

[54] **THREE-PLENUM MIXING DAMPERS**

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[52] U.S. Cl. **137/595; 137/607; 251/77;**
251/85; 62/325; 98/38; 165/103

[51] Int. Cl.² **F28F 27/02; F16K 11/10**

[58] Field of Search **62/325; 98/38, 401;**
137/595, 607; 251/77, 85; 165/22, 103

[56] **References Cited**

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Attorney, Agent, or Firm—Klarquist, Sparkman,
Campbell, Leigh, Hall & Whinston

[57] **ABSTRACT**

A damper shaft is movable 90° to a second extreme

position from a first extreme position in which a by-pass blade keyed rigidly to the shaft extends 45° across a by-pass air passage to fully close the passage; a warm air blade extends parallel to a warm air passage to fully open the warm air passage, and a cold air blade extends 45° across a cold air passage to fully close the cold air passage. In the second extreme position, the by-pass blade extends 45° across and fully closes the by-pass passage; the warm air blade extends 45° across and fully closes the warm air passage, and the cold air blade extends parallel to and fully opens the cold air passage. Lost motion or overrunning couplings couple the warm air blade and the cold air blade in such a manner that these two blades fully close their passages when the shaft is in a third, middle position in which the by-pass blade is parallel to and fully opens the by-pass passages. From the first extreme to the middle position, the by-pass blade is opening, the warm air blade is closing, and the cold air blade is held closed by its overrunning coupling. From the middle to the second extreme position, the by-pass blade is closing, the cold air blade is opening, and the warm air blade is held closed by its overrunning coupling. The overrunning couplings include springs which progressively increase the forces of closing when the shaft is turned further from the closed position of the warm air blade and the cold air blade to ensure minimum leakage.

