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First inventor	Patwardhan
Title of invention	Rapidly deployable system to suppress airborne epidemics
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ABSTRACT OF THE DISCLOSURE

This patent presents a method and some devices based on the method to achieve near zero air based transmission of disease within a business, while still allowing people to approach each other closer than arms length touching distance. This can be achieved with rapidly deployable portable units. It also presents a simple method to test whether the airflow structure requirements of the system have been met, and to adjust it if not.

DRAWINGS

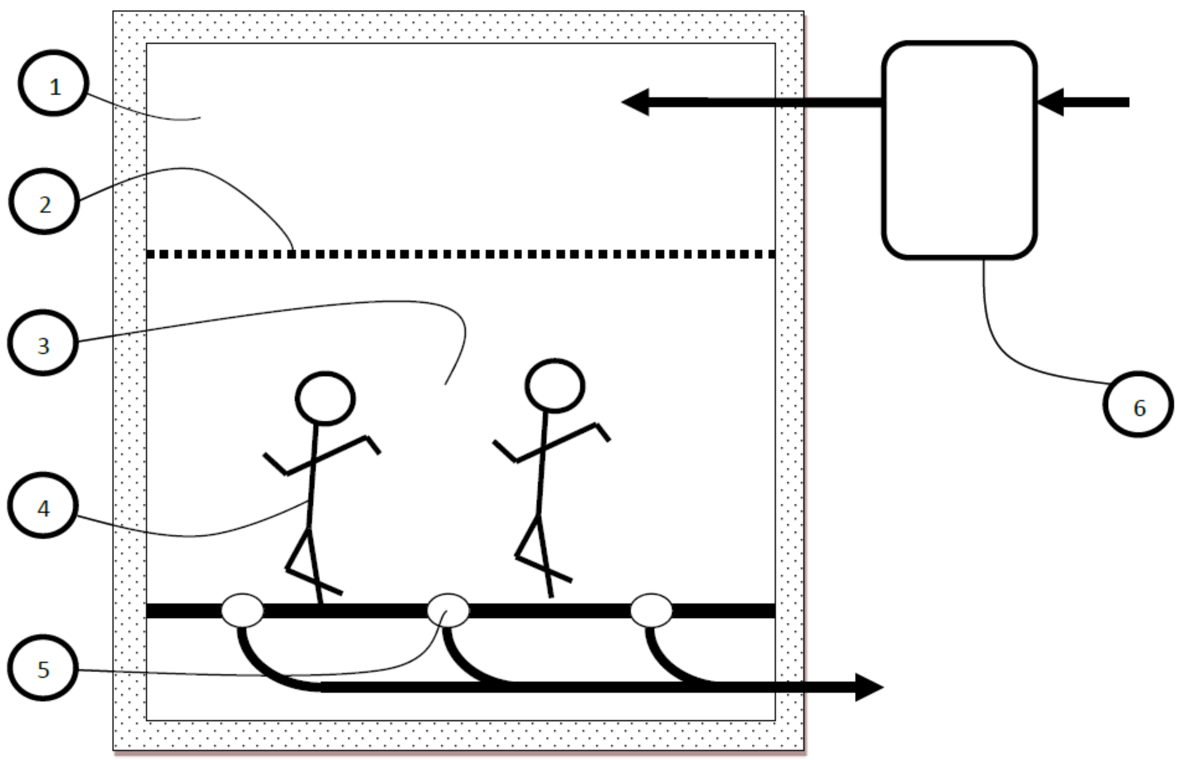

Figure 1

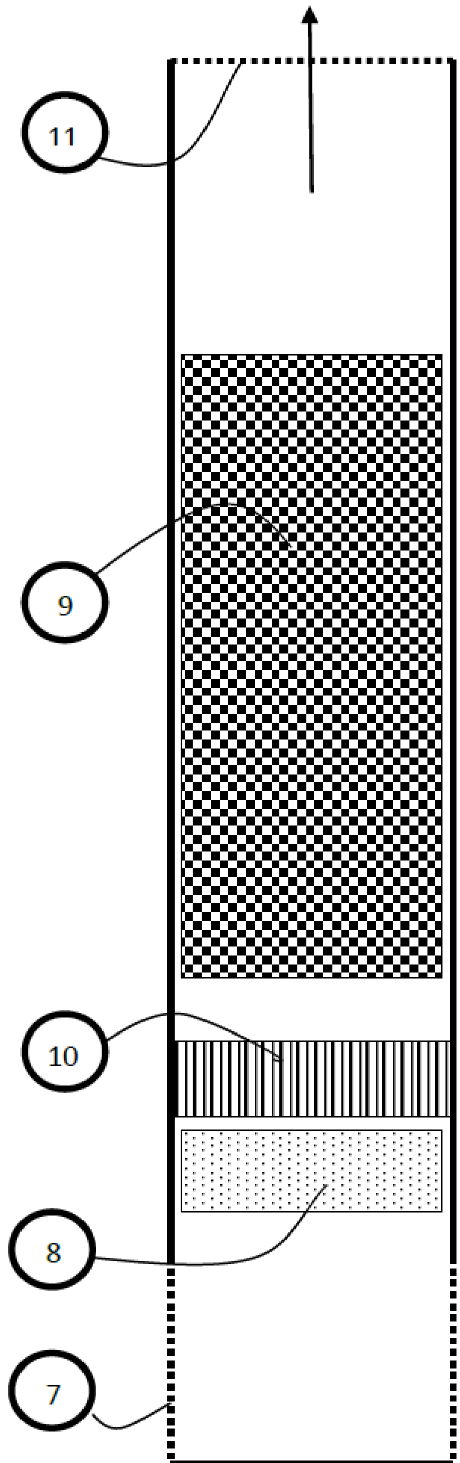

Figure 2

Rapidly Deployable System to Suppress Airborne Epidemics

CROSS REFERENCE TO RELATED APPLICATIONS:

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

RELATED AREAS:

This invention is related to the class of systems and devices to suppress transmission where a disease is transmitted primarily over air. Related areas include air handling systems, air purifiers, and air conditioning systems. Other related areas are laminar flow workbenches, laminar flow hoods, and laminar flow cleanrooms.

REFERENCES:

www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html

www.sentryair.com/portable-clean-room.htm

www.aircleansystems.com

BACKGROUND OF THE INVENTION:

The Covid-19 crisis has demonstrated the need for a rapidly deployable system that can effectively suppress transmission of airborne disease without requiring a complete lockdown of the population and shutdown of the economy. In epidemiology, the primary metric of the communicability of a disease is expressed in its **R** number, which is the average number of other people infected by an already infected person. If the **R** number is greater than one, the number of people infected grows exponentially; while if it is less than one the number of people infected decays and eventually the disease dies out except in some reservoirs. In the initial stages of an epidemic there is a substantial lack of information, and it is hard for the health authorities to determine any correct strategy.

