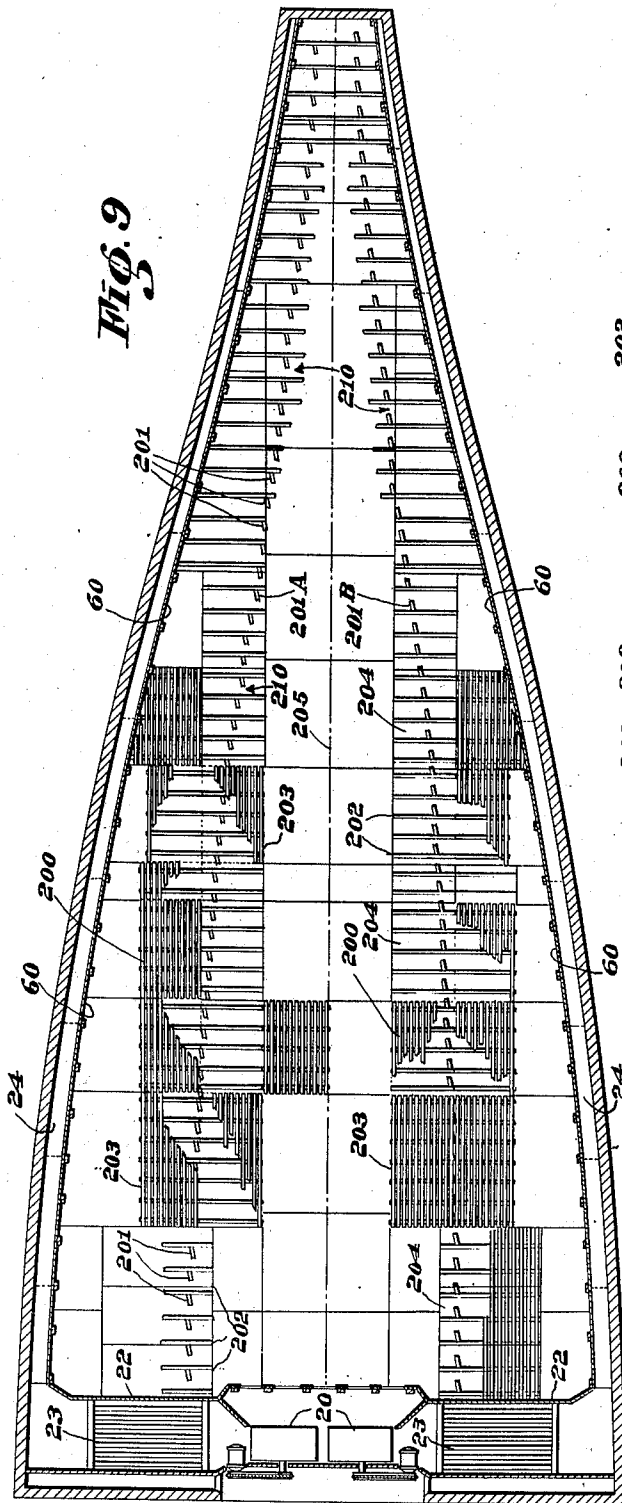
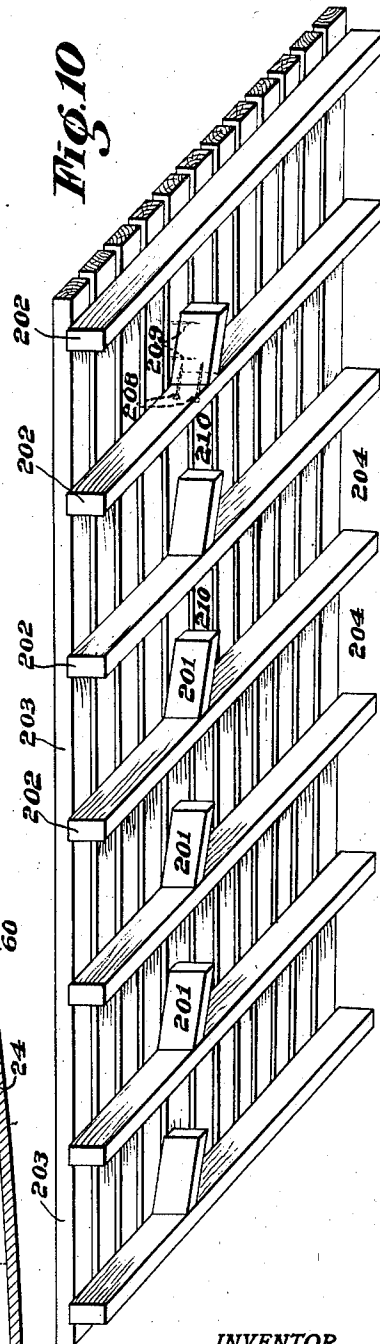
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AIR CIRCULATING METHOD AND APPARATUS

Filed May 24, 1933

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,111,938

AIR CIRCULATING METHOD AND APPARATUS

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Application May 24, 1933, Serial No. 672,602

17 Claims. (Cl. 98—52)

This invention relates to air circulating systems for use on board ship for preserving perishable cargo, and particularly to an improved apparatus and method for securing a uniform distribution of air currents throughout the compartment and for controlling the quantity of air flow while maintaining said distribution.

