

The Research and Development on CTJ10/96-6, the Strong Exhaust Driven by Air Pressure Sanitary Device of the Mine Rescue System

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ABSTRACT According to the technical specification requirements of the mine rescue system, CTJ10/96-6, we design a strong exhaust sanitary device driven by air pressure based on pneumatic control, which adopts a key control by mechanical button. It implements many functions, such as flushing and sealing the smell, measuring and strong exhaust by using mechanical and pneumatic transmission. It also meets the demand of design requirements for the safety and explosion-proof of the mine rescue system.

KEYWORDS

Rescue System
Strong Exhaust Driven
by Air Pressure
Sanitary Device
Research and
Development

1. Introduction:

CTJ10 / 96-6 Mine rescue system includes a refuge chamber, rescue cabin (car) etc.[1], which are escape and shelter equipments used in mines with a high-risk environment that are prone to fire, explosion and flooding. To ensure the survival needs of human personnel for a long duration, it is essential to have a safe and complete sanitary equipment that forms a complete set with the rescue system[2].

The types of sanitary equipment currently available in rescue systems, such as the vacuum suction type, mechanical packing type, electrically crushed cum forced discharge type, has faced problems such as high cost, high energy consumption, limited installation space, air pollution and also difficulty in waste discharge [3].

Our sanitary equipment design combined the surrounding requirements for its application and used a mechanical one key control for its pneumatic flush design, which achieved the function of explosion-proof,

water conserving pressurised flushing, is odourless, collects and measures waste, force discharge waste, and has features of low cost, easy operation and no electricity operation. It provides a reference for the series development of similar products [4].

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2. Overall structure and function

The overall principal structure was shown in Figure 1. It consists of a manual control mechanism, a waste collection cum discharge system and a pneumatic system.