To get a better handle on this, we can break down **R** into 4 separate components:

R ≡ [T][f][v][p]

where - [**T**] is the time an infected person is contagious

- [**f**] is the frequency at which a person meets other people
- [**v**] is the probability the person met is vulnerable to catching the disease
- [**p**] is the probability that transmission occurs when meeting a vulnerable person.

The **[]** are there to remind us that this is not a mathematical equation, just a statement of composition. Given the above breakdown, the following is roughly true:-

- **[T][f]** would be the number of people a contagious person meets
- **[T][f][v]** would be the number of vulnerable people a contagious person meets

The classic reaction to detection of a highly lethal infectious disease is reduce [**f**] for the infected person (i.e. to quarantine them) when we realize a person is infected because of the symptoms he or she displays. Then "contact tracing" is instituted to determine who the person has met, and what they did before they got the disease. The people they met before quarantine was started are also quarantined. This "contact tracing" and follow up data obtained during quarantine and treatment also provides information to determine the values of the various parameters, including its lethality, and basic transmission mechanism. Unfortunately some diseases (like Covid-19) are communicable even without showing symptoms (or the symptoms are very close to some other less lethal disease), and we only detect those cases when the person becomes sick enough to require hospitalization, or show clear symptoms, or test positive for the disease once tests are available. Contact tracing then fails because the links between cases are broken, or it is simply overwhelmed by the wide prevalence of the disease.