In transporting perishable cargo such as fruit, and particularly bananas, it is desirable to preserve the natural fresh condition of the cargo during shipment and the systems which have been generally adopted for this purpose have employed circulating currents of cold air. For uniform refrigeration of all portions of the cargo, it is essential in such systems to effect an even distribution of air currents throughout the entire space occupied by the cargo and such distribution has presented a problem due to the practicable inability of controlling the direction of air flow after the air has been introduced to the cargo compartment. Systems in which the air is introduced to the compartment at the bottom, beneath a perforate floor grating on which the cargo is supported, have employed outlet return ducts adjacent the ceiling of the compartment and provided with a large number of adjustable apertures to provide points of suction or low pressure at predetermined portions of the space above the cargo in an attempt to effect uniform distribution. Although such overhead return ducts may contribute toward the desired distribution at maximum volumes of air circulated, their effectiveness for this purpose has been limited even at maximum volumes, and at reduced volumes they have had almost no effect, and as they are expensive to install and involve a waste of valuable cargo space, such overhead ducts have not found favor in the art. In my prior Patent No. 1,835,085, granted December 8, 1931, I have disclosed a system in which the overhead duct is eliminated and distribution of the air lengthwise of the compartment is effected by conducting the air streams along each side of the compartment and to various predetermined portions of the bottom thereof through a number of downwardly sloping passages. It is an object of my present invention to improve on the construction disclosed in my prior patent by providing a method and apparatus which secure a still better distribution whereby to insure a more uniform flow upwardly through the cargo at all portions of the compartment.

Fruit is warm when loaded on the vessel at tropical ports and in order to properly preserve the fruit and retard the inherent ripening activ-

ity, the initial high temperatures of the fruit should be quickly reduced. This rapid reduction in temperature may be effected by employing large volumes of circulating cooled air. After the temperature of the fruit has been properly lowered, the volume of air circulated should also be reduced to prevent drying of the fruit and thus for efficiency of operation it is most desirable to be able to control the quantity of air circulated. However, such changes in the rate of air flow have heretofore produced troublesome changes in the distribution of the air currents through the fruit because of variations in the velocity of the air entering the compartment resulting from such different rates of flow.

It is my further purpose to provide a method and apparatus which not only afford the desired uniformity of distribution but which also include a system of controls adapted to vary the quantity of air distributed while, at the same time, maintaining the desired distribution.

These and further objects will appear from a detailed description of my novel apparatus and method taken in connection with the accompanying drawings, in which:

Fig. 1 is a plan view, partly in section, of a cargo compartment;

Fig. 2 is a sectional elevation view taken substantially along the line 2—2 of Fig. 1;

Fig. 3 is a sectional elevation view taken on the line 3—3 of Fig. 1;

Fig. 4 is an enlarged detail elevation view taken on the line 4—4 of Fig. 1;

Fig. 5 is an enlarged detail elevation view of my preferred construction of inlet aperture shutter;

Fig. 6 is a sectional elevation view taken on the line 6—6 of Fig. 5;

Fig. 7 is a sectional elevation view taken on the line 7—7 of Fig. 5;

Fig. 8 is a sectional elevation view of a side air duct;

Fig. 9 is a plan view of a cargo compartment showing a modification of my preferred control means; and

Fig. 10 is a bottom perspective view of a section of floor grating showing the baffles as used in my modified construction.

Referring to the drawings, the cargo compartment is defined generally by the sides 1 and 2 of the ship (Fig. 1), the bulkheads 3 and 4 and the upper and lower decks 5 and 6 (Fig. 2). The cargo rests on a floor grating 10, which, as indicated in Fig. 1, comprises a number of beams 11 extending in a direction lengthwise of the ship

and spaced from the bottom deck by the bearers 12 running in a crosswise direction. I have indicated diagrammatically in the drawings a floor grating which is constructed in sections, as in practice, whereby the grating may be easily removed for cleaning the lower deck, the individual grating sections being constructed to fit together and provide an assembled perforate flooring co-extensive with the entire lower deck of the compartment and uniformly spaced therefrom.

