Instruction Manual for Pipeline Repair Robot

CONTENT

I. Equipment Purpose:

For steel pipes with diameters of 12 inches, 16 inches, and 24 inches, the circumferential weld seam is made on the inner wall.

The process includes grinding and rust removal, vacuuming and cleaning, and spraying with anti-corrosion coating.

2inch	3inch	4inch	6inch	8inch	10inch	12inch	14inch
50.8mm	76mm	114mm	159mm	219mm	273mm	323.9mm	355mm
——	——	One machine covers		One machine covers			

16inch	18inch	20inch	22inch	24inch
406mm	457mm	508mm	559mm	610mm
One machine covers				

II. Equipment Composition:

The equipment consists of a battery-powered tractor, a control tractor, a grinding and rust-removing vehicle, and a dust extraction unit.

Cleaning vehicles, material storage vehicles, and anti-corrosion spraying vehicles, as well as wireless remote control modules and controls.

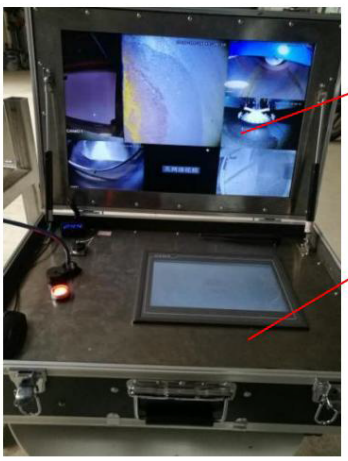
The equipment consists of the following components:

1. Wireless module and control box:

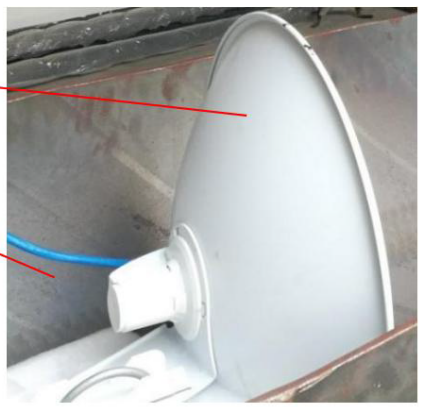
The wireless module uses a high-power bridge; the bridges are in pairs, one for each user.

One is mounted on the battery-powered tractor unit, and the other is connected to the control box; on the control box

The cover is the display, the cabinet is the touch screen, and it has a built-in control system.

