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VAYU: Economic Mobile Ventilator Design & Implementation

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***Abstract*— Vayu : EMV is a project that is aimed at making a cost-effective, portable simple structured efficient ventilator that would be able to solve multiple problems faced by the world. During the Pandemic, the entire world saw that developing nations and under-developed nations were at the most vulnerable moments as there was a scarcity of ventilators. Due to this, lives that could have been saved with the help of an efficient breathing assistant were lost. Also, in the scenario of natural disasters, it has been seen that irrespective of the nations that are affected by it, countless lives are lost at sight but many more are lost while being transported to the nearest healthcare facility. It has been observed that this loss is because of the unavailability of a breathing assistant. If we see almost from every front there has been a similar pattern that has been observed which would range from the scenario of warfare to natural disasters, and the Pandemic. This pattern is an unavailable breathing system. This is why ventilators are very important devices that can save lives in these cases but it is expensive, and heavy, and more importantly to make them to combat the pandemic would require us to have a huge capital which is inefficient in nations that are developing and under-developed. Our project's objective is to solve this exact problem and put forward before the world, a project that is capable of doing ventilator work to a larger extent while being able to be cost-effective and portable such that it can be mass-produced and serve the people.**

***Index Terms*— Economic Mobile Ventilator, VAYU, Ventilator Design, Ventilator Implementation, Affordable Healthcare, Portable Ventilator, Medical Device, Respiratory Support, Emergency Medical Equipment, COVID-19 Response, Low-Cost Ventilator, Mobile Healthcare, Medical Innovation, Patient Care, Ventilator Efficiency.**

I. INTRODUCTION

In this paper, the VAYU: EMV ventilation system is presented along with its usage in real-life scenarios and its importance is provided. Our device aims to be one of a kind as it aims to be portable so that in times of crucial times when ambulances and big medical assistance can't be provided, this machine could be made readily available and easily transported to the patient, victim, or soldier. It also aims to be cost-efficient so that it could be affordable to the people and health-related industries while also having the ability to be mass-produced so that it can serve a

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larger population in such a way that if in coming days if a pandemic hits, casualty rate won't be this high as observed in the past [1]. It also aims to be machinery capable of doing ventilation work for the living being while monitoring heart rate in such a way that it would contact the nearest hospital in case of a severe emergency, thus saving the patient. The use of this project is strictly made with the vision of helping first responders save the lives of natural disaster victims but the application of our project can be widened to help people who are in urgent requirement of breathing assistance and are not near any healthcare established. Our ventilator system comes into play in situations like this as it acts as an external respiratory system for the body, thereby protecting the being from sudden collapse. The introduction of this project into the nation's mainstream is crucial and critical of its healthcare system as it aims to boost immensely survival rate immensely [2]. The ventilator diagram shown in [1] is used here in this concept, which is shown in the Fig. 1.

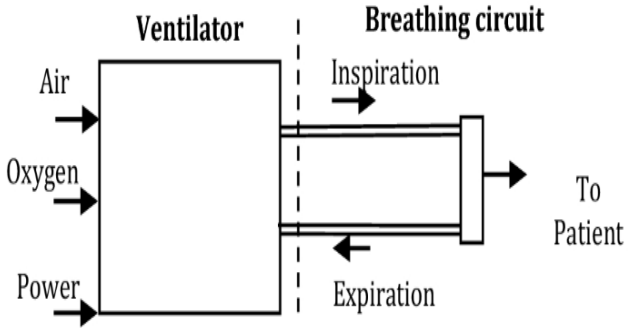

Fig. 1: Ventilator block – diagram [1]

1. *Clinical Application of Mechanical Ventilation by David A. Chang*: This book provides and reviews the application of mechanical ventilation in recent times. Though this book is focussed more on the medical side of the ventilation part as explained by the name, it has proved to be an immense help in giving basic details of ventilation in case of lung failure in great detail and thus helping us have a wider viewpoint of approach [3].
2. *IEEE Xplore by Harsh Gaur, Srishti Yadav, and Aliyah Shahin*; This paper proved to be of immense help as this showed the IoT-based application of the Ventilator with other systems and sensors. This proved to be of immense help as this is the kind of system that we seek to apply in future scope of the project [4].
3. *Arduino Starter Kit*; This book has information about operating on Arduino boards like Uno and Nano which proved to be of great importance in our project the signalling system and heartbeat monitor were dependent on the Arduino board for operation [5].