The general type of air circulating system which, as described in my prior patent above noted, I have found best adapted for refrigerating perishable cargo in such compartments, comprises, in general, a pair of fans 20 disposed at one end of the compartment and adapted to withdraw vitiated air from the interior of the compartment through apertures 21 (Fig. 3) located near the upper deck 5. The air is forced by the fans 20 to port and starboard through the end air duct 22 which encloses suitable temperature reducing means 23, such as cooling coils containing circulating brine, and the air, after becoming chilled through contact with the cooling coils, passes lengthwise of the ship through the side air ducts 24 lining both sides of the compartment. The ducts 24 are similar in construction and, as indicated in Fig. 2, each of them encloses a plurality of sloping air directors 25 which are substantially horizontally disposed at the air entrance end of the side air duct 24 and slope downwardly to various portions of the bottom thereof. The bottom extremities of the side air passages 26 defined by adjacent pairs of continuous air directors communicate with various predetermined portions of the space beneath the floor grating and the air passing under the grating from both sides of the ship passes toward the center line of the compartment and rises upwardly through the entire volume of cargo resting on the perforate floor grating. After passing through the cargo the air is drawn lengthwise of the compartment, passing out through the openings 21 and the circulation cycle is repeated.

As described in my above noted patent, I provide at the entrance to each of the passages 26, a door 30 (see also Fig. 4) adapted to vary the opening at the air entrance end of the passage. By suitable positioning of the doors 30 I am able to compensate for the relatively larger air resistance in the side passages which extend for a considerable distance lengthwise of the compartment whereby, as described hereafter, to provide for the passage of equal volumes of air through the passages regardless of the length of travel of the air from the air entrance end of the side duct.

It will be noted from Fig. 1 that the taper of the ship as it extends fore or aft of amidships results in a converging of the side air ducts, and it has been found that if equal volumes of air are delivered to equal portions of floor grating lengthwise of the ship, the air flow will either be insufficient to reach the center line at the broader portions near amidships, or will rush to the center line at the tapered portions without passing upwardly through the cargo disposed in proximity to the sides of the compartment at the narrow portions. It has been found that this disadvantage can be obviated by providing that the equal volumes of air, which, as stated above, pass through each of the side air passages 26 defined by the sloping air directors, are delivered to substantially equal volumes of cargo. To this end, those side air passages which com-

municate with the narrower portions of the compartment are constructed to deliver air to greater portions of floor grating lengthwise of the compartment than the passages which lead to the broader portions of the compartment nearer amidships. Thus as indicated by a comparison of Figs. 1 and 2, the air passage 40 delivers air to a volume of cargo space defined by the height of the compartment, the distance lengthwise of the ship between the extremities of the air directors 41 and 42 (which distance I have indicated at A in Fig. 1), and the distance crosswise of the ship defined substantially by the mean of the distances B and C between the sides 1 and 2 of the ship. The passage 50 extending a greater distance lengthwise of the compartment is constructed to feed to a volume of cargo space equal to that above defined as fed by the passage 40 by spacing the delivery end of the air directors 51 and 52 relatively far apart so that the distance D lengthwise of the ship will, for the relatively narrower mean crosswise dimension (the average of E and F), define a volume of cargo equal to that fed by the passage 40. If desired an additional air director section, such as is indicated at 29 in Fig. 2, may be used in the wider air passages.

I have found in practice that when the air which is forced through the side air ducts 24, is deflected downwardly by the air directors 25, there is a marked tendency for the air to pile up against the bottom of the forward air director defining a side passage, so that, taking for example the pair of directors 51 and 52, there will be a large amount of air passing upwardly through the cargo along the area immediately behind the dotted line F, and an insufficient supply in the area immediately forward of the line E.

Referring to Figs. 4-8 inclusive, I will now describe my novel construction of side air duct with which I am able to obviate this unbalanced distribution lengthwise of the compartment and secure a substantially uniform flow of air through all portions of grating throughout the entire compartment. In constructing the side air ducts 24, a number of posts 63 (Figs. 1 and 2) are erected between the upper and lower decks 5 and 6 and the air directors 25, suitably sloped and spaced vertically from each other, are supported between the posts 63 and the heat insulating material 62 (Fig. 8) which lines the inner surfaces of the ship's sides. The partition 60, which defines the side duct, comprises a number of boards laid vertically against the air directors 25 and between the posts 63, (Fig. 4), the said partition being flush with the upper deck but terminating some distance above the lower deck and floor grating as indicated at 61. A longitudinal member 70, which supports my novel shutters 80 to be described, is then laid against the inner surfaces of the posts 63, running the full length of the duct 24 and fitting tightly against the lower margin of the partition 60. As indicated in Fig. 8 the surface of the lower deck 6 in proximity to the side duct 24 is lined with heat insulating material 71 which may comprise an initially plastic substance retained in place by angle irons 72. A piece of timber 73 is laid the full length of the duct 24, resting on the lower deck 6 and positioned vertically below the edge 61 of the partition 60. By this construction, the side duct 24 communicates with the interior of the compartment through a large number of apertures 74, all of substantially the

same size and each bounded on the top and bottom by the members 70 and 73 (or the heat insulating material 71) and on the sides by adjacent posts 63. These apertures are covered by a perforate rat-proof screening 75.

