



# XZ320 Horizontal Directional Drill Operation Instruction

Xuzhou Construction Machinery Group Co.,Ltd

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## Preface

Thank you for selecting XZ320 horizontal directional drill produced by Xugong Road Construction Machinery Co., Ltd.

The machine can operate effectively with longer service life by accurate usage and maintenance. Please read and understand the manual especially safety notices and operate according to regulations before usage. Manual shall be placed with equipment together for reference at any time.

The manual includes structure, performance, operation, lubrication, maintenance, storage and transportation. Please refer to attached instructions for usage instructions and maintenance of engine, hydraulic pump, motor, speed reducer and guide detector, etc.



Warning! Reconfiguration may cause dangers without manufacturer's permit before usage. Please consult to manufacturer or designated dealer before reconfiguration or manufacturer has no responsibility for any consequence caused by impermissible reconfiguration.

Note: XZ320 horizontal directional drills have gained many patent licenses issued by the State Intellectual Property Office (SIPO) (with ZL patent No.: 031428282, 02288040.2, 02283784.1 and 02288046.1). Anybody who counterfeits it will be prosecuted for his legal responsibility.

We may modify description and technical specification of the manual at any time. We have rights to improve and create the equipment. Please contact Xugong Road Machinery Co., Ltd, dealer or log on [WWW.XCMGJC.COM](http://WWW.XCMGJC.COM) to query relational information if you want to know the latest information.

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## I. Introduction

XZ320 horizontal directional drills (hereinafter referred to as drills) are a kind of construction machine to set various underground utilities without excavating the earth's surface. They are widely used to set pipes which pass across highways, railways, buildings, rivers, downtown areas, historic districts, crop and vegetation protection zones which are difficult to excavate as well as water supply, coal gas, power supply, telecommunication, natural gas and petroleum pipes. Drill bit plates and re-expanding holes with different models shall be selected according to pipe diameter. They have characteristics such as compact structure, high rotation speed of power heads, large torque and push-pull effort, quick driving speed, flexible operation, quick construction speed, low comprehensive expense and high economic and social benefits.

### 1. Designation:



### 2. Applicable scope

It is suitable for sandy soil, clay and pebbles, etc. Most of non-hard rocky zones in China can be constructed and the ambient temperature is between  $-10^{\circ}\text{C}$  and  $+45^{\circ}\text{C}$ .

### 3. Product characteristics

#### 3.1 Reliable power

Total power is 140kW for water-cooled vortex pressurized engine with 6 cylinders. It can provide torque of 12,000N·m and pull-back force of 320kN (which can reach 400kN if driven by oil cylinder).

#### 3.2 Large-flow mud

Mud pump can provide mud with sufficient flow during synchronous pushing, pulling or back rotation during drill operation.

#### 3.3 High rotation speed of power head

Main axle of power head can drill with high speed to increase operating efficiency when drilling and towing auger stem. Power head also can rotate with high speed to increase operating efficiency when drilling pivot holes and small-diameter holes.

#### 3.4 Floating strong auger stem holder

The most advanced jaw vice and double-floating-gear of power head in the world shall be selected and specific patent technique, namely, floating strong auger stem holder shall be adopted when assembling drilling stems. It has large shackle torque, quick and reliable holding and simple maintenance. Double-floating-gear can be adopted to reduce thread abrasion in 2 ends of auger stem effectively and prolong service life of auger stem so as to reduce construction cost as well as rupture risk of auger stem.

### 3.5 Rubber crawler

Hydraulic rubber crawler has the minimum damage to side pavement, lawn and beauty spots.

### 3.6 (Optional) hydraulic anchor devices

Hydraulic drive with high efficiency can be selected to position drills quickly, reliably and stably.

### 3.7 (Optional) auxiliary loading/unloading device of auger stem

Auxiliary loading/unloading device of auger stem can be selected to reduce operator's effort.