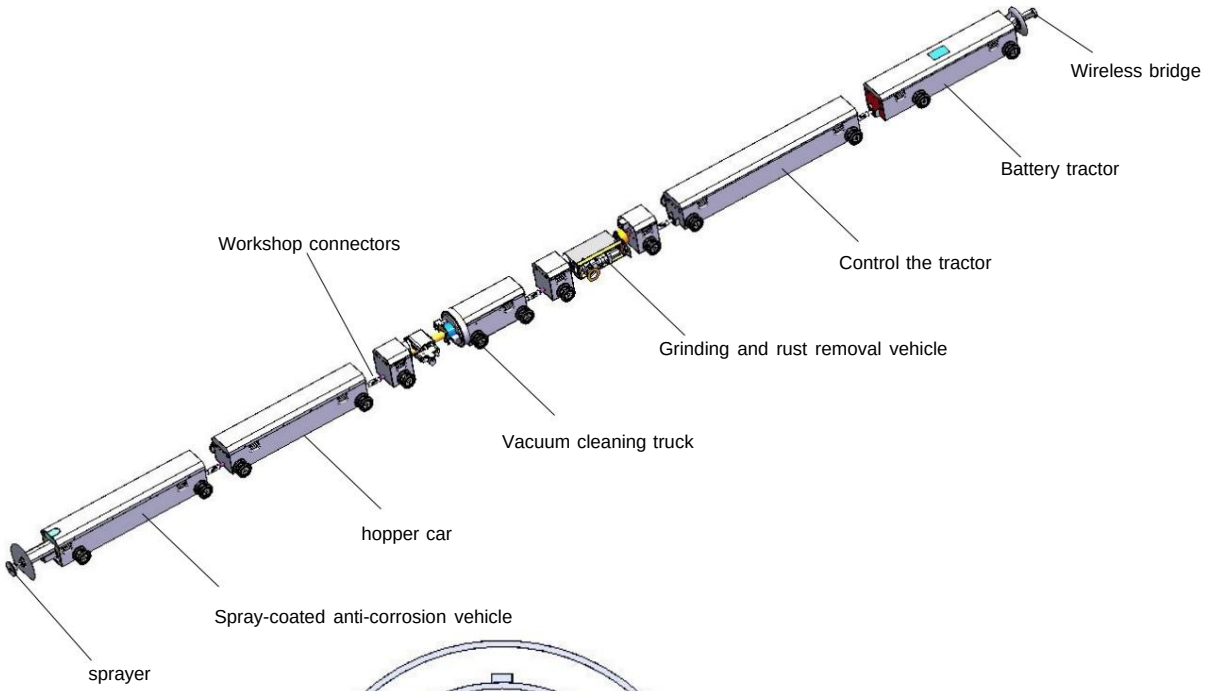


control box

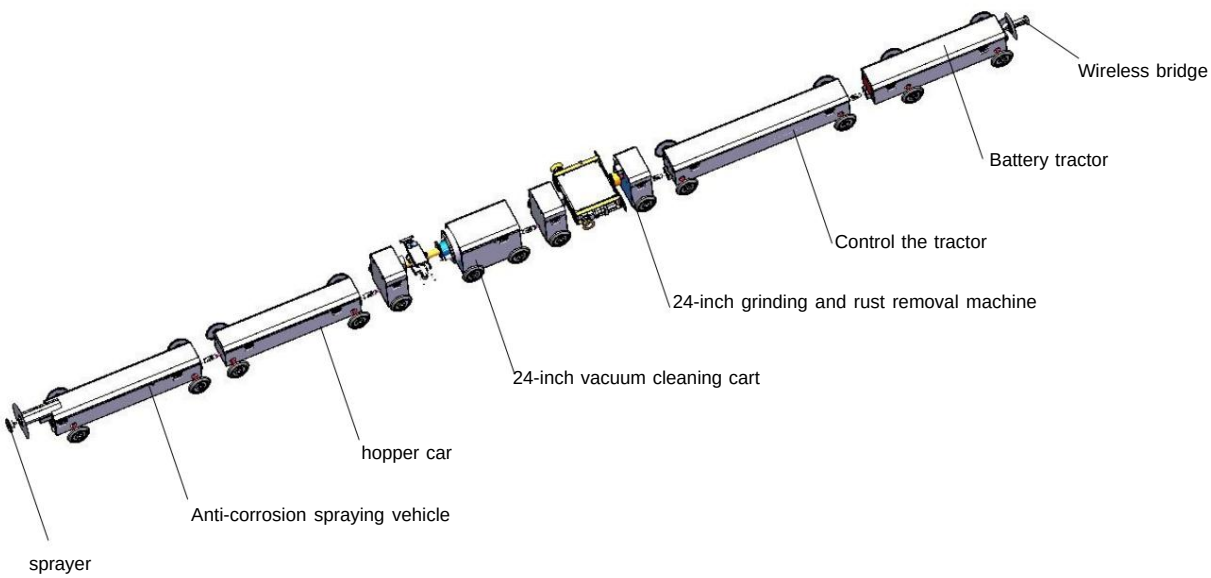


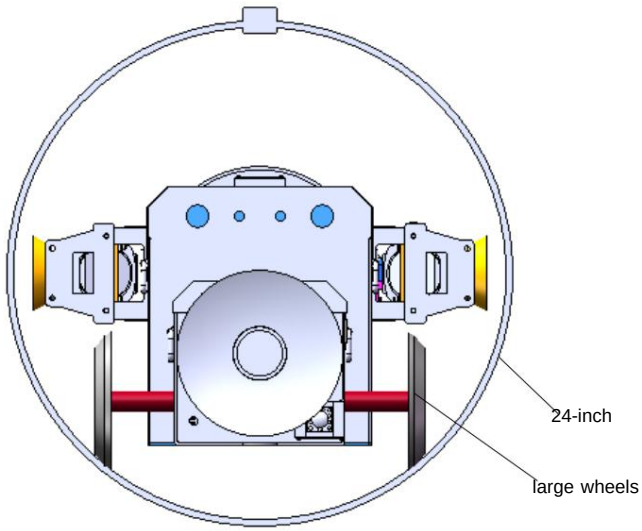
wireless module

2. Composition of the internal patching robot:



Schematic diagrams of 12-inch and 16-inch internal patching robots





Schematic diagram of a 24-inch internal patching robot

As shown in the schematic diagram of the internal patching robot above, this equipment consists of six parts.

The components, in order, are: battery tractor, control tractor, grinding and rust removal vehicle, and vacuum cleaner.

The workshop consists of cleaning vehicles, material storage vehicles, and anti-corrosion spraying vehicles, and is connected by universal joints.

And cables and communication cables.

1) Battery-powered tractor:

Built-in traction motor, working lithium battery pack, and wireless bridge installed at the front of the vehicle.

LED lights, system switches, and cameras.

2) Tractor control: Built-in control lithium battery pack, control system and a tractor unit

Generator.

3) Grinding and rust removal machine:

The grinding and rust removal machine is equipped with a camera on the side, and the central spindle supports the entire grinding process.

The components can rotate continuously, and two sets of grinding machines are provided. The grinding machines can move freely.

Extend and retract.