To obviate the above described unbalanced air flow, lengthwise of the compartment, in various portions of the area of floor grating fed by a single sloped side air passage, I provide that the several apertures 74 leading from any one passage are progressively varied in size to reduce the normally large flow adjacent the forward air director of a passage and to increase the flow near the director forming the rear boundary of the passage. For that purpose I provide a plurality of shutters 80, each one of which, as shown in Fig. 4 extends between a pair of adjacent posts 63 and bounds the upper edge of an aperture 74. The posts 63 are each recessed at 81 to receive the extremities of the shutters 80, said recesses being elongated to permit vertical movement of the shutters 80. The shutters are temporarily secured to the lower margin of the member 70 by means of the bolts 82 passing through elongated slots 83 in the shutters and having nuts 85 and in this manner I provide for independent vertical movement of each of the shutters whereby the apertures 74 disposed in proximity to the forward air director of a passage may be opened to a lesser degree than those disposed near the rear director. Thus the usually excessive flow adjacent the forward director and the insufficient flow near the rear director may be balanced to provide a uniform flow. It will be noted that although the passages 26 gradually increase in width at the air outlet extremities (Fig. 2), they communicate with the compartment through apertures 74 which are uniform in width whereby there are a larger number of apertures 74 leading from the wider passages than from the narrower ones. I have found that this arrangement contributes to the uniformity of flow due to the fact that the irregularity is greater in the wider passages which, however, are provided with a correspondingly greater number of variable apertures with which to regulate the air flow. For a still finer adjustment I may provide that the shutter nearest the forward director of a passage slant downwardly to provide an angular opening which tapers off to a point as it extends forwardly. Of course, if desired, other of the shutters may also be suitably slanted and in this manner I provide that the normally unbalanced lengthwise distribution is effectively equalized.

As stated above, it is desirable to regulate the volume of air circulating through the cargo (or number of air changes per unit of time) at various stages in the voyage whereby initial high fruit temperatures may be quickly reduced and yet excessively high air velocities may be modified when not required to maintain the fruit at the desired temperature. Such variations in volume of air circulated have been found however to produce an unbalanced transverse distribution due to the fact, as above noted, that the resultant variations in jet velocity at the apertures 74 cause the air either to rush to the center line of the compartment under the grating without passing upwardly through the fruit near the sides of the ship or, if the volumes are decreased, to pass into the compartment at such reduced velocities as not to reach the center line in any substantial amount. To compensate for this tendency toward unbalanced transverse distribution upon fluctuations

in volume distributed and, at the same time to maintain the uniform lengthwise distribution obtained as above noted I provide that the apertures 74 may be not only individually varied in size in the manner and for the purpose above described, but they may also be collectively varied in size whereby to accommodate increased or decreased volumes of air while substantially maintaining uniformity of distribution both lengthwise and transverse of the compartment.

Referring to Figs. 4, 5, and 6, each of the shutters 80 is provided with a pair of bell crank levers 100, each of which levers is positioned in a recess 101 formed in its shutter 80. The bell crank levers are pivoted to studs 102 secured to the supporting member 70 and extending into the recess 101 of the shutter 80. In proximity to the forward end of the horizontal arm of each of the bell crank levers 100, the shutter 80 is provided with a pair of lugs 103 and 104 (Fig. 6) extending upwardly from a plate 105 suitably secured in the upper surface of the recessed portion, as indicated and constituting, as will appear, a supporting bracket for the shutter. A bolt 110 passes through the lugs 103 and 104 and is suitably secured therein by means of the nut 111. The bolt 110 is spaced from the plate 105 to slidably receive an arcuate cam extension 112 formed in the horizontal arm of the bell crank lever 100. The upwardly extending member of the bell crank lever 100 is pivotally connected at 120 to a rod 121 which, as indicated in Fig. 2, extends the full length of the compartment, passing freely through suitable recesses 122 (Fig. 6) in the posts 63 and joining, in the manner above described, the upwardly extending arms of all of the bell cranks. The said rod, at its forward end, is pivotally connected at 123, (Fig. 4), to a lever 124 pivoted at 125 to the frame of the ship. The upper end of the lever 124 is bifurcated at 126 and receives the trunnions 127 on a sleeve 130, screw threaded on a shaft 131 rotated by the hand wheel 132. The rod 121 is suitably supported throughout its length. By this construction it will be apparent that if the shutters 80 are released for freedom of vertical movement by loosening the nuts 85 of the bolts 82 which secure them through the elongated slots to the supporting member 70, rotation of the hand wheel 132 will cause longitudinal movement of the rod 121 and rotation of each of the bell cranks 100 to raise and lower each of the shutters 80 as indicated by the dotted lines in Fig. 5. All of the shutters will be simultaneously raised or lowered a substantially equal amount.

