No. 855,118. PATENTED MAY 28, 1907.

C. A. MORRIS.

METHOD OF VENTILATING TUNNELS.

APPLICATION FILED JULY 14, 1905.

4 SHEETS—SHEET 1.

Fig. 1.

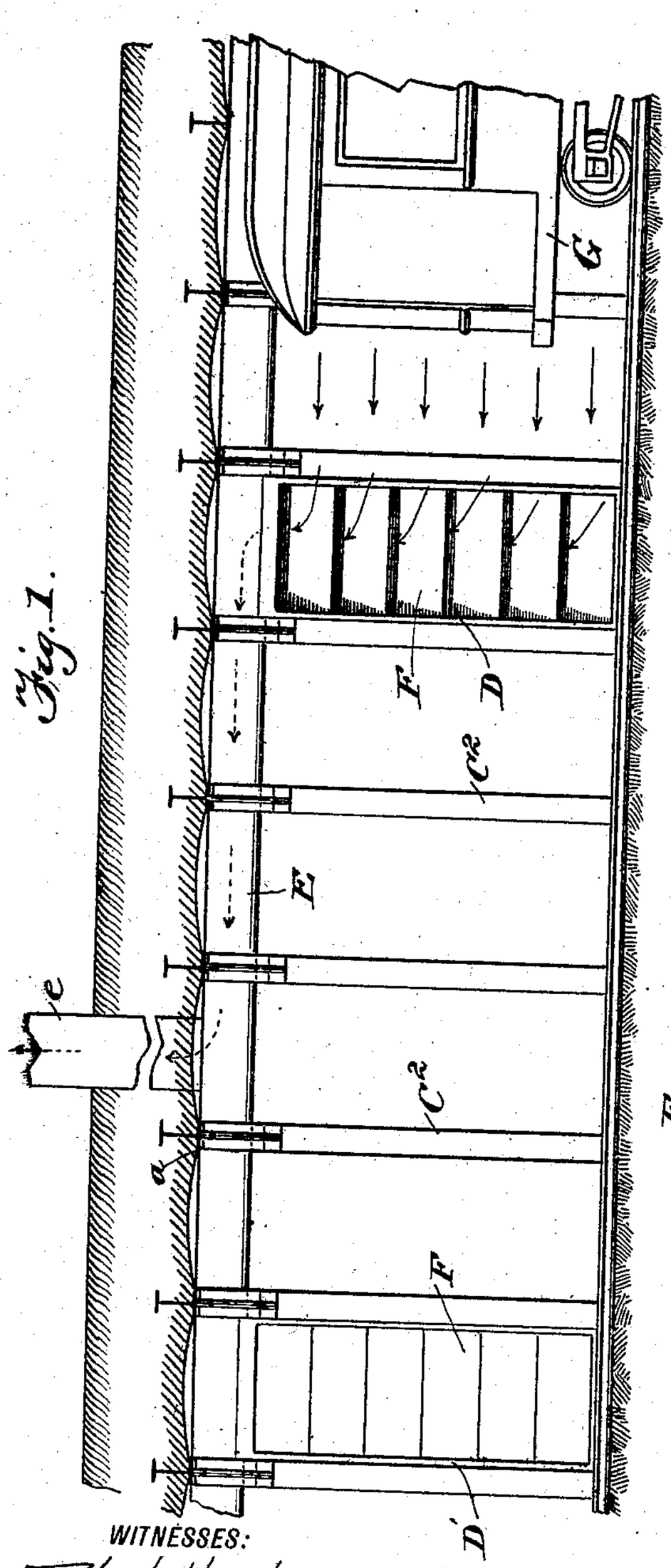
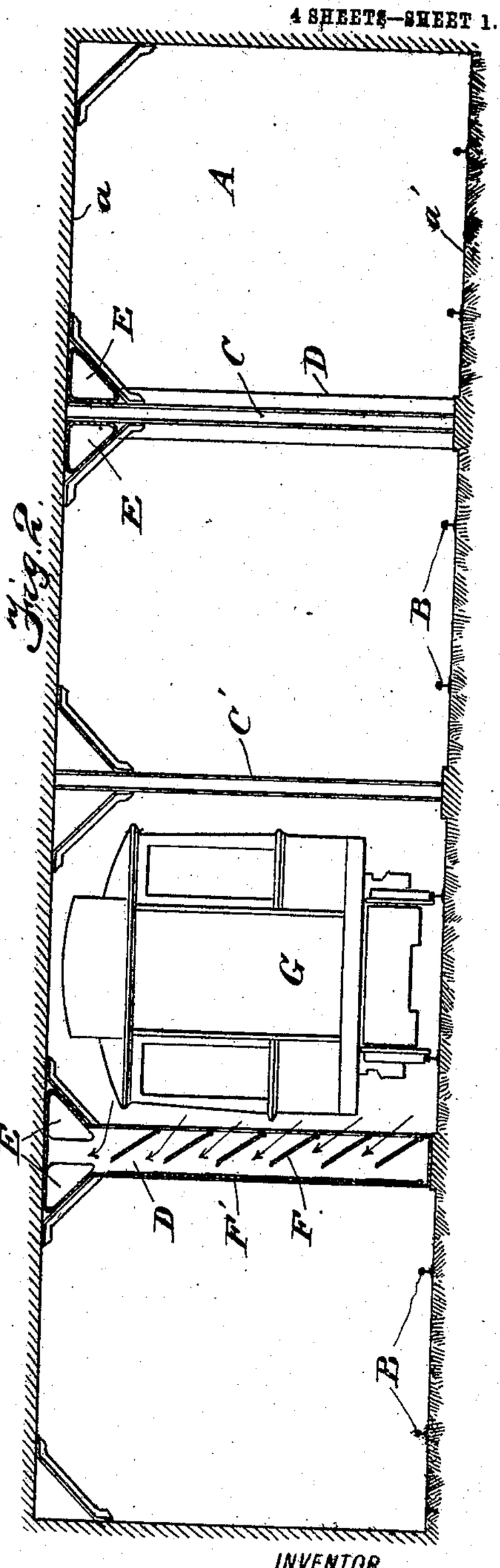


Fig. 2.



