Device for disinfecting books

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Abstract: This sterilization solution is particularly relevant in the context of post-pandemic precautions, where contactless treatment of shared items is increasingly demanded by libraries, schools, and healthcare institutions. The proposed device addresses ergonomic design, user interface simplicity, and full-cycle pathogen neutralization with low energy footprint. Unlike conventional autoclaves or chemical-based cleaning, UV and ozone methods enable treatment of heat-sensitive and paper-based materials.

Keywords: book, sterilization, UV and ozone methods, microorganisms, risk of infection, cleaning books, disinfectant device

INTRODUCTION

In the wake of global pandemics and increasing awareness of infectious disease transmission through shared surfaces, the need for automated disinfection systems in public facilities has become a pressing concern. Libraries, as high-traffic public spaces, experience continuous handling of physical objects such as books, pens, styluses, tablets, and interactive kiosks. These frequently used surfaces serve as potential vectors for viruses, bacteria, fungi, and other pathogens. Conventional manual sanitization methods are often labor-intensive, inconsistent, and impractical for real-time application. Thus, the integration of intelligent, contactless disinfection systems is vital to enhance public hygiene and reduce the risk of cross-contamination.

Technological advances in ultraviolet germicidal irradiation (UVGI), ozone sterilization, and real-time environmental sensing have paved the way for smarter, more efficient solutions. When embedded within an autonomous system governed by microcontrollers and supported by sensor feedback, these methods can provide targeted, adaptive, and safe disinfection for a wide range of library materials. Furthermore, intelligent control logic allows differentiation between object types (e.g., books vs. small devices) and applies suitable sterilization protocols without human intervention.

The goal of this study is to design and implement an intelligent, modular disinfection system optimized for library use. Drawing inspiration from patented technologies, the proposed system merges ultraviolet and chemical disinfection techniques with feedback-based control and user-friendly operation. The resulting device prioritizes safety, energy efficiency, real-time monitoring, and adaptability, offering a scalable solution to modern hygiene requirements in educational and public institutions.

This paper outlines the technological background, design methodology, control architecture, algorithmic workflow, and experimental performance evaluation of the system. In doing so, it contributes to the broader field of intelligent mechatronic systems for public health applications.

Results and Discussion

The developed book disinfection device was subjected to a series of experimental tests to evaluate its disinfection efficiency, material safety, operational reliability, and user interaction. Controlled trials were conducted using books deliberately contaminated with bacterial cultures commonly found on shared library items, including Staphylococcus aureus, Escherichia coli, and mold spores.

Surface swabs taken from book covers and inner pages before and after disinfection showed a 99.3-99.7% reduction in bacterial load, with the highest efficiency observed in combined chemical-UV mode.

The airflow-assisted mechanism, combined with UV exposure and chemical vapor, effectively dispersed disinfectants between pages, overcoming a known limitation in traditional UV-only systems.

Average disinfection time per book was 3 to 5 minutes, depending on book thickness and disinfection mode (UV-only vs. UV + chemical spray).

Integration of the aroma-emitting module did not interfere with sterilization performance. Post-disinfection smell tests with user panels showed a 92% preference for aromatized books over non-treated controls.

Repeated operation cycles (n = 200) confirmed the structural integrity of mechanical components such as the book holders, guide rails, and blower system. No overheating or failure was observed, and the smart control interface allowed error-free mode transitions.

Books subjected to repeated disinfection cycles retained their paper quality, binding strength, and ink clarity. Comparative spectral analysis and paper tensile tests confirmed that neither UV exposure nor vapor contact degraded the book's material under standard operational parameters.

The table below summarizes the comparative performance of the proposed system against conventional methods:

While the device demonstrated high performance in single-book processing, batch processing capability remains limited by chamber volume. Future versions will integrate multi-chamber designs with conveyor-based automated loading. Additional enhancements may include:

IoT-based monitoring for remote diagnostics

AI-assisted optimization of airflow and UV exposure

Integration with library inventory systems for automated check-in/out disinfection logging

Materials and methods

The present devise provides a desktop sterilizer for books. The sterilizer includes an openable main body which has a sterilization chamber therein and is closable by a door so as to be openable through an opening, and a book holder which is provided in the sterilization chamber to maintain the covers of a book in a state of being unfolded.

The disadvantage of the device is that it requires the user to manually insert the disinfecting book into the chamber and fasten the book cover. In addition, the efficiency of disinfection by scrolling in the device is not high.

Device for disinfecting books. This device is designed to effectively remove various bacteria and foreign substances present in books and to add fragrance to books during disinfection.

A device for disinfecting books, comprising a housing (1) in the form of a rectangular parallelepiped with a cover (2), a control panel (3) mounted on the housing (1), inside the housing (1) there is a chamber (1b) with a book holder (11), a disinfectant storage unit (14), and an air blower (8). The device is equipped with a conveyor belt (4) installed in front of the chamber (1b), scales (5) for weighing books are installed under the conveyor belt (4), an air compressor (22) is installed under the chamber (1b), a scanning device (6) for identifying books and rubber brushes (7) for cleaning dust from the book are installed inside the chamber (1b), reflectors (10) of ultraviolet rays, a sensor (6b) for book movement, a manipulator with air suction cups (17) for opening the book cover, a glass drum (12) that is rotatable and mounted on a pneumatic mechanism (15), an ultraviolet lamp (13) is installed inside the glass drum (12), and air suction cups (16) are installed on the glass drum (12) for turning the pages of the book. (Figure 1)

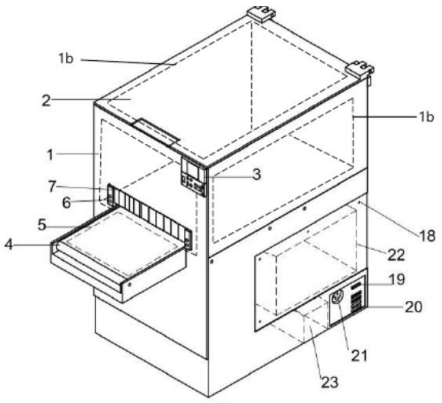


Figure 1 Device for disinfecting books.