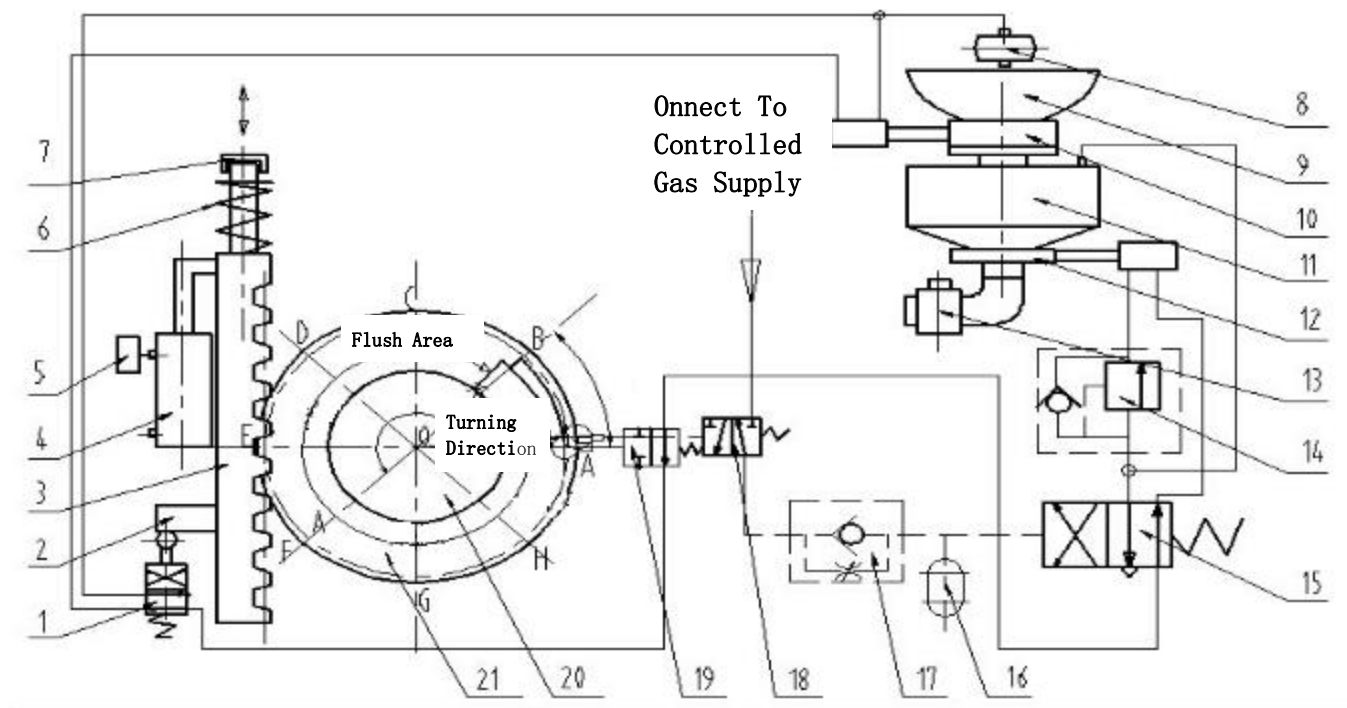


Figure 1 Overall structure diagram

1. Four port two position mechanical valve 2. Pressing plate 3. Driving rack 4. Damping cylinder 5. Control valve 6. Return spring 7. Operating handle 8. Water pressuriser 9. Potty 10. Upper air control valve 11. Waste collection tank 12. Lower air control valve 13. One-way stopping valve 14. One-way sequence valve 15. Four port two position directional air control valve 16. Gas container 17. One-way control valve 18. Three port

two position directional mechanical valve 19. Two port two position directional mechanical valve 20. Cam 21. Drive gear.

2.1 Work process description. The/Our sanitary equipment is divided into two work processes, flushing and waste discharge, which are shown specifically in Figure 2 .