Since it may take 6 months or more for a vaccine, therapeutics, palliatives, and/or tests for the disease to be developed, reducing **[T]** or **[v]** is often not an option in the short term. Reducing [**p]** normally requires changes in individual personal behavior over which health authorities do not have sufficient control or even visibility. In the case of Covid-19 many health authorities resorted to reducing **[f]** for most of the population via "lockdown" or "stay-at-home" orders. Unfortunately, given that humans are social animals, **[f]** is the primary driver of the happiness of people, and also the health of the economy. Reducing **[f]** for the whole population thus results in general malaise of the popular mood, and an economic crash. In fact, the poorer segments of the population with low reserves are very dependent on constant interaction to acquire the resources they need to survive, and reducing **[f]** generally could actually result in more deaths than the disease would have caused. Given all that, a strategy to reduce **[f]** for the whole population will meet with popular resistance and active non-cooperation, defeating the reduction of **[f],** as happened over 2020 Thanksgiving and Christmas in the US**.** It is also not recommended practice in the history of epidemiology.

Unlike individuals, businesses are much more susceptible to targeted control by health authorities. They are motivated by their licensing and the economic impact of reducing **[f]** to find and enforce ways of reducing **[p]** within their businesses. By co-opting businesses, health authorities can feasibly attempt to reduce **[p].** For contact based transmission, this can be done by "social distancing" and "cleanliness" rules (NPI in CDC parlance).

The most difficult transmission mechanism to suppress today is airborne transmission. The most common methods are complete isolation in severe situations, in other cases use of adequate ventilation is recommended, and/or wearing masks. In the 1940s, a technique called "upper room UV" was used to sterilize air in classrooms to suppress the spread of measles. This relied on high ceilings to provide an adequate volume in which air could be sterilized. Many hospitals install UV lamps in their ventilation ducts. Adequate ventilation relies on proper mixing to dilute the concentration of the pathogen to an acceptable value.

In contrast, this patent describes a method and related systems that can reduce **[p]** for airborne disease within businesses to near zero by **avoiding** mixing. While the cost and total required airflow is too high for such systems to be active during normal times, they can be rapidly deployed during a crisis. This is especially true if health regulations require some level of preparedness during normal times.

Businesses that have installed such systems could even be allowed to advertise themselves as "a safer place to meet". People will then voluntarily choose to meet at such businesses instead of in less controlled environments. To keep businesses honest about their implementation they should NOT be exempt from liability if a patron gets sick.

Health authorities should also make sure home environments are sufficiently isolated from each other, so unintentional boosts to **[f]** are avoided. It is not very helpful if two adjacent apartments share air, as can be detected by the ability to smell a neighbor's cooking, or worse, their bathroom emissions.

DETAILED DESCRIPTION:

Figure 1 shows a system to help a business achieve near zero transmission of disease via air. The business first creates a pool **(1)** of "clean" (live pathogen free) and conditioned air above the heads of its patrons. This is where mixing of fresh air should take place. Air is then drawn down from this pool through the space **(3)** occupied by patrons **(4).** If necessary, there is a diffuser **(2)** that blocks turbulence in the pool from entering the patron space **(3).** The goal is to create a flow in the patron space **(3)** that is essentially laminar with very little or no mixing. Each patron **(4)** breathes in "clean" air that came down from the pool, and the air they exhale is entrained by the flow, potentially contaminating the flow. The laminar air flow is adjusted to be sufficiently fast that the contaminated air cannot reach the mouth or nose of another patron. Perfectly laminar flow is not required, only that any eddies be smaller than the inter-person distance. Sufficiently below patron heads, air is removed from the patron space by one or more appropriately placed exhaust ports **(5).** A gap under a door that vents air to the outside qualifies as an exhaust port. The removal of this air effectively creates the downward flow in the patron space **(3).** If outside air is considered “clean” enough, the pool can be filled with outside air without any treatment other than normal air conditioning **(6)**.