12 Claims, 8 Drawing Figures

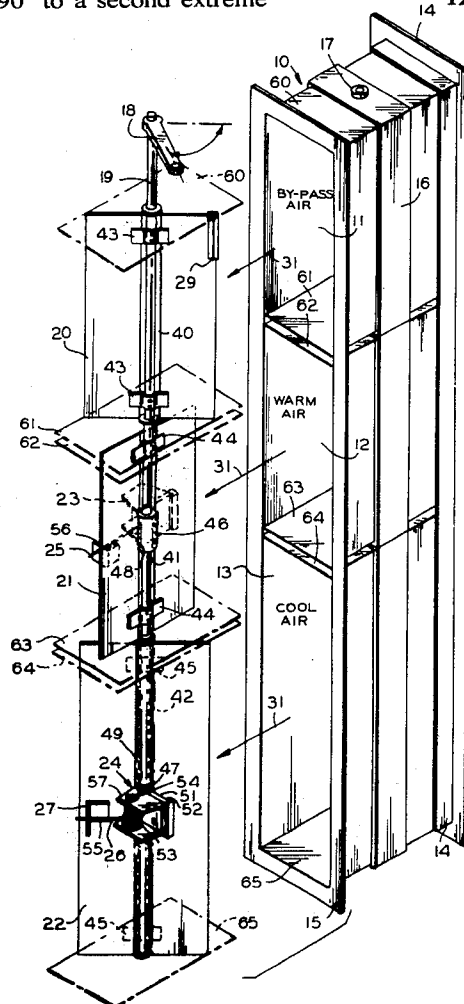


FIG. 1

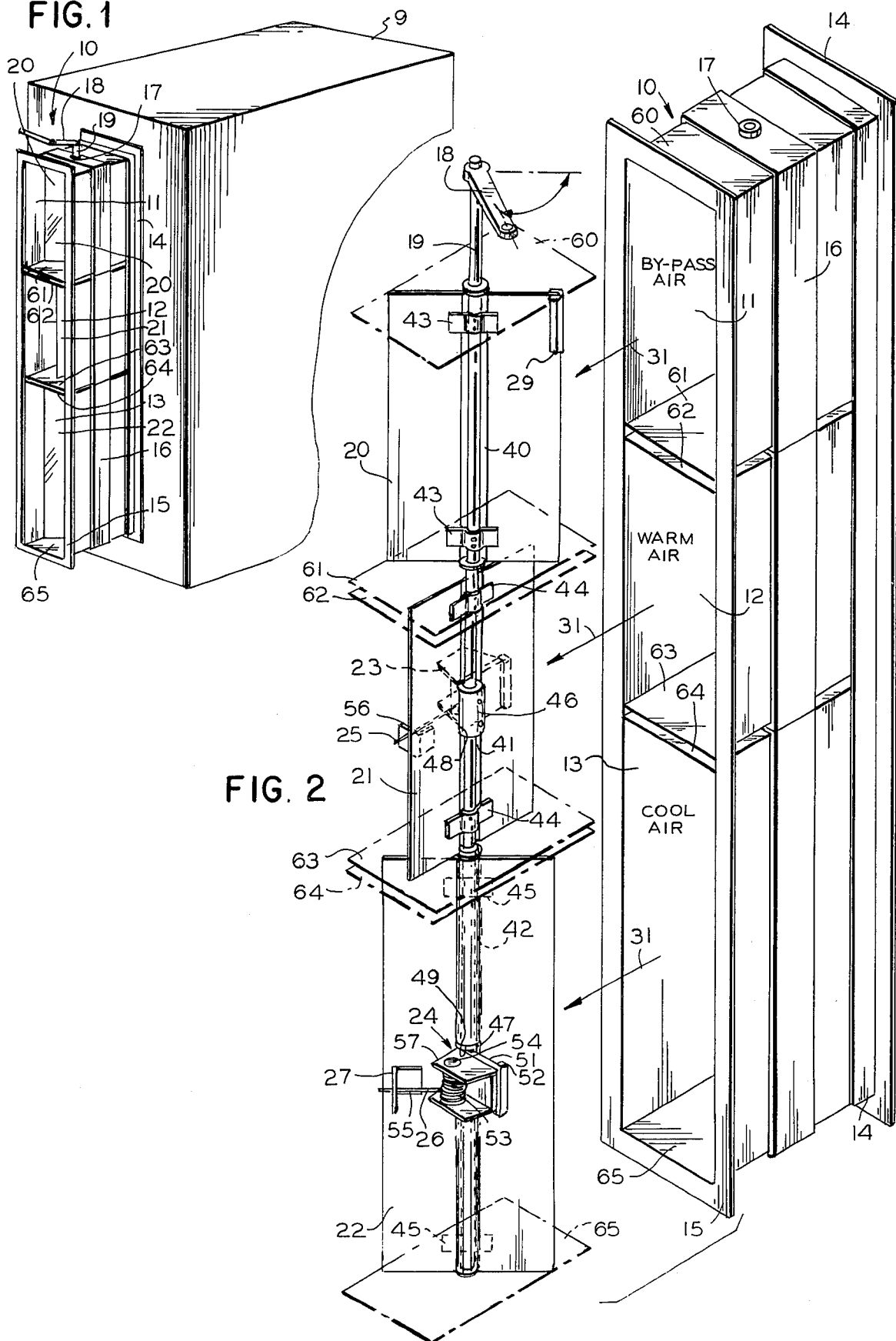


FIG. 2

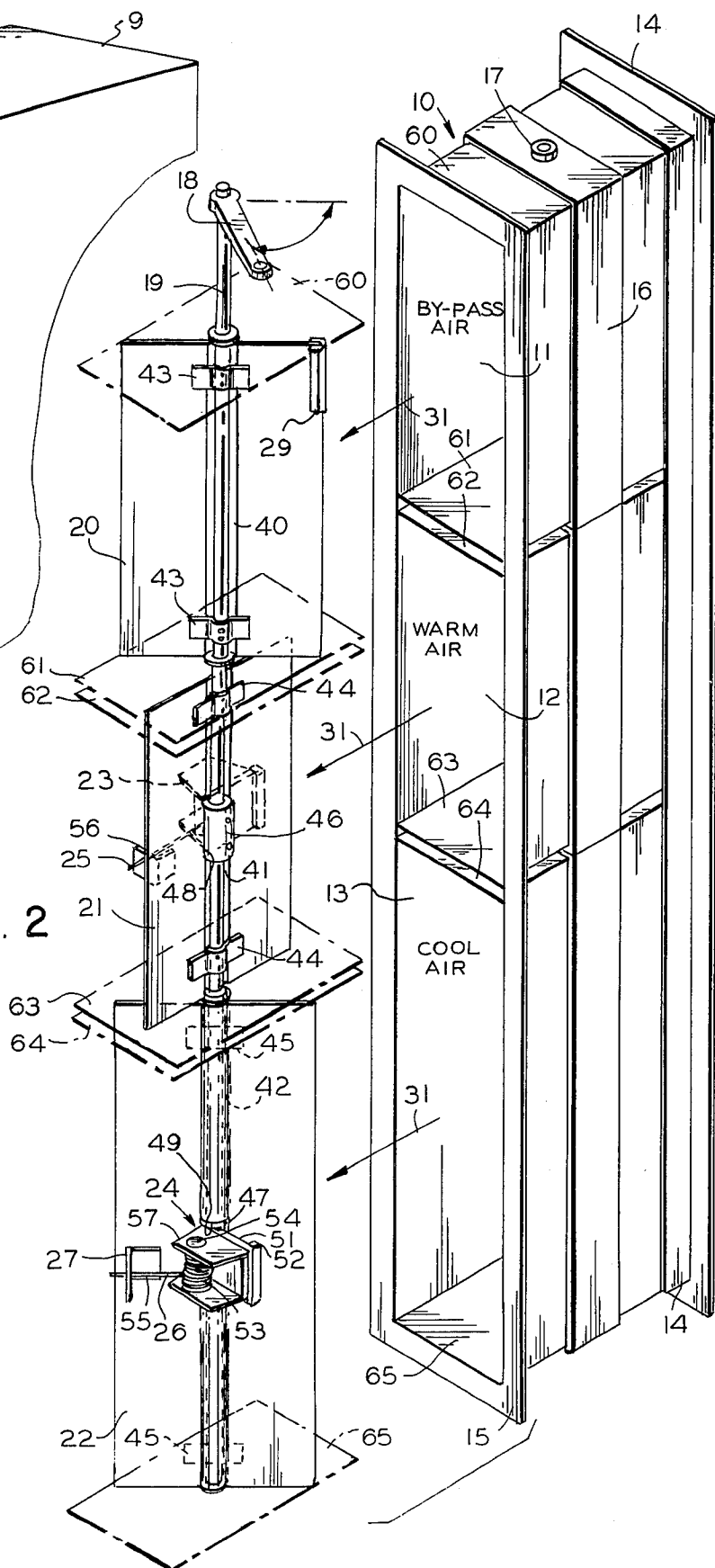


FIG. 4

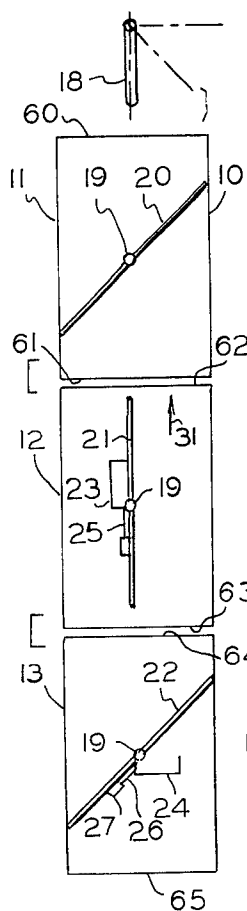


FIG. 5

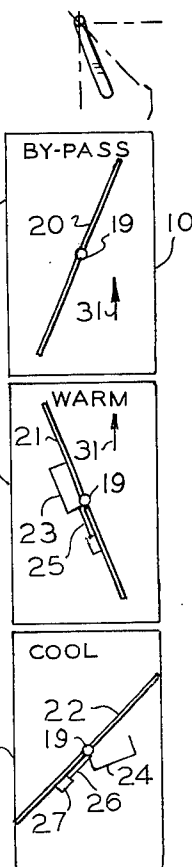


FIG. 6

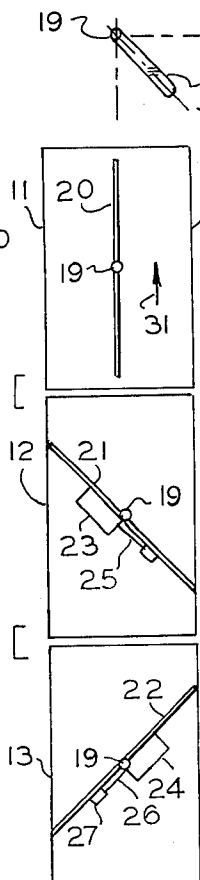


FIG. 7

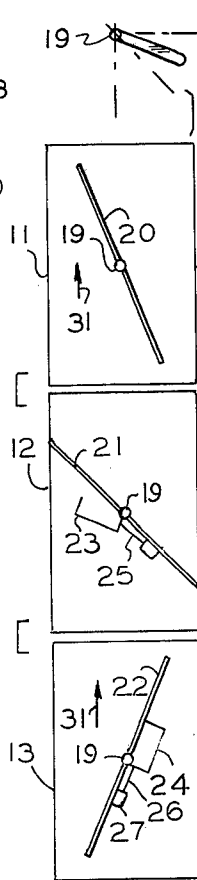


FIG. 8

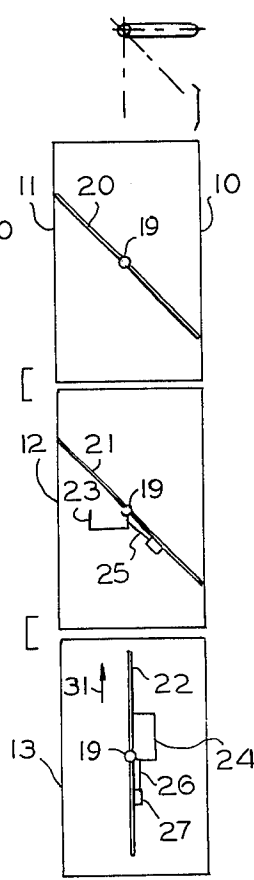
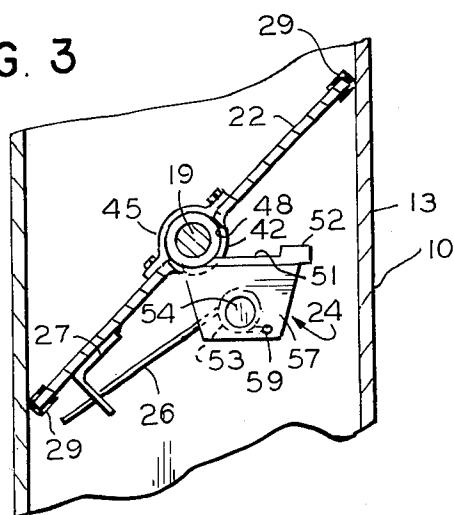


FIG. 3



THREE-PLENUM MIXING DAMPERS

FIELD OF THE INVENTION

This invention relates to dampers for mixing air at different temperatures and/or other conditions, in heating, ventilating and air-conditioning systems.

BACKGROUND OF THE INVENTION

In one of the methods commonly used to condition more than one area in a building from a single air handling device, the air handling device forces air through two parallel chambers or plenums. One of the plenums contains a heating