### 3.8 Hydraulic power assisting device

Hydraulic power assisting device shall be provided for complex stratum with jamming of a drilling tool. The maximum back-pull force can reach 40kN to reduce construction risks effectively.

## II. Structure, Properties and Main Parameters

1. Please refer to Figure 1 for outline dimension of drills.

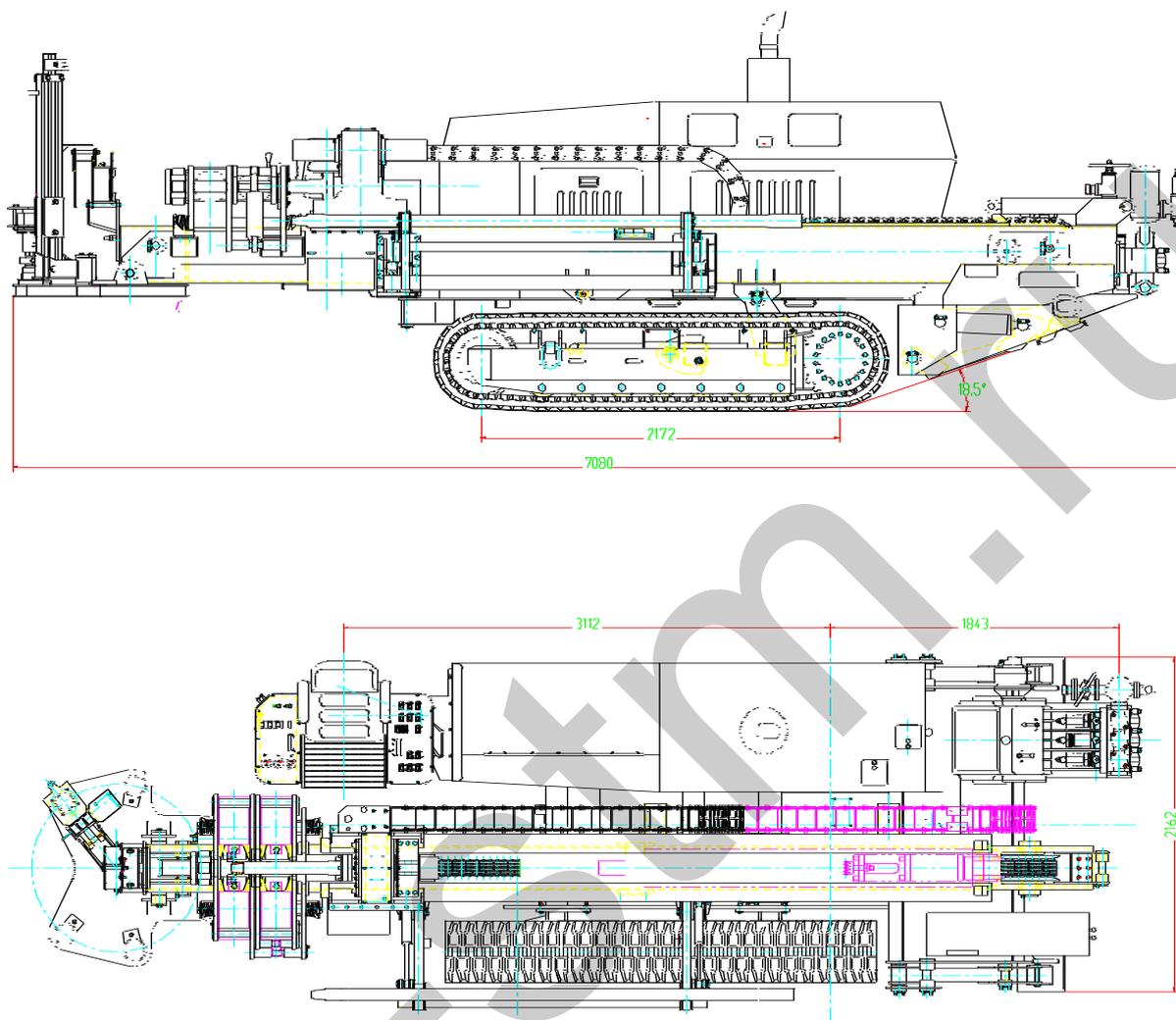


Figure 1 Outline drawing of drill

2. Please refer to Table 1 for main performance and parameters.

Table 1

Item	Unit	Parameter	
The maximum back-tow/feeding force	kN	320(400)/200	
The maximum operating speed of power head	m/min	20	
The maximum torque of power head	N·m	12000	
Rotation speed of power head	r/min	0~140	
Bore diameter	mm	Φ127	
The maximum diameter of re-expanding hole	mm	Φ800	
Length of (single) auger stem	m	3	
Diameter of auger stem	mm	Φ73	
(Extreme) bending radius of auger stem	m	65	
The maximum mud flow	L/min	320	
The maximum mud pressure	MPa	8	
Engine model		D6114ZG	
Rated power	kW/r/min	140/2300	
Driving speed	km/h	3	
The maximum climbing gradient	%	30	
Machine weight	kg	10500	
Outline dimension (under transportation status)	Length	mm	7100
	Width	mm	2250
	Height	mm	2450

### III. Operating principle and structure

#### 1. Operating principle

XZ320 horizontal directional drills mainly consist of upper directional drill part and lower traveling part. Engine of lower part drives oil pump to provide power to motor then drive driving wheel by driving speed reducer to realize rotation and brake functions of chassis.

Drilling: Drilling inclination shall be adjusted firstly and the machine shall be

fixed by anchor device. The probe shall be installed into the drill bit to connect drill bit body, auger stem and power head for drilling. Mud pump also shall pump mud during synchronous drilling for soil cutting and heat dissipation of protective wall and drill bit during drilling or back towing. Position of drill bit shall be measured by receiving signals issued by probe in the wireless probe through earth's surface receiver. Power head shall stop rotation and adjust inclined drill bit plate toward required direction if necessary. Ground receiver will monitor feeding direction when pushing power head without rotation. Drilling shall be continued after defining accurate direction. Direction can be adjusted for many times during drilling until ending.