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4 SHEETS—SHEET 2.

Fig. 1.

Fig. 2.

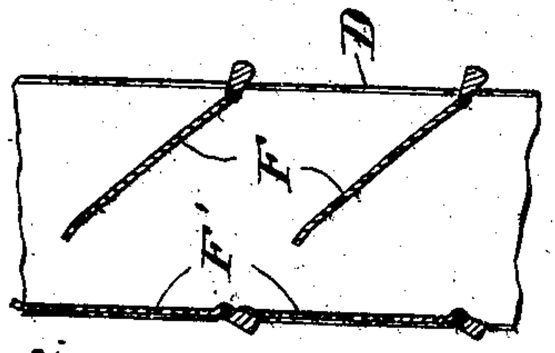

Fig. 3.

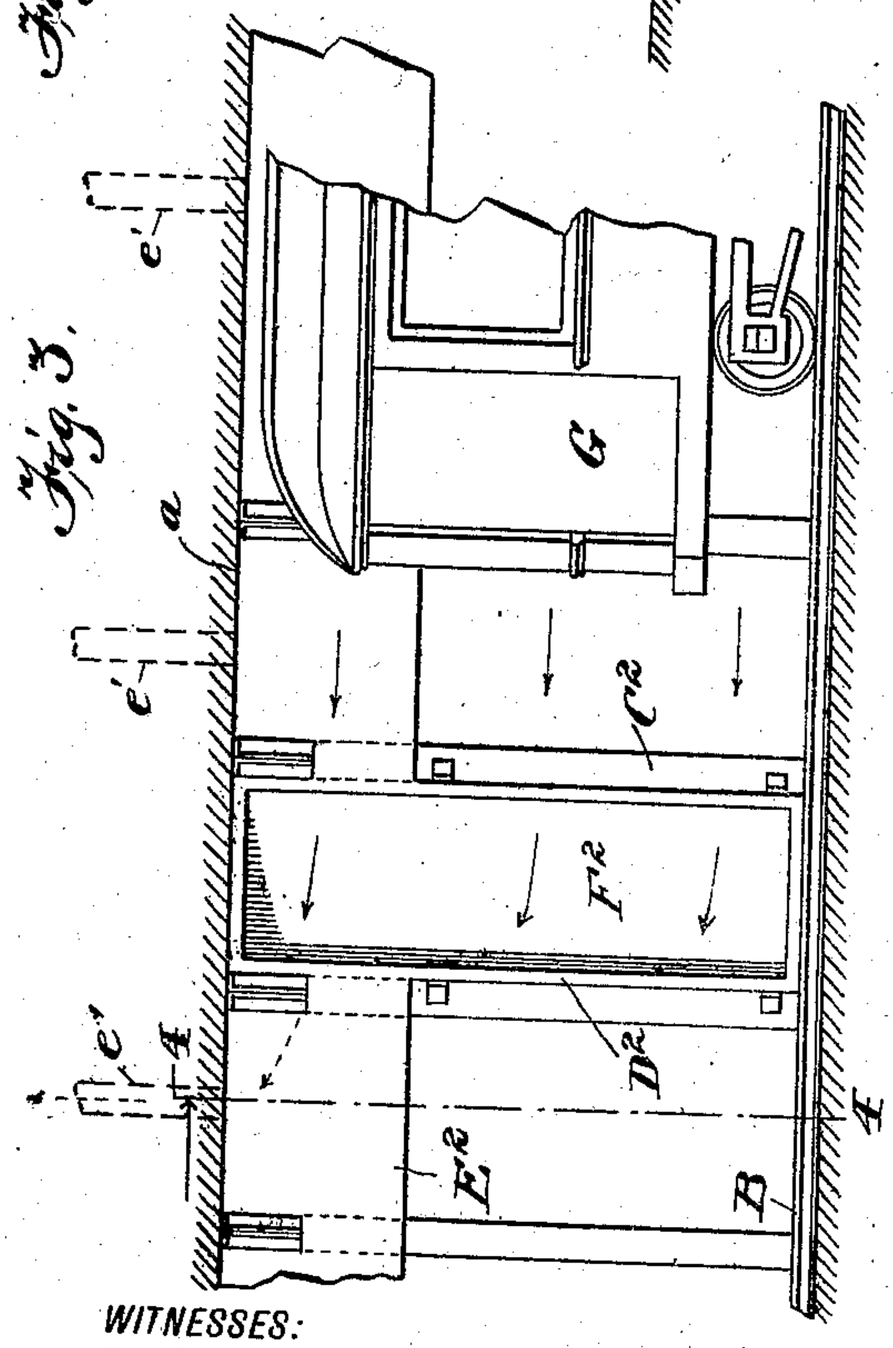

Fig. 4.