device for raising the temperature of the air passing through it. The other plenum contains a cooling device for lowering the temperature of the air passing through it. Thus, the single air handling device provides a source of warm air and cool air which is then delivered through a duct or ducts to each of the several spaces. A temperature-sensing device, normally a room thermostat, operates a motor (or motors) which positions damper blades in the ducts in such a way that warm air is delivered if the space is cool, cool air is delivered if the space is over-heated, or a mixture of warmed air and cooled air is delivered if the space is at or near the desired temperature. The above-described system is effective, but is inherently wasteful of energy. The warm air must be warm enough to heat the coldest space, the cool air must be cool enough to cool the warmest space, and all other spaces served from the air handling device receive a mixture of warm air and cool air — that is, air at some intermediate temperature between the warm air and the cool air. The wastefulness of mixing heated air with cooled air has been recognized, and triple-plenum systems have been designed for the purpose of eliminating the warm air-cool air mixing process. Triple-plenum systems of the prior art have a third plenum, usually referred to as a by-pass plenum because the air delivered to it has by-passed the heating device and cooling device. It has been neither heated nor cooled, and is referred to as by-pass air. The source of by-pass air is not important to this invention. The dampers for triple-plenum systems are operated in such a way that cooled air can be mixed with by-pass air, or warmed air can be mixed with by-pass air, but warmed air is not mixed with cooled air. Previous mixing damper arrangements for triple-plenum systems have suffered from one or more of the following.