Pipe layout: Different re-expanding hole drill bits shall be used after drilling according to pipe diameter and category for once or multiple back drilling to reach required aperture. Power divider can be connected to set pipe during the final back drilling and towing until all pipes are positioned. Mud shall be supplied during the entire process.

## **2. Main structure**

XZ320 horizontal directional drill is an integral drilling device. It mainly consists of chassis, power head, drilling rig, engine system, semi-automatic access assembly of auger stem, jaw vice, anchor device, drilling tool, hydraulic system, electric system and mud system, etc.

### **2.1 Chassis**

Chassis mainly consists of automatic chassis, left and right driving devices. Hydraulic leg is supplied in the rear of automatic chassis.

Driving device consists of crawler tension device, rubber crawler, drive wheel, guide wheel, supporting wheel and driving speed reducer, etc. Embedded planetary reducer (including motor) shall be provided for driving speed reducer.

Crawler tension device consists of tension oil cylinder, guide wheel and oil cup, etc. It is used to maintain certain tensivity of crawler by adopting lubricating grease.

### **2.2 Engine system**

As power source of the entire system, engine system includes engine, water heat dissipater, air filter and muffler, etc. D6114 pressurized water-cooled engine of Shanghai Diesel Engine Co., Ltd shall be selected and its rated power is 140kW/2300r/min.

### **2.3 Power head**

As a main operating mechanism of machine, output axle of power head

shall be driven by hydraulic motor. Drill bit shall be mainly driven for revolution, drilling and back towing and hollow hole of drill collar is the mud channel to enter into auger stem.

## **2.4 Drilling rig**

As a sliding & supporting device of power head, drilling rig shall slide on the guide rail by push-pull mechanism of oil cylinder to bear push-pull and rotation torque of the entire machine.