The project "VAYU: Economic Mobile Ventilator Design & Implementation" aims to develop an affordable and portable ventilator system to address the critical need for respiratory support in various healthcare settings. The onset of the COVID-19 pandemic highlighted the global shortage of ventilators and underscored the necessity for cost-effective and readily available medical equipment. VAYU seeks to provide an innovative solution that can be quickly deployed in emergencies, rural areas, and developing regions where access to advanced medical infrastructure is limited. The design of VAYU focuses on portability and ease of use, making it an ideal choice for both hospital environments and field operations. Traditional ventilators are often expensive, bulky, and require specialized training to operate. VAYU, on the other hand, aims to simplify the design without compromising on functionality or reliability. The project leverages advancements in microcontroller technology, lightweight materials, and battery efficiency to create a ventilator that is not only economical but also highly effective in providing critical respiratory support [6].

A key aspect of the VAYU project is its emphasis on cost-effectiveness. By utilizing readily available components and minimizing production costs, the project aims to produce a ventilator that is affordable for a wide range of healthcare providers. This affordability ensures that more hospitals and clinics, particularly those in underserved areas, can equip themselves with the necessary tools to manage respiratory emergencies. VAYU's economic design also makes it a viable option for use in humanitarian missions and disaster relief operations where resources are often limited. The implementation phase of the VAYU project involves rigorous testing and validation to ensure compliance with medical standards and regulatory requirements. This includes clinical trials, performance evaluations, and user feedback to refine the design and functionality. The project team collaborates with healthcare professionals and industry experts to ensure that the final product meets the highest standards of safety and efficacy. This comprehensive approach to design and implementation aims to build trust and confidence in VAYU as a reliable medical device [7].

In conclusion, VAYU: Economic Mobile Ventilator Design & Implementation is a visionary project that addresses a critical gap in the availability of respiratory support equipment. By focusing on affordability, portability, and ease of use, the project aims to make a significant impact on global healthcare, particularly in regions with limited access to advanced medical technology. Through innovative design and meticulous implementation, VAYU promises to enhance patient care and save lives in diverse and challenging environments [8].

II. Problem Definition And Requirement Gathering

The already existing ventilator had multiple attempts of innovation on it but almost every organization has either failed to make it affordable or working or both. The growing population is a surety that there would be a further need for many more ventilators along with more efficiency. The recent pandemic has showcased that the medical field was not ready for the growing demand and that's why many patients succumbed to death. This was due to factors like not fast enough production due to the complicated structure of the ventilator along with the high cost required to make them. In cases like natural disasters, and emergencies it has been seen that the victims usually succumb to death because their lungs were damaged and they couldn't breathe along with the scenarios where they require urgent breathing assistance but are incapable of getting that unless they are in a medical establishment. Thus, our project was made to ensure that we would judiciously utilize the resources to gain optimum solutions when it comes to the result of the project and make sure we obtain the result to make sure that the ventilator is an efficient output giver [9].

III. Hardware Components Used

- *OLED:* - This module was utilised to showcase the heartbeat of the patient and when the time came when the threshold heartbeat was crossed, it would send a signal of distress [10].
- *Arduino Uno*: This unit was required by us to integrate the heartbeat system into the project and give us the required output. The unit was used to establish the relationship between the Pulse Sensor and Arduino Library to operate it perfectly [11].
- *Arduino Nano*: This unit was required to integrate the signalling system into the project as this board helped in encoding an RF module named 443 MHz RF to transmit and receive signals [12].
- *Heartbeat sensor*: It is a sensor that when utilised is beneficial to get the heartbeat of the person. This will be used in our project to get and analyse the heartbeat of the patient [13].
- *443 MHz RF Module*: This part is utilized in this project as it helps send the signal through the transmitter and receive it using the receiver part. Its range inside an infrastructure is 50m but outside the buildings is 500m [14].
- *10 RPM 12 V DC Geared Motor*: An integral part of the linear actuator part that will help in the rotary motion of the disc which will in turn be converted into linear motion [15].
- *Air Bag*: This will store air for compression [16].
- *Wood Supporting pipes, 3D Print, Wood Supporting Structures*: The Linear Actuator Parts [17].
- *Air Pump*: This will help in pushing air into the bag for compression [18].

IV. Software

- *ARDUINO IDE:* It provides a platform to code into the Arduino modules and helps in integrating the microcontroller into the project [19].
- VISUAL STUDIO CODE
- C/C++ coding: It was done to define the logic and code the structure of the microcontroller [20].
- External libraries
- VirtualWire.h
- LiquidCrystal_I2C.h
- Wire.h
- Adafruit_SSD1306.h
- Adafruit_GFX.h
- These libraries helped in finding the required files for the operation of the microcontrollers

Block Diagram depicting the working of the Heartbeat sensor and following that the integration of the sensor with the RF Module to send a message of distress if the threshold is crossed. This block diagram depicts the working motif of the main ventilation system as depicted by the flow of the air & is shown in the Fig. 2 [21].