- a. Need for unusual precision in manufacture.
- b. High cost.
- c. Excessive complexity.
- d. Excessive leakage of air past nominally closed dampers.
- e. Difficulty in obtaining correct sequencing of damper movements.
- f. Restriction of the air passages through the damper assemblies.

SUMMARY OF THE INVENTION

The present invention provides a triple-plenum mixing damper assembly which overcomes the difficulties experienced with previous designs. It consists of three passages through which air can pass, one damper blade in each passage, turned either directly by a drive or by overrunning couplings driven by the drive. In a three-plenum damper assembly forming a specific embodiment of the invention, the drive comprises a shaft to which the by-pass damper blade is keyed, and to which

a warm air damper blade and a cold air damper blade are connected by lost motion or overrunning spring couplings. The damper blade in the by-pass air passage is attached to the shaft, and rotates with the shaft. It is in the open position at the mid-point of the shaft rotational movement, and is fully closed by either clockwise or counter-clockwise shaft rotation of approximately 45° from this midpoint. The damper blades in the warm air passage and the cool air passage have rotational movement of approximately 45° each. They are positioned by the spring-loaded damper positioners or overrunning couplings rather than being turned by direct attachment to the shaft. The spring-loaded damper positioners are fixed to the shaft and arranged in such a way that the rigid arm is in contact with and "positions" the damper blade through approximately 45° of shaft rotational movement. Through the other approximately 45° of shaft rotational movement, the damper blade is held closed against the sides of the air passage by the spring, while the rigid arm moves away from contact with the damper blade. By properly arranging the angular displacement of the damper blades and the blade positioners on the shaft, and by making the blades the correct size to contact the sides of the air passage at approximately 45° angular displacement from the through-axis of the passage, a single damper motor, operating a single shaft is able to operate a set of three-plenum mixing dampers in such a way that the mixing dampers allow the passage of air in any of the following combinations:

- a. All warm air.
- b. A mixture of warm air and by-pass air.
- c. All by-pass air.
- d. A mixture of by-pass air and cool air.
- e. All cool air.

They do not permit the mixing of warm air with cool air. In addition, when any damper blade is in its fully open position, its air passage is essentially unobstructed.

In the drawings:

FIG. 1 is a fragmentary perspective view of a conditioning system including a three-plenum damper forming one embodiment of the invention;

FIG. 2 is an enlarged, exploded, perspective view of the damper shown in FIG. 1;

FIG. 3 is an enlarged, fragmentary, horizontal sectional view of the damper of FIG. 1; and,

FIGS. 4 to 8 are schematic views showing various positions of adjustment of the three dampers of the assembly of FIG. 1.

Referring now in detail to the drawings, there is shown therein a three-plenum damper forming a specific embodiment thereof and including a damper housing 10 having a by-pass air passage 11 at its top, a warm air passage 12 in the middle and a cool air passage 13 at its bottom. The three air passages may be arranged in any other order if desired.

Means for connecting the inlet side of the damper housing to a blower source 9 (FIG. 1) of air is shown as a flanged member 14, and means for connecting the outlet side of the damper housing to ductwork or other distribution device (not shown) is shown as flanged member 15. Frame 16 provides rigidity and contains shaft bearings 17. By-pass damper blade or vane 20 is fixed or keyed to the shaft and turns with the shaft. Warm damper blade or vane 21 and cool damper blade or vane 22 are rotatable on the shaft 19, and are not

given rotational movement directly by the shaft. The blades 21 and 22 have operative relationship to the shaft by lost motion couplings including damper positioning devices 23 and 24, respectively, fixed or keyed to the shaft and turning with the shaft. Coil spring assemblies 25 and 26 maintain a force on damper blades 21 and 22, which hold the blades in contact with the damper positioners unless one of damper blades 21 and 22 is closed and the shaft is turned further in the direction closing that blade, in which event, the coil spring assembly exerts a progressively increasing closing force on the closed blade to minimize leakage. Also, to minimize leakage, edges of the blades are provided with sealing strips 29 of resilient material, showing of the strips being omitted for purposes of clarity except for a portion of one of the strips on the blade 20 in FIG. 2. These strips provide continuous seals even though the blades may not be perfectly aligned with the sides of the air passages. The resilient material compresses, and thus makes up for any slight irregularities or imperfections in the metal parts as the closing force increases.