4) Vacuum cleaning cart: Features a built-in sealed dust collection chamber and a telescopic rotating vacuum head.

Camera.

5) Material hopper cart: Equipped with a built-in paint pump and a material hopper; the pump is a custom-made type.

Metering pump.

6) Anti-corrosion spraying vehicle: Equipped with a paint pump and a material hopper; the pump uses a fixed-pump design.

The metering pump is equipped with a high-speed spraying motor at the front end, and the motor shaft is fixed.

The sprayer is stationary, with a camera and LED lights below the motor, spraying paint and solids.

The chemical agent enters the sprayer simultaneously through the copper feed pipe, and then passes through the sprayer.

The mixture is thoroughly mixed on the conical surface and then sprayed out at high speed by the sprayer.

7) This internal fitting robot is designed to be applicable to three pipe diameters simultaneously, and adopts...

The design scheme is: the 12-inch and 16-inch models share the same complete robot, only...

Simply change the position of the wheel axle. (As for the 24-inch wheels...)

Below, a special grinding and rust removal cart and a vacuum cleaning cart were designed for 24-inch wheels.

His vehicle was shared, and all the small wheels were replaced with large wheels.

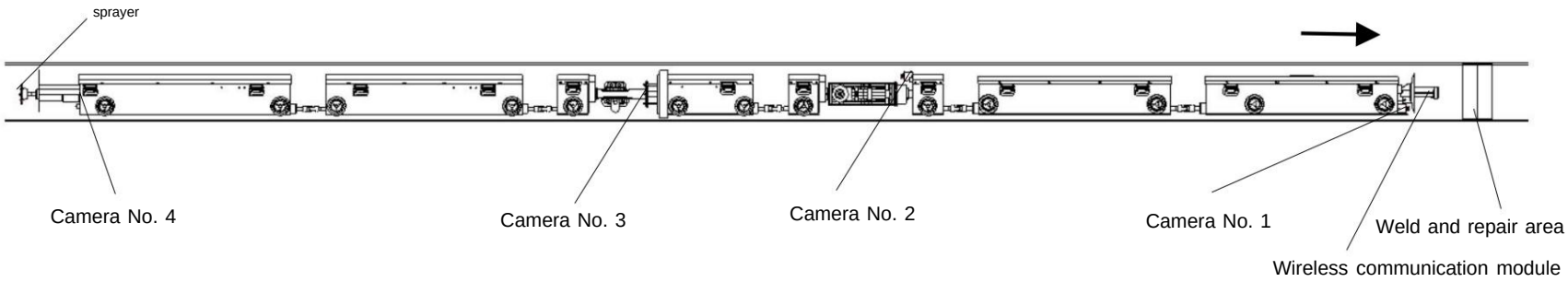


Figure 1 Explanation: The internal welding robot enters the pipeline and moves forward along the pipeline. When camera 1 detects the weld seam, the operator will also see it on the monitor of the control box. Continue forward along the weld seam. When camera number 2 detects the weld seam, the operator presses the stop button on the control box, slowing down the robot's speed. (The robot will then be observed through the camera.) The video shows the operator aligning the grinding brush with the weld seam, initiating the grinding and rust removal program. Once the grinding program is complete, the machine automatically stops and returns to its original state. The operator initiates the forward program, and the robot continues to move forward. When camera number 3 detects the weld seam, the operator presses the stop button on the control box, reducing the robot's speed. Set the speed to slow. The operator, using a camera, aligns the suction head with the weld seam and starts the vacuuming program. Once the vacuuming program is complete, the machine automatically stops and resumes normal operation. Return to the original state. The robot continues to move forward, and when camera number 4 sees the weld, it starts the spraying program to cover the weld and its repair area.

