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A Portable Insulated Single-Mast Mobile Lifting Platform with Enhanced Stability Terrain Adaptability and Efficient Material Supply for Aerial Operations

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Abstract: *Single-mast mobile lifting platforms currently available in the market are plagued by critical limitations during aerial operations. Specifically, when moving with heavy loads at height, they are prone to balance loss and tipping, posing severe safety hazards. Their application is restricted to perfectly flat surfaces, significantly narrowing their operational scope. Moreover, material replenishment necessitates lowering the platform to the ground, leading to inefficient workflows. This study presents a portable insulated single-mast mobile lifting platform designed to address these issues. It enables stable movement during aerial operations and eliminates the need for frequent lifting/lowering for material replenishment. Through coordinated efforts between ground personnel and aerial operators, materials can be supplied rapidly and efficiently, thereby enhancing the overall efficiency of aerial work. Field validation confirms its high practicality in real-world scenarios.*

Keywords: *Aerial Work; Lifting Platform; Feeding Component; Stabilizing Component; Moving Track*

1. Introduction

In the contemporary context of rapid development in electric power, construction, and municipal engineering, aerial operations are fundamental yet fraught with challenges. For example, in the construction of high - rise buildings, workers must install exterior facades and conduct equipment inspections at great heights. In power grid maintenance, technicians frequently need to repair and maintain elevated power lines [1-2]. Aerial work platforms play a pivotal role in ensuring the safety and efficiency of these operations. Among them, single - mast mobile lifting platforms are widely used due to their compact size and flexibility. However, current models on the market are plagued with multiple limitations. They are prone to instability when moving with heavy loads at height, which poses significant safety risks to operators [3]. Their application is also restricted to flat terrains, severely limiting their operational scope in complex outdoor environments. Additionally, the inefficiency of material replenishment during aerial work, which often requires lowering the platform to the ground, leads to substantial time waste [4]. These issues not only endanger the well - being of workers but also impede the progress and productivity of projects, thus highlighting the urgent need for innovative solutions [5].

The portable insulated single-mast mobile lifting platform is a device specifically designed for special high-altitude operation scenarios. Its core function is to provide safe, efficient, and insulated high-altitude operation solutions for industries such as electric power, construction, and municipal engineering [6-7]. Single-mast lifting platforms generally have small center of gravity offset, making them suitable for use in places with small lateral space [8-9]. They are divided into mobile and fixed types: fixed lifting platforms can carry higher loads, while mobile ones facilitate continuous position adjustment during high-altitude operations [10].

With the advancement of smart grid construction, overhead line operations face the challenges of refinement of maintenance projects and complexification of operational environments [11-12]. However, traditional high-altitude operation equipment such as scaffolding and other mechanical devices have certain safety hazards [13-14]. The existing single-mast mobile platforms are prone to tipping and losing balance when carrying heavy materials for high-altitude operations and requiring local movement. They

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can only move on flat terrain, leading to many limitations in high-altitude operations. Moreover, each material replenishment requires descending to the ground, resulting in low work efficiency. When moving the lifting platform, operators must get off, and although standard mobile lifting platforms allow operators to stay on board, their operation is very complex, causing inconvenience [15].

In view of the existing limitations and the gaps in previous research, this study aims to develop a portable insulated single - mast mobile lifting platform. By integrating innovative design concepts and advanced technologies, this platform is expected to overcome the shortcomings of traditional models. It is designed to provide enhanced stability during aerial movement, adapt to diverse terrains, and enable efficient material supply, thereby significantly improving the safety and efficiency of aerial operations in various industries.

2. Overall Architecture

This present study has invented a portable insulated single-mast mobile lifting platform, which can effectively solve the problems of low work efficiency and safety caused by inconvenient operation mentioned in the above background technology. The main structures of the present invention include sliding groove, stabilizing component, fixing block, rotating rod, ground- touching rod, mounting platform, positioning block, feeding component and hanging rod.

2.1 Sliding groove

The sliding groove refers to a groove-shaped structure in this lifting platform device, which is used to guide objects (such as sliders, rods, etc.) to perform linear sliding along a fixed direction. Its core function is to enable relevant components to move smoothly along a predetermined path by restricting the movement track, while possibly undertaking the roles of load-bearing, positioning, or transmitting motion, etc. The schematic diagram of the sliding groove is shown in Figure 1 as follows.

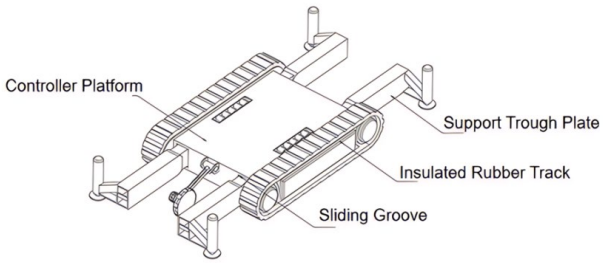

Figure 1: Schematic Diagram of the Sliding Groove

2.2 Stabilizing component

As shown in Figure 2, the device is equipped with a stabilizing component. Controlling the rotation of the three-phase motor will drive the driving wheel to rotate. When the driving wheel moves close to the ground, it can push the controller platform to slide on the outer side of the moving track. At this time, the controller platform will slide on the outer side of the moving track through the moving rollers. Thus, even when the aerial platform carries operators and a large amount of materials needed for high-altitude work, the controller platform can move stably without worrying about the center of gravity of the lifting mast shifting due to heavy load, preventing the entire aerial work platform from tilting during movement in high-altitude operations.

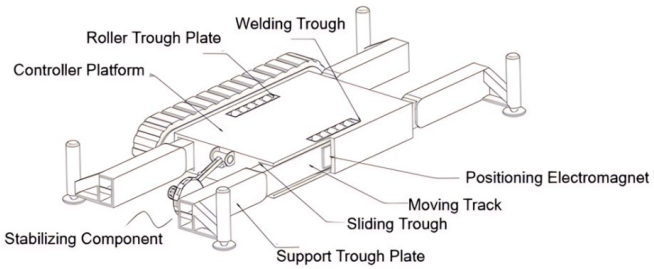

Figure 2: Schematic Diagram of the Structure of the Stabilizing Component.

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2.3 Fixing block

The fixing block works by moving the support channel plates on both sides towards the two ends of the moving track respectively, controlling the support cylinders to extend downward to support the support seats on the ground. The support positions of the four support seats are adjusted separately according to the terrain, and at this time, the insulating rubber tracks will leave the ground. Then, the four support channel plates are all adjusted to the horizontal position, and the controller platform will also be in the horizontal position, so that the controller platform can adapt to different terrains, expand the application range of the lifting platform, ensure that the lifting platform can also be used on outdoor unpaved ground, and improve the use convenience. The schematic diagram of fixing block installation structure is shown in Figure 3 as follows.

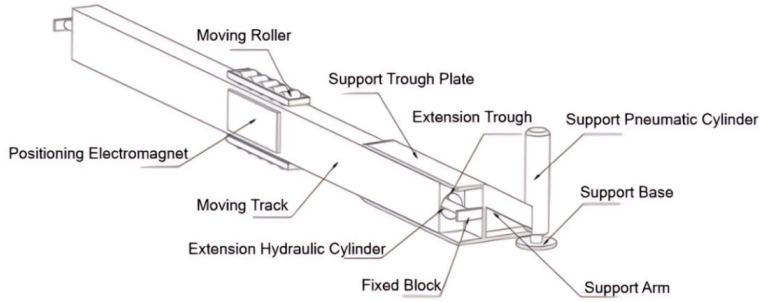

Figure 3: Schematic Diagram of Fixing Block Installation Structure.

2.4 Rotating rod

The rotating rod is shown in Figure 4. It can ensure the stable movement of the controller platform, improve the safety in use, expand the application range of the aerial work device, and further enhance the convenience of use. Moreover, local movement does not require the mast to be lifted and lowered multiple times to adjust the balance, which further improves the comfort of operators and enhances the efficiency of aerial work.

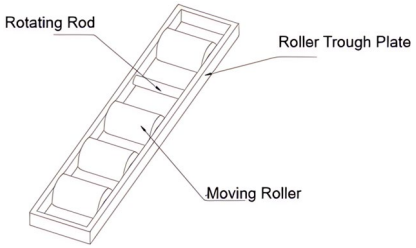

Figure 4: Schematic Diagram of Rotating Rod Installation Structure.

2.5 Ground- touching rod

The ground-touching rod serves two purposes: on the one hand, it enhances the friction between the driving wheels and the ground to facilitate stable subsequent movement; on the other hand, it forms a triangular support to keep the center of gravity low and can detect human induction. According to site requirements, the limit cylinder of the ground-touching rod can drive the limit rod to move for real-time adjustment and maintain stability. The schematic diagram of ground-touching rod installation structure is shown in Figure 5 as follows.

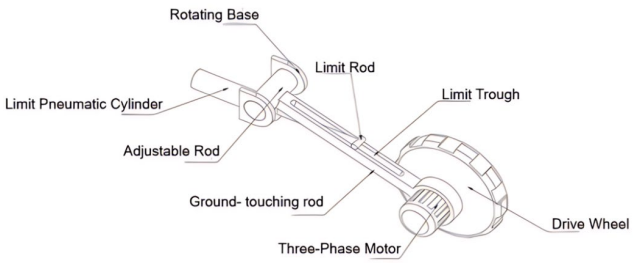

Figure 5: Schematic Diagram of Ground-Touching Rod Installation Structure.

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2.6 Mounting platform

As shown in Figure 6, the installation platform is the main structure of this lifting platform invention. A fixing rod is welded to the top of the controller platform, and an installation platform is welded to the top of the fixing rod. A lifting main engine is installed on the top of the installation platform, a lifting mast is installed on the front face of the lifting main engine, and an adjusting arm is installed at the telescopic end of the lifting mast. The installation platform connects each component of the device to facilitate collaborative operation.

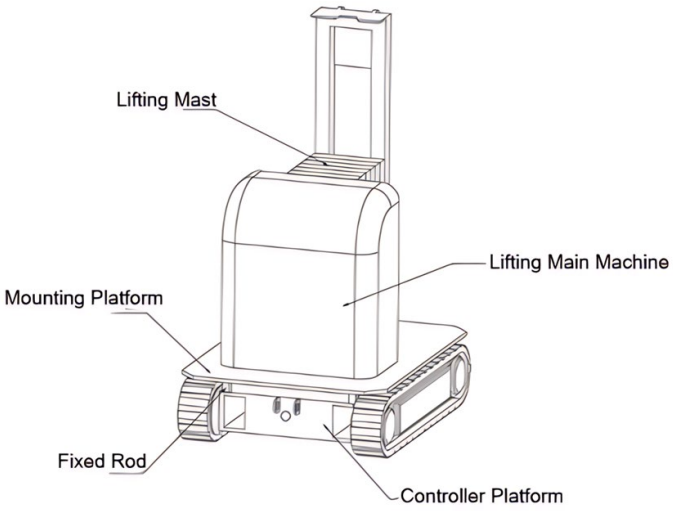

Figure 6: Schematic Diagram of Installation Platform InstallationStructure.

2.7 Positioning block

An aerial platform capable of transporting staff, with a protective frame welded to the top of the aerial platform. A positioning block is welded to the front of the top of the protective frame, and this structure is equipped with anti-slip grooves. When the aerial platform is lifted to a high altitude for use, operators can place small tools like nails inside the anti-slip grooves. This device is used to transport staff to high altitudes for work, and the installation of anti-slip grooves facilitates the staff's operations. The schematic diagram of positioning block installation structure is shown in Figure 7 as follows.

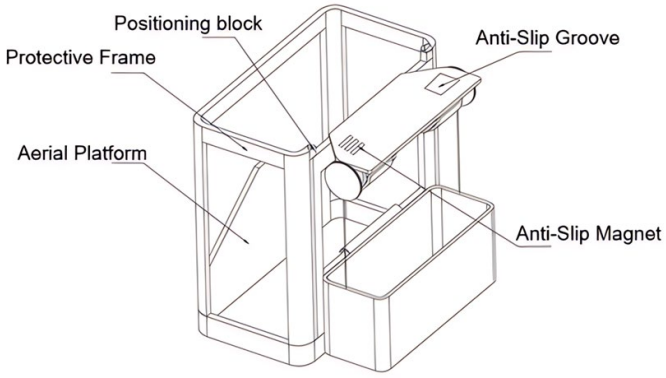

Figure 7: Schematic Diagram of Positioning Block Installation Structure.