An additional approximately 45° counter-clockwise rotation of the shaft 19, as viewed in FIG. 6, (approximately 90° total from the position shown in FIG. 4 to the position shown in FIG. 8) fully closes by-pass damper blade 20 in its counter-clockwise closed position, keeps warm damper blade 21 fully closed with its positioner 23 removed approximately 45° from contact with the damper blade 21, and fully opens cool damper blade 22.

At any shaft rotational position between zero and 45° from the position illustrated in FIG. 4, one position being illustrated in FIG. 5, air will flow through both the warm air passage 12 and the by-pass air passage 11, and a mixture of warm air and by-pass air will be delivered to the conditioned space. At any shaft rotational position between 45° and 90° from the position illustrated in FIG. 4, one position being illustrated in FIG. 7, air will flow through both the by-pass air passage 11 and the cool air passage 13, and a mixture of cool air and by-pass air will be delivered to the conditioned space.

Arrows 31 show flow routes in FIGS. 2 and 4 to 8. In FIG. 4, the shaft 19 is shown in the full-clockwise position in which the by-pass damper blade 20 is fully closed, the warm damper blade 21 is fully open, and the cool damper blade 22 is fully closed. When the damper positioner 24 is angularly removed from the cool damper blade 22 by approximately 45° from its position shown in FIG. 6, the cool damper spring assembly 26 exerts a closing force on the cool damper blade 22 through bracket 27 while permitting the shaft to overrun the fully closed position of the blade 22.

Counter-clockwise rotation of the shaft 19 of approximately 45° from the position shown in FIGS. 2 and 4 fully opens by-pass damper blade 20 and fully closes warm air damper blade 21 while keeping cool air damper blade 22 fully closed. The spring assembly 26 for the cool air damper blade is sufficiently stressed (as the parts are shown in FIG. 6) to keep damper blade 22 closed despite the 45° turning movement of the associated positioner 24 toward the damper blade 22. In fact, at approximately the 45° mark, the cool air damper positioner 24 will come into contact with, but not yet move the cool air damper blade 22. Meanwhile, the warm air damper positioner 23 will remain in contact

with the warm damper blade 21 even though the counter-clockwise movement, above referred to, tends to move the positioner 23 away from the damper blade 21, the damper blade 21 being maintained in contact with the positioner 23 by the stress in the associated spring 25.

The blades 20, 21 and 22 (FIG. 2) have vertical grooves 40, 41 and 42 receiving about one-half of the diameter of the shaft 19 and clips 43 are fixed to the blade 20 and pinned to the shaft to key the blade 20 to the shaft. Pairs of clips 44 and 45 fixed to the blades 21 and 22, respectively, mount the blades 21 and 22 rotatably on the shaft 19. The positioners 23 and 24 have sleeve portions 46 and 47, respectively, fixed to the shaft to key the positioners to the shaft. The sleeve portions fit closely and are free to rotate in cut out portions 48 and 49 in the central portions of the blades 21 and 22. The positioners have arm portions 51 with folded over contacting pads 52 at their outer ends. The coil spring assemblies 25 and 26 have coil portions 53 mounted on pins 54 carried by clevis-like brackets 57 of the positioners 23 and 24, and also have arm portions 55 resting in notched portions of brackets 27 and 56. The springs are loose on the pins 54, and have end portions 59 (FIG. 3) extending through holes in the brackets 57 to lock to the brackets. When the shaft 19 overruns either the blade 21 or the blade 22, the springs merely wind up further, as illustrated in FIG. 3.

Top, bottom and intermediate partition plates 60, 61, 62, 63, 64 and 65 (FIG. 2) form the tops and bottoms of the passages 11, 12 and 13, and, for purposes of illustration, are shown outside the housing. The shaft extends rotatably through these partitions. One or more blowers (not shown) supply the three passages with by-pass air at ambient temperature, warm air at a warmer temperature, and cool air at a lower temperature.