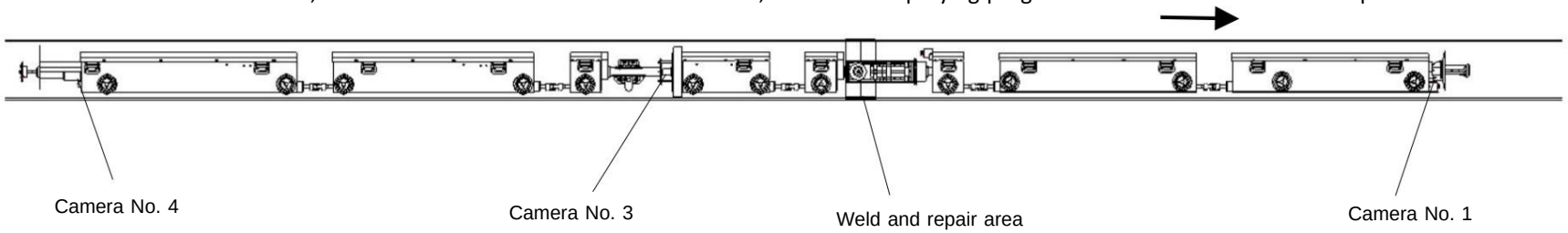
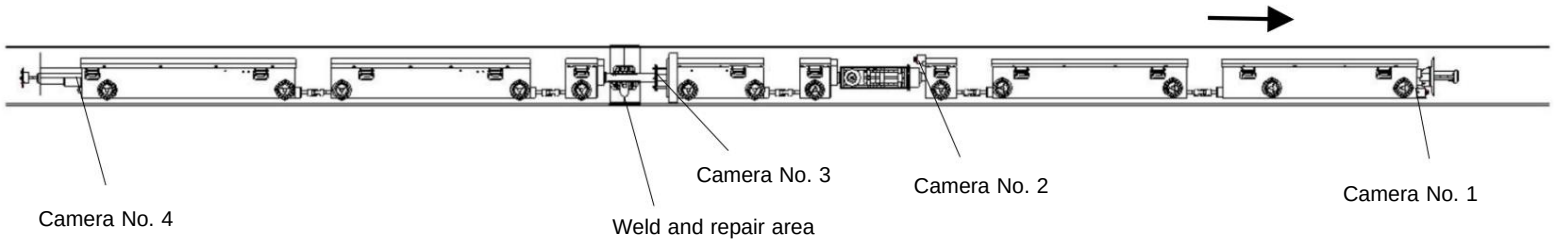
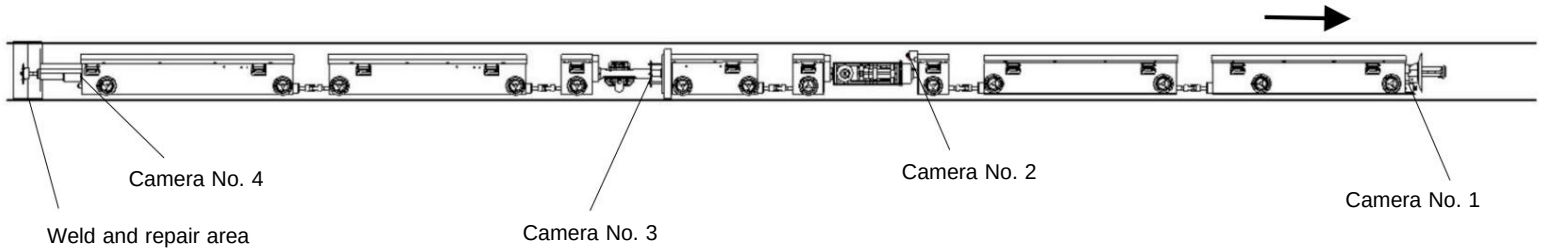


Figure 2 Explanation: All cameras can wirelessly transmit video in real time to... On the control box outside the pipeline, operators can view these video feeds. The internal patching robot is operated in real time to complete each action.


Camera No. 4
Weld and repair area
Camera No. 3
Camera No. 2
Camera No. 1


Camera No. 4
Weld and repair area
Camera No. 3
Camera No. 2
Camera No. 1

The image above shows footage from a vehicle-mounted camera, depicting rust removal and anti-rust spraying.

Rotten.

III. Robot Parameters:

project	index
Pipeline patching robot	
Applicable pipe	12-inch, 16-inch, 24-inch
diameter weld positioning accuracy	±3mm
walking speed	0-25 m/min (adjustable)
Number of polishing groups	1 set (12 and 16 inches) / 2 sets (24 inches)
Grinding speed	13000 rpm
Grinding precision	St3~Sa2 (Remove visible deposits until metallic base color is visible)
Spraying motor speed	0-12000 RPM (adjustable)
Coating thickness	50-1000 micrometers (depending on coating characteristics and parameters)
Applicable coating types	Liquid epoxy two-component
Wireless communication distance	Within the pipe, the maximum real-time range is 500 meters; beyond that, there is a delay.
System power supply	One 48V 70AH lithium battery and one 48V 50AH lithium battery.
Battery life	8-10h
Traction motor unit	3 groups
Camera	4 units
silo	2 compartments (1 compartment each for paint and hardener)
pump	2 units (1 for paint and 1 for hardener)
control box	
Voltage	24V (lithium battery pack)
Battery life	12h
Control method	Touchscreen (8 inches)

