Virtual Research Presentation Conference

ELECTROSTATIC PRECIPITATOR CONCEPT STUDY TO FIGHT AGAINST COVID-19

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Program: Spontaneous Concept

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Introduction

COVID-19 is essentially an airborne disease. Indoor air purification and decontamination is paramount for the fight against the pandemic. Portable air purifiers could be installed quickly when needed in hospital or residential rooms, small businesses and public buildings to help slow the spread of the virus.

The demand for portable air purifiers increased significantly since start of the pandemic and skyrocketed recently due to massive brush fires and dismal air quality.

The goal of the project is to develop a technical documentation to assist in design, testing and certification of portable/modular air cleaners with germicidal properties, cleaning effectiveness and energy efficiency measurably outperforming any other designs currently available on the market.

Problem Description

Two basic air filtration systems usually implemented in portable air cleaners: mechanical (HEPA filters) and electrostatic precipitators (ESP)

Mechanical filters are not energy efficient, can't capture effectively small particles ≤1μ and require periodic filters replacement what might be a hazard due to potential exposure to live pathogens.

Electrostatic filters (ESP) do not require filters replacement, are more effective in capturing fine and ultrafine particles, can be much more energy efficient and have germicidal properties due to cold plasma of corona discharge [5].

However, with all the benefits of the ESP you don't find them among best recommended models.

Why is that?

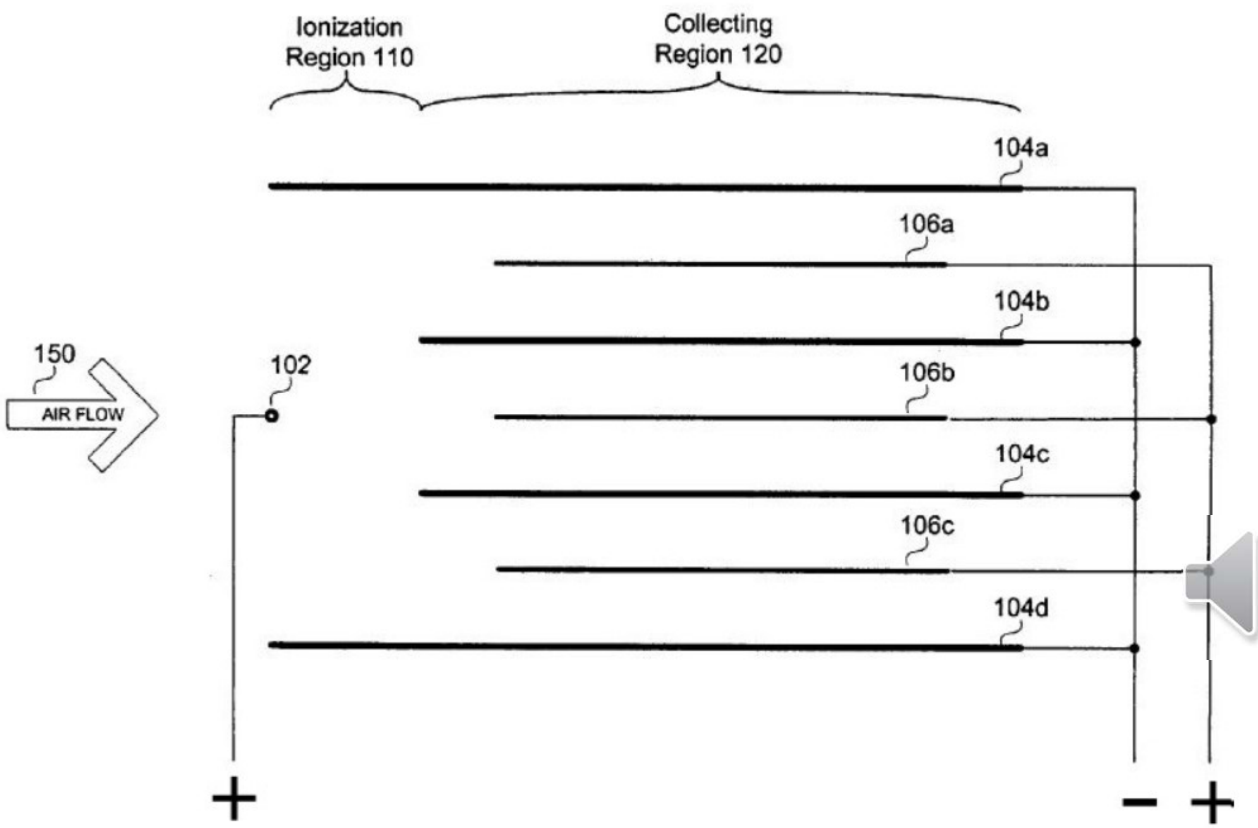
ESP drawbacks

- Accumulated dust grows “whiskers” and eventually shorts the collecting plates. It leads to significant reduction in collection efficiency and requires frequent maintenance.
- Due to the “whiskers” grows the practical value of electric filed in the collection region is limited significantly below theoretical breakdown values. It leads to relatively low single pass collection efficiency and, as a result, mediocre electrical efficiency of the system.
- Corona current could generate undesirable ozone concentration in closed spaces and have a negative impact on human health.

