FIRE AND HEAT RADIATION DAMPER

Inventor: Sherwin S. Tarnoff, Northbrook, Ill.
Assignee: Air Balance, Inc., Chicago, Ill.
Filed: Aug. 3, 1973
Appl. No.: 385,475

Int. Cl. ........................ E05F 15/20
Field of Search .................. 160/1-6, 34, 160/35, 84 R, 235, 232; 126/287.5, 290

References Cited
UNITED STATES PATENTS
685,481 10/1901 Kinnear ...................... 160/23 R X
866,830 9/1907 Vance ...................... 160/235 X
3,401,734 9/1968 McCabe ...................... 160/1 X
3,687,185 8/1972 Singer ...................... 160/1
3,690,080 9/1972 Dillard ...................... 160/84 R X

Primary Examiner—Philip C. Kannan
Attorney, Agent, or Firm—Fitch, Evan, Tabin & Luedeka

ABSTRACT

A radiation shield means for limiting the transfer of heat by radiation is provided for a fire damper having a curtain wall shiftable from an open damper position allowing air flow through an opening in the damper to a closed position in which the curtain wall blocks air flow through the damper opening. Preferably, the curtain wall is formed with reversely folded and hinged damper blades and the radiation shield means comprises a pair of asbestos fabric sheet shields loosely tucked into the blades for stowage and for unfolding into generally planar sheets with shifting of the damper blades into a curtain wall position. The fabric shields are disposed on opposite sides of the damper blades and have loose and minimal contact therewith and with the blades define a pair of air spaces. A coating retains the asbestos fibers against liberation into an air stream flowing through the damper opening.

7 Claims, 7 Drawing Figures
This invention relates to fire dampers and more particularly to fire dampers having a metal curtain wall movable from an open condition in which air may flow through an opening in the damper to a closed position in which the curtain wall substantially blocks the flow of air and smoke or fire through the damper opening.

Fire dampers of this general kind usually include a square or rectangular frame for fitting in an air duct and are usually installed either in a vertical position as in a vertical wall or in a horizontal position as in a ceiling or floor. In some instances, the curtain wall may be made of a single piece of steel, but a preferred curtain wall construction comprises several foldable damper blades hinged along longitudinally extending edges thereof for pivoting between a folded, stacked position allowing air to flow through the damper and an unfolded, extended curtain wall position blocking air flow through the damper. Herein, the invention is described in connection with a folding, hinged blade fire damper as disclosed in U.S. Pat. No. 3,327,764.

More specifically, a folded stack of hinged blades is held adjacent one end or the top of the damper frame by a heat releasable means, such as a fusible link which melts when exposed to a predetermined temperature. Release of this means occasioned by high temperature allows the blades to drop and unfold to block air flow through the damper. In horizontal installations, springs are connected to the blade assembly to pull the blades across the damper opening when the fusible link or other temperature actuated means releases the blades for unfolding. In vertical installations, gravity may suffice to close the damper. As the blades move to form the curtain wall, each pivot about its connection with an adjacent blade with the blades moving generally into a flat planar curtain wall.

Fire dampers of the aforementioned kind usually have steel blades and a steel frame, which provides good structural strength to maintain the curtain wall closed to any substantial flow therethrough of smoke, fire and heated air when the damper is exposed to high temperature fires and when streams of water from fire hoses are played theragains. These fire dampers have met widespread commercial acceptance and have proven very satisfactory. However, there are occasions requiring fire dampers which are not only effective in blocking the flow therethrough of fire, hot air, and smoke but which also effectively limit heat transfer by radiation to alleviate the likelihood of ignition of or failure of structural materials on the other side of the fire damper from the heat source. Generally speaking, steel fire dampers of the aforementioned kind have failed to meet Underwriters Laboratories, Inc. radiation tests at high temperatures as the steel blades do not reduce sufficiently the radiation heat transfer through the damper.

Accordingly, a general object of the present invention is to provide a new and improved fire damper capable of severely limiting the transfer of heat by radiation across the damper.

Other objects and advantages of the invention will become apparent from the detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a cross-sectional view of the fire damper with its curtain wall in the closed position and embodying the novel features of the invention;

FIG. 2 is a cross-sectional view similar to FIG. 1 but with the curtain wall in the open position;

FIG. 3 is a front elevational view of the fire damper shown in FIG. 2;

FIG. 3A is a cross-sectional view taken along the line 3A—3A of FIG. 3.

FIG. 4 is a cross-sectional view of another fire damper with its curtain wall in the closed position and embodying the novel features of the invention;

FIG. 5 is a cross-sectional view similar to FIG. 4 but with the curtain wall in the open position; and

FIG. 6 is a plan view of the fire damper shown in FIG. 4.

As shown in the drawings for purposes of illustration, the invention is embodied in a fire damper 11 having a frame 12 with means in the form of a metal curtain wall 13, as best shown in FIG. 1. The curtain wall 13 is movable between the closed position shown in FIG. 1 in which the curtain wall closes an opening 14 (FIG. 3) through the rectangular frame 12 and an open position, as best seen in FIGS. 2 and 3, in which the curtain wall is folded to the top of the frame and exposes the opening 14, thereby allowing the flow of air through the damper. The frame is typically of rectangular shape with a first pair of vertically extending, parallel side frames or walls 17 and 18 joined at opposite ends to a second pair of parallel horizontally extending top and bottom walls 19 and 20. Herein, the curtain wall 13 comprises a plurality of metal damper blades 22 pivotally mounted at respective longitudinally extending edges 23 to an adjacent blade or blades, as fully described in U.S. Pat. No. 3,327,764, for moving between the unfolded or unstacked position, shown in FIG. 1, and the folded or stacked position shown in FIGS. 2 and 3.

The curtain wall 13 is held in the open position by a releasable securing means 34, which may take several forms, but herein is illustrated as including a pair of depending straps 25 carrying a fusible link 26 extending across the bottom of the lowermost blade 22. The fusible link will, on the occurrence of excessive heat as occasioned by a fire and at a predetermined temperature, melt, releasing the blades to move to the closed position forming the curtain wall as shown in FIG. 1, closing the opening 14 and confining the fire. In other instances, a heat sensor located at a remote location may actuate means to release the link 26, thereby releasing the blades 22 to shift to the closed position. When the frame 12 is in a vertical position, the blades 22 may drop under the force of gravity; however, when the frame 12 is installed in a horizontal position as will be described in connection with the embodiment illustrated in FIGS. 4, 5 and 6, the blades are released to be shifted by the forces of springs 27 to the closed position.

In the closed curtain wall position, the damper blades 22 are generally adequate to block the flow of hot air and smoke therethrough, particularly when equipped with smoke seals along the side edges of the blades for sealing against air flow, as disclosed in U.S. Pat. No. 3,729,043. Although heat transfer through the thin steel blades is relatively good, the damper blades 22 are not usually touching anything except the frame 12 and hence heat is not transferred from the blades to any great extent. On the other hand, heat transfer by radiation may be quite large, particularly where a very high temperature, e.g., 1,800°F., is present on one side of
the fire damper. Also, the blades may buckle when the temperature of the blades if allowed to become very high and create spaces between or about the blades thereby allowing air to flow through the curtain wall. In some tests, it has been found that sufficient heat is transferred across the fire damper by radiation to ignite materials or to cause the failure of structural materials on the side of the damper opposite from the heat source. Preferably, the fire damper should be effective in blocking heat transfer by radiation, convection and conduction as having sufficient structural integrity at high temperatures to resist impingement of high velocity streams of water. As cost is always an important factor, the solution to the problem of protection by heat transfer across the damper should preferably be simple and inexpensive.

Heretofore, in fire dampers as described in the aforementioned patents, a fire on one side of the damper transferred heat by convection and radiation directly to the steel blades and the steel blades being a good radiator of heat radiated heat from the other side of the damper by permitted transfer by convection, even while blocking the flow of hot air, smoke and fire through the damper opening 14. Some very old patents in the art such as U.S. Pat. No. 827,677 suggested the use of asbestos sheets or coatings on the damper blades to insulate the same. But these have at least two drawbacks, and this solution is not known to be in use at the present time. Asbestos fibers from the coatings are dangerous to one's health and are not usually allowed in air moving equipment; and attaching of the asbestos directly to the steel blades results in considerable heat transfer by conduction through the asbestos to or from the blades. Another suggestion in U.S. Pat. No. 685,481 is to provide a fabric or coating with rolled damper blades and would be subject to the objections of fiber generation and heat transfer by conduction to or from the blades. These also leave the hinged joints uncovered.

In accordance with the present invention, improved resistance to heat transfer and particularly to heat transfer by radiation and convection is provided in a fire damper by spacing at least one radiation shield 30 or 31 from an adjacent side of a metallic curtain wall 13 to define therewith an air space 32 or 25 when the shield is extended with the curtain wall 13 to cover the opening 14 through the damper. Preferably, a pair of radiation shields 30 and 31 are used on opposite sides of the curtain wall 13, and they preferably are fireproof fabric sheets such as woven asbestos fabric sheets having a surface coating to severely retard or stop erosion of asbestos fibers therefrom by the flowing air stream.

Heat transfer by conduction from the upstream radiation shield, for example, the shield 30, to the facing flat sides 33 of the blades 22 is severely limited because of the small area of contact, if any, between the shields 30 and the blades 22 and because of the loose contact therebetween. The same condition between the other sides 37 of the blades 22 and the facing fabric shield 31 also results in little heat transfer by conduction to and through the radiation shield 31 to the other side of the damper. Preferably, one or both of the radiation shields 30 and 31 are held taut when extended to reduce the likelihood of the shield conforming to or lying against large surface areas of the curtain wall 13.

Because of the generally small dead air spaces 32 and 35, heat transfer by convection to or from the spaces on either side of the damper from or to the blades 22 is limited, and the heat transfer by convection between an adjacent radiation shield 30 or 31 and a blade facing side 33 or 37 is not great. Also, as will be explained in greater detail, the two radiation shields 30 and 31 reflect radiant heat and effectively divide the fire damper into a plurality of successively re-radiation zones or sections with a plurality of temperature drops therebetween. As a result of these re-radiation zones, the total effect of radiant heat transferred is, as may be calculated by using Stefan-Boltzman's law, considerably reduced from prior art dampers without such re-radiation zones. These greater numbers of re-radiation and temperature drop zones result in successively lower maximum radiation temperatures at each of the successive heat radiating surfaces; and, because radiation according to Stefan-Boltzman's law depends upon the difference between the fourth power of the temperatures of the radiating surfaces, the result of reducing temperature differentials becomes a very significant factor in the overall amount of heat transferred.

Assuming a fire is on one side of the damper and raises a temperature $T_R$, on a first side of the damper to a relatively high temperature, for example 1,800°F, the heat from the fire is transferred by radiation and convection to exterior surface 39 of the radiation shield 30 and heat is then conducted by conduction therethrough to the interior surface 41 of the radiation shield 30 to raise its temperature to a temperature $T_I$. The heated interior shield surface 41 will radiate the heat to the facing surface 33 of the metal blades 22. Relatively little heat is transferred to the blades 22 by conduction for the reason that there is relatively little, if any, contact between the blades 22 and the interior surface 41 of the asbestos shield 30. Even at the points of contact between the shield 30 and the blade interconnections 23, there is relatively little force or pressure contact between the shield 30 and the blades 22 as would provide a good heat conductive path. From the standpoint of heat transfer by convection, the space 32 is generally intended to be a small closed air space with any air flow circulating therein by natural convection being relatively slow moving and without achieving a good scrubbing of surface air at the interior shield surface 41. The net result is a low convection heat transfer between the interior surfaces 41 of the shield 30 and the facing surfaces 33 of the blades 22.