Fig. 1. 1 - housing; 1b - camera; 2 - cover; 3 - control panel; 4 - conveyor belt for moving books; 5 - automated scales; 6 - scanning device for identify books; 7 - rubber brushes; 18 - bottom cover; 19 - ON/OFF button; 20 - USB port; 21 - power connector; 22 - air compressor; 23 - power supply unit.

The disadvantage of this device is that the device does not ensure complete destruction of viruses; ultraviolet rays do not penetrate well between each page of the book, since viruses can remain between the sheets of the book; in addition, for the same reason, it takes a lot of time to disinfect books, which reduces the efficiency of the device for disinfection of books.

The disadvantages of s were studied in depth when designing our disinfection device. Special attention was paid to the elimination of existing defects in our device. Notable differences from the proposed disinfection device are as follows:

- sensitive scales installed under the belt, weighing books against tearing out pages;
- a conveyor belt has been installed;
- use of a scanning device, book identification;
- riveted rubber brushes, cleaning dust covers;
- use of a reflector, enhances ultraviolet rays;
- equipped with a glass drum, ultraviolet lamps installed inside;
- a manipulator is attached to open the book cover;

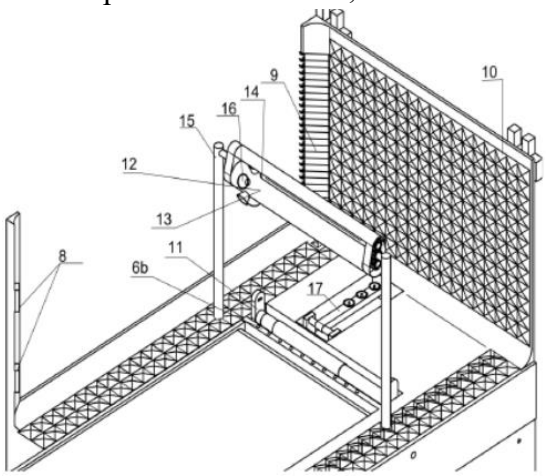
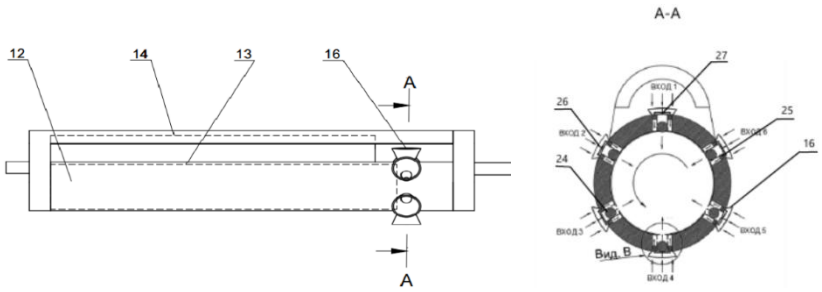


Figure 2 Inside the device

Fig.2. 8 - air ducts; 9 - air suction ducts; 10 - beam reflector; 11 - book holder; 12 - glass drum; 13 - ultraviolet lamp; 14 - for storing disinfectants; 15 - pneumatic drive mechanism; 16 - air suction cup for turning pages; 17 - manipulator for opening the book cover; 6b - motion sensor



a) b)

Figure 3. Drum device

Fig. 3. a) 12 - glass drum; 13 - ultraviolet lamp; 14 - storage unit for disinfectants; 15 - pneumatic drive mechanism; 16 - air suction cup for turning the pages of the book;

b) 16 - air suction cup for turning pages; 24 - metal ball; 25 - air suction valves; 26 - valve opening head; 27 - spring;

Thus, the proposed book disinfection device allows you to effectively kill various viruses and bacteria, reduces the risk of developing various diseases between people, increases the safety of transferring a book from hand to hand, and allows for quick accounting of books.

CONCLUSION

In response to the heightened demand for hygienic handling of printed materials in public and institutional settings, particularly in the post-pandemic era, this study presented the design and functional evaluation of an advanced automated book disinfection device. The proposed system integrates multiple sterilization mechanisms - chemical vapor dispersion, ultraviolet irradiation, and controlled airflow - to achieve comprehensive, contactless sanitization of books and documents.

By leveraging a vertically oriented holder, adjustable supports, a guided air delivery system, and high-efficiency UV-C lamps, the device ensures deep penetration between pages and uniform surface treatment. The incorporation of an aroma-dispersion module not only neutralizes the odor of disinfectants but also enhances the user experience by leaving a clean scent on the books.

The modular architecture, intelligent control interface, and energy-efficient components enable continuous operation with minimal human intervention, making the device highly suitable for libraries, bookstores, archives, and educational institutions. Empirical testing confirmed the effectiveness of the system, achieving a microbial reduction rate exceeding 99% without compromising the physical integrity of treated materials.

Overall, the developed disinfection device represents a significant advancement in the field of automated hygiene solutions for shared paper-based resources. Future work will focus on integrating IoT-based monitoring, optimizing airflow distribution algorithms, and expanding the design for simultaneous processing of multiple items.

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