The proposed design is addressing the deficiencies of ESP systems with end product that has all the advantages of the ESP air cleaners without above-mentioned drawbacks.

Methodology

Portable ESP air cleaner for consumer application usually employs two-stage plate precipitator geometry where separate charging section ahead of collecting section has the benefit of minimizing ozone emission [1].



- Corona electrode (wire) 102 is connected to a positive high voltage potential to generate corona current and charge particulate matter entrained in the airflow in ionization region 110.
- The charged particles are collected on oppositely charged collector plates 104.
- The driver plates 106 have high voltage potential relatively to collector plates. They generate high electric field in the collecting region to drive charged aerosol particles to the collector plates.

Methodology

Proposed design implements “insulated drivers” technology where thin layer of high voltage insulation applied to driver electrodes. It eliminates potential for high voltage flashovers due to dust accumulation and allows for significantly higher electric filed in collection region. That in turn leads to much higher single pass efficiency and electrical efficiency. The method was first developed by SI Design group with patent US 707789 [2]. The ESP air cleaner was developed using the described technology (model SI724).

The SI724 design demonstrated high effectiveness in fine dust capture, electrical efficiency several times higher than any other designs on the market, measurable germicidal properties and low ozone emission achieved by implementation of catalytic filters [3].

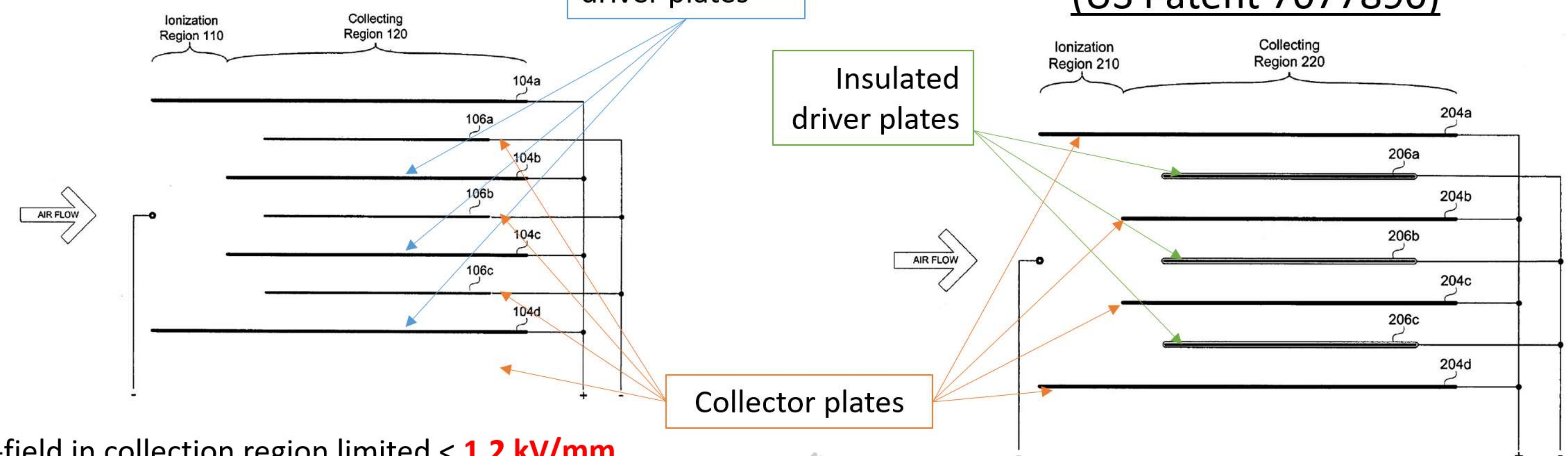
However, the model is no longer in production, there are no currently available designs on the market that benefit from the technology and no documentation available to assist in design of such air purifier.

We recreated the design and generated detailed documentation to serve as a practical guide in design and commercialization of such ESP system.