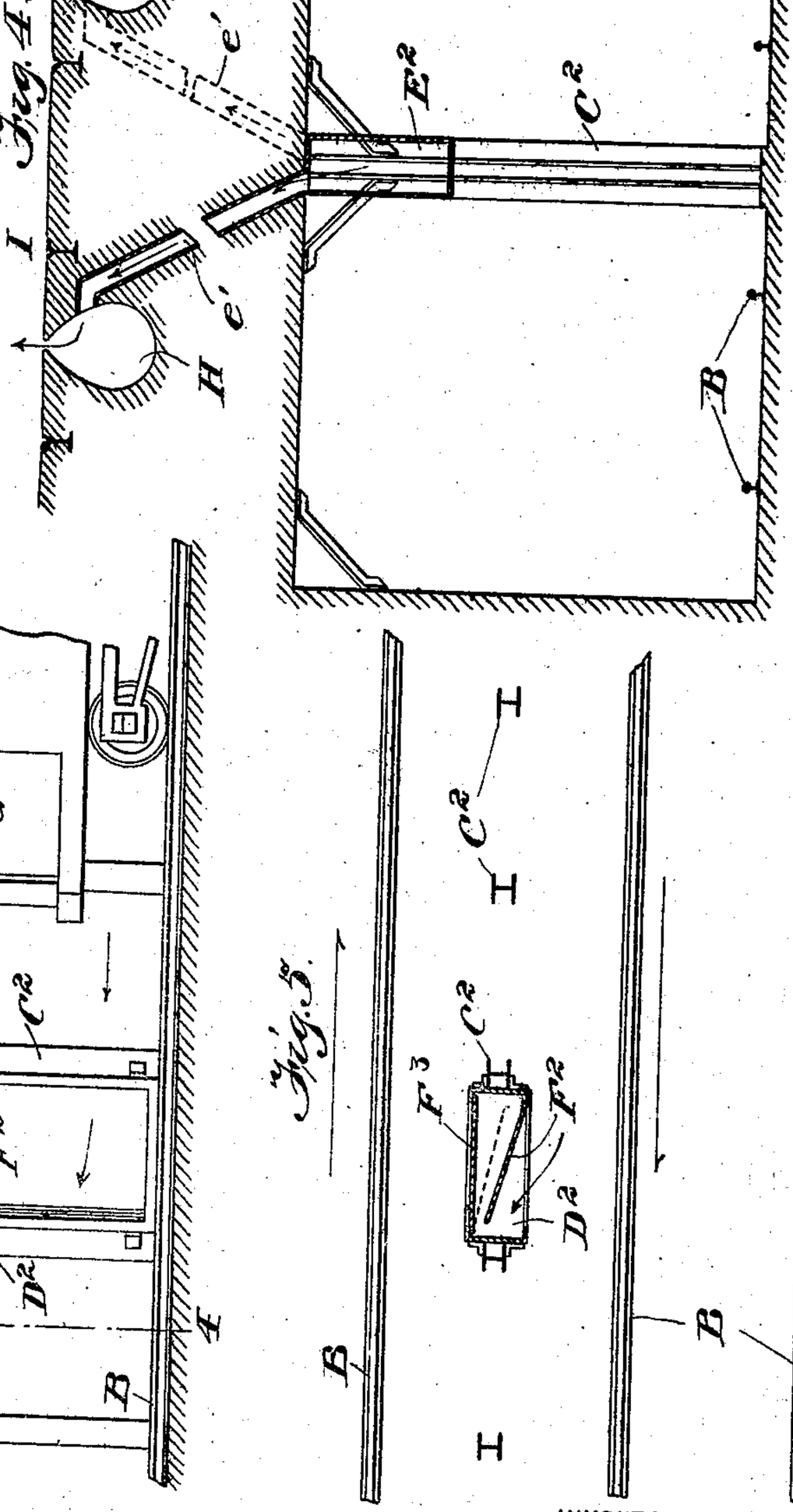

Fig. 5.

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4 SHEETS—SHEET 3.

Fig. 7.

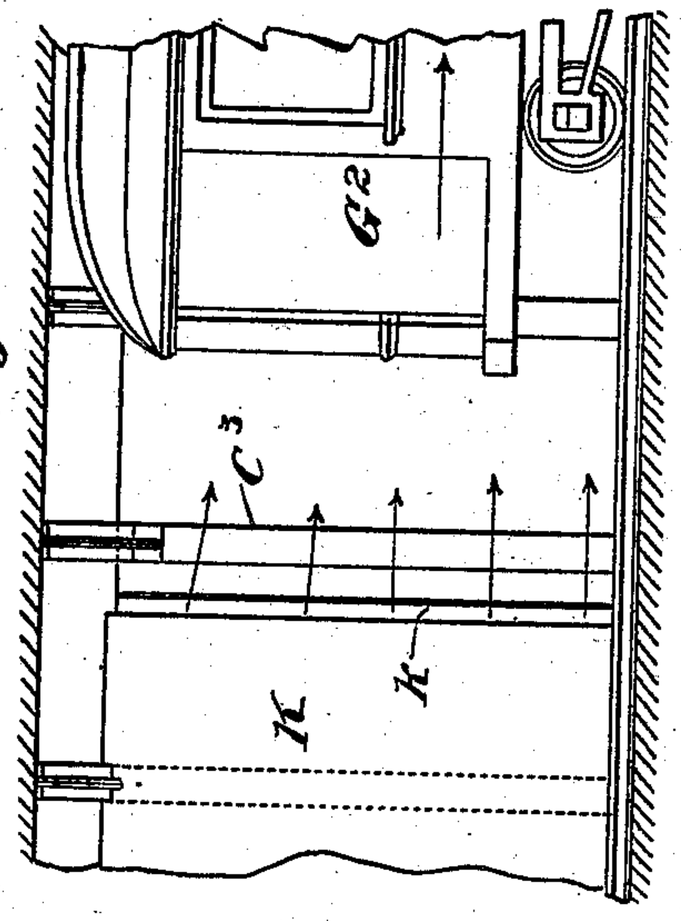


Fig. 6.