By arranging the blades 20, 21, and 22 to close their air passages at approximately 45° angular displacement from the through-axis, a relatively constant width of opening for air flow is attained. In contrast, conventional dampers, whose blades close at 90° angular displacement from the through-axis, do not attain such relative constancy. That is to say, the variation in opening width is less than $\pm 5\%$ for blades closing at 45°, as compared to variations in opening width of more than $\pm 20\%$ for blades closing at 90°.

What is claimed is:

1. In a three-plenum damper,
 - a by-pass air passage,
 - a warm air passage,
 - a cold air passage,
 - a by-pass blade movable in the by-pass passage between a first closed position through an open position and a second closed position,
 - a warm air blade movable in the warm air passage between a closed position and an open position,
 - a cold air blade movable in the cold air passage between a closed position and an open position,
 - drive means for driving the by-pass blade between the first and second closed positions thereof,
 - first resilient coupling means driven by the drive means for moving the warm air blade from the open position thereof to the closed position thereof when the by-pass blade is moved from its first closed position to its open position and for holding the warm air blade in its closed position while the by-pass blade is moved between its open position

and its second closed position, and second resilient coupling means for moving the cold air blade from its closed position to its open position while the by-pass blade is moved from its open position to its second closed position and for holding the cold air blade in its closed position while the by-pass blade is moved between its open position and its first closed position.

2. The three-plenum damper of claim 1 wherein movement of the by-pass blade is limited to not substantially greater than 90° between its first closed position and its second closed position and movement of each of the warm air blade and the cold air blade between their open and closed positions is limited to about 45°.

3. The three-plenum damper of claim 2 wherein the drive means comprises a shaft extending through all the passages and keyed to the by-pass damper and connected to the first and second resilient coupling means.

4. The three-plenum damper of claim 1 wherein the drive means comprises a shaft extending through all the passages and keyed to the first and second resilient coupling means.

5. The three-plenum damper of claim 4 wherein each resilient coupling means includes an arm keyed to the shaft for pushing its associated blade and spring means urging the last mentioned blade toward engagement with the arm.

6. The three-plenum damper of claim 5 wherein each spring means comprises a torsion spring having one end engaging the blade and the other end engaging the arm, whereby the spring exerts progressively increasing closing force on the blade as the shaft is turned further beyond the closed position of the blade.

7. The three-plenum damper of claim 1 wherein each resilient coupling means exerts an increasing closing force as the drive means tends to move the blade driven by that coupling means beyond the closed position of that blade.

8. In a damper construction,
a plurality of parallel passages,
a shaft extending through the passages,
a plurality of vanes in the passages and mounted on the shaft,
means keying a first one of the vanes to the shaft,

overrunning resilient coupling means coupling a second one of the vanes to the shaft,
and stop means for limiting movement of the second one of the vanes with the shaft through a predetermined angle and permitting the shaft and said first one of the vanes to move further.

9. In a damper construction,
a passage,
a shaft extending across the passage,
a vane mounted rotatably on the shaft,
a pusher arm keyed to the shaft for engaging the vane and moving it with the shaft when the shaft is turned in one direction and tending to move it away from the vane when the shaft is turned in the opposite direction,
and spring means between the pusher arm and the vane biasing the vane toward engagement with the pusher arm.

10. The damper construction of claim 9 including a pin carried by the arm, the spring being a coiled torsion spring mounted on the pin and having one end connected to the arm and the other end connected to the vane.

11. The damper construction of claim 9 in which the spring means increases its biasing force on the vane when the vane is in a closed position and the shaft is turned further in a vane closing direction.

12. In a three-plenum damper,
a by-pass passageway,
a warm air passageway,
a cold air passageway,
a blade turnable in each passageway,
means for moving the blade so that while air can pass simultaneously through the by-pass passageway and either the warm air or cold air passageway, air is precluded from moving simultaneously through the warm air and cold air passageways,
said blades being of such size relative to their passageways that their movement is restricted to approximately 45° from a central position whereby a more constant opening width for the travel of air is attained than with blades permitted to turn 90° from a central position.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,911,953

DATED : October 14, 1975

INVENTOR(S) : ALLEN P. CROMBIE and ROY M. STEEGE

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

In the abstract [57], line 17, "passages" should be
--passage--.

In the claims, Claim 1, column 4, lines 52 and 57
"aid" should be --air--.

Signed and Sealed this

thirtieth Day of December 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks