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Development and Application Method of Auxiliary Equipment for Pole Erection in Power Distribution Networks

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Abstract: The construction of power distribution networks often encounters challenges associated with traditional pole erection methods, particularly in complex terrain, which can lead to low operational efficiency and heightened safety risks. This paper focuses on the development of auxiliary equipment for pole erection in distribution networks, outlining the design requirements based on functionality, efficiency, and equipment characteristics. Building on this foundation, we provide a detailed description of the equipment's structural components, including a tracked transportation system, a remote control mechanism, and a pole erection device. The construction process is outlined in detail, along with essential precautions during operation. This auxiliary equipment and its application process aim to enhance the standardization, safety, and efficiency of pole erection tasks in challenging scenarios.

1. Introduction

With the rapid development of the power industry, the construction and renovation of distribution networks are becoming increasingly frequent. As a crucial component of power grid construction, pole erection in distribution networks directly affects both the stability of the grid system and the safety of construction personnel0. Traditionally, pole erection relies on large equipment such as cranes0, Scraper pole with twisting mill00, and manual jacks. However, in mountainous and confined terrains, these large machines often cannot access the site, resulting in low operational efficiency. Additionally, challenging topography, aging equipment, and improper handling by workers significantly increase safety risks. Statistics show that the manual pole erection method using pole pullers requires an average of 10 workers and takes around 120 minutes per pole, demanding extensive manpower coordination, resulting in high labor intensity and prolonged construction time, which severely impacts project timelines and reliability of power supply, while also heightening safety risks. Therefore, developing auxiliary equipment for pole erection that can adapt to various working environments, enhance construction efficiency, and ensure operational safety is imperative, in line with the principles of machine replacing manpower, technology strengthening safety and technology ensuring security.[1]

This paper focuses on the research and application of a specific auxiliary device for pole erection in distribution networks. It introduces the components of the complete auxiliary system, analyzes its core innovations, and outlines the comprehensive workflow developed for this device. Furthermore, the paper explores how to effectively apply this auxiliary equipment in scenarios where cranes and other support vehicles cannot reach, while establishing construction precautions and completion inspection standards.

2. Equipment Design

2.1. Design Requirements for Auxiliary Equipment for Pole Erection in Distribution Networks

The auxiliary equipment for pole erection must meet several design criteria:

Functionality: It should operate effectively in locations inaccessible to cranes and other support vehicles, reducing manpower from 10 to fewer than 3 workers, thereby demonstrating the effectiveness of “machine replacing manpower.”[2] It must enhance safety during pole erection and standardize operational methods to improve construction regulation, in alignment with the principles of “machine replacing manpower,” “technology strengthening safety,” and “technology ensuring security.”

Efficiency: The equipment should decrease construction time for erecting a single pole from 120 minutes to under 15 minutes, thus enhancing efficiency and reducing labor intensity.

Equipment Characteristics: The total weight of the auxiliary equipment should not exceed 3 tons, with the excavating device weighing no more than 2 tons for portability and compatibility with construction teams' self-dumping cranes. The load capacity should be at least 2 tons to assist in erecting poles ranging from 8 to 12 meters. Additionally, it should be able to climb slopes up to 30°during acceptance tests, indicating its operational versatility across various scenarios.

2.2. Structural Design

The auxiliary equipment for pole erection consists of a tracked transportation system, a remote control system, and a pole erection device. The overall assembly is illustrated in Figure 1. The physical image is shown in Figure 2.

1) Tracked Transportation System

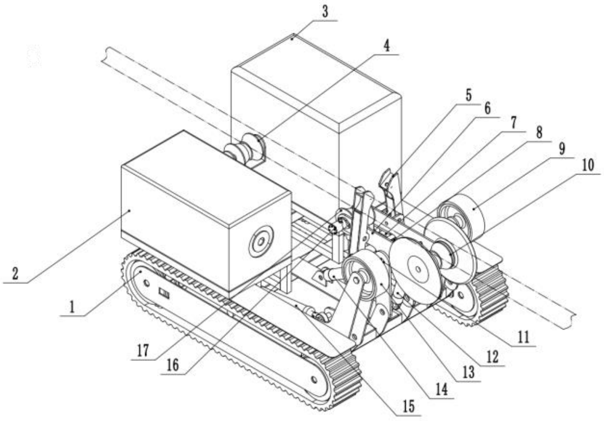
The tracked transportation system includes a tracked vehicle, a fuel tank symmetrically mounted on the vehicle's base, a valve block, a remote control electrical box, and an engine.

2) Remote Control System

The remote control system comprises a remote control electrical box and a remote control unit, with the controller design shown in Figure 3.

3) Pole Erection Device

The pole erection device features a pole clamping mechanism, a mobile roller system, and a support wheel system.[3] The clamping mechanism includes a boom connected to the tracked vehicle base, with a forward-tilting cylinder and a lifting cylinder. The pole's horizontal arm is connected to the boom, with a mobile roller system positioned within the same vertical plane. The horizontal arm also includes a clamping cylinder and a clamp driven by this cylinder. The support wheel system connects to the tracked vehicle base on both sides of the clamping mechanism, with support wheels linked via support cylinders. The mobile roller system consists of driven and passive rollers connected to both ends of the horizontal arm, driven by hydraulic motors, alongside a rear roller fixed between the tank, remote control electrical box, and engine via the boom.



1. Tracked Vehicle; 2. Oil Pump; 3. Engine; 4. Rear Roller; 5. Clamp; 6. Horizontal Arm; 7. Support Cylinder; 8. Clamping Cylinder; 9. Support Wheel; 10. Passive Roller; 11. Boom; 12. Forward-Tilting Cylinder; 13. Support Wheel 2; 14. Lifting Cylinder; 15. Support Cylinder 2; 16. Hydraulic Motor; 17. Driven Roller

Figure 1: Assembly Diagram of Auxiliary Equipment for Pole Erection in Distribution Networks:

Figure 2: Physical picture of equipment

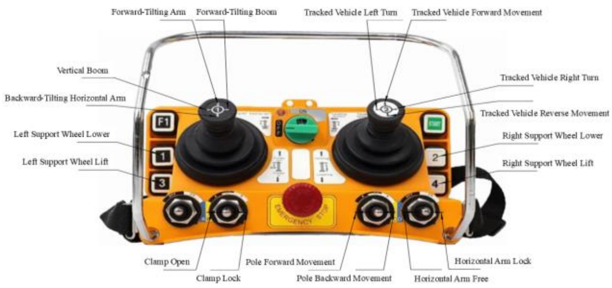


Figure 3: Remote Control Unit

3. Practical Application

To ensure personnel safety and construction efficiency, it is essential to follow the specified operational procedures rigorously. The workflow is illustrated in Figure 4.

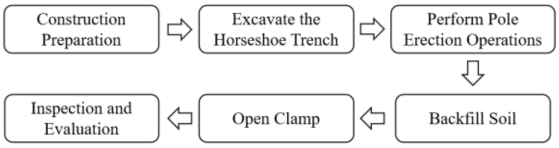


Figure 4: Pole Erection Construction Workflow Diagram

3.1. Construction Preparation

The designed equipment is generally used for cement poles under 12 meters, particularly in relatively complex terrains.

1) Technical Preparation

You should familiarize yourself with the design drawings and master the operation of the remote control buttons, the principles of the pole erection equipment, the sequence of the remote control operations, and the construction procedures for erecting poles. Additionally, you should be aware of the safety considerations during the construction.

2) Personnel Organization

You should designate a site supervisor who is responsible for all technical and safety-related tasks. To ensure effective execution, all personnel on-site should be under the unified command of this supervisor.

3) Equipment Preparation

The pole erection equipment is transported to a nearby area by a delivery vehicle, which can use a crane to unload the equipment from the truck. You should follow the numbering in Figure 1 to start the engine (3) of the pole erection mechanism, which sets all components to their initial state, ensuring the horizontal arm (6) is level and the clamp (5) is open. The crane will then lift the pole horizontally and place it onto the pole erection mechanism. The hydraulic motor (16) will activate to rotate the driven roller (17), adjusting the pole to a balanced position (with the center of gravity for a 12-meter pole at 5.2 meters). Next, the clamping cylinder (8) will engage to secure the pole with the clamp (4). You should plan the route in advance to ensure the slope does not exceed 30 degrees. While moving, observe the surroundings to prevent the pole from colliding. You should use the remote control to maneuver the tracked vehicle forward and backward to transport the pole to the pole hole location, waiting for the hole to be excavated before proceeding with the erection.

4) Pole Inspection

Before erecting the pole, conduct a thorough inspection, checking for any issues with the pole's horizontal and vertical alignment, as well as ensuring the top is sealed and free from bending. The pole must meet all requirements before proceeding with the erection.

3.2. Excavation of Horseshoe Trench

You should take a 12-meter pole as an example and use an excavator to dig the horseshoe trench according to the dimensions shown in Figure 5. Start the excavator and operate the joystick, digging from shallow to deep according to the specified dimensions. Use specialized tools to level the bottom of the trench, and finally, ensure the surface is smooth before moving the excavator back to a safe distance of at least 15 meters.

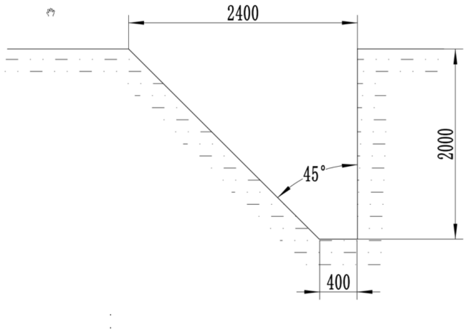


Figure 5: Schematic Diagram of Horseshoe Trench Excavation

3.3. Pole Installation Operations

During the pole installation operations, the relative positions of the utility pole, equipment, and trench are illustrated in Figure 6.

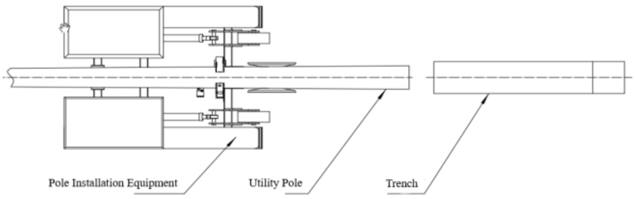


Figure 6: Schematic Diagram of Utility Pole Installation and Its Relative Position to the Trench

You should activate the pole installation equipment and remotely control it to move near the trench. We need to ensure that the centerline of the pole installation equipment aligns with the centerline of the trench. Move forward until the bottom end of the utility pole extends 2 meters beyond the vertical plane of the trench, as shown in Figure 7.

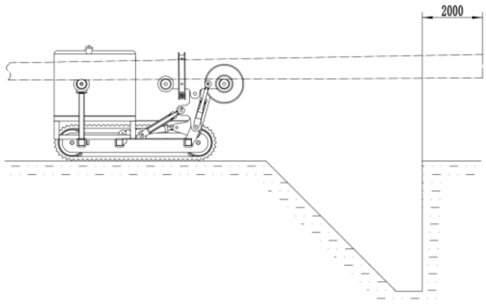


Figure 7: Schematic Diagram of Remote Control Equipment Positioning

Using the remote control, lower Support Wheels 6 and 10 until they make contact with the ground, then stop.[4] You should activate Hydraulic Motor 14 to rotate counterclockwise, which will move the utility pole backward until the larger end of the pole is aligned with the vertical plane of the pole hole, as shown in Figure 8.

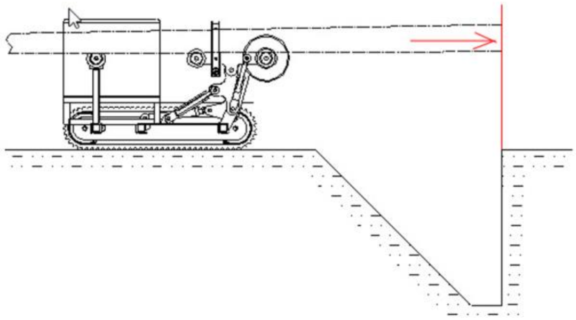


Figure 8: Schematic Diagram of Remote Control Equipment Alignment

You should activate Hydraulic Cylinder 14 to raise the horizontal arm of the pole installation equipment from a horizontal position to a 45-degree angle. At this point, the utility pole is placed into the inclined edge of the trench. We need to engage Hydraulic Motor 16 to drive the driven roller 17, which will transport the bottom end of the utility pole down to the bottom of the trench, as shown in Figure 9.