With the construction above described, the operation of effecting an initially uniform air distribution and subsequently varying the volume of air flow while maintaining that distribution is as follows: After the side air ducts 24 are constructed and the shutters 80 put in place with the tightened nuts 85 securing them to the supporting member 70, and before the bell crank mechanism is put in place, the apparatus is tested for air distribution. For this purpose the fans 20 are first rotated at a speed which will produce a volume of air flow which will constitute substantially the average maximum rate of flow in use. A proper positioning of the doors 30 standing at the air inlet end of the side passages 26 will insure an approximate equality of flow through the several passages 26, as is well known. By means of smoke bombs or similar apparatus disposed at various positions on the floor grating, the distribution of air flow can be determined.

If it is found that the flow is excessive, as is common, adjacent that portion of the floor grating near the forward air director defining a side air passage, the shutter 80 controlling the aperture 74 feeding to that portion of the floor grating, may be suitably lowered to reduce the aperture. The shutter 80 is temporarily secured in that position by the bolts 82 and in this manner all of the apertures 74 leading to the compartment may be varied and temporarily fixed to secure a uniform flow of air both longitudinally and transversely throughout the entire compartment including its broad and narrow portions. The bell crank levers 100 are then secured in place with their cam portions passing under and adjacent the bolts 110 in the supporting brackets and the upwardly extending arms of all the bell cranks are then secured to the rod 121. As the shutters 80 are disposed at varying distances above the beam 73 defining the lower edge of the aperture 74, for the purpose above described, the bell cranks 100 connecting the rod 121 and the supporting brackets of the shutters 80 will have to be suitably positioned relatively to the shutters to preserve the temporarily fixed positions of the shutters. This can be readily accomplished in a number of ways, as by cutting the various recesses 101 to different depths in the shutters 80 or by using suitable spacing means or by properly inclining the cam arms 112 of the bell cranks. After the bell cranks have been properly positioned the nuts 85 on the bolts 82 are loosened so that the shutters are supported by the arms 112 of the bell cranks, their varied vertical positions, obtained as above, being maintained. The nuts 85 are not thereafter tightened and the bolts 82 merely act as guides through the elongated slots 83 to permit collective vertical movement of all the shutters 80 as effected by rotation of the hand wheel 132.

In commercial operation the fans 20 are rotated to produce the desired number of air changes per minute in the cargo compartment, depending upon the rapidity of retriuration desired. The air will be distributed uniformly lengthwise of the compartment due to the proper relative vertical positions of the individual shutters 80 which were secured before the bell cranks 100 were installed. It may be found, however, that the distribution of the air transverse of the compartment is not uniform, that is, if the apertures 74 are smaller in size than is proper for the volume of air distributed, it will be found that the velocity of the air at the apertures 74 caused by the large volume passing through the small apertures will result in a large portion of the air rushing under the floor grating toward the center line of the ship and an insufficient amount of air passing upwardly through the grating disposed near the sides of the compartment. The necessary uniform transverse distribution may be now effected by rotation of the hand wheel 132 whereby to open simultaneously all of the apertures 74 to reduce the velocity at those apertures of the large volume of air. Due to the fact that all of the apertures 74 are widened substantially the same amount, the balance of distribution lengthwise of the ship will remain undisturbed. A similar collective variation is of course also made on the opposite side of the ship, if necessary.

After the fruit has been suitably reduced in temperature, it is desirable, for efficient refrigeration, to reduce the volume of air circulated.

For that purpose the fans 20 are retarded the proper amount. Although the desired uniform distribution lengthwise of the compartment will remain unaltered at this reduced volume of air circulated, it may be found that the jet velocities at the apertures 74 are insufficient to force the air to the center line of the ship and that a proportionally excessive quantity of air is passing upwardly through the cargo disposed near the sides of the ship. To obviate this, the hand wheels 132 are rotated to close all of the apertures 74 an equal amount and the increased velocity caused by the passage of air through the decreased apertures 74 will cause the desired amount of air to travel to the center line of the ship.

From the above description it will be understood that the collective control for transverse distribution upon fluctuation in volume of air circulated is essentially a jet velocity control. The initial individual positioning of the shutters 80 does not, however, insofar as the longitudinal distribution is concerned, affect the jet velocity of the air entering the aperture 74 which is varied, due to the fact that as there are a plurality of such apertures fed by a single side air passage a variation in the size of one of those apertures will merely cause more air to flow through the remaining apertures of the passage without materially affecting the air velocity through the aperture varied.