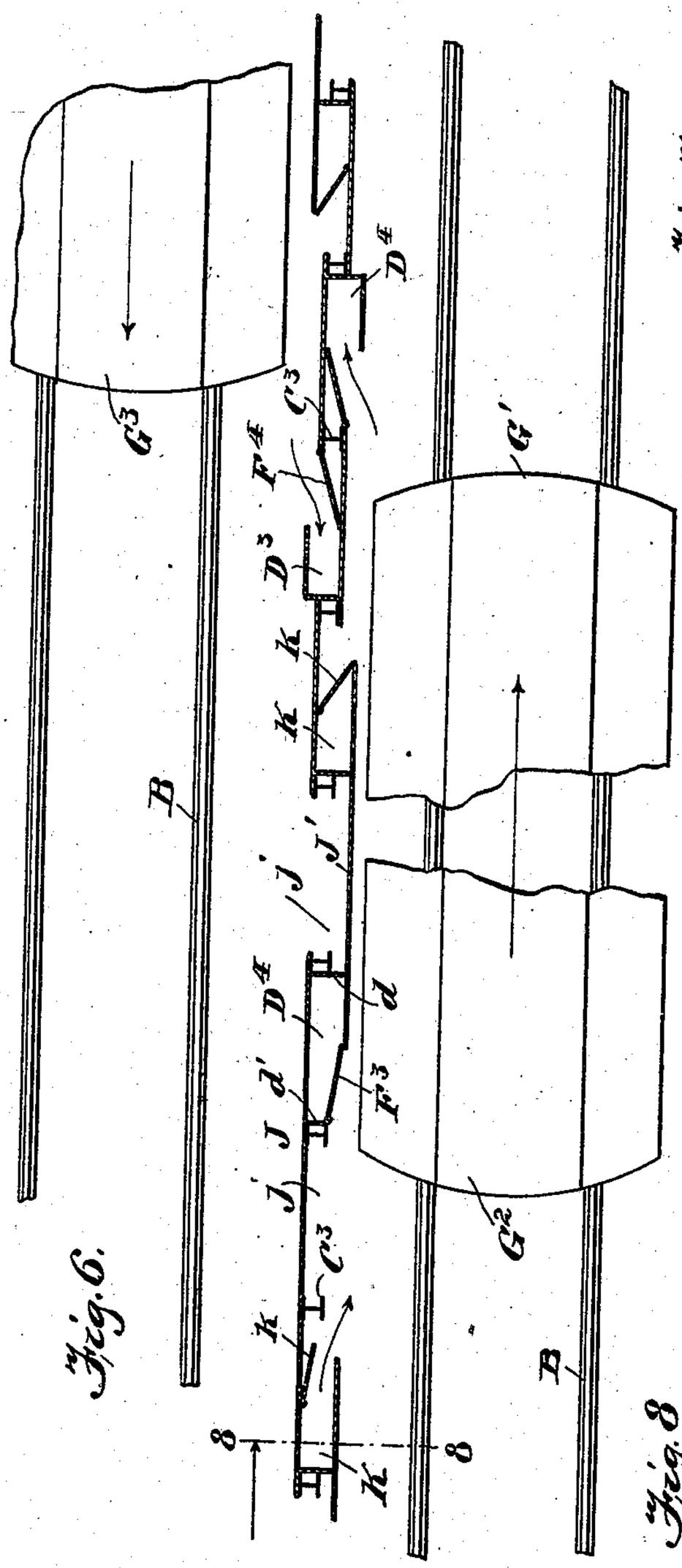
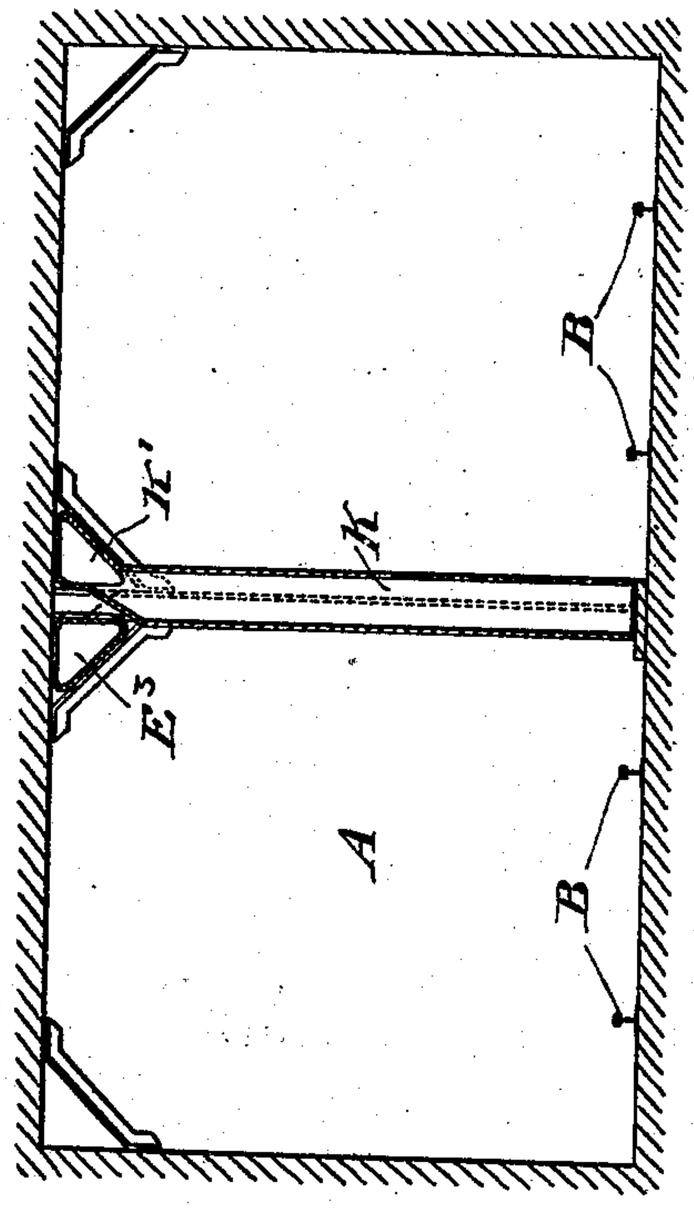


Fig. 8



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4 SHEETS—SHEET 4.