However, the air conditioning costs are liable to be high, since the total air flow required is much higher than that required by normal fresh air replacement. All the heating or cooling and humidity control applied to the intake air is lost through the exhaust ports. If the removed air is cleaned by an appropriate cleaning system it can be re-circulated back to the clean pool, and the business can reduce the air conditioning cost. These cleaning systems can be portable, and be installed inside the business. In addition, cleaning stale air before venting it outside also prevents the business from "polluting the neighborhood".

Figure 2 shows an example cleaning system. An intake port **(7)** near floor level, which qualifies as an extension of an exhaust port **(5)** of Figure 1, leads to a filter **(8),** followed by a sterilization section **(9)**, if necessary. A fan **(10)** placed anywhere in the airstream pumps the air through the cleaning system to an output port **(11)** which is located in the clean pool **(1)** of Figure 1.

The filter needs to be able to eliminate particles large enough to show a laser beam, like smoke particles. Ideally, it would also clear the target pathogens from the air stream flowing through it, making the sterilization section unnecessary. The CDC says the SARS-Cov-2 virus mostly transmits via respiratory droplets, which are 5μ or larger, but the virus itself is estimated to be 60-140 nm. A regular high grade filter available at retail should be good enough to suppress droplet based transmission. However, if the health authorities decide live airborne virus needs to be removed, we would need a ULPA filter, turning the patron space **(3)** almost into a laminar flow cleanroom. Or we can use a sterilization section to kill it.

Downward flow is best for most situations. Gravity pulls down large particles, and the airflow pulls down small particles. However for a situation like people on a choir stand you want the flow to be perpendicular to the average plane of heads, and have a physical barrier to prevent the throw of droplets by people in back rows over the heads of the people in front of them.

A downward speed of 3 inches per second should be sufficient to prevent exhaled air from a calm seated person reaching the mouth or nose of another person 2 feet (or more) away. This is close enough for people to reach out and touch each other. Unfortunately, when a person coughs, sneezes, or even speaks or sings loudly this will not be enough if they are facing each other. So, for the situation where people can be facing each other, a transparent physical barrier should be installed between them that at least drops below neck level, and an exhaust port can be located close to the bottom edge of the barrier. This will still allow them see each other, and to even hold hands under the barrier. If the patrons in the establishment are expected to be more active, the airflow speed should be increased commensurately. The establishment can ask people to wear masks until they are seated. The establishment can also ask if people are coming from the same household, and dispense with the physical barrier if they are.

There is no need to rebuild the air handling system of an establishment to achieve these goals. The cleaning system can be packaged with ductwork leading from ground level to ceiling level as a portable recirculation unit. For example, one can package a HEPA filter, a fan, and a duct leading up to ceiling level into a single floor standing device that cleans and recycles air. Or one can hang such a combination from the ceiling, and that reaches down to a table, around which people meet. Or one can place units that contain the filter and a fan on the floor along a wall, and then install a false wall making the space between the false wall and the real wall the recirculation duct. This is particularly useful in a commuter train or bus. Or one can place the units containing the filter and fan in a line in the middle of the establishment space, with two false walls on either side of the line, and the space between the false walls becomes the recirculation duct. These portable systems can be designed to carry advertising or decorative features on the recirculation duct, making them fit into the decor of the establishment. The only thing that will usually be necessary to retrofit in an existing air handling system is to install a diffuser to defeat the mixing within the patron space that is designed into most air conditioning systems. If the air conditioning intake is near the ceiling, ductwork will be required to bring dirty air up from the floor to the intake. One needs to ensure that there are enough recirculation units to generate an adequate downward flow everywhere in the patron space. For example, if the patron space measured 900 square feet (30' x 30'), and the required downward flow velocity was 3"/second, then the total upward flow in the portable units must be at least 225 cubic ft/second. If the upward flow in the units was 9ft/second, the total floor area of the units would be 25 sq ft. The ability to reposition the recirculation units, or to adjust the airflow in them, gives the business a measure of control over the laminar airflow within the patron space.