In this manner my novel apparatus provides for uniformity of distribution both lengthwise and transverse of the compartment and provides further for varying the quantity of air distributed while at the same time maintaining the desired distribution. It will be noted furthermore that my transverse flow control mechanism is adapted for operation when the compartment is loaded and it is under such conditions that changes in volume are made and control of velocity required. I have found that for ready commercial use it is advantage to calibrate the quadrant 133 for various settings of the shutters 80 as are required to produce proper transverse distribution for various desired volumes of air circulated.

Referring now to Figs. 9 and 10, I will describe a modification of the preferred embodiment of my invention wherein I provide apparatus which automatically compensates for variations in velocity resulting from increase or decrease in volume of air circulated without the necessity for a manual operation.

With the exception of the above noted automatic feature, the air control system of my modified form is constructed just as that described above for my preferred form. Thus as indicated in Figs. 9 and 10, the fans 20 are provided for circulating air to port and starboard through the end air duct 22 over the cooling coils 23 and thence longitudinally of the cargo compartment through the side air ducts 24 which are constructed with sloped side air directors identical with the directors 25 described in connection with my preferred embodiment. The forward ends of the corresponding passages 24 defined by the side air directors 25 are progressively varied in size to feed equal volumes of cargo space and the same type of shutter 80 is provided with individual vertical control means to prevent excessive air flow in proximity to the forward air director defining a side passage. The doors 30 at the entrance to the side air passages are also retained. In my modification, however, I do not employ the several bell crank levers 100 with

their associated mechanisms including the rod 121 but I compensate for variations in jet velocities at the apertures 74 automatically.

As indicated in Fig. 9, the lateral bearers 202 which support the longitudinal beams 203 and maintain the said beams in spaced relation above the surface of the lower deck, form, when the grating sections are assembled, a plurality of independent air passages 204 extending underneath the beams 203 from one side of the ship to the other, and from these passages the air passes into the compartment through the spaces separating adjacent beams 203. I have found that the undesirable variations in air distribution resulting from velocity fluctuations upon changes in volume of air circulated may be automatically controlled to a large degree by partially restricting the air passages 204 at a distance approximately half way from the side 60 of the air duct to the midship line 205. For that purpose I provide in each of the continuous passages 204 on both sides of the midship line a baffle 201 which extends approximately half way across the passage 204 to provide a restricted opening 210 which is approximately one-half the width of the passage 204. The baffles 201 are secured by suitable nails or screws 208 and 209 to the bearers 202 and the beams 203 respectively. The baffles 201 preferably slant away from the bearers 202, to which they are secured, and toward amidships. Baffles 201 are provided for the proper sections of floor grating whereby when the grating is assembled the baffles will be aligned lengthwise of the ship and approximately half way from the side air duct to the midship line as shown. It will be noted that for any given passage 204 the baffle 201 on one side of the ship, such as at 201A, will be secured to that bearer of the passage which is opposite the bearer to which the baffle 201 on the other side of the ship, as indicated at 201B, is attached.

In the use of my modified control apparatus, the shutters 80, of the apertures 74 are first vertically positioned so that the desired longitudinal distribution throughout the volume of cargo fed by each side passage (as indicated by the spaces A and D in Fig. 1) is effected, equalizing the flow both lengthwise and transverse of the entire compartment as described in connection with my preferred form of apparatus. It will be remembered however that in the preferred form the initial setting of the shutter 80 to obtain uniform transverse and longitudinal distribution was made under the conditions of maximum air flow. In the modified form, however, when the initial positioning of the shutters 80 is made, the fans should be rotated at a speed to give approximately the minimum volume of air flow which will be used in practice and the various settings of the shutters 80 should be such that the proper longitudinal distribution is effected and also the collective heights of the shutters 80 should be such that the proper distribution transversely of the ship is obtained just as in the preferred embodiment but in this case for the minimum air flow. When the shutters are positioned to produce this result they are tightly secured and, in my modified form, are not thereafter loosened.

In use it will be found that when the volume of air distributed is increased, as required for a rapid reduction in fruit temperatures, the increase in jet velocities at the apertures 74 will be counteracted by the baffles 201. By restricting the passages 204 half-way to the midship line the increased velocity of the air as it enters the

passage will meet with the resistance caused by the increased flow passing through the restricted openings 210 with the result that the air will not rush to the midship line but the proper amount of air will flow upwardly between the beams 203 at the port and starboard sides of the ship. The resistance to the passage of air through the openings 210 will increase as the volumes of air introduced to the passages 204 increases and thus the baffles 201 automatically control the transverse distribution as the volumes of air flow are varied. The opposed relation between the two baffles 201 of a given passage 204, as indicated at 201A and 201B is conducive to better distribution as I thereby provide that the streams through the two restricted openings 210 of a passage do not oppose each other and cause a concentration of air flow upwardly at the midship line but rather the air streams pass each other and provide a uniform flow upwardly between the baffles 201A and 201B.