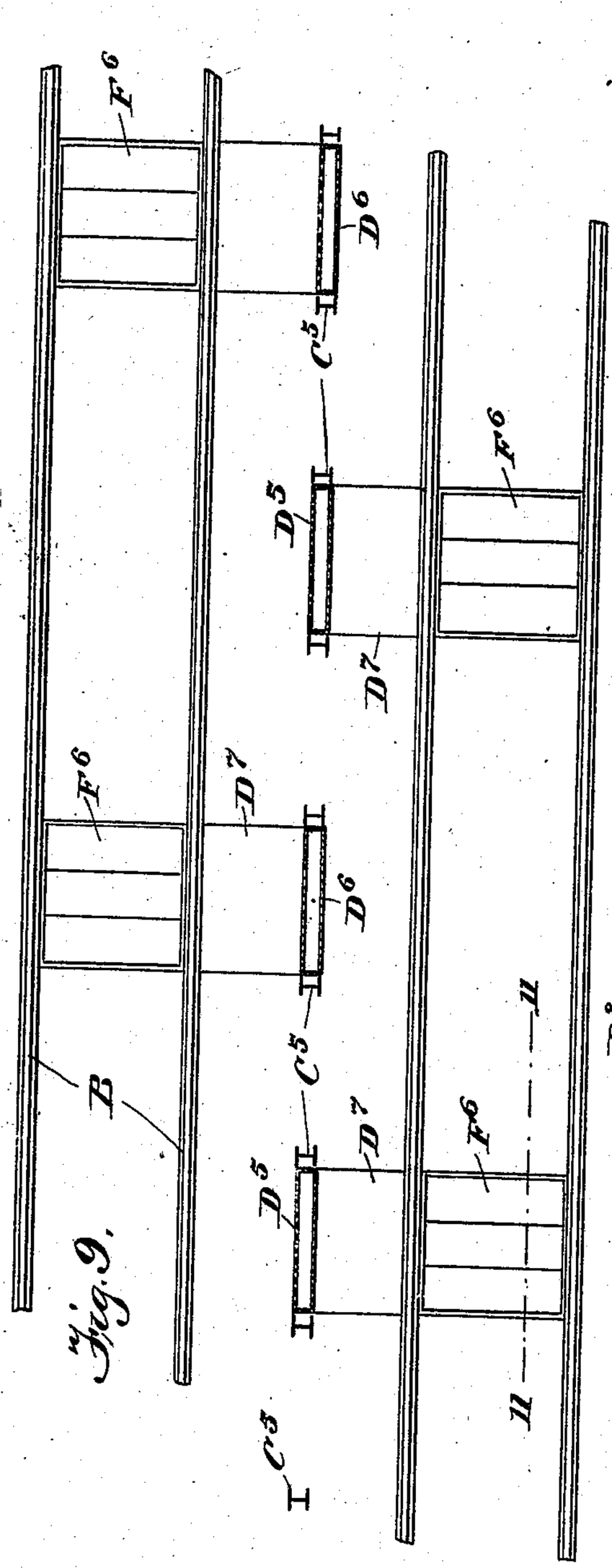

Fig. 9.

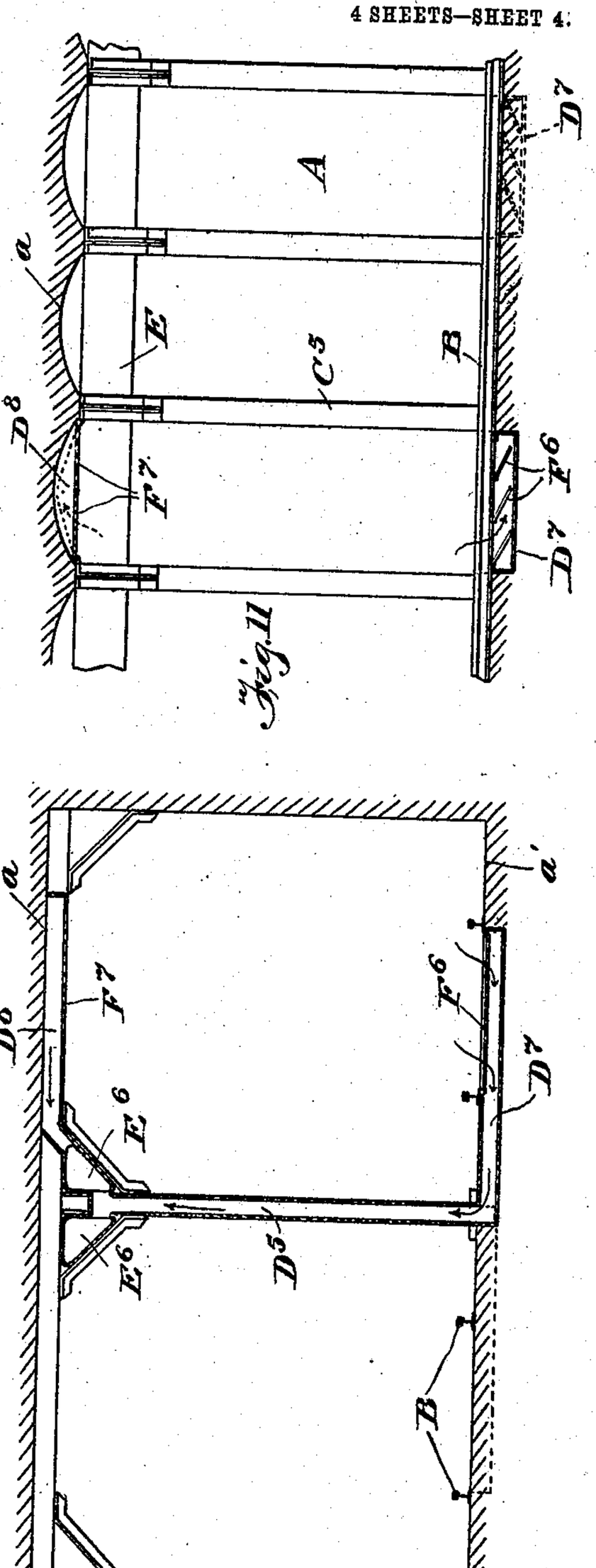

Fig. 11.