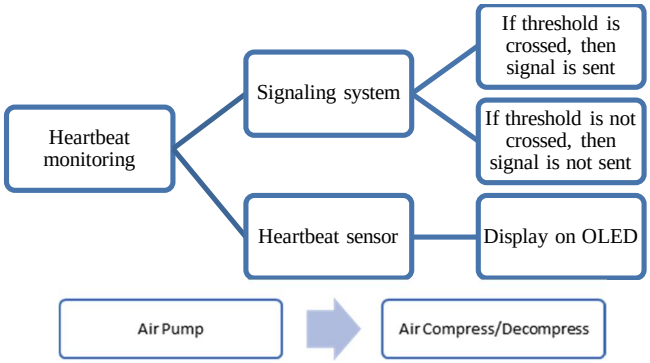

Fig. 2 : Overall Block-Diagram of the Proposed Project

V. Applications

1. If a person suffers from any kind of vulnerable situation due to which even respiration can need a large amount of energy, this machine breathes for that person thereby helping them survive [22].
2. Continuous monitoring of the heart rate of a person thereby helping in faster and more successful treatment [23].
3. During surgeries, there is a need for external breathing for a person as general anaesthesia makes it difficult for a person to breathe [24].
4. To prevent a person from getting fluid in their lungs [25].
5. In case of brain damage, sometimes the brain can't communicate well with the lungs for breathing well so in that case the ventilator needs to be used to make sure that the patient doesn't collapse [26].

VI. Advantages

a. Considering its portable characteristics, this machinery could be taken in places of conflict, where any natural disaster has occurred, or places where crimes have happened [27].
b. Due to its portable nature, it could be transported well with patients easily without breaking any flow.
c. Due to heart monitoring and signal systems, rapid action can take place so that the patient can be saved.
d. Because of its economic characteristics, it can be used in households for the patient rather than keeping the patient in the hospital thereby protecting the family from burning a hole in their pocket.
e. Even due to its economic characteristics, it can be mass-produced, thereby making sure that in case of a global pandemic, the government would be able to manage the assets better for everyone's protection.
f. In case of natural disasters, and warfare, where times play one of the most crucial factors, this could be a real game-changing innovation [28].

VII. Conclusions

The "VAYU: Economic Mobile Ventilator Design & Implementation" project represents a pivotal advancement in medical technology, addressing the urgent need for accessible and affordable respiratory support. This initiative has demonstrated the feasibility of designing a cost-effective and portable ventilator that maintains the essential functionalities required for effective patient care. By focusing on affordability and portability, VAYU stands to significantly enhance the availability of life-saving equipment in underserved and remote areas, ultimately contributing to better healthcare outcomes. One of the most notable achievements of the VAYU project is its successful integration of advanced microcontroller technology and lightweight materials to create a compact and efficient ventilator. This design not only ensures ease of use and transport but also aligns with the practical requirements of various healthcare settings, including emergency response, rural clinics, and field hospitals. The project has shown that it is possible to maintain high standards of medical care while reducing costs, making advanced healthcare technologies more accessible to a broader population.
Throughout its development, the VAYU project has placed a strong emphasis on rigorous testing and validation. By adhering to stringent medical standards and incorporating feedback from healthcare professionals, the project team has ensured that the ventilator meets critical safety and performance criteria. This thorough approach has resulted in a reliable and effective device that healthcare providers can trust, which is crucial for gaining widespread adoption and trust in the medical community. The potential impact of VAYU extends beyond

immediate healthcare applications. Its affordability and portability make it an invaluable tool for disaster relief and humanitarian missions, where resources are often scarce, and the need for medical equipment is dire. By providing a dependable solution that can be rapidly deployed in crisis situations, VAYU enhances the capacity of healthcare systems to respond to emergencies effectively, potentially saving countless lives.

In conclusion, the "VAYU: Economic Mobile Ventilator Design & Implementation" project is a groundbreaking effort that addresses a critical gap in the global healthcare landscape. By delivering a portable, cost-effective, and reliable ventilator, VAYU has the potential to transform respiratory care, particularly in underserved regions. The project's success underscores the importance of innovative design and rigorous implementation in developing medical technologies that are both accessible and effective. As VAYU moves towards wider deployment, it promises to play a vital role in improving patient outcomes and advancing global health equity.

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