This system also suggests an improvement to home air purifiers that boosts the speed at which they can clean air in a room. Home air purifiers are generally floor or table top units that suck in room air, clean it, and eject the clean air back into the room at approximately the same position, thus mixing it with the remaining dirty air. They have to move multiple times the room volume through the device to achieve a certain level of purification through progressive dilution, and that is never complete. However, if we attach a duct so that the clean air is delivered at the opposite end of the room (and achieve zero mixing), then only one room volume needs to be moved through the purifier to perfectly clean the air in the room.

One consideration when using UV light to kill pathogens is the total hold time of air illuminated with UV light. That can be traded against UV intensity. Hold time is correlated with hold volume. If one has high ceilings, this is easy to achieve, as in the “upper room UV” concept used in the 1940s. One can also use half of the business space as kill space, or use a neighboring closed business as the kill space.

A big reason for not using laminar air flow is the uncertainty of whether a specific implementation is sufficiently good, or actually achieves the desired airflow. This is typically determined using a computer simulation of the airflow in the space - something that is beyond the typical capability of the average small business. So this patent also presents a simple method to test whether an implementation is good enough. The method is as follows:-

> Install a smoke generator (like a burning incense stick) at approximately the position where a patron's head would be. Run the system for a few minutes, then examine the smoke trails. This is best done viewing the trail against a black background. One can also shine a laser pointer around the space, and especially in the "clean" pool. Smoke should not be visible anywhere except below the smoke generator, and leading down from there to an exhaust port. Once it passes this test with no people, one can try again with people moving around, and seeing what that does to the smoke.

Note that this test does NOT confirm that the air is pathogen free, as those particles may be too small to provide adequate scattering of the laser beam. It only confirms the airflow structure is proper. This simple method can be used by health inspectors to determine whether an establishment has properly implemented its airflow. They will still need to inspect the filters and sterilization system. This method can also be used by the establishment to tune the airflow in and placement of the various recirculation units so the proper airflow is achieved in the patron space.

Restaurants using this system should be aware that plating will be very important, since flavors will be undetectable until food is actually placed in the patron’s mouth. Similarly, bars should realize individual’s pheromones will undetectable until there is actual contact.

CLAIMS:

I claim:

1. A method whereby a business can significantly reduce airborne spread, where:

A pool of live pathogen free [clean] air is created above its patrons, and
Air is drawn from this pool in a laminar manner thru space occupied by patrons, and
Air is removed from the patron space below where heads are expected to be, and
People facing each other are separated by a barrier dropping at least to neck level.

2. A simple method to test whether an installation meets requirements, where:

Smoke generators are hung where patron's heads are expected to be located, and
The system is run for sufficient time, and
A laser pointer is shone around the establishment space, especially the clean pool, and
The laser beam is invisible, except directly below a smoke generator, and leading from there to a nearby exhaust port.

3. A one pass system implementing the method of claim 1 where:

The pool is created by fans and ductwork bringing in outside air, and
Optionally, the air has been conditioned for temperature and humidity, and
Optionally, has a diffuser that establishes the bottom of the pool, blocks turbulence within the pool from reaching into the patron space, and starts a laminar flow in the patron space, and
One or more appropriately placed exhaust ports sufficiently below patron heads that collect air from the patron space and vent it to the outside.