Fig. 10.

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UNITED STATES PATENT OFFICE.

CHARLES A. MORRIS, OF BLOOMFIELD, NEW JERSEY.

METHOD OF VENTILATING TUNNELS.

No. 855,118. Specification of Letters Patent. Patented May 28, 1907.

Application filed July 14, 1905. Serial No. 269,605.

To all whom it may concern:

Be it known that I, CHARLES A. MORRIS, a citizen of the United States, residing at Bloomfield, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Methods of Ventilating Tunnels, of which the following is a specification.

My invention relates to the ventilation of tunnels and subways, and more particularly to tunnels in which passenger trains, particularly electrically propelled, are operated.

The object of this invention is to expel the stagnant, foul or heated air from underground structures, particularly subways or tunnels in which are operated cars or trains; and, also, to secure an ample supply of fresh air to the tunnel, or other structure. This object is accomplished by displacing the air by the movement of a car, train, or other body, the latter having a piston-like action on the air in the tunnel or other structure. The air thus displaced finds an exit through flues or conduits, the latter being independent of the passenger entrances or exits, and such air is trapped against return to the tunnel or structure to be ventilated.

The displacement of the stagnant air takes place, preferably, in advance of the moving train, which is adapted to have a piston-like action on the confined body of stagnant air. Fresh air is induced to flow into the tunnel through the passenger entrances and exits by the suction created due to the movement of the trains, or, if desired, the inflow of fresh air may take place through flues or conduits independent of such exits and entrances.

The flues or conduits, for the exit of foul air, or the ingress of fresh air, or both, may be constructed in various ways. It is preferred, however, to utilize the columns or pillars ordinarily employed in tunnel construction in the erection of such air flues, and to locate said flues at suitable intervals throughout the length of the tunnel. An important feature of each air flue consists in the employment of a valve or valves which are normally closed against the passage of foul air from the flue back into the tunnel, such valves being operated preferably by the air current or pressure generated by the movement of the train, whereby the stagnant air is caused to flow from the tunnel into the flue. Its return is arrested by the automatic valve or valves, it being allowed to discharge through the flue or flues extending exteriorly of the tunnel. The flues may have separate points of discharge into the outer atmosphere, or such flues may communicate with and discharge into a common conduit running lengthwise of the tunnel, preferably above the same.

Different embodiments of the invention are illustrated by the accompanying drawings, forming a part of this specification, wherein like characters of reference are used to indicate corresponding parts in all the figures.

Figure 1 is a vertical longitudinal sectional elevation through a portion of the tunnel equipped with my ventilating means and illustrating diagrammatically the operation of a moving train in displacing the stagnant air. Fig. 2 is a vertical cross section through the tunnel shown by Fig. 1 illustrating a series of four tracks therein and the ventilating devices used in connection therewith; Fig. 3 is a vertical longitudinal section somewhat similar to Fig. 1 and showing another embodiment of the ventilating devices; Fig. 4 is a vertical cross section on the line 4—4 of Fig. 3, illustrating another method of discharging the stagnant air from the ventilating flues of the tunnel; Fig. 5 is a horizontal sectional plan view through the structure represented by Fig. 3, illustrating a portion of two adjoining tracks; Fig. 6 is a sectional plan view of another embodiment of means for discharging the stagnant air from the tunnel and for supplying fresh air thereto by devices wholly independent of the passenger entrances and exits; Fig. 7 is a sectional elevation taken longitudinally through a portion of the tunnel, illustrating the means for suplying fresh air due to the suction created by the moving train; Fig. 8 is a vertical cross section taken in the plane of the dotted line 8—8 of Fig. 6, looking in the direction of the arrow; Fig. 9 is a sectional plan view through another embodiment of the invention, wherein the stagnant air is adapted to enter the flue and discharge conduits at the top and bottom, respectively, of the tunnel; Fig. 10 is a vertical cross section through the structure shown by Fig. 9; Fig. 11 is a vertical longitudinal sectional elevation in the plane of the dotted line 11—11 of Fig. 9; Figs. 12 and 13 are views illustrating different means for counterbalancing the movable valves of the air eduction flues.

A designates a tunnel or an underground subway, the roof *a* of which is supported by columns or pillars, arranged in rows as indi-

cated at C, C′, C². The bed or floor *a′* of the tunnel has one or more railway tracks B, on either of which is adapted to travel a car, or a train of cars, indicated at G.