## **2.5 (Optional) auxiliary loading/unloading device of auger stem**

Auxiliary loading/unloading device of auger stem shall be used to lighten operator's intensity and accelerate construction schedule.

## **2.6 Strong auger stem holder**

It includes upper and lower jaw vices and it is in the previous part of sliding support. Upper jaw vice has clamping and rotation motions. Upper and lower jaw vice will coordinate with motion of power head to screw down or loosen threads of auger stem. Special buffer device of our company shall be used to reduce thread abrasion and prolong service life of auger stem.

## **2.7 (Optional) anchor devices**

Ground anchor is used for anchorage of the entire machine. It is located in the front end to increase stability. It shall be pressurized by oil cylinder for drilling in/out of anchor rod driven by low-speed and large-torque motor.

## **2.8 Vehicle-mounted mud system**

Large-flow mud pump of 320L/min shall be adopted for vehicle-mounted mud system. Horizontal reciprocating single-effect piston pump with 3 cylinders shall be used as mud pump which is driven by hydraulic motor to provide pressure mud for drill.

## **2.9 Electric system**

Electric system of horizontal direction drill mainly consists of engine monitoring, mud pump control, jaw vice control, high-speed driving control and high-speed push-pull control of power head, etc.

### **2.9.1 Engine part and lamp alarm:**

DC 24V single-line power shall be adopted for the machine with negative electrode ground system. Power shall be generated by 2 series storage batteries of 12V and power generator. Storage battery shall supply power during vehicle startup and power generator shall supply DC 24V to the machine power utilization system and charge storage battery at the same time after operation.

**·Water temperature gauge**

Water temperature gauge of engine is used to display temperature of cooling liquid of engine. Water temperature alarm switch is off and indicator lamp is on when water temperature is higher than setting value and shutdown is required for inspection.

**·Oil pressure gauge**

Oil pressure gauge is used to display pressure of power generator oil. Oil pressure alarm switch is closed and indicator lamp is on when oil pressure is less than setting value and shutdown is required for inspection. (Indicator lamp will be on if power generator stops operation.)

**·Fuel oil gauge**

Fuel oil level indication of engine: Oil shall be added in a timely manner if fuel oil level is super-low.

**·Hourly rotation speed list**

To record operating hours and current rotation speed of power generator.

**·Voltmeter**

The list is to measure voltage of electric system.

**·Jamming alarm of hydraulic filter**

Indicator lamp is on to indicate that oil filter shall be cleaned due to jamming.

**2.8.2 Mud pump control**

Mud pump switch is used to control mud pump and mud pressure can be displayed by mud pressure gauge. Mud pressure variation shall be monitored carefully during operation. Check if mud channel is jammed or not if mud pressure is high and operation speed of piston reduces.

**2.8.3 Jaw vice control****·Rotation switch of post-jaw vice**

The switch is used for clockwise or counter-clockwise rotation of post wrench.

**·Clamp switch of post jaw vice**

The switch is used to control clamp of post jaw vice.

**·Clamp switch of front jaw vice**

The switch is used to control clamp of front jaw vice.

**2.8.4 Double-speed control of power head**

Push-pull speed of power head is controlled by one switch. Push-pull speed of power head will be doubled by pressing high-speed push-pull switch of power head and normal speed will be restored by loosening the switch. High-speed push-pull can be adopted to save auxiliary period during drilling or back towing if main axle is not connected to auger stem. (Mud pump will stop operation automatically when using high-speed push-pull function.)

High-speed rotation of power head shall be controlled by manual valve on power head box. Manipulation rods of the valve shall be placed in different positions to guarantee different rotation speed of power head. (Please do not use high-speed rotation function of power head during large-aperture construction.)