ESP Configurations: conventional design (left) and insulated drivers (right)

Conventional Design

ESP with Insulated Driver Electrodes (US Patent 7077890)

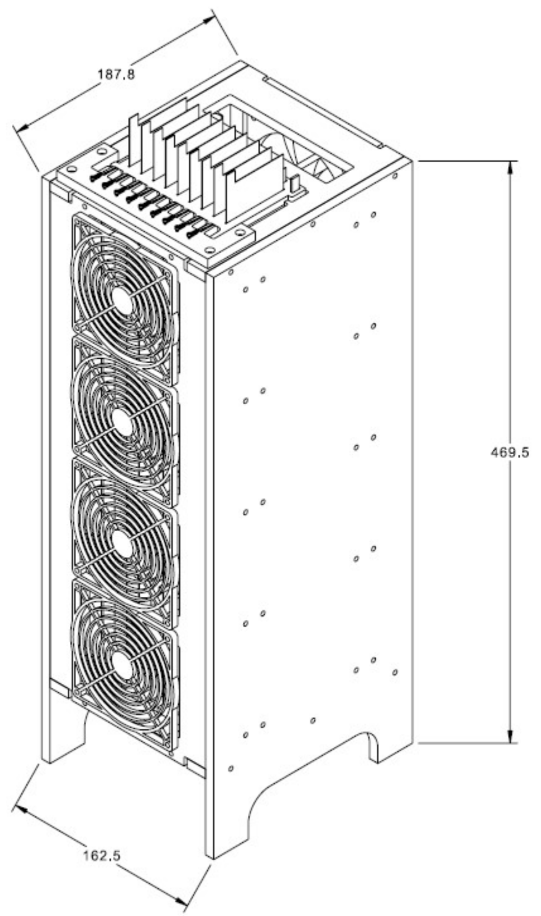


E-field in collection region limited < **1.2 kV/mm**

1. Susceptible to “whisker” growth leading to reduced collection efficiency
2. Fragile collection plates are easy to deform during cleaning which inevitably leads to flashover between adjacent plates and system shutdown

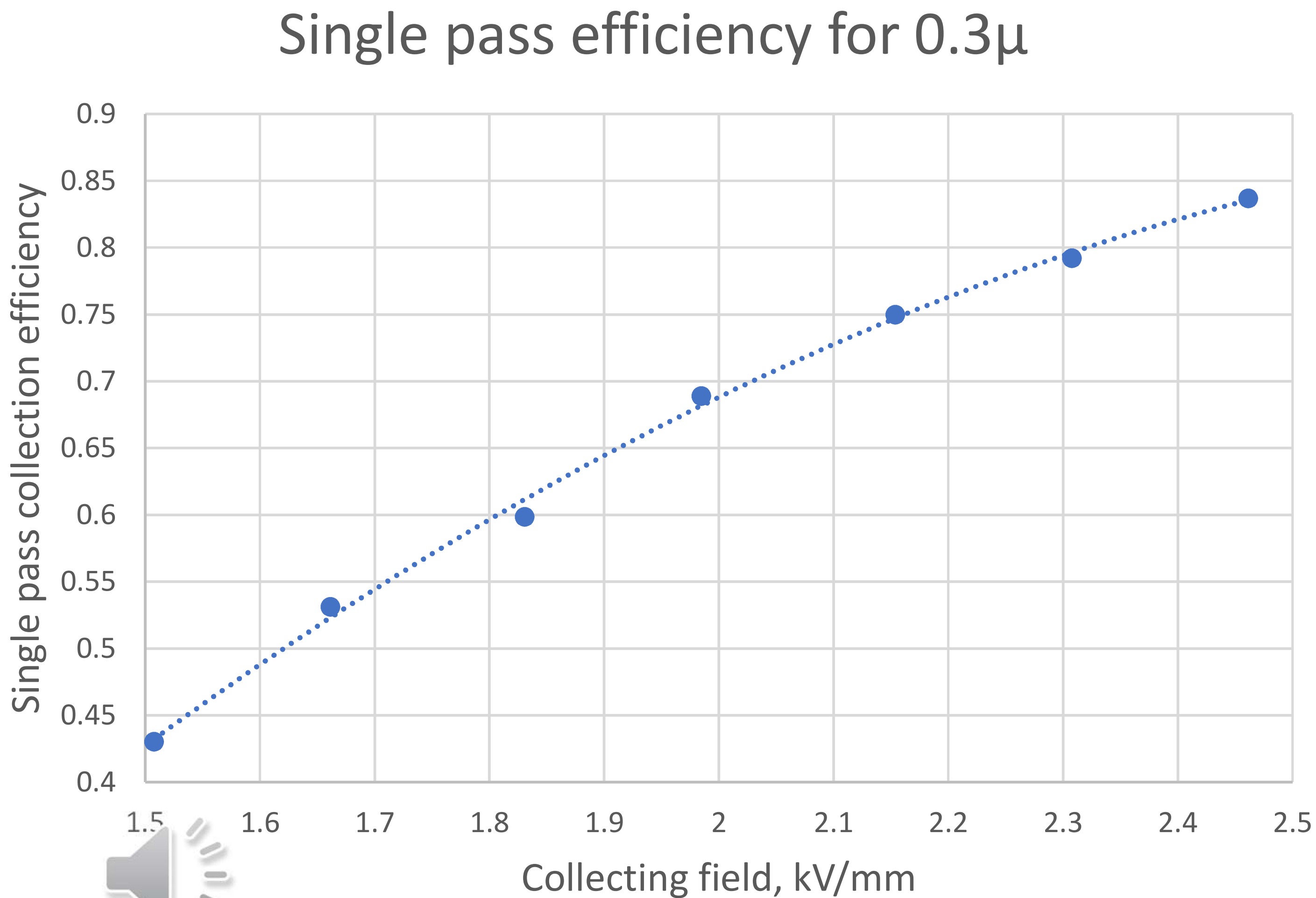
Optimum E-field in collection region is **2.4 kV/mm**