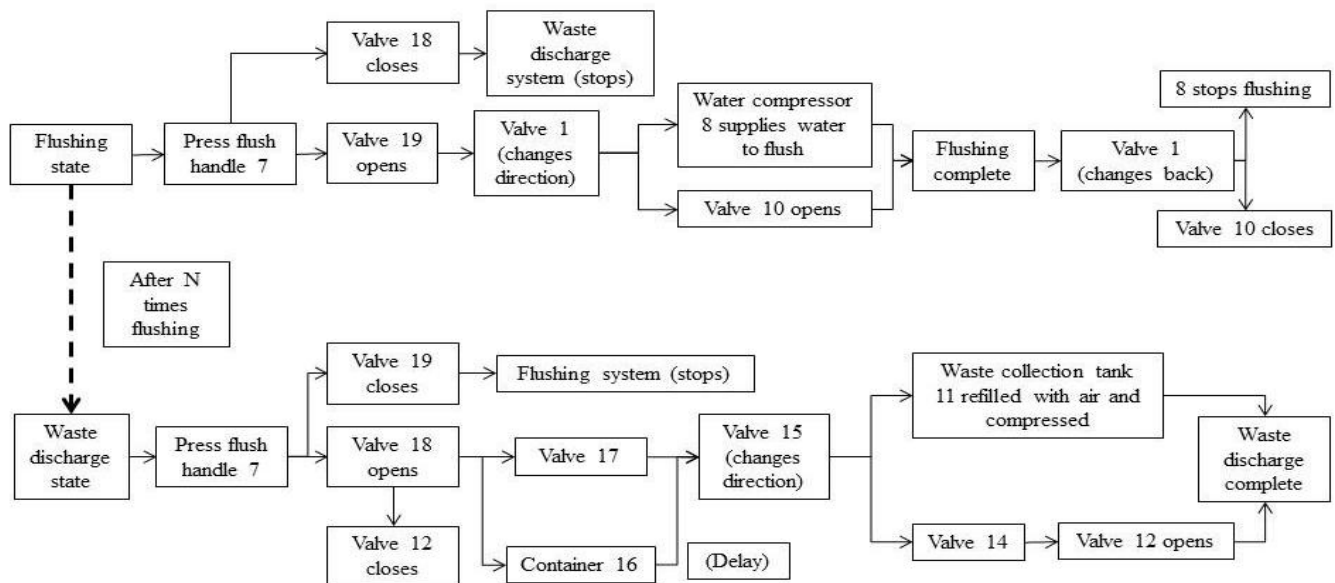


Figure 2 Work process block diagram

2.2 One-key manual control mechanism and function. As shown in Figure 3.

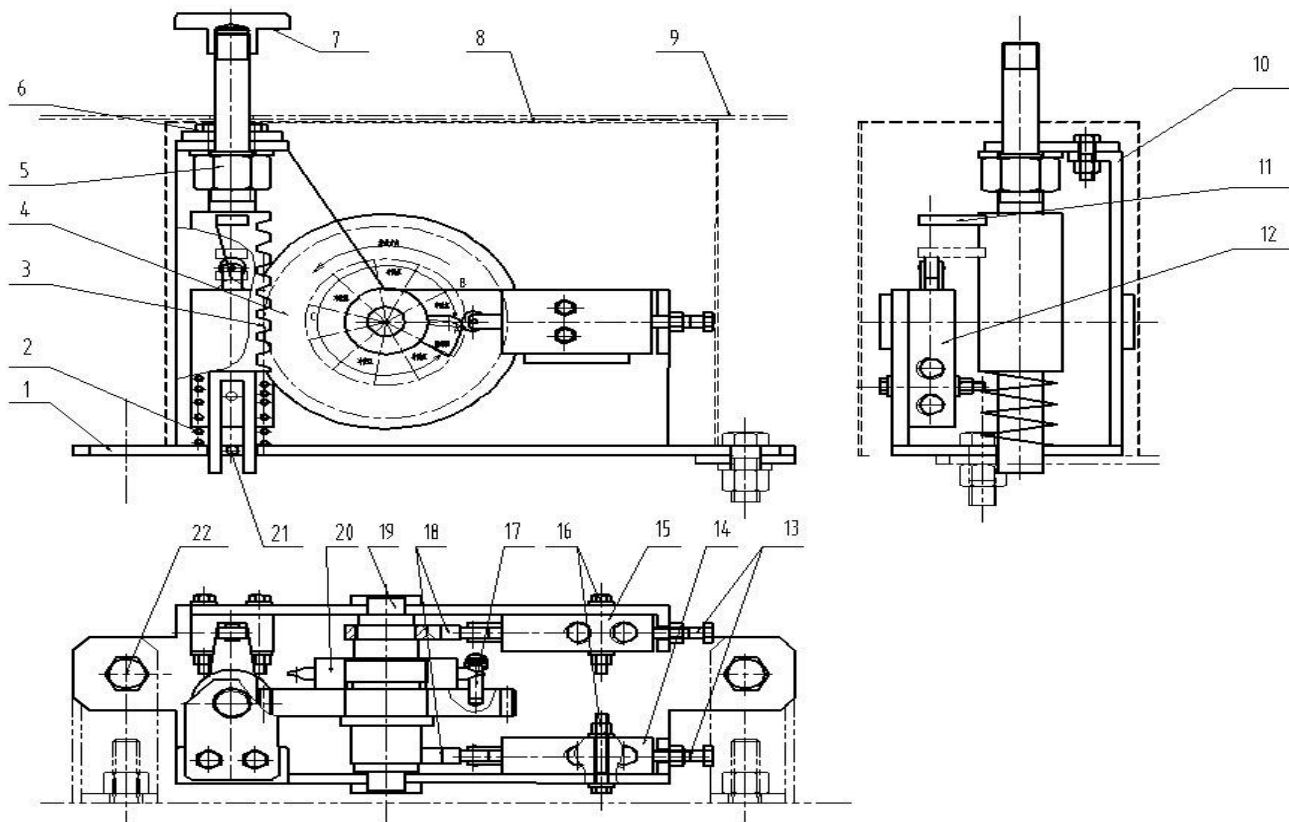


Figure 3 One-key manual control structural diagram

1. Mounting Plate 2. Return spring 3. Drive shaft (Rack) 4. Drive gear 5. Positioning nut 6. Locking nut 7. Operating handle 8. Control mechanism cover plate 9. Toilet cover 10. Support column 11. Pressing plate 12. Four port two position directional mechanical valve 13. Adjustment screw 14. Three port two position directional mechanical valve 15. Two port two position directional mechanical valve 16. Mounting nut 17. Pin 18. Cam 19. Main axle 20. Geared one-way clutch 21. Anti-rotation pin 22. Mounting bolt.

2.2.1 Implementation of flushing and waste discharge functions. When both cam 18 is in the flushing zone, press down handle 7, which drive shaft (rack) 3 will move down a certain distance, driving drive gear 4 to rotate at a fixed angle. At the same time, pressing plate 11 that is fixed to drive shaft (rack) 3 presses down valve 12, which supplies compressed air to the water pressuriser and the lower control valve to achieve the flushing action. When both cam 18 rotates to the waste discharge zone, under the control action of pneumatic components in the pneumatic system and the effects of gas pressure, the forced discharge of waste externally is achieved.

2.2.2 Implementation of count function. Drive gear 4 was installed on main axle 19, and pins 17 (two) were fixed on one end of the drive gear, and the other end

embedded in the tooth gear of the one-way clutch 20. Clutch 20 and cam 18 (two) are connected to the main axle. For every flush, the handle through the driving rack drives gear 4 counterclockwise by an angle, thus the clutch is in 'close/bite' state, and the pin toggles clutch 20 to drive