For conveying the vitiated or foul air from the tunnel, I provide a plurality of eduction flues or conduits indicated at D D′. These conduits are preferably vertical, and they are placed at suitable intervals. These flues D D′ are constructed or erected between adjacent columns of a pair in each row of columns C, C′, C², thus utilizing the columns or pillars which are employed in the construction of the tunnel. In Fig. 1 of the drawings, I have shown two of the flues D D′ at every sixth column, but it will be understood that the distance between the flues is not material and can be increased or decreased as may be desired. Each eduction flue for the vitiated air is constructed to trap the air entering therein against return to the chamber of the tunnel, and this trapping means may be embodied in various forms of construction, some of which are illustrated in this application as different embodiments of the present invention. In the construction of each flue shown by Figs. 1 and 2, the sides of said flue are formed by a plurality of flap valves indicated at F F′. The valves on one side of the flue are pivoted so as to open inwardly under the pressure of the air which is produced by the movement of the car G on one of the tracks, and these valves are adapted to be held in closed positions normally by any suitable means, such as a form of counterpoise, two forms of which counterpoise are represented by Figs. 12 and 13, either of which may be used. It will be seen that the valves F on one side of each flue D D′ are adapted to be opened by the pressure of air when the train moves in one direction along the second track B, but the valves F′ in the other part of said flues are intended to be opened by the pressure of air which is displaced by the movement of a car or a train adapted to travel on an adjacent, or the first, track of the series provided in the tunnel.

The flues D D′ communicate at their upper ends with the conduit E. This conduit is provided at or near the upper ends of the columns C², directly below the roof *a*. This conduit runs lengthwise of the tunnel, just below the arch or roof thereof, and said conduit is shown by Fig. 1 as being provided with a discharge branch *e*. The branch of the conduit may lead to any suitable place of discharge exteriorly of the tunnel, as for example through the roof of the kiosks, which provide an entrance to, and an exit from, the tunnel for the convenience of passengers in obtaining access to the train or in leaving the tunnel. It is evident that the branch *e* of the conduit may be carried to any other place of discharge for the foul or vitiated air.

I contemplate the employment of the eduction flues between any desired rows of columns, and in Fig. 2 the eduction flue E is shown as being provided at the upper ends of the row of columns C. It should be understood that the eduction flues, similar to the flues D D′ of the columns C², are provided between the columns of the row C, and it is evident that similar eduction flues and an overhead conduit may be provided in connection with the columns C′ without departing from my invention.

In the operation of the system, the movement of a car or a train, such as G on one of the tracks, compresses the air in the tunnel, thus creating or establishing a current. The pressure of the vitiated air in advance of the moving car G is utilized in opening the flap valves of the successive eduction flues, as indicated by the arrows in Fig. 1. The air thus compressed will not only open the flap valves, but it will readily flow into the flue and thence pass through the conduit into the discharge branch *e* thereof. The air, however, is trapped by the automatic closing of the flap valves in the flue, so as to prevent the return of the vitiated air to the chamber of the tunnel. It will be noted that the movement of the train through the tunnel compresses the air in advance thereof so as to expel the vitiated air through separate ducts or flues which are independent of the entrances or exits from the tunnel, thus preventing the passengers when entering or leaving the tunnel from encountering a blast of vitiated air. At the same time, the movement of the train through the tunnel creates a suction in the rear of the train, which is sufficient to draw fresh air through the passenger entrances or exits into the chamber of the tunnel, but this particular method of ventilating the tunnel is not relied upon exclusively for the maintenance of fresh air in the tunnel through the passage entrances or exits, because, as will hereinafter appear, the supply of fresh air may be induced, by suction of the moving train, to flow through conduits and flues independent of the exits and entrances.

In the embodiment of the invention shown by Figs. 3 and 5 inclusive of the drawings, the detailed construction of the eduction flue is modified and provision is made for discharging the vitiated air through the conduits of underground electric or cable surface railways. Instead of employing two series of normally closed flap valves on the respective sides of each air eduction flue, I may employ a single vertical valve or gate on each side of said flue. As shown by Fig. 5, the single vertical valve F² is hung at one edge thereof so as to be opened by the pressure of air generated by the movement of a train in one direction, as shown by full lines, but the other vertical valve F³ on the opposite side of the eduction flue is adapted to be opened by pressure of air in advance of a train traveling

in an opposite direction on an adjacent track, as indicated by dotted lines. The flue D^2 is constructed between adjacent columns of the row, and said flue has communication with an overhead or elevated conduit E^2. From this conduit extend the branches e', which have communication with the conduit H of a surface railway I, thus making provision for discharging the vitiated air by flues into the conduits, and from thence into the street directly over the tunnel, as shown by Fig. 4.

A further modification of the ventilating system is represented by Figs. 6, 7 and 8 of the drawings, wherein the movement of a train through the tunnel serves to not only displace the vitiated air therefrom through flues independent of the passenger entrances or exits, but such movement of the train also establishes a suction by which fresh air is supplied to the chamber of the tunnel through flues which are also independent of the passenger entrances and exits. In Fig. 8 the system is shown in connection with the tunnel having only two tracks B, and a single row of columns C^3, but it will be understood that the system may be extended to apply to tunnels having three, four or more tracks, as may be found necessary or expedient. On one fo the tracks is adapted to travel a train, the front and rear cars of which are indicated respectively, at G' G^2, while on the adjacent track is adapted to travel another train, the front car of which is indicated at G^3. In this embodiment of the invention the spaces between the columns of the row C^3 are built up so as to provide a substantially continuous partition, which runs lengthwise of the tunnel and serves to divide the latter into compartments or chambers, said partition being constructed so as to secure the eduction flues for the vitiated air at proper intervals, and the induction flues for the fresh air also at intervals. The partition running lengthwise of the tunnel consists of sections J J', arranged between and relatively to the columns C^3, as represented more particularly by Fig. 6, said parts J J' of the partition being interrupted or broken at suitable intervals so as to provide the recesses or spaces j between certain of the columns, in which recesses or spaces the trackmen may stand out of the way of the trains adapted to travel on the tracks B. The eduction flues D^3 D^4 are provided on each side of the partition by suitable walls d d'. The entrances to the flues D^4 on one side of the partition are normally closed by flap valves F^3, adapted to be opened in one direction by a train G' G^2 on one of the tracks, but the entrances to the other flues D^3 are normally closed by flap valves F^4, adapted to open in another direction by the pressure of air generated by the movement of a train G^3 traveling in an opposite direction on the adjacent track, as will be readily understood by reference to Fig. 6. Alternating with the eduction flues D^3 D^4 are fresh air induction flues K, the same being constructed in the longitudinal division wall or partition wall of the tunnel, and each being provided with a flap valve or gate k, which is so hung and arranged to be opened by the suction created by the movement of the train, or the last car G^2 thereof, whereby the suction induces the flow of fresh air through the flues K into the tunnel back of the train. The valves to the induction flues are hung so as to be normally closed and prevent the entrance of fresh air into the tunnel except at the time of the passage of a train, the suction from which create a partial vacuum sufficient to open the valves k, and thereby provide a successive series of air inlets to the tunnel for the purpose of replacing the vitiated air which is expelled in advance of the train through the eduction flues D^3 D^4.

