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DESIGN & FABRICATION OF POWER GENERATOR FOREARMS MACHINE

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Abstract : In an era where energy sustainability is paramount, the "Power Generator Forearms Machine" project emerges as a pioneering effort to harness human biomechanical energy for practical applications. With a focus on innovation and efficiency, this project seeks to design and develop a machine capable of converting the kinetic energy generated by forearm movements into electrical power. Through a fusion of engineering ingenuity and biomechanical principles, our team endeavors to create a compact and ergonomic device that seamlessly integrates into daily routines. Leveraging advanced software and hardware technologies, we aim to optimize the efficiency and usability of the power generation process while prioritizing user comfort and safety. Utilizing techniques such as CAD modeling, and prototype testing, we iteratively refined the machine to maximize energy conversion efficiency and reliability. By harnessing the potential of human biomechanical energy, the "Power Generator Forearms Machine" promises to offer a sustainable and accessible source of electricity for various applications, ranging from personal electronics to off-grid power solutions. Through this innovative endeavor, we aspire to contribute to the advancement of renewable energy technologies and empower individuals to make meaningful strides towards a greener future.

IndexTerms - Power Generator Forearms Machine, energy sustainability, biomechanical energy, innovation, efficiency, electrical power, engineering ingenuity, compact design, ergonomic, advanced technology, usability, safety, CAD modeling, prototype testing, energy conversion efficiency, reliability, renewable energy, off-grid solutions, greener future.

I. INTRODUCTION

1.1 Overview

In a world where the unrelenting demand for energy and the imperative to prioritize physical well-being have become defining global challenges, innovation at the intersection of these two fundamental aspects is taking center stage. Energy is the lifeblood of our modern society, essential for our sustenance, progress, and comfort. The consumption of energy resources has been accelerating since humans first walked the Earth, reaching unprecedented levels in recent times. The necessity of moving towards a future reliant on sustainable energy is unquestionable. Simultaneously, public awareness of the importance of physical fitness and health is on the rise. People are increasingly conscious of the sedentary lifestyles and health-related issues that have permeated our daily routines. The gym, once a niche, has evolved into an essential space for maintaining physical well-being. As individuals strive to lead healthier lives, the energy generated from their exercise activities is typically untapped, slipping through the cracks. Our pioneering project, the "Design and Fabrication of Power Generator Forearms Machine," aspires to rewrite the narrative by offering a holistic solution. At its core, it represents a groundbreaking approach to exercise equipment and sustainable energy solutions. The objective is to create an ecosystem where the kinetic energy generated during forearms exercise routines is not just expended but meticulously harnessed and ingeniously converted into valuable electrical power. This innovative dual-purpose machine marries the realms of fitness and electricity generation, providing a holistic and forward-thinking solution for a future marked by sustainability and well-being.

The present global landscape is beset with a complex web of challenges, chief among them being the relentless demand for clean and renewable energy sources. As the global population continues to swell, highly populated countries such as India and China face soaring energy requirements. The traditional methods of energy generation have taken a toll on our planet, depleting finite resources and contributing to environmental degradation. This confluence of factors highlights the pressing need for a transformation in the way we perceive and harness energy. Simultaneously, physical fitness and well-being have gained prominence in our lives.

The gym, once a space for fitness enthusiasts, has transcended into a hub for people from all walks of life. The Power Generator Forearms Machine is born from the realization that this paradigm presents a unique opportunity to shift from energy consumption to energy production. Traditional gym equipment consumes energy while users expend valuable human effort. Our project ingeniously inverts this scenario. In this context, we proudly present the "Design and Fabrication of Power Generator Forearms Machine," an innovative solution that transcends the boundaries of traditional exercise equipment. The machine leverages cutting edge technology to capture and convert the kinetic energy generated during forearms exercise routines into a valuable source of electrical power. It signifies a revolutionary approach to fitness equipment and sustainable energy solutions, seamlessly blending these two global imperatives.

1.2 Current Situation:

In the contemporary landscape, the world grapples with a complex web of challenges, with energy generation and environmental preservation at the forefront. The relentless demand for clean, sustainable energy sources continues to surge. Concurrently, sedentary lifestyles and health-related concerns have proliferated, casting a significant shadow on public well-being. The irony lies in the fact that traditional gym equipment consumes energy while the human effort invested is essentially dissipated. It's time for a transformative shift in this paradigm. Our Power Generator Forearms Machine seeks to address this very incongruity. By harnessing the kinetic energy generated during forearms exercise routines, we embark on a journey to turn the tide, shifting from energy consumption to energy production within the realm of fitness.