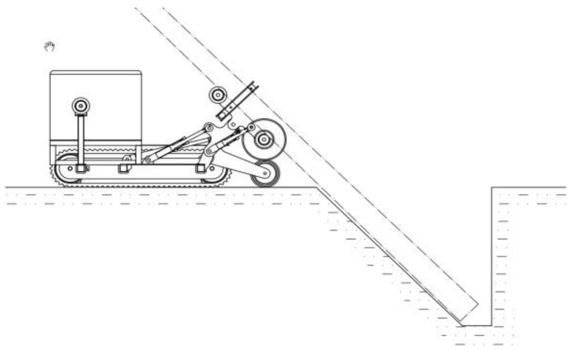


Figure 9: Schematic Diagram of Utility Pole Transportation to the Trench

You should release the pressure within the rotary cylinder 12 on the horizontal arm. We need to operate the tracked vehicle 1 to move forward, transitioning the utility pole from a 45-degree angle to a 90-degree angle. Ensure that the utility pole is vertically aligned, as shown in Figure 10.

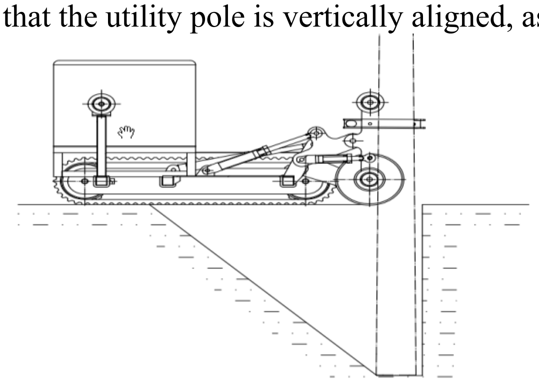


Figure 10: Schematic Diagram of the Utility Pole in Vertical Position

3.4. Backfilling and Releasing the Pole Clamp

Using an excavator, backfill the trench with soil and compact it layer by layer. Once the backfilling is complete, release the pole clamp 5 and move the tracked vehicle 1 backward. You should raise support Wheels 9 and 13, close the forward-tilt hydraulic cylinder 12, and elevate the support hydraulic cylinder 15 to return to the initial state. This process concludes, and the next pole installation operation can commence.

3.5. Inspection and Evaluation

1) Inspection Items
Depth of the pole hole (20% of the total pole length)
Verticality of the utility pole
Pole inclination (within 3‰)
2) Quality Assessment
Qualified Level: The primary inspection items meet requirements, general inspection items basically comply with standards, and any individual deficiencies that have been addressed can still meet requirements.
Excellent Level: The primary inspection items comply with standards and design requirements, general inspection items meet standard requirements, and acceptance is successful on the first attempt.
3) Precautions
You should ensure thorough familiarity with the functions of the remote control buttons, the working principles of the equipment, basic troubleshooting, and emergency response procedures.[5]
The centerline of the pole installation equipment must align with the centerline of the pole hole. The transition from 45 degrees to 90 degrees should be executed slowly to avoid the risk of tipping.
After the pole is installed, the clamp must be released before moving backward.
The entire pole installation process should be monitored by a responsible person; any issues should be reported immediately for timely resolution.[6]
Field tests were conducted on multiple towers with different parameters, and the results are shown in Table 1:

Table 1: Experimental results

Tower parameters (m)	Standing time (minutes)	Error (cm)
eight	five	twenty
ten	six	twenty-one
twelve	seven	twenty-three
fifteen	ten	twenty-six
eighteen	twelve	thirty

4. Conclusion

The construction and renovation of distribution networks are frequent, making pole installation operations crucial. Traditional pole installation methods face challenges in complex terrain, such as low efficiency and high safety risks. Therefore, developing new auxiliary equipment for distribution network pole installation is essential. This paper focuses on the study of such auxiliary equipment, addressing the following aspects:
1) Design Requirements
Clearly identified design needs for auxiliary equipment include functionality (adaptation to special sites, reduction of manpower, enhanced safety and compliance), efficiency (shortening duration, reducing labor intensity), and equipment characteristics (requirements related to quality, load capacity, and climbing ability).
2) Structural Design
The paper provides a detailed description of the equipment's structural design, which includes a tracked transport device, a remote control system, and a pole handling device, along with the

composition of each component.

In terms of practical application

1) Strict Construction Procedures

A comprehensive construction process is outlined, encompassing preparation (technical, personnel, equipment, and pole inspections), trench excavation, pole installation, backfilling, and pole clamp release. Each stage has specific operational requirements. The inspection and evaluation section includes checks for pole hole depth and verticality, along with standards for qualified and excellent quality ratings.

2) Noteworthy Precautions

Key considerations during construction are listed, such as mastering operational skills, ensuring alignment of equipment centerlines with pole hole centerlines, essential points for pole installation operations, and monitoring by a responsible individual.

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