The damper blades 22 being good conductors of heat will readily transmit heat by conduction from one side or surface 33 to its opposite side or surface 37. The blade surfaces 37 are likewise spaced generally by the dead air space 35 from the radiation shield 31 and have a low heat transfer by convection therewith between the reasons given above. Heat transfer by conduction from the blade surfaces 37 to the radiation shield 31 is small because of small engaging surface areas and the lack of tight, intimate contact with the blades 22 and the shield 31.

The blade surfaces 37 which are at a temperature $T_2$ transmit heat by re-radiation to the interiorly facing surface 45 of the radiation shield 31 heating the latter to a temperature $T_3$. Heat will flow through the shield 31 by conduction to the opposite exterior side 47 thereof. Heat is re-radiated therefrom to the surrounding atmosphere to raise the temperature on the other side of the fire damper to a temperature $T_4$. 
The statement that the radiation shields 30 and 31 have loose and little contact with the blades 22 does not exclude substantial and intimate contact with a top blade 22a at the top wall 19 and a bottom blade 22a as these locations are protected or hidden by defining flanges 40 of the top wall walls 19 and by upwardly projecting flanges 42 of the lower frame wall 20 and are generally outside of the re-radiating blades at the opening 14 in the damper. While heat is transferred to and through the frame and therefrom, this quantity of heat transferred has not resulted in a failure of the illustrated damper in acutal radiation tests, as described herein. As will be explained, these manners of connection of the shields 30 and 31 to the frame 12 and to the curtain wall 13 are simple and low in cost.

Without the radiation shields 30 and 31, the temperature drop across the radiation damper was generally \( T_1 - T_2 \), and the temperature drop \( T_2 - T_3 \) with there being relatively little reflection of the radiant heat by the blades 22. As there were no dead air spaces in these prior art dampers, air could sweep and scrub the blades 22 on both sides thereby transfer heat readily by convection between the areas at temperatures \( T_1 \) and \( T_3 \). Also, as the temperatures \( T_1 \) and \( T_2 \) remained relatively high, the multiplying of these temperatures to the fourth power will demonstrate the magnitude of greater heat transfer by radiation without radiation shields 30 and 31 than with the radiation shield 30 and 31 which, e.g., provide four temperature drops and transfer zones, viz., zones \( T_1 - T_2 - T_3 - T_4 \). Therefore, it will be seen that because of the reduced heat transfer by conduction, convection and radiation through the illustrated fire damper, there results a lower temperature on the side of the fire damper opposite from the fire with the damper having radiation shields 30 and 31 than for a similar fire damper without such radiation shields.

The illustrated radiation shields 30 and 31 extend the width of the blades 22 and into opposite channels 51 each defined between a pair of blade guide flanges 53 and 54 which project inwardly from the vertical side walls 17 and 18 of the damper frame. In some instances, the radiation shields may shift outwardly from behind an edge of one of the flanges 53 or 54, but the shield will still retain their effectiveness. In this preferred embodiment of the invention, the radiation shields 30 and 31 are both formed from a single piece of asbestos woven fabric which has a first end 55 at the top wall 19 of the frame and extends downwardly to define the radiation shield 30 to an integral bottom portion 56 looped about the underside of the lowermost damper blade 22a. The bottom portion 56 is integral with the radiation shield 31 and this, in turn, extends to a second end 57 for the asbestos fabric, which end is disposed beneath the overlapping first end 55 of the fabric. The ends 55 and 57 of the asbestos fabric are sandwiched and captured between the top damper blade 22a and the top wall 19 by a pair of fasteners 59, such as rivets. The latter secure the blade tightly to the frame and hold the fabric ends parallel and aligned so that opposite edges 60, FIG. 3, of the fabric are parallel to the frame side walls 17 and 18 when the damper blades 22 are in the closed position. The bottom portion 56 of the fabric may also be secured to the bottom blade 22a by a series of fasteners 61 to assure proper positioning of the radiation shields 30 and 31 across the opening 14. Preferably, the length of the respective shields is related to the final position of the lower blade 22a, when the curtain wall is in the closed position, such that the shields 30 and 31 are relatively taut and have minimal contact with the blades and maintain the dead air spaces 32 and 35. The fabric is thus positioned between to top blade and the top frame wall 19 and between the bottom blade and the bottom frame wall 20 thereby reducing the heat transfer by conduction from the prior art damper construction in which metal blades abutted the metal top and bottom frame walls 19 and 20.