1.3 Solution

The "Design and Fabrication of Power Generator Forearms Machine" constitutes a groundbreaking solution to these multifaceted challenges. At its core is an innovative energy harvesting system that adeptly captures the kinetic energy generated during forearms exercise routines and ingeniously converts it into valuable electrical power. This dual-purpose machine not only provides an effective and tailored workout experience but also contributes to clean energy generation.

One of its notable features is the incorporation of a dual-motor arrangement, allowing users to choose from three different levels of power generation capability. As individuals engage with our machine, the horizontal motion they produce during their workouts becomes a potent source of clean electricity. What sets our invention apart is its synergy: the more effort exerted during exercise, the greater the electrical power generated, forging a harmonious link between physical activity and sustainable energy production. In a world where the quest for clean energy and improved health converge, our project emerges as a transformative catalyst. It offers an innovative solution that not only contributes to a more sustainable future but also actively encourages healthier lifestyles.

With the "Design and Fabrication of Power Generator Forearms Machine," we embark on a mission to empower individuals, promote fitness, and harness the untapped potential of human movement for the betterment of both the environment and society at large. Our vision extends to a future where every exercise session propels us toward a brighter, cleaner, and healthier tomorrow, marking a true fusion of human well-being and planetary betterment on an unprecedented scale.

1.4 Basic Working Principle

1. User Exercise: The project relies on individuals using forearm gym equipment for exercise. Users perform exercises on the forearm equipment as they would in a typical gym routine.
2. Mechanical Energy Generation: While using the forearm equipment, the mechanical energy generated by the users' movements is harnessed. Specifically, the project focuses on converting the linear motion generated during exercises into rotational motion, which can then be used to generate electricity.
3. Rack and Pinion Mechanism: A crucial part of the project is the use of a rack and pinion mechanism. The rack is connected to the forearm gym equipment, and it moves up and down as users exercise. The pinion (a circular gear) meshes with the rack, and this interaction converts the linear motion of the rack into rotational motion.
4. Electrical Generation: The rotational motion of the pinion is used to rotate a motor. This motor, when spun, generates electrical energy. The motor essentially converts the mechanical energy from the forearm exercise into electrical energy.
5. Energy Storage: The electrical energy generated is typically in the form of direct current (DC). This electricity can be stored in a battery for later use. Storing the energy in a 4 battery ensures that the electricity generated during exercise can be used when needed, even when users are not actively exercising.
6. Power Utilization: The stored electrical energy can be utilized to power various applications, such as lighting, charging electronic devices, or any other electrical equipment.
7. Dual Purpose: Importantly, the project serves a dual purpose. It not only provides users with an exercise platform but also contributes to energy generation and sustainability. This dual-purpose aspect makes it an innovative solution to reduce energy consumption and promote physical fitness.
The project's effectiveness depends on the efficiency of the conversion mechanisms, including the rack and pinion system, the generator, and the energy storage system. Regular maintenance is necessary to ensure the smooth operation of the equipment and maximize energy generation.

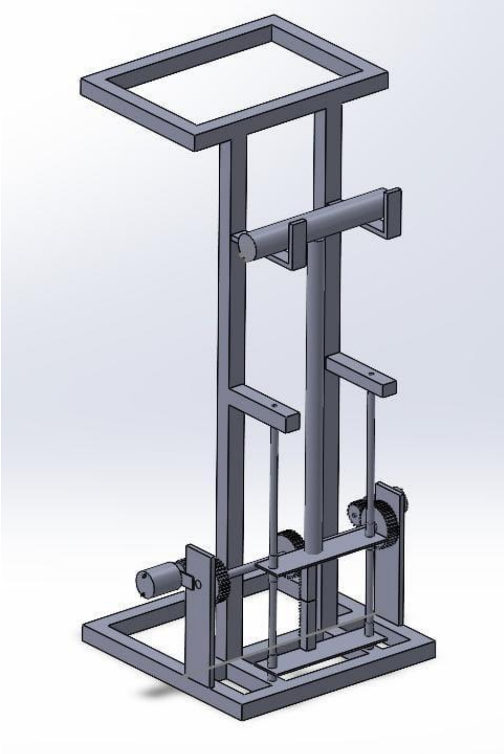

Figure 1.1- Isometric View of CAD Model

II. RESEARCH AND METHODOLOGY

2.1 Assembly and connections

A rack and pinion system is a linear actuator consisting of a circular gear (the pinion) engaging with a linear gear (the rack). It works by converting rotational motion into linear motion. When the pinion is rotated, it drives the rack linearly, and vice versa. This mechanism incorporates spur gears. The maximum force transmission in this mechanism depends on the tooth pitch and the pinion size.

A gym-powered electric generator offers a method of generating electricity using modified stationary gym equipment. It converts human/mechanical energy into electrical energy through a DC motor connected to the exercise equipment. The generated energy can then be stored in various types of lead-acid batteries for later use, such as powering lights or appliances. For AC appliances, a CFL Driver inverter circuit is required to convert the DC current into the standard 230 volts AC current.

The system employs two 500 rpm motors, with their shafts attached to spur gears that mesh with the driver spur gears to produce electricity. A chain is utilized, linked to the gripping rod and the upper base of the guide mechanism, providing resistance during exercise movement and generating power simultaneously. The machine is designed with a 2 motor arrangement to offer two levels of generation capability and includes provision for racking gym weight plates. Its objective is to generate electricity from the horizontal motion generated during a workout.

2.2 Structural Components used:

- Top Frame
- Fixators
- Plates
- Base
- Vertical Shafts
- Spur Gears (Driven)
  - Diameter: 30mm
  - Width: 18mm
  - Teeth: 17
- Gear Rack
  - Length: 180mm
  - Width: 18mm
  - Depth: 4mm
  - Tooth space: 1mm
- Driver Gears
  - Diameter: 60mm
  - Width: 18mm
  - Teeth: 36

- Vertical Guide Shafts
- Motor Clamps
- Side Plates
- Screws and Bolts

2.3 Electrical Components used:

- Motors
  - ➢ Two 500 rpm 12v DC Motors
- Connecting Wires
- Battery
  - ➢ 12v 4Ah Lead-Acid Battery
- Output Setup-

Figure 2.1 - 2 Sockets, 1 Switch and 1 Indicator Light Setup connected to the CFL Driver Inverter Circuit