The arrangement of the floor grating and baffles of my modification may be varied to suit the needs of the user. Thus if desired the use of a baffle to partially restrict each individual air passage may be dispensed with and I may employ baffles which completely close say, one-half of the under grating passages communicating with any one side air passage leaving the remaining passages completely free. In that event I prefer to dispose the baffles in alternative arrangement similar to the arrangement of baffles 201A and 201B above described whereby the under grating passages 204 which are completely obstructed on one side of the ship are left free on the other side. Also, I do not wish to limit myself to the disposition of baffles half-way from the side air duct to the midship line as it may be preferable to dispose them nearer or farther from the side duct particularly where some of the passages 204 are completely blocked off. If desired the individual shutters 80 in either the preferred or modified embodiments may be made extensible in length to provide the desired variations in size of the openings 74. I do not wish to limit myself in any such details except as indicated in the appended claims.

I claim:—

1. In an air circulating system for a cargo compartment, the combination of an air duct adapted to deliver air to the compartment, a plurality of apertures in said duct communicating with the interior of the compartment, means for varying the sizes of individual apertures independently of each other for balancing the flow of air through said apertures and means for collectively varying the sizes of a plurality of said apertures whereby to control the distribution of the air upon changes in volume of air circulated.

2. In an air circulating system for a cargo compartment, the combination of an air duct adapted to deliver air to the compartment, a plurality of separate air passages in said air duct adapted to conduct air to predetermined portions of the compartment, a plurality of apertures in each of said passages leading from the passages to the interior of the compartment, means for varying the sizes of individual apertures independently of each other for balancing the flow of air through said apertures and means for controlling the distribution of the air transverse of the compartment upon changes in volume of air circulated.

3. In an air circulating system for a cargo compartment, the combination of an air duct adapted to deliver air to the compartment, a plurality of

separate sloping air passages in said air duct adapted to conduct air to predetermined portions of the compartment, said passages being adapted to conduct air to approximately equal volumes of cargo space by communicating with progressively longer portions of cargo space as the compartment tapers transversely, a plurality of apertures in each of said passages leading from the passages to the interior of the compartment, means for varying the sizes of individual apertures independently of each other for balancing the flow of air throughout the compartment and means for collectively varying the sizes of a plurality of said apertures whereby to control the distribution of the air upon changes in volume of air circulated.

4. In an air circulating system for a cargo compartment, the combination of an air duct adapted to deliver air to the compartment, a plurality of separate sloping air passages in said air duct adapted to conduct air to predetermined portions of the bottom of the compartment, said passages being adapted to conduct air to approximately equal volumes of cargo space by communicating with progressively longer portions of cargo space as the compartment tapers transversely, means for varying the volume of air passing through said passages, a plurality of apertures in each of said passages leading from the passages to the interior of the compartment, means for varying the sizes of individual apertures of a single passage independently of the others for balancing the flow of air throughout that portion of the compartment fed by the apertures leading from said single passage and means for collectively varying the sizes of a plurality of apertures in a plurality of passages whereby to control the transverse distribution of the air upon changes in volume of air circulated.

5. In an air circulating system for a cargo compartment, the combination of an air duct disposed at one end of the compartment, means for withdrawing air from the compartment through said end air duct, an air duct disposed along a side of the compartment and communicating with said end air duct, a plurality of separate downwardly sloping air passages in said side air duct leading to predetermined portions of the bottom of the compartment, means for equalizing the volume of air passing through the several air passages, a plurality of apertures in each of said passages leading to the interior of the compartment, a shutter for each of a plurality of said apertures, means for varying the relative positions of the shutters independently of each other to change the sizes of individual apertures and secure uniform air distribution throughout the compartment by counteracting the effect of the slope of said passages and means for collectively varying the positions of a plurality of the shutters while maintaining their said relative positions whereby to effect substantially uniform transverse air distribution upon changes in volume of air circulated.

6. In an air circulating system for a cargo compartment, the combination of an air duct disposed adjacent a side of the compartment adapted to deliver air to the compartment, a plurality of separate air passages in said side air duct adapted to conduct air to predetermined portions of the bottom of the compartment, a perforate floor grating adjacent the lower deck of said compartment, a plurality of separate air passages communicating with the side air passages and extending transversely of the compartment beneath the floor grating, and a plurality of baffles in

said transverse air passages adapted to resist partially the passage of air through said transverse passages whereby to control automatically the transverse distribution of the air upon variations in volume of air distributed.