**2.9 Principle of hydraulic system is shown in Figure 2.**

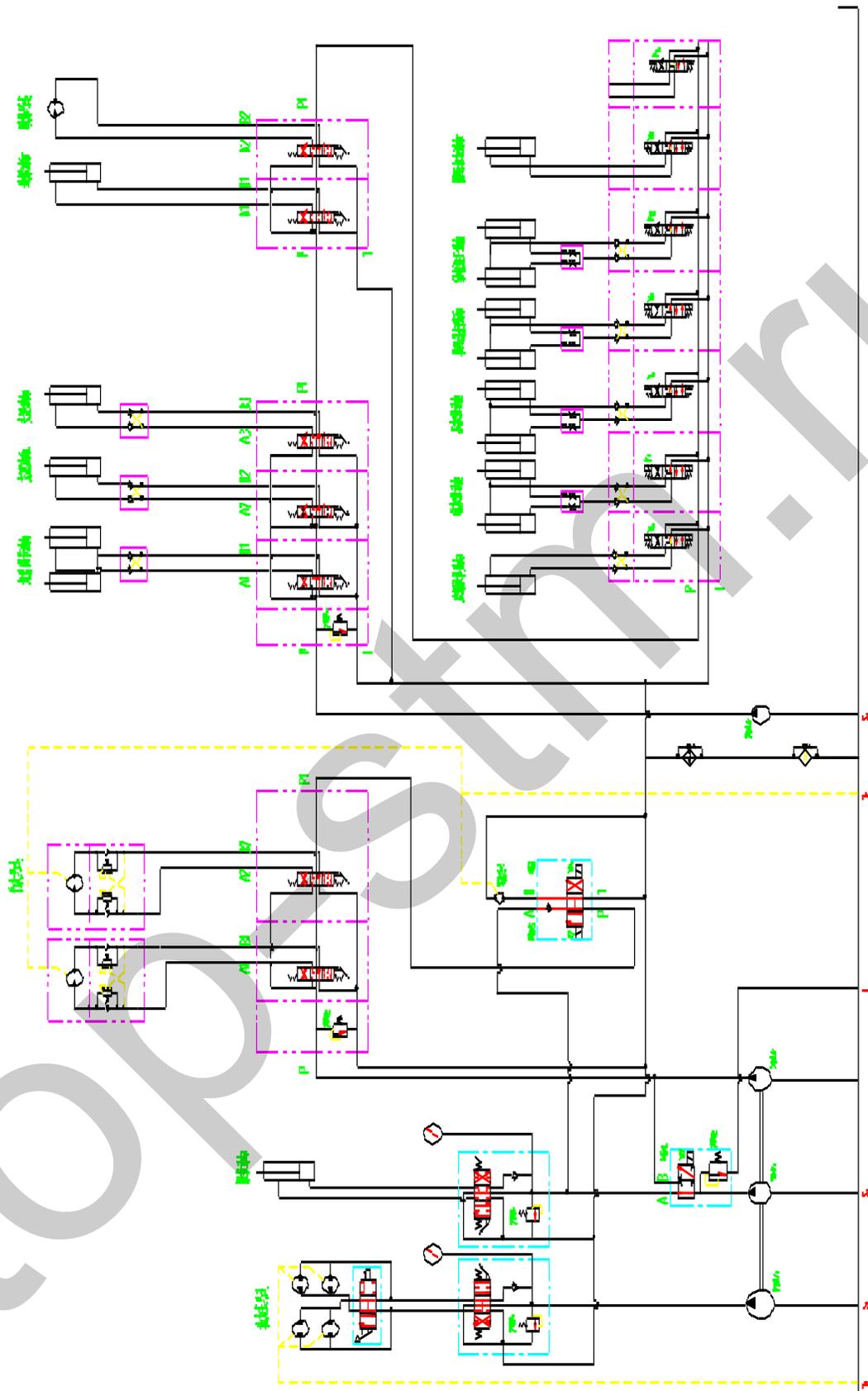


Figure 2 Principle diagram of hydraulic system

2.9 Principle of electric system shown in Figure 3

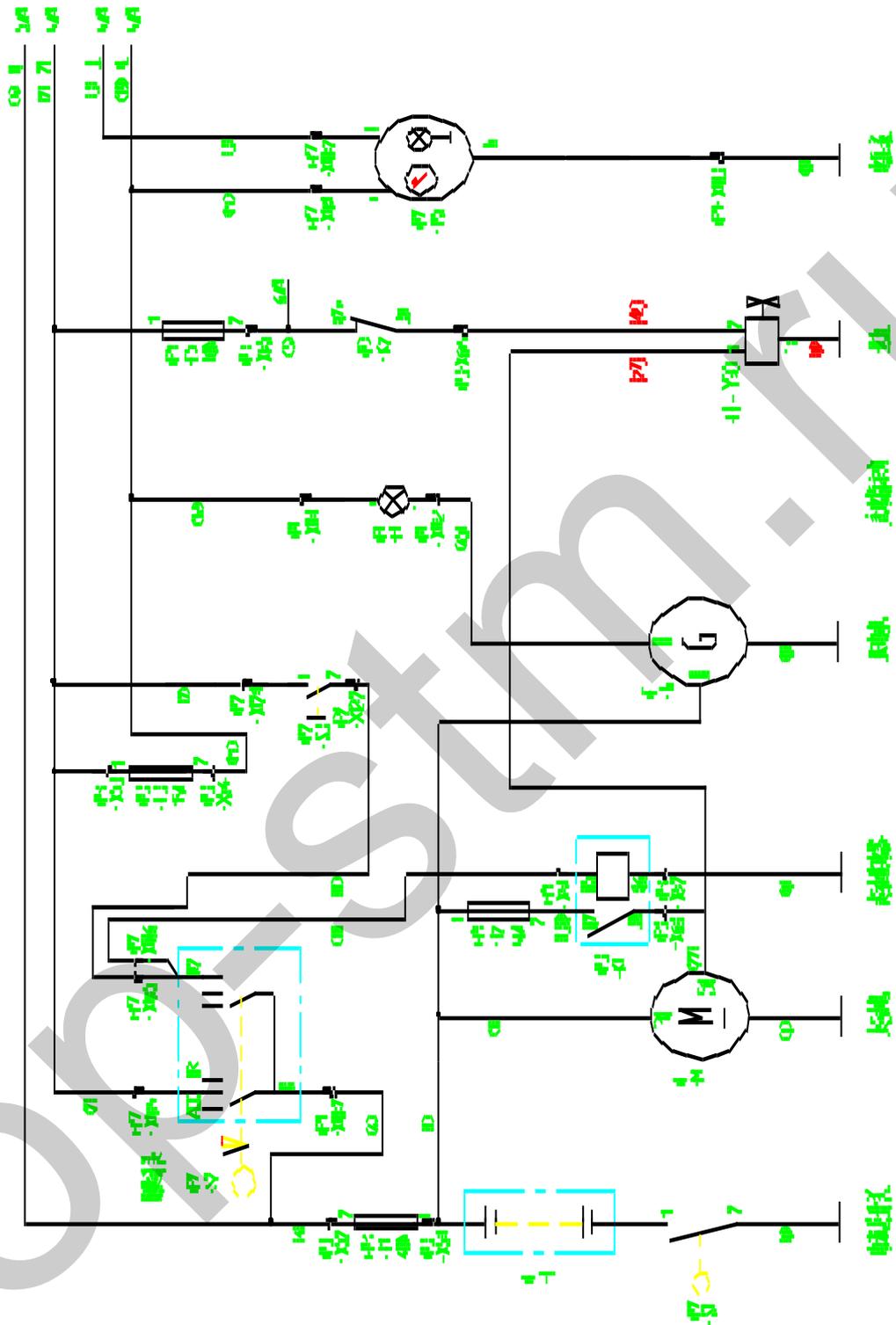