2.8 Feeding component

As shown in Figure 8, the invention is equipped with a feeding component, allowing ground operators to place materials inside the placement chamber. Then, the operators control the material box to rise again with the materials. After the hook groove plate ascends to the top of the hanging rod, the material box is lowered slightly so that it can be hung on the outer side of the hanging rod, fixing the material box in place. Subsequently, aerial operators can retrieve materials from the inside of the through slot, enabling rapid high-altitude material replenishment without repeatedly lifting and lowering the mast for replenishment. Through the collaboration between ground personnel and aerial operators, material

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replenishment can be carried out quickly and efficiently, further enhancing the efficiency of high-altitude operations.

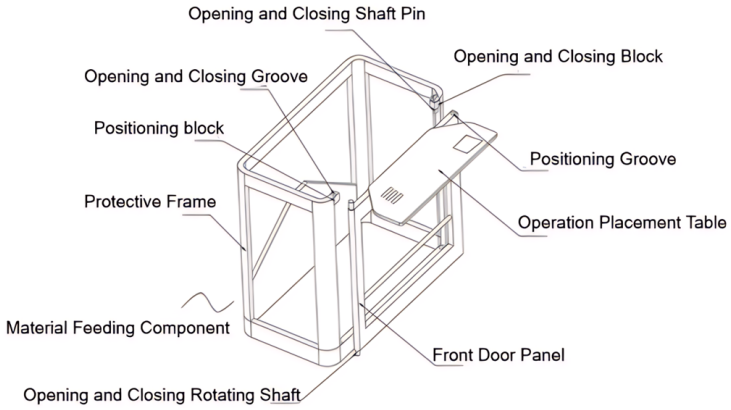

Figure 8: Schematic Diagram of Feeding Component Structure.

2.9 Hanging rod

The Figure 9 shows the hanging rod. The hanging rod is used to fix the material box. Aerial operators can retrieve materials from the inner side of the through slot, enabling rapid high-altitude material replenishment. During the process of material replenishment and waste materials being lowered to the ground, aerial operators do not need to descend to the ground at all. This not only improves work efficiency but also reduces the physiological discomfort caused by frequent ascending and descending, allowing operators to complete high-altitude operations more comfortably and further enhancing operational safety.

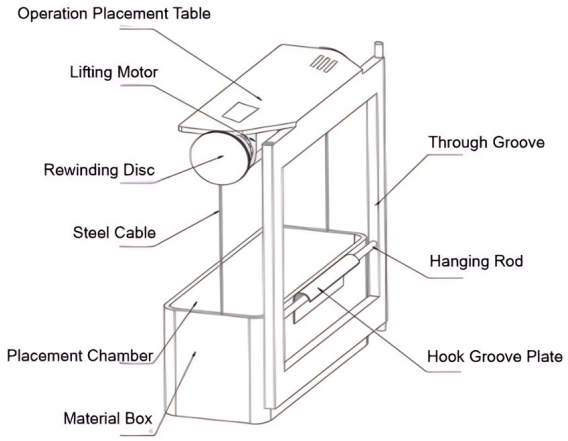

Figure 9: Schematic Diagram of the Hanging Rod Installation Structure.

3. Working Principle

3.1 Support and Adjustment of the Device

The working principle of the device is as follows.Fisrt, the operator drives the insulated rubber crawler via the controller platform to move the equipment to the target aerial work position. The extension hydraulic cylinders inside the extension slots are then controlled to extend outward, driving the fixed blocks to slide the support channel plates along the outer sides of the moving tracks to both ends until reaching the maximum extension position of the cylinders. Simultaneously, the operator extends the support cylinders downward to push the support bases onto the ground for fixing. The extension lengths of the four support bases are adjusted according to the terrain, lifting the insulated rubber crawler off the ground. Horizontal adjustment ensures the four support channel plates and the controller platform are level, enabling adaptive support on unpaved surfaces and greatly improving usability.

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3.2 Stability Control for Aerial Movement

After the platform is leveled, the operator retracts the limit cylinders to drive the limit rods, which pull the ground contact rods through the limit slots, forming a downward-pressing triangular support structure. This enhances the friction between the drive wheels and the ground while reducing the impact of center-of-gravity fluctuations.