Video display screen	4 screens (4 cameras)
monitor	10-inch

IV. Operating Procedures:

1. Connect the plugs between the devices to the network cable connectors.

2. Connect the control box battery to the control box plug.

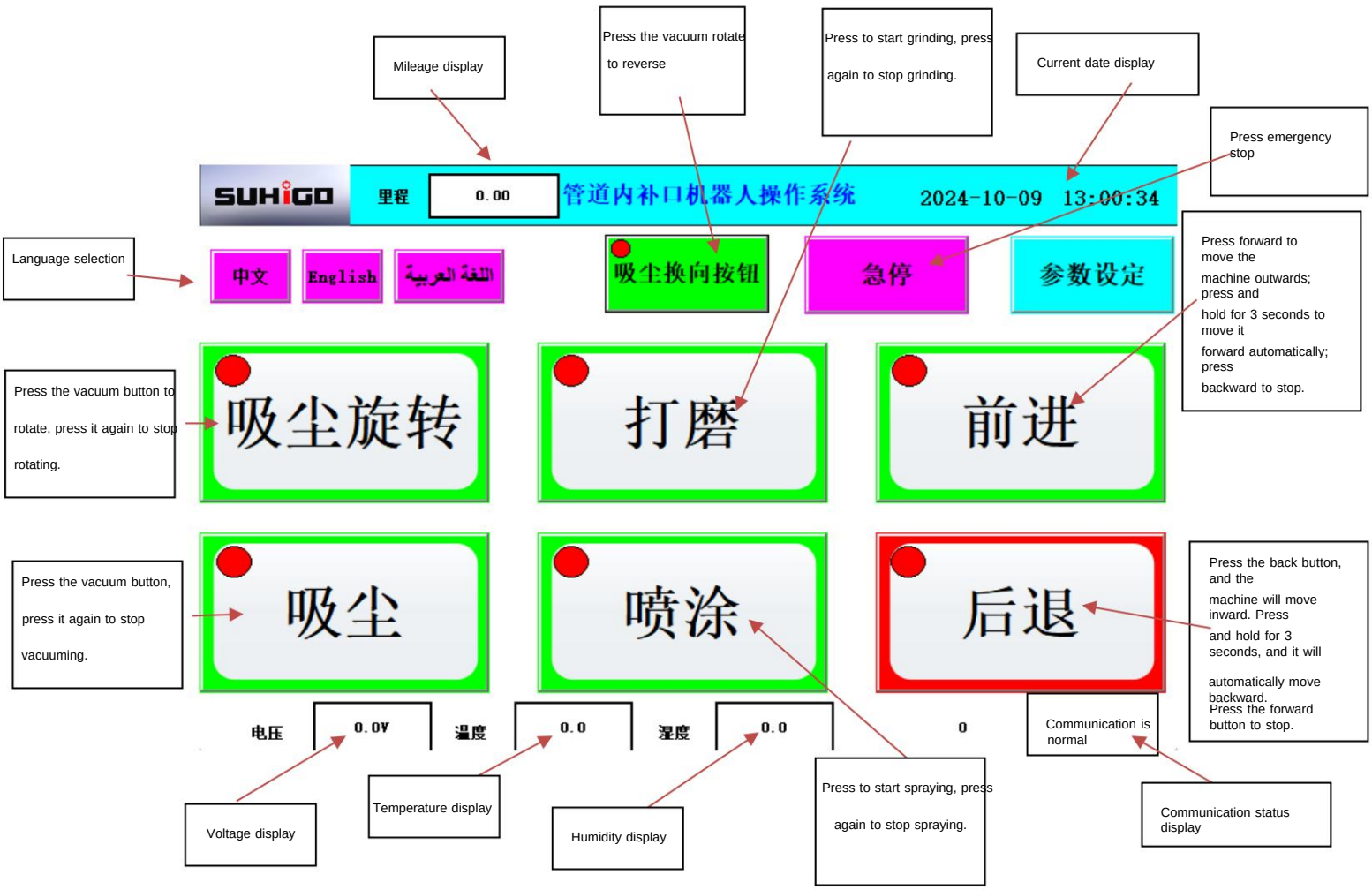
3. Connect the network cable plugs between the control box and the wireless bridge.