Figure 3 The 1<sup>st</sup> schematic diagram of electric system

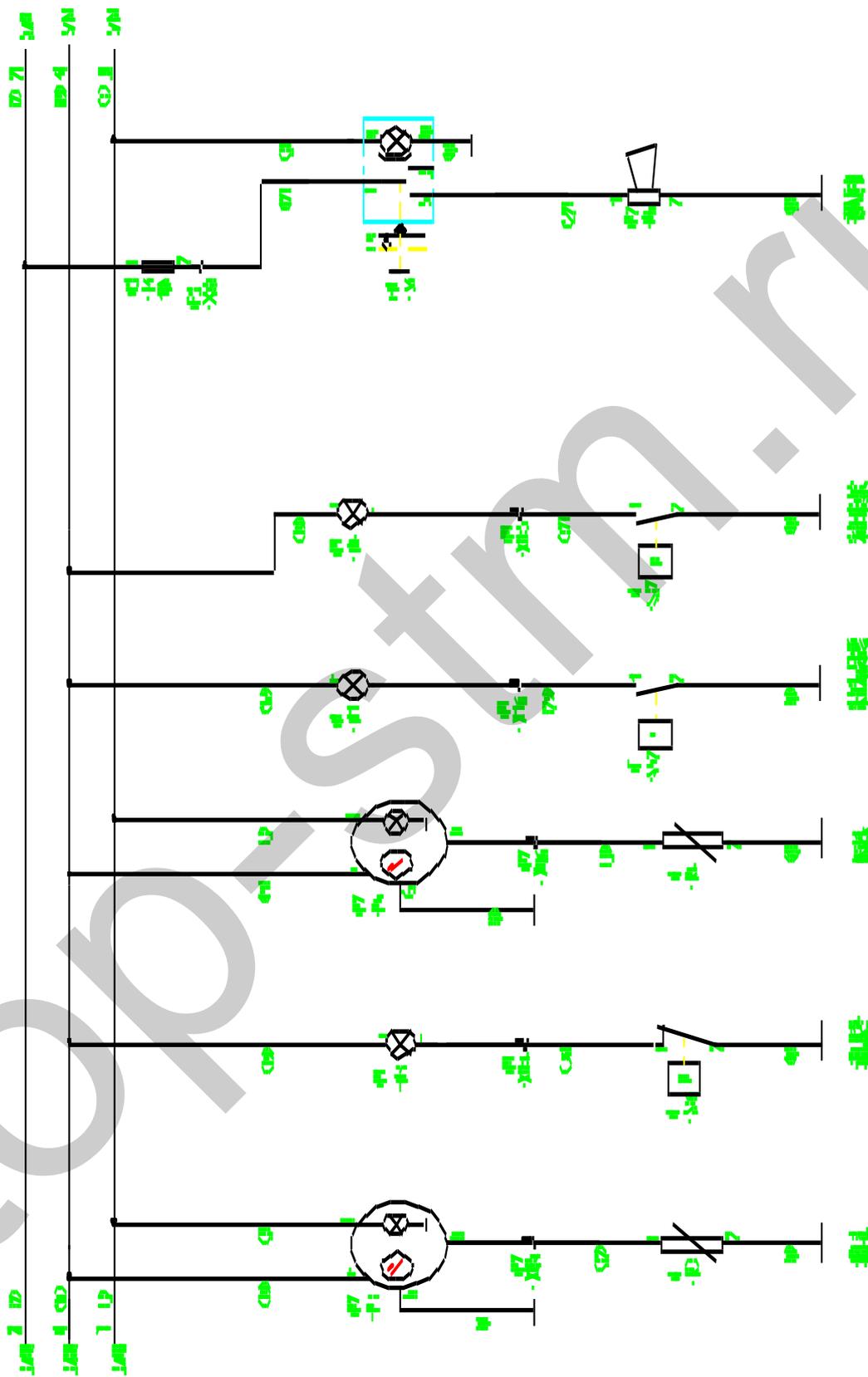


Figure 3 The 2<sup>nd</sup> schematic diagram