cam 18 to rotate at the same angle. When flushing is completed, the handle rises back by the return spring 2, and the gear cum clutch rotates clockwise back to the initial position, at this time the clutch is in the 'open/release' state, while the main axle and the cam remain unchanged in place [5].

Through estimates of waste and flush water, and the volume of the waste collection tank being determined, set the drive gear to rotate by 45° for every flushing process. That is, for every seven times of flushing, the waste collection tank is emptied once.

In addition, positioning nut 5 and locking nut 6 combined can be used to adjust the travel distance of drive rack 3 to ensure valve 12 operates in place. Anti-rotation pin 21 connected to the through-groove of the lower end of the drive rack prevents rack rotation, and ensures the engagement of the drive rack and gear. Adjusting bolt 13 (two) is used to control the contact distance of the roller of valve 14 and 15 with cam 18 [6].

2.3 Pneumatic systems and functions

The pneumatic system diagram is shown below in Figure 4. The pneumatic system consists of a gas supply section, pressurised water production cum flushing water section, forced waste discharge and other section(s) [7].

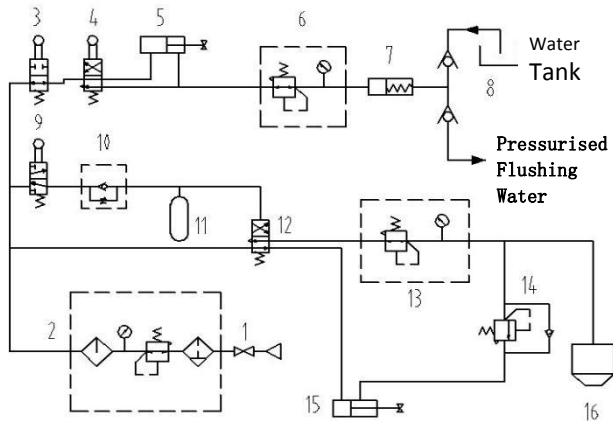


Figure 4 Pneumatic system schematic diagram

1. Stopping valve 2. Air supply assembly 3. Two port two position directional mechanical valve 4. Four port two position directional mechanical valve 5. Upper air control valve 6. Relief valve with pressure gauge 7. Water pressuriser 8. Check valve (water) 9. Three port two position directional mechanical valve 10. Throttle check valve 11. Gas container/tank 12. Four port two position directional air control valve 13. Relief valve with pressure gauge 14. One-way sequence valve 15. Lower air control valve 16. Waste collection tank