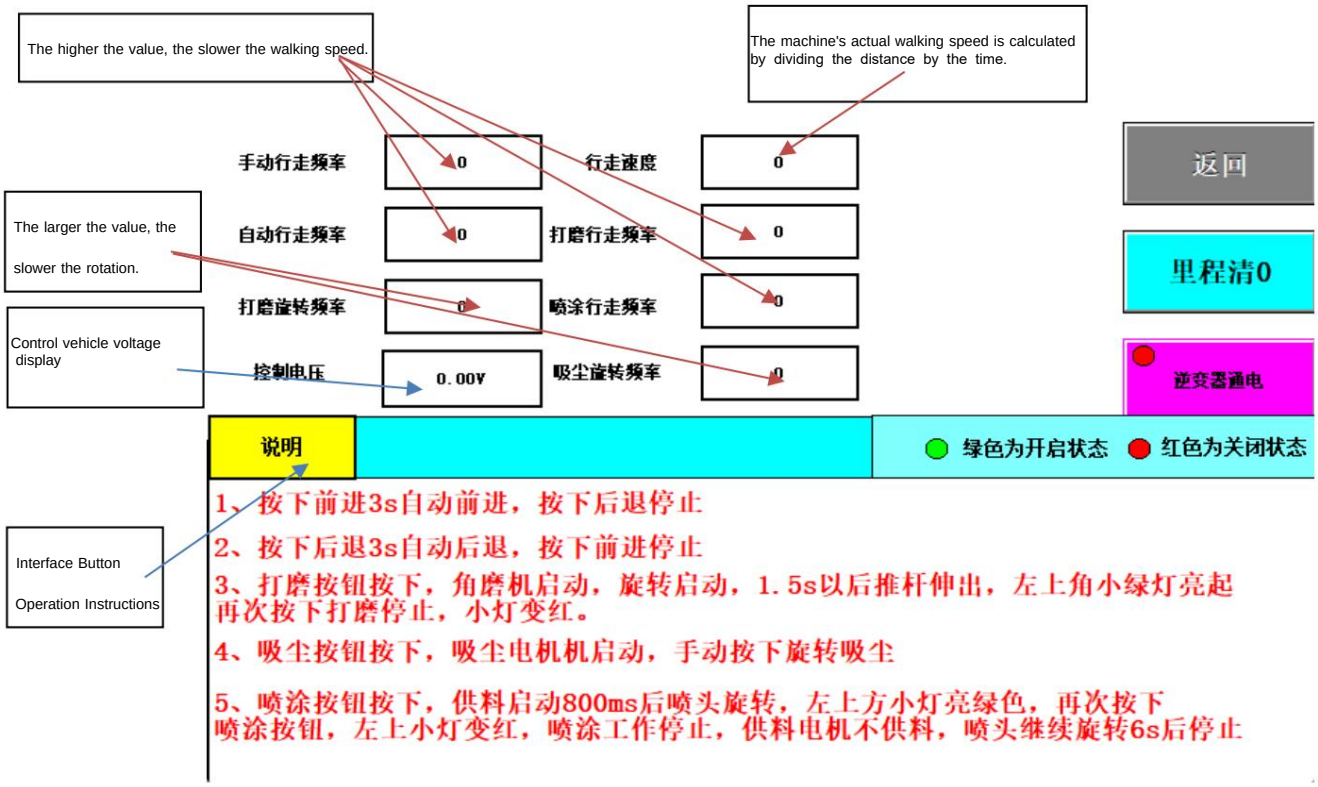
4. Power on the machine and the control box.

5. After proper connection, you can operate the system via the touchscreen on the control box.

   Button controls the equipment to move forward, backward, grind, spray, and perform other actions.

6. The touchscreen interface is as follows:





7. Precautions for using the internal patching machine

7.1. Operating Conditions

1. Normal operating environment (temperature and humidity): Pipeline temperature -10-50ÿ, relative humidity below 25-85%RH (non-condensing); 2. Main operating voltages:

DC48V

battery on the patching vehicle, AC220V for the angle grinder, AC220V for the spraying motor, and material pump. DC24V & AC220V; Control box DC24V;

7.2. Battery Protection

The internal charging port equipment and control box must be charged after each day's use. The voltage of the internal charging port equipment must not be below DC48V or the control box must not be charged.

Avoid working with the equipment below DC 23V to prevent various electrical components from malfunctioning due to low voltage.

7.3. Equipment Start-up

1. After the equipment is powered on, all the lights on the equipment will turn on. If they do not turn on, turn off the switch and power on again as soon as possible.
2. First turn on the equipment switch, then turn on the control box switch. The equipment will automatically connect in about 3-5 minutes and communication will be normal.
3. After communication is normal, test all the functions outside the pipeline. Only after confirming that there are no problems can you enter the pipeline for construction.

7.4. Equipment Cleaning

1. Clean the dirt from the RJ45 connector and equipment plug promptly. Since the internal patching equipment is frequently disassembled and moved, clean the dirt from the plug and RJ45 connector promptly after each return to prevent image loss or connection problems.

2. After each use, disassemble the sprayer and soak it in thinner or industrial alcohol.

3. Clean the copper tube outlet of the sprayer promptly with thinner or industrial alcohol.

4. When changing paint, promptly discharge the old paint and clean the hopper before adding new paint.

5. Clean the camera monitoring the spraying process at the rear of the patching vehicle promptly with thinner or industrial alcohol to prevent fogging that could affect patching quality.

6. When the equipment is not in use for an extended period, clean the copper tube and sprayer promptly to prevent adhesion and difficulty in cleaning and use during the next application.

7.5. Equipment preservation

1. Equipment storage temperature: -20 to 70℃ (non-condensing);

2. If the equipment is not used for a long period of time, please charge and discharge it at least once every 5 months;

3. The equipment is equipped with fragile electrical components such as a monitor and touch screen, batteries, PLC, and frequency converter. Please handle the equipment with care when moving or transporting it.