4. A system implementing the method of claim 1 where:

The pool is created from air that has been cleaned, and

Optionally, has a diffuser that establishes the bottom of the pool, blocks turbulence within the pool from reaching into the patron space, and starts the laminar flow in the patron space, and

One or more exhaust ports sufficiently below patron heads that collect air from the patron space and deliver it to a cleaning system, and

The cleaning system is one or more filters good enough to remove the pathogen, and

The clean air output of the cleaning system is delivered to the clean pool, optionally through an air-conditioning system, and

Appropriately placed fans and ductwork to move air through the system.

5. A system implementing the method of claim 1 where:

The pool is created from air that has been cleaned, and

Optionally, has a diffuser that establishes the bottom of the pool, blocks turbulence within the pool from reaching into the patron space, and starts the laminar flow in the patron space, and

One or more appropriately placed exhaust ports sufficiently below patron heads that collect air from the patron space and deliver it to a cleaning system, and

The cleaning system is one or more filters, and UV illumination effective enough to kill the pathogen on particles that make it through the filters, and

The clean air output of the cleaning system is delivered to the clean pool, optionally through an air-conditioning system, and

Appropriately placed fans and ductwork to move air through the system.

6, Any system with one or more systems of claim 3, 4, or 5.

7. A device implementing a part of the system of claim 6 where:

The exhaust port, cleaning system, fans, and a duct rising up to deliver clean air to the pool, and optionally, a control that can be used to regulate the amount of air flowing through the device, are combined into a single floor standing unit.

8. A device implementing a part of the system of claim 6 where:

The exhaust port, cleaning system, fans, a duct bringing up air from exhaust port level and an optional airflow control are combined into one ceiling hung device.

9. A device implementing a part of the system of claim 6 where:

The exhaust ports, cleaning systems, and fans are combined into a unit, and
One or more such units are placed along a line along a wall, and
The duct returning air to the pool is the space between a false wall attached to that device and the real wall adjacent to the line.

10. A device implementing a part of the system of claim 6 where:

The exhaust ports, cleaning systems, and fans are combined into a unit, and
One or more such units are placed along a line within the space, and
The duct returning air to the pool is the space between two temporary walls on either side of the line.

11. An improvement to a commuter train carriage or plane, where:

The device of claim 9 is installed against the side wall(s) of the carriage or plane.

12. An improvement to existing air purification systems, where:

A duct is added so that the intake and the output of the total purification system are at opposite ends of the airspace to be cleaned.

CERTIFICATION AND REQUEST FOR COVID-19 PROVISIONAL PATENT APPLICATION PROGRAM

(Page 1 of 1)

First Named Inventor:	Niket Keshav Patwardhan
Title of Invention:	Rapidly Deployable System to Suppress Airborne Epidemics
Contact information to include in database (optional)	niketkp@yahoo.com

APPLICANT HEREBY MAKES THE FOLLOWING CERTIFICATIONS AND REQUESTS THAT THE USPTO INCLUDE THE DESCRIPTION OF THE ACCOMPANYING PROVISIONAL PATENT APPLICATION IN A PUBLIC DATABASE.

1. The description of the accompanying provisional patent application concerns a product or process relating to COVID-19 and such product or process is subject to an applicable FDA approval for COVID-19 use.

2. The accompanying application is in the English language.

3. The accompanying application is being filed in DOCX format via the USPTO's Patent Center filing system, together with this form.

4. The applicant understands that while the required filing fee for the accompanying provisional application may be deferred by acceptance into this program, the appropriate filing fee must be paid in order for a subsequent U.S. nonprovisional application to claim the benefit of the filing date of the accompanying provisional application. Applicant recognizes that the filing fee due in the future may be more than the current fee due and that by deferring payment of the filing fee, there may be an increase in the total fee due.

5. Applicant authorizes and requests that the description, including the specification and any drawings, claims and/or abstract of the accompanying provisional patent application, as well as this form, be included in a searchable online public database.

6. Applicant understands that inclusion in the public database is a publication of the description and this form.

Signature /Niket Patwardhan/	Date 2020-12-29
Name (Print/Typed) Niket Patwardhan	Practitioner Registration Number

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☐ *Total of ________ forms are submitted.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.