2.3.1 Gas supply section. The gas was supplied according to the usage requirement of equipment (Maximum personnel and survival time), after calculating the volume of their own compressed gas cylinder. After decompression, the air was passed through an air filter, relief valve and air lubricator for optimization, and is divided three ways into respective work sections [8].

2.3.2 Pneumatic flushing

When the operating handle is not pressed, the system is in a stationary state, waste collection tank 16, valve 5 and valve 15 are connected so that the waste tank remained sealed. When the button is pressed and the flushing action commences, only valve 4 activates. At the same time, compressed air drives valve 5 that are connected to the bottom of the potty and the waste

collection tank 16 to collect waste flushed from the potty; some compressed air also feeds the water pressuriser through valve 6. Under the action of compressed air, pressurised water from the water pressuriser completes the flushing through two check valves 8. After a flush, the handle is released and both valve 4 returns position, valve 5 closes to complete the sealing of the waste collection tank; while the water pressuriser under the action of the built-in spring returns to position and draws water by the combined action of two check valves 8 to prepare for the next flush. Valve 6 regulates the pressure of flushing water [9].

2.3.3 Forced discharge

Forced discharge was used in the rescue system in order to adapt to the special circumstances of flooding or high pressure gas explosion, while still able to empty the waste outside the waste collection tank. When the system is in force discharge mode, the button is pressed to change the direction of valve 3, 4 and 9. But, because of the mechanical valve 3 is in the OFF/STOP state, even though mechanical valve 4 is open, no compressed air is supplied and flushing is disabled. While valve 5 is closed for the waste collection tank to be pressurized. At the same time, mechanical valve 9 changes position, compressed air through throttle check valve 10 propels valve 12 to change direction. Gas tank 11 stores gas to prepare for valve 10 and 12 to delay disconnection of the airline [10].

(1) Implementation of forced discharge. After air control valve 12 changes direction, compressed air decompresses through relief valve 13, then channeled directly into waste collection tank 16 and through valve 14 into valve 15. Due to the role of sequence valve 14, compressed air first filled the sealed waste tank 16, and when the pressure rises to the set-pressure, valve 14 activates and valve 15 is opened for the waste inside the tank to discharge and shoot out through a check valve [11].

(2) Implementation of delay function. Since waste tank 16 will take some time to increase its pressure before valve 14 activates, while the combination buttons are in inching state in force discharge mode; by using throttle check valve 10, gas container 11 and activating valve 12 to form a delay in disconnecting the airline, we can guarantee that when the operating handle returns to position, the control valve 12 is still in the activated state, ensuring the implementation of forced discharge. When the pressure of compressed air and the volume of gas tank is constant, throttle check valve 10 can be adjusted to change the discharge time of forced discharge [12].

(3) Regulating the pressure of forced discharge. By adjusting the appropriate pressure for relief valve 13, we can obtain the required forced discharge pressure, and also regulates the opening speed of valve 15[13]. To get a higher forced discharge pressure, the overall structural strength and mounting strength of waste collection tank 16 needs to be improved [14]. The output pressure of gas supply assembly 2 is higher than the set value of relief valve 6 and 13 is to improve stability when delaying the disconnection of gas line, and to ensure the sealing performance of valve 5 and 15 when closed.

3.Conclusion

Since the sanitary device was installed in the mine rescue system, it has operated continuously for 96 hours in a closed transport operation with full personnel (10 person). Its gas consumption, water consumption, odour sealing, forced waste discharge and other functions are normal, and each technical indicator had met design requirements. The device was supported by Hunan Science and Technology Agency's science and technology project fund.

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