For small-range movement, the positioning electromagnets are turned off to release their adsorption fixing with the moving tracks. The three-phase motor is then controlled to drive the wheels, and through the linkage of the ground contact rods and adjustment levers, the controller platform is pushed to slide along the outer sides of the moving tracks. The moving roller device assists in reducing frictional resistance.

At the end of an aerial work segment, the controller platform is moved to the middle of the outer side of the moving tracks, and the positioning electromagnets are activated to re-fix the platform and tracks via magnetic adsorption. The operator lowers the aerial platform while retracting all support bases to bring the controller platform back to the ground. After moving to a new work site, the support channel plates and support cylinders are restarted, and the ground contact rods are tensioned to adjust different heights, ensuring the driving stability of the controller platform on the new terrain. Finally, the operator can place small tools like nails inside the anti-slip grooves to prevent them from rolling off during platform movement, and ensure quick access during use, improving operational convenience.

3.3 Material Supply

When operators need to replenish materials at height, the lifting motor is controlled to drive the winding disc to rotate, releasing the steel cable to lower the material box to the ground. Aerial operators disconnect the hook channel plate from the hanging rod, and ground personnel place materials into the placement chamber of the material box. The winding disc then retracts the steel cable to lift the material box. After the hook channel plate rises to the top of the hanging rod, the material box is finely adjusted downward to be hung and fixed on the outer side of the hanging rod. Aerial operators retrieve materials from the material box through the through-groove, achieving efficient supply without mast elevation/lowering.

3.4 Personnel Access

After the aerial platform lands on the ground, the operator loosens the opening/closing shaft pin inside the opening/closing block, removes it from the positioning slot to release the position restriction of the front door. The front door is rotated to the side, allowing operators to quickly enter/exit from the inside of the protective frame, shortening work preparation time and enhancing emergency evacuation efficiency. The structure schematic diagram of a portable insulated single - mast mobile lifting platform is shown in Figure 10 as follows.

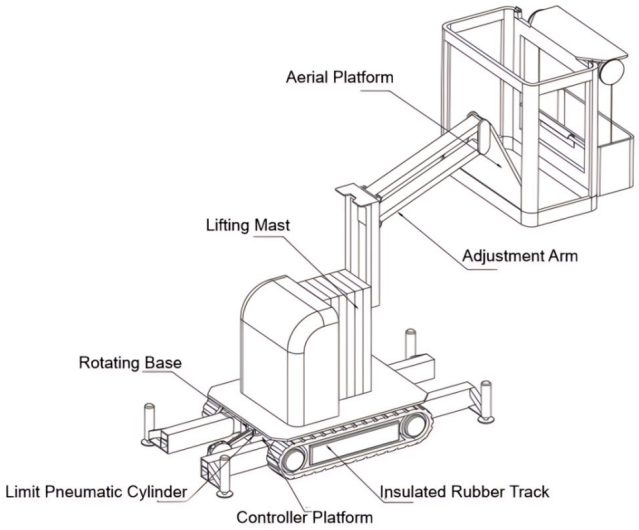

Figure 10: Structure Schematic Diagram of a Portable Insulated Single - Mast Mobile Lifting Platform

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4. Conclusion

This device is specially designed for special aerial work scenarios, enabling smooth movement during aerial operations. The fixed support of the support cylinders and moving tracks, in conjunction with the triangular support structure, ensures stable movement on uneven terrain. Localized movement eliminates the need for repeated mast elevation/lowering to adjust balance, which not only enhances operator comfort but also reduces work interruption time and improves aerial work efficiency. The tool fixing design not only avoids the risk of falling objects at height but also shortens tool access time through standardized storage, enhancing operational convenience. For material replenishment, collaboration between ground and aerial personnel completes material supply and waste transportation, avoiding physiological discomfort caused by frequent operator elevation/lowering and improving both work efficiency and safety.

The invention studied in this paper features a scientific and reasonable structure, is safe and convenient to use, has demonstrated superior functions in practical applications. This research is of great innovativeness. Compared with the prior technology, this invention features a scientifically rational structure and safe, convenient operation.

Acknowledgements

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