1. Much higher collection efficiency
2. No “whisker” growth issue
3. Use of insulated drivers makes the system immune to flashover as a result of plate deformation



ESP Mechanical Model

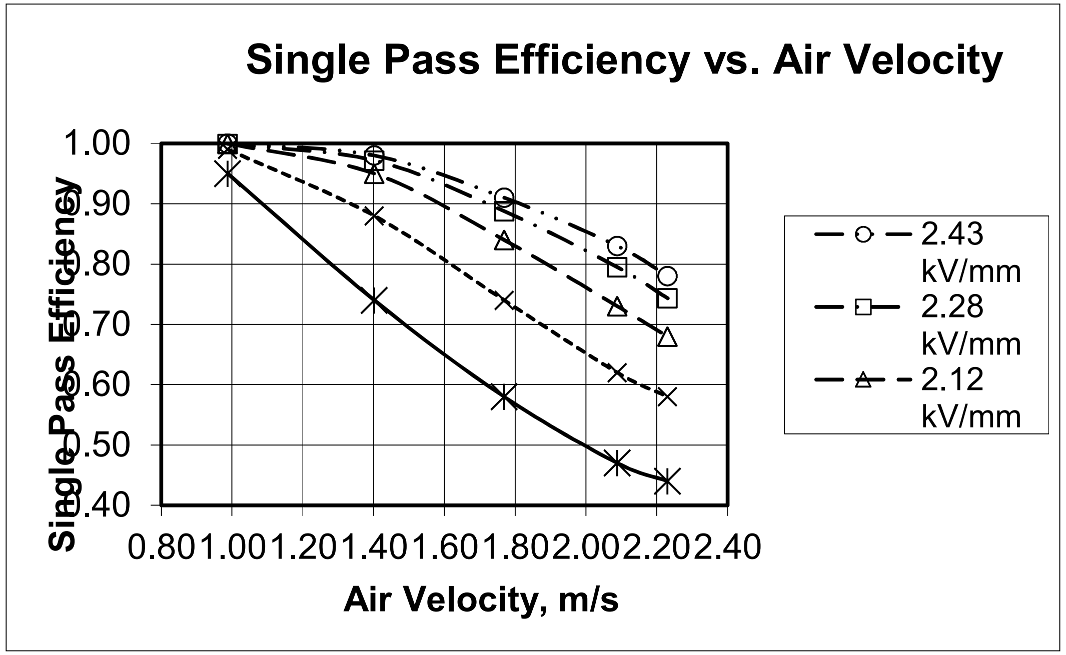
Includes insulated driver electrodes and catalytic filters to mitigate ozone emission



ESP Performance vs. Collecting Field

Dust particles migration velocity and performance of the air cleaner increases with collecting field accordingly

Expected parameters of the optimized design



Single pass collection efficiency vs. air velocity and collecting field strength.

All parameters (air velocity, collecting field strength and corona current) optimized for different modes of operation to maximize performance and minimize ozone emission below safety guidelines

Expected parameters of the design	
CADR (Clean Air Delivery Rate)	100 to 200 CFM
Targeted Room Area	150 to 300 sq. feet
Single Pass Efficiency	≥97% for 1μ particles
Energy Efficiency for best Energy Star certified air cleaners	5 to 10 CADR/W
Energy Efficiency for ESP with insulated drivers technology	**20 CADR/W**

Project Results

We made a prototype and generated adequate documentation to serve as a practical guide for design, optimization, testing and certification of ESP air cleaners with insulated drivers. It's sufficient for technology transfer to potential industry partner willing to invest in industrial design and commercialization of the technology.

As a potential option for space application, it could lead to development of air remediation systems for use on manned spacecraft, orbiting stations, and habitat modules.

The complete technology report contains detailed specification, mechanical drawings, electrical schematic, optimization strategy, test procedures and certification requirements. It's available upon request.

References

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