The eduction flues D^3 D^4 communicate at their upper ends with horizontal conduits E^3 extending close to the roof on one side of the columns C^3, as indicated by Fig. 8, and from these conduits E^3 extend suitable branches by which the foul air may be discharged at any suitable or convenient place or places. With the fresh air induction flues K communicates another conduit K', the latter being substantially parallel to the foul air conduit E^3 and adapted to supply fresh air from a suitable source outside of the tunnel to the fresh air conduits K, the two conduits E^3 and K' being compactly disposed below the arch of the tunnel and relatively to the columns C^3.

A further modification of the invention is represented by Figs. 9, 10, and 11, wherein provision is made for the intake by the eduction flue of vitiated air at the floor and the roof of the tunnel. The eduction flues D^5, D^6, are constructed between the columns C^5 of one row within the tunnel A, said flues being spaced at proper intervals, as shown by Figs. 9 and 11. Each flue is shown as having a branch D^7 at its lower end and another branch D^8 at its upper end, the branch D^7 being constructed in the floor or bed a', while the branch D^8 is in the roof or arch a of said tunnel. The lower branch D^7 of each eduction flue opens upwardly through the bed or floor a', and is constructed with one or a plurality of valves F^6 adapted to be normally closed and to be opened by the pressure of air due to the passing of the train, thus admitting foul air into the branch D^7, from whence it passes through the flue through a suitable discharge conduit E^6. The other branch D^8 of the eduction flue is constructed in the roof a, so as to have an opening into the top part of the tunnel, and as is evident by an inspection of Fig. 11, this flue D^8 has one or a plurality of valves F^7, which are normally closed and are adapted to be opened by the pressure of air for the purpose of admitting the foul air from the

top of the tunnel into the branch D^8, from whence the air flows through the conduit E^6. As shown by Fig. 9, the bottom branches D^7 of the adjacent flues D^5 D^6 extend in opposite directions, so as to lie below or within the respective parallel tracks B, thus making provision for admitting foul air to the respective flues associated with the different tracks of the tunnel.

Under some circumstances it may be desirable to cool the fresh air supplied to the tunnel, or other chamber. It is evident that the fresh air may be cooled by any known form of refrigerating appliances so related to the fresh air induction flues as to cool the air before it is discharged into the tunnel.

Changes in the form, size, proportion, and minor details in construction may be made without departing from the spirit of the invention or sacrificing any of the advantages thereof, and I, therefore, reserve the right to make such alterations and modifications as fairly fall within the scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The method of ventilating an underground structure which consists in expelling foul air from said structure and admitting fresh air thereto by the motion of a moving car or body in the structure, and trapping the expelled foul air against return to said structure.

2. The method of ventilating underground structure's which consists in forcing air out of said structure through normally closed outlets, by the motion of a moving car or body therein, trapping the expelled air against return to said structure, and also drawing fresh air into the structure through normally closed inlets operated by the movement of said train.

3. The method of ventilating railway tunnels which consists in displacing the air in the tunnel, and forcing it out of said tunnel, by the motion of a moving car, conducting the expelled air to a place of discharge independent of the entrance to, or exit from, the tunnel, and trapping the air against return to the tunnel.

4. The method of ventilating railway tunnels which consist in establishing a current of the foul air in the tunnel by the motion of a car; inducing the inflow of fresh air by the suction created by the motion of the car; conducting the foul air to a place of discharge exteriorly of the tunnel; and trapping the foul air against return to the tunnel.

5. The method of ventilating railway tunnels which consists in displacing the air in, and forcing it out of, the tunnel by the motion of a moving car therein, utilizing the pressure of the displaced air in trapping the same against return to the tunnel, and conducting the trapped air to a place of discharge exteriorly of the tunnel.

6. The method of ventilating tunnels and similar chambers which consists in compressing the air therein by a moving body, automatically expelling such compressed air from the tunnel through normally closed exits, and automatically introducing fresh air in said tunnel through normally closed inlets.

7. The method of ventilating tunnels which consists in simultaneously drawing fresh air into the tunnel through normally closed inlets and compressing the foul air in said tunnel by a moving car, and in utilizing the air thus compressed to automatically operate valved exits to the tunnel, whereby such foul air is permitted to escape against return to the tunnel.

8. The method of ventilating tunnels which consists in compressing the foul air therein by a moving body and in utilizing said compressed air to automatically operate normally closed exits for the escape of said compressed foul air from the tunnel, and simultaneously admitting fresh air to the tunnel through normally closed inlets operated by said moving body.

9. The method of ventilating tunnels and similar chambers, which consists in expelling foul air from the tunnel by the piston-like action on such air of a car or train moving in said tunnel; drawing fresh air into the tunnel by the suction created by said car or train; and cooling the fresh air prior to, or at the time of, its admission to the tunnel.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

CHARLES A. MORRIS.

Witnesses:

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