- CFL Driver Inverter Circuit-

Figure 2.2 - CFL Driver Inverter Circuit

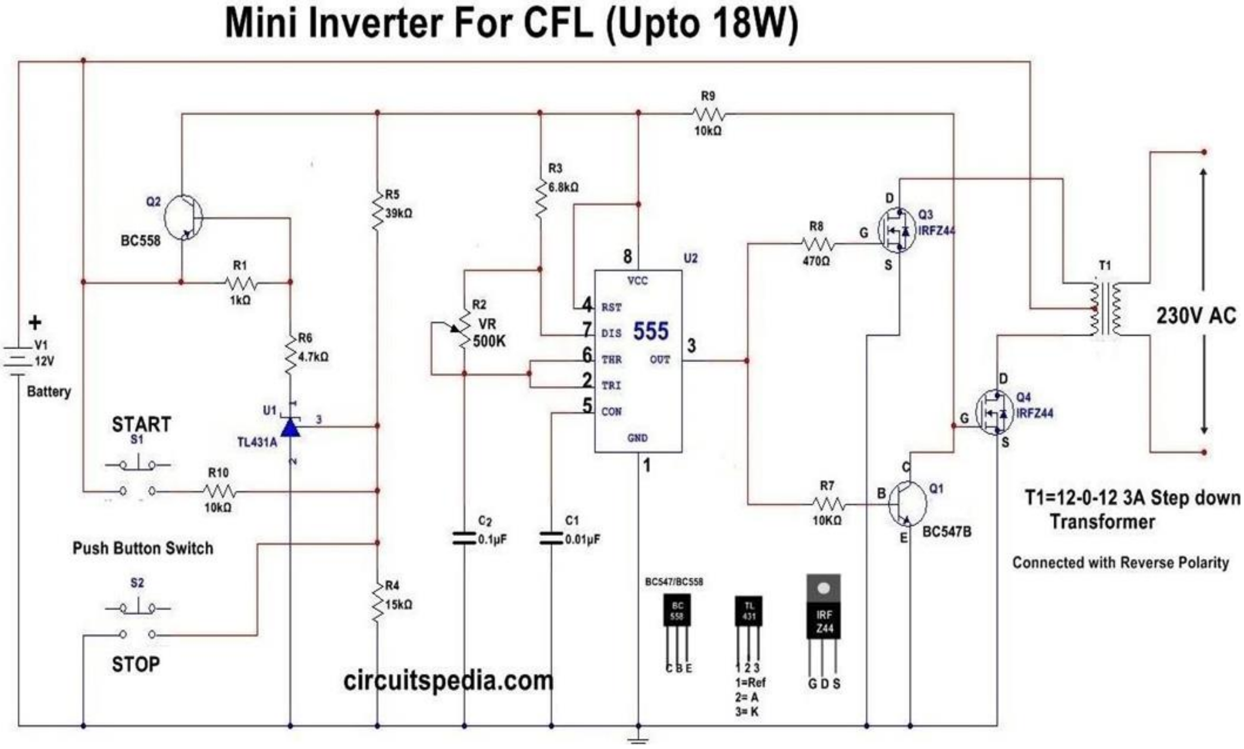

Figure 2.3 – Schematic diagram of CFL Driver Inverter Circuit

Working of CFL Driver Inver Circuit

When the output of the 555 timer IC is high, MOSFET Q3 allows current to flow through the primary winding coil of the transformer, inducing high-voltage AC at the secondary winding. Here, a step-down transformer is connected in reverse, meaning the primary winding is connected to the output. When the output of the 555 timer is low, MOSFET Q4 pulls the current to the ground, inducing a voltage at the secondary winding. MOSFETs Q3 and Q4 operate alternatively according to their gate voltage, switching on and off in a push-pull manner.

When switch S1 is momentarily pressed, the CFL connected to the 230V AC output terminal glows. When switch S2 is momentarily pressed, the CFL is switched off. TL431 is used here to prevent the deep discharge of the battery.

At low voltage, the circuit will automatically disconnect. The circuit produces an output voltage of approximately 230V AC.

- **Components of CFL Driver Inverter Circuit-**

IC
555-1
Resistor
10k-3, 4.7k-1, 15k-1, 39k-1, 6.8k-1, 470 ohm-1
Transistor
BC558-1, BC547-1, TL431-1
MOSFET
IRF Z44-2
Capacitor
0.1uf-1, 0.01uf-1
Push button switch -2
preset -1 500k
Transformer
12-0-12 3A

2.4 Working

The user engages with the system by placing their hands on the provided platform. Utilizing wrist movements, they manipulate the gripping rod connected to the top of the guide mechanism, facilitating its vertical motion along the guide shafts. This action results in the engagement of the rack with the driver gear in the middle, initiating its rotation. The other two driver gears are interlocked with the driven gears linked to the shafts of two motors. All three driver gears are interconnected with each other with the help of horizontal shaft. Consequently, the motor shafts are set into motion, causing a shift in the magnetic field surrounding the motor's coils. This alteration in magnetic flux induces an electromotive force (EMF) or voltage in the coils, leading to the generation of a current through the wires attached to the motor.
Initially, this current measures around 2-3 volts at 100 milliamperes, which is insufficient for powering devices with higher energy requirements, such as LED tube lights, drilling machines, or laptop chargers. To address this limitation and cater to the

demands of medium to high power appliances, we have incorporated a CFL Driver inverter circuit along with a 12V 4Ah Lead-acid battery into the system.

The current generated by the motor is directed into the CFL Driver inverter circuit, which features several components designed to enhance its functionality. Primarily, the current is elevated to a range of 12-13.5 volts and 800 milliamperes using a DC-DC boost converter integrated into the circuit. This boosted current is then utilized to charge the battery, ensuring a stable power supply. Subsequently, the battery outputs a consistent current of 4Ah within the voltage range of 12 to 13.5 volts.

To facilitate the operation of appliances requiring AC current, the system employs a step-up transformer within the CFL Driver inverter circuit. This transformer ramps up the current to 240 volts and 1 ampere, while also converting it into AC current, thus enabling the seamless operation of various appliances.

In summary, the integration of the CFL Driver inverter circuit and the Lead-acid battery enhances the functionality of the system, enabling it to power a diverse range of appliances effectively. This comprehensive solution streamlines the user experience while ensuring reliable and efficient performance across various applications. This project has undergone several tests, demonstrating its capability to power a diverse range of appliances, including mixer grinders, LED bulbs/tube lights, laptops, ceiling fans, small water pumps, geysers, and many more.

The full image of the working model is shown below –

Figure 2.4 - Front View of Working Model

III. RESULTS

3.1 Appliance Compatibility Testing

Extensive testing with different appliances confirmed the system's compatibility and performance across a wide range of loads. Performance metrics, including voltage stability, battery capacity, and compatibility with specific appliances, were analyzed.

The time an appliance can run on the given battery capacity has been calculated. A spectrum of appliances ranging from high power consumption to low power consumption are tested.

During these procedures a stable voltage output of 230 V and 1 amp was recorded from the CFL Driver Inverter Circuit.

Table 3.1– Run Time of Five Different Appliances

Appliance	**Appliance Power Rating (W)**	**Battery Capacity(Wh)**	**Run Time (hours)** *Formula-* $\frac{Battery\ capacity}{Appliance\ Power\ rating}$
Drilling Machine	350	48	0.137
LED Bulb	10	48	4.8
LED Tube light	18	48	2.67
Laptop	50	48	3.84
Smartphone charger	18	48	2.67

3.2 Battery Charging Performance

The Lead-acid battery exhibited reliable charging performance using the generated current from the motor and DC-DC boost converter. Charging tests revealed an average charging time of 4 to 5 days to fully charge the battery, considering a average run time of 17 hours a day (typical time a gymnasium operates daily) for the machine and actual charging time of 1-2 hours (average) daily for the battery. This mismatch of charging hours is due to the intermittent nature of machine usage. Additionally, maintaining a fixed polarity of the current generated by the exercise to charge the battery posed a challenge as the two motors provide different polarities. During the upward motion of the mechanism, only one motor provides the correct polarity for charging the battery, while during the downward motion, the other motor provides the correct polarity. This polarity alternation is a result of the motors' shafts rotating in opposite directions throughout the exercise as the motors are facing each other. The calculation for the charging time is given below-

Formula for Total Charge – Total Charge (Ah) = Charging current × Effective Charging time

Formula for Charging Time -

$$\text{Charging Time} = \frac{Battery\ Capacity\ (Ah)}{Total\ charge\ per\ day\ (Ah)}$$

Table 3.2 - Charging Time of Battery with respect to different Parameters

Charging current (A)	**Effective Charging time**	**Total Charge (Ah)**	**Charging time (days)**
0.8	1	0.8 Ah	5 days
0.7	1	0.7 Ah	5.71 days
0.6	1	0.6Ah	6.67 days
0.8	1.5	1.2 Ah	3.33 days
0.7	1.5	1.05 Ah	3.81 days
0.6	1.5	0.9 Ah	4.44 days
0.8	2	1.6 Ah	2.5 days
0.7	2	1.4 Ah	2.86 days
0.6	2	1.2 Ah	3.33 days
Average			**4.18days**

3.3 Long-Term Reliability Testing

Long-term reliability tests conducted over a three-month period demonstrated the system's durability and stability under continuous operation. Minimal component degradation were observed, with overall system performance remaining consistent over time.

Table 3.3 - Calculation of Failure Rate for the Overall System and the Motor

Observation	Value
Daily run time of the machine (hours)	17
Number of months in the observation period	3
Total days of observation	90
Total operating hours for the system (hours)	17 × 90 = 1530
Total operating hours for the motor (hours)	17 × 90 = 1530
Number of failures observed for the system	2
Number of failures observed for the motor	1
Failure rate for the overall system (%)	(2 / 1530) * 100 ≈ **0.1307%**
Failure rate for the motor (%)	(1 / 1530) * 100 ≈ **0.0654%**

3.4 Applications:

1. Gymnasiums and Fitness Centers: It's primarily used in gyms to convert workout energy into electrical power.
2. Eco-Friendly Power Generation: Offers a green and sustainable method to generate electricity for gym equipment and lighting.
3. Energy Conservation: Helps conserve energy by capturing and utilizing the mechanical energy from exercise, reducing reliance on traditional power sources.

3.5 Advantages:

1. Sustainability: Promotes the use of abundant and sustainable human power for ecofriendly electricity.
2. Cost-Efficient: Significantly reduces operational costs by using freely available human power instead of expensive fuel sources.
3. Dual Purpose: Converts gym equipment into dual-use machines, providing exercise benefits and electricity generation.
4. Eco-Friendly: Reduces carbon footprint by decreasing reliance on conventional power sources, often derived from fossil fuels.
5. Versatile: The concept can be applied to various types of exercise machines, making it adaptable to different gym settings.

3.6 Disadvantages:

1. Mechanical Complexity: Involves mechanical components that may require maintenance and could lead to mechanical losses over time.
2. High Initial Cost: Implementation may require a significant upfront investment in retrofitting or installing specialized equipment in gyms.
3. Efficiency Variability: The effectiveness of power generation depends on the number of people using gym equipment; during low-occupancy periods, energy generation and storage may be insufficient. 4. Energy Storage: Effective energy storage solutions are necessary to ensure a continuous power supply when the gym is not in use or during peak demand periods.

IV. CONCLUSION

The system for converting workout energy into electrical power has been extensively tested for compatibility, performance, and reliability across various parameters. It demonstrates efficiency in powering a spectrum of appliances commonly found in gymnasiums, from high- power drilling machines to low-power LED bulbs and smartphone chargers. Battery charging performance is reliable but faces challenges due to the intermittent nature of machine usage and the need to maintain consistent polarity during charging. Despite these challenges, the system exhibits an average charging time of 4 to 5 days to fully charge the battery, ensuring continuous operation despite the polarity alternation issue. Long-term reliability testing over a three-month period indicates minimal component degradation and consistent system performance under continuous operation. Failure rates for both the overall system and the motor remain remarkably low, underscoring the durability and stability of the system. Cost analysis reveals a moderate project cost, with structural and electrical components constituting the bulk of expenses. However, the long-term benefits of reduced operational costs and energy conservation justify the initial investment. The system's applications span gymnasiums, eco- friendly power generation, and energy conservation, highlighting its versatility and potential impact on sustainability efforts. Advantages include sustainability, cost-efficiency, dual- purpose functionality, eco-friendliness, and versatility. However, disadvantages such as mechanical complexity, high initial cost, efficiency variability, and energy storage challenges should be addressed to maximize the system's effectiveness and adoption.

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REFERENCES

[1] Mahendhar, Mittapally, Abdul Mehraj, Erraboina Dheeraj Yadav, and Kethireddy Lokesh Reddy. "Power Generator Forearm Machine." International Journal of Creative Research Thoughts (IJCRT) Volume 10, Issue 6 June 2022.

[2] Bhandari, Avish, Itte, Shailesh, Jangipuria, Jas, and Harayan, Ramesh. "Power Generation Using Gym Equipment." International Research Journal of Engineering and Technology (IRJET) 06, no. 02 (2019): 2623-2625.

[3] Hasnabadkar, Mayur S., Hritesh V. Jadhav, Kiran P. Salunke, Akash S. Bhoye, and Prof. Swati K. Dhamale. "Power Generation Using Forearm Machine." International Journal of Advance Research and Innovative Ideas in Education (IJARIIE) 8, no.4 (2022): 16895.

[4] P, Chandrakanth, Jyothi, Hemanthkumar P C, and C Shivarajkumar. "Power Generation Using Forearm Gym Equipment." International Journal for Research in Applied Science & Engineering Technology (IJRASET) 10, no. VI (June 2022).

[5] Kumar, M., and G. S. Mundada. "Energy Harvesting from Gym Equipments." International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering 5, no. 07 (2017): 127-131.

[6] Musharraf, M., I. Saleem, and F. Iqbal. "Energy Generating Gymnasiums Machines for Renewable, Sustainable and Green Energy." International Research Journal of Engineering and Technology 5, no. 12 (2018).

[7] Desai, Sumeet, Rushikesh Dhongade, Sumit Sane, Darshan Chaudhary, and Vipin Gawande. "Power generation using gym equipment (lat pull down)." (2019): 7705-7707.

[8] Gondane, Dipeeka A., Aniket M. Dighade, and Priyanka V. Raut. "Treadmill Based Electricity Generator for Domestic Purpose." (2019): 2395-0056