In accordance with the present invention, the radiation shields 30 and 31 are in a stowed condition above the opening 14 by being nested or folded between adjacent blades 22. When the blades 22 fall from the damper open position shown in FIG. 2, the fabric unfolds to provide the generally planar sheet-like radiation shields 30 and 31 each extending the width and height of the damper opening 14. Herein, the shields 30 and 31 also extend above and below the opening 14. In the stowed position, as best seen in FIG. 2, the shield 30 is folded with the fold plies or portions 30a and 30b tucked between each of the pairs of adjacent folded blades 22; and in a like manner the fabric shield 31 is folded with fold plies or portions 31a and 31b tucked between a pair of respective adjacent blades 22.

When the fire damper is installed in a vertical position as shown in FIGS. 1-3, the weight of the metal fire curtain 13 is normally sufficient to insure the dropping of the lowermost portion thereof such as the lowermost blade 22a to the bottom wall 20 of the frame 12 and to carry the fabric shields 30 and 31 downwardly therein while unfolding the same. However, in horizontal installations, such as in a ceiling, springs 27 (FIG. 4) are provided to pull the curtain wall 13 to the closed position. In this instance, each of a pair of springs 27 is fastened to an outer end of the lowermost damper blade 22a by one of the rivets 61 which also serve to fasten the lower loop of the fabric to the bottom blade 22a. The springs 27 are usually metal negator springs which are disposed in the opposite channels 51 adjacent the side walls 17 and 18 of the frame for winding about spools 63. The spools 63 are disposed at the bottom of the channels 51 and fastened to the side walls 17 and 18, as best seen in FIG. 6, near the bottom frame wall 20. The damper shown in FIGS. 4-6 is identical to the damper shown in FIGS. 1-3 except that the springs 27 and spools 63 have been added thereto and hence common reference characters have been used for both embodiments of the invention.

The preferred asbestos fabric is obtainable from Raybestos-Manhattan, Inc. of Elmhurst, Illinois and is tightly woven asbestos fabric which is provided with a fiber retention coating such as, for example, a coating of polyurethane to limit fiber liberation from the fabric by the moving air stream. This decreases the fiber deposition into the air stream flowing through the damper opening 14. Under recent health and safety codes, asbestos fiber materials, which have been found to be injurious to health, are regulated, particularly for use in air moving equipment or in air ducts such as a fire damper air duct installations in which streams of moving air may abrade or erode fibers from the shield. In accordance with the present invention, the polyurethane coating is present on both sides 39 and 41 of the radiation shield 30 and both sides 45 and 47 of the radiation shield 31. Such coatings of the entire asbestos fabric have reduced the amounts of asbestos fibers lib-
erated to well below acceptable levels and to as low as 0.0015 particles per cubic centimeter. Although in the event of fire, the polyurethane coating melts when subjected to the high temperatures contemplated herein, the melting of the coating does not adversely affect the heat transfer limitations of the radiation shields 30 and 31 and of the damper 11. Preferably, the asbestos fabric is formed with a tight weave so that after the coating melts, the radiation shields 30 and 31 remain sufficiently impermeable to substantially block air flow therethrough and thereby limit heat transfer by convection through the pores of the fabric. That the coating is destroyed by fire and thereupon liberates the asbestos fibers is not significant as the radiation shields still function effectively for their intended purpose. The release of asbestos fibers during the emergency is negligible, and the asbestos fabric will not be used again after the emergency. The fire damper will be replaced or repaired. The weave of the asbestos fabric is sufficiently tight if the fabric stops convection flow to blades as the closed blades of the curtain wall prevent any direct air flow through the damper and the asbestos fabric need not be so tight as to perform this function. It will be appreciated that other fire resistant materials may be used for the radiation shields 30 and 31 than that described above and still fall within the purview of the present invention.

A fire damper of the general type described herein has successfully survived a radiation test for Underwriters' Laboratories in which the damper 11 was mounted horizontally in a ceiling. The ceiling was formed of fire resistant tiles and it was spaced by a plenum chamber, in which an air duct was mounted, from an overhead floor slab which was supported by members extending upwardly from the ceiling. In this Underwriters' Laboratories test, the temperature in the room (T\(_{\text{D}}\)) is approximately 1,800°F, and the test is continued until either a component fails or the temperature (T\(_{\text{D}}\)) in the plenum reaches 1,000°F. In this test, the fire damper 11 successfully blocked heat transfer therethrough as would raise the plenum temperature to 1,000°F for a 2-hour period; and, after 2 hours, but before reaching a 1,000°F air temperature in the plenum, another component of the ceiling-floor-slab test assembly failed. Based on present knowledge, it is expected that in a similar test with better ceiling-floor-slab materials that the damper 11 should pass at least a four-hour test before 1,000°F air temperature is attained in the plenum.

From the foregoing, it will be seen that the present invention provides an improved fire damper particularly resistant to radiation heat transfer. Because the steel curtain will can withstand high temperatures and provides a structural rigidity, the fire damper may be mounted in a vertical wall to pass fire hose tests in which a water discharge from a water hose is blocked by the blade assembly. Moreover, the damper of the present invention may use coated asbestos fabric for radiation shields without liberation of large quantities of asbestos fibers in the air stream flowing therethrough.

While a preferred embodiment has been shown and described, it will be understood that there is no intent to limit the invention by such disclosure but, rather, it is intended to cover all modifications and alternate constructions falling within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A fire damper comprising a frame having a pair of side walls and top and bottom walls joined to said pair of side walls and encompassing an opening through which air may flow; a metal curtain wall means associated with said frame and movable from an open damper position permitting air to flow through said opening to a closed position substantially closing the opening in said frame to air flow therethrough, a first radiation shield positioned in a stowage condition leaving said opening exposed and movable therefrom to an effective position for covering said opening, said first radiation shield being disposed on one side of the curtain wall means and generally spaced therefrom when the latter is in its closed position, a second radiation shield positioned in a stowage condition leaving said opening exposed and movable therefrom to an effective position for covering said opening, said second radiation shield being disposed on the opposite side of said curtain wall means and generally spaced therefrom when the latter is in its closed position, and means holding said curtain wall means in said open position and said radiation shields in the stowage condition and operable in response to high temperatures to release said curtain wall means for movement to said closed position and said radiation shields to said effective positions.

2. A fire damper in accordance with claim 1 in which said first and second radiation shields each comprise an asbestos fabric sheet and in which a coating on said sheets retains fibers of asbestos from free liberation into an air stream flowing through said opening.

3. A fire damper in accordance with claim 1 in which said curtain wall means is comprised of a plurality of elongated metal damper blades hingedly connected together at parallel longitudinally extending edges, said blades being reversibly foldable and stackable in said open damper position, and in which said radiation shields each have portions thereof tucked between said folded blades when the latter are in said open damper position.

4. A fire damper in accordance with claim 3 in which said first and second radiation shields comprise integrally connected portions of an asbestos woven fabric and in which said are formed in said fabric by tucking said fabric between adjacent facing blades when the blades are in the open damper position.

5. A fire damper in accordance with claim 4 in which a plastic coating covers said asbestos fabric to prevent erosion of the asbestos fibers from the fabric.

6. A fire damper in accordance with claim 3 in which said radiation shields comprise asbestos fabric sheets no more than loosely contacting said blades except for the topmost and bottommost blades and covering said opening when said curtain wall is in the closed position.

7. A fire damper in accordance with claim 6 in which said sheets are secured to the top one of said damper blades and to said top frame wall and to the lowermost one of said blades.