7. In an air circulating system for a cargo compartment, the combination of an air duct disposed adjacent a side of the compartment adapted to deliver air to the compartment, a plurality of separate air passages in said side air duct adapted to conduct air to predetermined portions of the bottom of the compartment, a perforate floor grating adjacent the lower deck of said compartment, a plurality of separate air passages communicating with the side air passages and extending transversely of the compartment beneath the floor grating, and a plurality of baffles disposed in said transverse air passages at a predetermined distance from said side air duct adapted to restrict partially said transverse passages whereby to restrain the passage of increased volumes of air beyond said predetermined distance from the side air duct upon increase in total volume of air circulated.

8. In an air circulating system for a cargo compartment, the combination of an air duct adapted to deliver air to the compartment, a plurality of separate air passages in said air duct adapted to conduct air to predetermined portions of the bottom of the compartment, a plurality of apertures in each of said passages leading from the passages to the interior of the compartment, means for independently varying the sizes of individual apertures for balancing the flow of air through said apertures and means for automatically controlling the transverse distribution of the air upon variations in volume of air circulated.

9. The method of circulating air in a cargo compartment which comprises passing separated streams of air longitudinally of the compartment, subsequently dividing individual streams and simultaneously introducing them into the compartment by passing them thereto through a plurality of separate apertures, varying the relative divided proportions of each of the streams so divided by changing the relative sizes of said apertures and controlling the velocity of the air as it passes through the apertures by varying collectively the sizes of a plurality of said apertures.

10. The method of circulating air in a cargo compartment which comprises passing separated streams of air longitudinally of the compartment, subsequently dividing individual streams and simultaneously introducing them into the compartment by passing them thereto through a plurality of separate apertures, varying the volume of air circulated and subsequently securing the desired velocity of the air for the changed volume as it passes through the apertures by varying collectively the sizes of a plurality of said apertures.

11. The method of circulating air in a cargo compartment which comprises passing separated streams of air longitudinally of the compartment, subsequently dividing individual streams and simultaneously introducing them into the compartment by passing them thereto through a plurality of separate apertures, varying the relative divided proportions of each of the streams so divided by changing the relative sizes of said apertures and partially restricting the passage of air after it has been introduced into the compartment to distribute the air independently of the volumes of air circulated.

12. The method of circulating air in a cargo

compartment which comprises passing a stream of air longitudinally of the compartment, subsequently dividing the said stream and simultaneously introducing the stream into the compartment by passing it thereto through a plurality of separate apertures, subsequently changing the quantity of air circulated and maintaining substantially constant the velocity of the air as it passes through the apertures by varying collectively the sizes of a plurality of said apertures.

13. The method of circulating air in a cargo compartment which comprises passing a stream of air longitudinally of the compartment, subsequently dividing the said stream and simultaneously introducing the stream into the compartment by passing it thereto through a plurality of separate apertures, subsequently changing the quantity of air circulated and regulating the transverse distribution of the air for the changed quantity of air circulated.

14. In an air circulating system for a cargo compartment, the combination of a sloping air passage adapted to deliver air to the compartment, a plurality of apertures at the end of said sloping passage and communicating with the interior of the compartment, shutters disposed at the discharge end of said passage, and means for securing the shutters in different positions relative to each other for varying the relative sizes of the apertures whereby to minimize inequalities of air flow incident to the slope of said passage.

15. In an air circulating system for a cargo compartment which tapers in the direction of its length and has a perforate floor grating to support the cargo, the combination of an air duct extending along each side of the compartment, each air duct opening into the interior of the compartment, beneath the floor grating, through a plurality of apertures, shutters for the said

apertures, and means securing the individual shutters in different positions relative to each other to obtain different sized aperture openings in various apertures lengthwise of the compartment whereby to equalize the distribution of incoming air across the compartment by controlling the velocity thereof.

16. In an air circulating system for a cargo compartment which tapers in the direction of its length and has a perforate floor grating to support the cargo, the combination of an air duct extending along each side of the compartment, each air duct opening into the interior of the compartment, beneath the floor grating, through a plurality of apertures, means within each air duct directing substantially equal volumes of air to equal volumes of cargo space, shutters for the said apertures, and means securing the individual shutters in different positions relative to each other to obtain different sized aperture openings in various apertures lengthwise of the compartment whereby to equalize the distribution of incoming air across the compartment by controlling the velocity thereof.

17. In an air-circulating system for a cargo compartment, a sloping passage, means for delivering air to said passage, a discharge outlet for said passage communicating with the interior of the compartment, shutter means associated with said outlet, means to adjust the position of said shutter means to close said outlet in different amounts at different portions thereof to compensate for inequalities of air flow incident to the slope of said passage and means to adjust said shutter means for changing the total area of said outlet while substantially preserving said compensating adjustment thereof to control the air velocity as it passes through said outlet.

HECTOR HARRIS ROBSON.