8. Troubleshooting Instructions for Internal Patching Machine

8.1. Power Supply Issues

1. After connecting the patching trolley, turn on the switch normally. All lights should illuminate. If the switch trips immediately upon activation, it indicates a short circuit in the patching trolley. In this case, disassemble each trolley and restart it to check each component.

2. Check all plugs for foreign objects, short wires, or exposed wires;

3. If the power control of the patching vehicle trips when only the power is turned on, disconnect the inverter and use a multimeter to measure the continuity at the inverter's input terminals (normally no continuity; otherwise, replace the inverter);

4. If the inverter's input terminals are normal, disconnect the power cable of the 86 stepper driver. Use the same method to measure the continuity at the driver's power input terminals (normally no continuity; otherwise, replace the 86 driver);

5. Check all aluminum-cased power modules for proper function. Replace any modules with burnt or broken wires;

6. The patching vehicle's battery voltage is approximately DC58V after a full charge (battery consumption range is DC48V-DC58V). If it drops below 48V, charge it promptly, as the voltage may fluctuate with usage time;

8.2. Light does not turn on after power-on

1. Replace the light;

2. Replace the step-down module;

8.3. Camera has no image after power-on

1. Check the camera for a burnt smell;

2. Use a multimeter to check if the camera's power supply is a normal DC 12V (red +, black -);

3. Check if the camera's power module is damaged and replace the module;

4. Check the network cable port for foreign objects or if the network cable is damaged or broken;

5. If none of the above issues are found, replace the camera;

8.4. Communication problems

1. The device communicates via a wireless bridge Ethernet communication system. During normal communication, the power light on the wireless bridge is constantly on, the communication light flashes, and the remaining four red, yellow, and green lights are communication network signal lights. These should normally be constantly on. Three constantly on lights indicate an incorrect receiver angle and poor communication quality. In this case, the receiver needs to be adjusted; it must be placed face-to-face.

2. The touchscreen configuration displays communication information. Normally, this is indicated by a green "Communication Normal" message. In environments with network fluctuations or poor communication quality, this message will flash green ("Communication Normal") or red ("Communication Failure"). A communication interruption is indicated by a red "Communication Failure" message.

3. If communication is interrupted for more than 6 minutes, the trolley will automatically move forward out of the pipeline. This action will not be triggered within the first 15 minutes after power-on.

4. Poor communication environments (high-voltage areas, strong geomagnetic areas) will inevitably cause communication problems. Receiver position and angle will also affect communication quality. During automatic movement of the trolley, these are considered normal network fluctuations.

5. After a communication interruption, all ongoing actions will be stopped for 3 seconds. If no communication with the upper control system is established within 6 minutes, the trolley will automatically move forward.

6. The touchscreen communication flickers between normal and faulty communication. This is due to communication latency. The default communication latency is 200ms. A latency exceeding 200ms will be considered a communication failure. During this period, the touchscreen may operate intermittently. Operations within the 200ms latency will result in operation, while inaction will occur when the latency exceeds 200ms (e.g., if the communication latency is 400ms and the program refresh latency is 200ms, a communication failure will occur). This is not an actual disconnection. Adjusting the receiver position or waiting for the network to stabilize will resolve the issue.

8.5. The grinder is not turning.

1. Check if the inverter power button on the touchscreen is pressed; (Pressing the inverter power button should illuminate the configuration indicator light.)

2. Check if the angle grinder switch is turned on; (Turn on the switch.)

3. Check if the angle grinder carbon brushes are broken; (Replace the carbon brushes.)

4. Check if the angle grinder is burnt out (overly tight mechanical springs or loose wire can cause burnout; improperly adjusted angle grinder positions can cause the grinding brush to press too tightly against the tube wall, leading to burnout. Adjust the spring and wire positions so that the wire brush is just touching the tube wall when the electric push rod extends. After adjustment, rotate the touchscreen and observe if the wire brush position is correct.)

5. Check if the inverter outputs AC220V (Check if the inverter output voltage display shows 220V in red). If the voltage display does not show 220V after pressing the inverter power button on the touchscreen, replace the inverter.

6. Check the 7-pin connector for foreign objects or broken wires.

7. Replace the angle grinder.

8.6. The spray painting motor is not turning.

1. If the spray motor does not rotate inside the pipeline, press the inverter reset button on the touchscreen, wait 5 seconds, and then restart the spray motor to see if it starts. If it does not start, press the inverter power button. The inverter power indicator on the touchscreen will light up red. Wait 10 seconds, then press the inverter power button again. The inverter power indicator on the touchscreen will light up green. Wait 5 seconds and then click to start the spray motor.

2. If method 1 does not solve the problem of the spray motor not rotating, turn on the control cart and press the motor rotation button. Observe if the inverter starts. If it does not start, replace the relay for starting the spray motor. If it starts and has output, check if there are foreign objects in the 7-pin connector, if the connector is broken, and if the connector after the spray motor is properly connected.

3. Replace the inverter.

Inverter parameters：

F000 0	F001 1	F003 400
F004 400	F005 400	F026 1
F140 0.4	F141 220	F142 2.5
F143 2	F144 12000	F163 2
F164 1	F165 3	

8.7. Inverter has no output

1. Check if the DC 48V power supply is normal (is the voltage below 48V?), and if the inverter indicator light is green. A red indicator light indicates overload or output short circuit.

2. Check if the inverter switch is on.

3. Check if the power button on the touchscreen inverter is on.

4. Unplug the output connector and restart the inverter.

5. Replace the inverter.

Other matters

Instructions for anti-corrosion coatings:

Introduction: This coating is made of epoxy resin and fatty amine resin, with the addition of non-toxic pigments, fillers, and additives. The resulting paint film is non-toxic, has strong

adhesion, and dries quickly. It exhibits excellent resistance to acid, alkali, and salt corrosion, as well as superior resistance to water, oil, and weathering. This coating has passed the appraisal and approval of the Ministry of Health and the Provincial Health Department, and has been issued a "Sanitary Permit for Products Involving Drinking Water Safety." It is used for internal and external corrosion protection of drinking water containers, water supply pipelines, and equipment.

Product Information:

Item	Content
Color	milky
Volume Solids	98%±1%
Gloss	bright
Gross Solids	99%±1%
Flash Point	100℃
Specific Gravity	1.55±0.2g/ml
Recommended Film Thickness	≥450μm
Theoretical Usage	2m2/kg（No loss）
Surface Drying Time	4H（25℃）
Complete Drying Time	18H（25℃）
Usage Temperature	Maximum temperature resistance under dry conditions: 120℃
Shelf Life	12 months（Store in a sealed container at 23°C indoors）

Construction Instructions:

It is recommended to complete the process in one coat to minimize the number of coats.

Mixing ratio	1:1	Recommended wet film thickness	≥450μm
Construction method	Dual-temperature dual-pipe feeding	Recommended dry film thickness	≥450μm
Applicable period of mixture	1h（25℃）		

Drying time

Substrate temperature	5℃	10℃	20℃	25℃	40℃
Touch drying	8h	8h	6h	6h	3h
Cure drying	24h	24h	20h	16h	12h
Complete drying	14d	14d	10d	7d	5d

Preparation before coating: To ensure stable adhesion, the steel pipe surface must meet the rust removal standard of ISO 8501-1:1988 Sa2.5 or St3. The surface should be free of visible grease and dirt, and free of mill scale, rust paint coatings, and foreign matter. Any residual traces should only be slight discoloration in the form of dots or streaks. If the above conditions cannot be guaranteed, coating application will easily result in peeling, cracking, chalking, and poor adhesion between the coating and the inner wall of the steel pipe, thus losing its anti-corrosion effect.

Coating preparation: GZ-12 solvent-free epoxy coating comes in two packages: coating and hardener. Before application, heat each package in a water bath to 60℃±5℃, then pour them into the two hoppers of the spraying truck, cover the hoppers, and attach an insulation layer to the outer wall of the hoppers to ensure that the temperature dissipates as slowly as possible.

Coating quality control: During coating, the relative humidity should not exceed 85%. Application is not recommended in rainy, snowy, or windy weather conditions. The finished coating has a uniform color, consistent thickness, and is free from obvious defects such as pores, cracks, and sagging. Dry film thickness measurement is performed according to SSPC PA2 or ISO2808 using an electronic thickness gauge.

Equipment maintenance:

During continuous operation, daily cleaning of the hopper is unnecessary. If operation is to resume after a few days, the hopper and copper pipes must be thoroughly cleaned with a thinner before storage. Upon completion of the project, if storage is required, the hopper and copper pipes must be thoroughly cleaned with a thinner, and the solution allowed to completely evaporate before storage.

During continuous operation, charging the lithium battery pack at night and using it normally during the day is the optimal battery pack maintenance method.

Upon completion of the project, if storage is required, the lithium battery pack must be fully charged before storage; otherwise, it will become depleted and fail. After storage, the lithium battery pack should be turned on every 10-15 days to prevent damage, and ideally, it should be recharged.

Before each operation, a thorough inspection of the machine is recommended to prevent loose or missing screws.

Equipment Storage: If the equipment is to be stored for an extended period, it is best to place it in its original packaging box.

Table 1 - Pump Speed and Discharge Rate Record Table

FJC-SL2025-001

Number	A coating - pump 1		B Curing Agent - Pump 2	
	Rotational speed（rpm）	Output（g）	Rotational speed（rpm）	Output（g）
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				

Appendix 2—PQT Process Evaluation Data Recording Table

FJC-SL2025-002

Number	Width （cm）	Asymmetric quantities (mm)	Wet film thickness measurement (μm)			
			up	down	left	right
1						
2						
3						
4						