of electric system

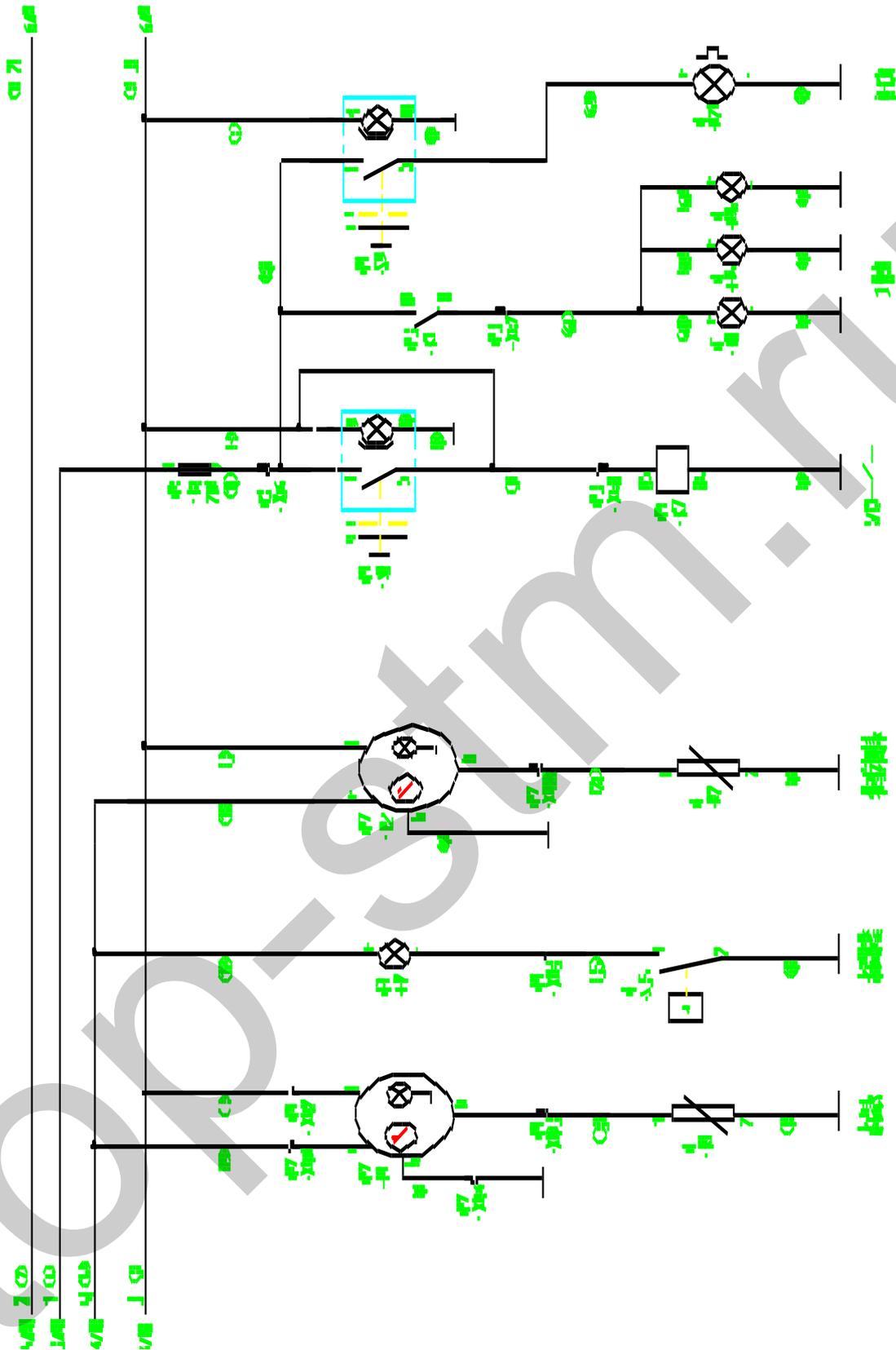


Figure 3 The 3<sup>rd</sup> schematic diagram of electric system

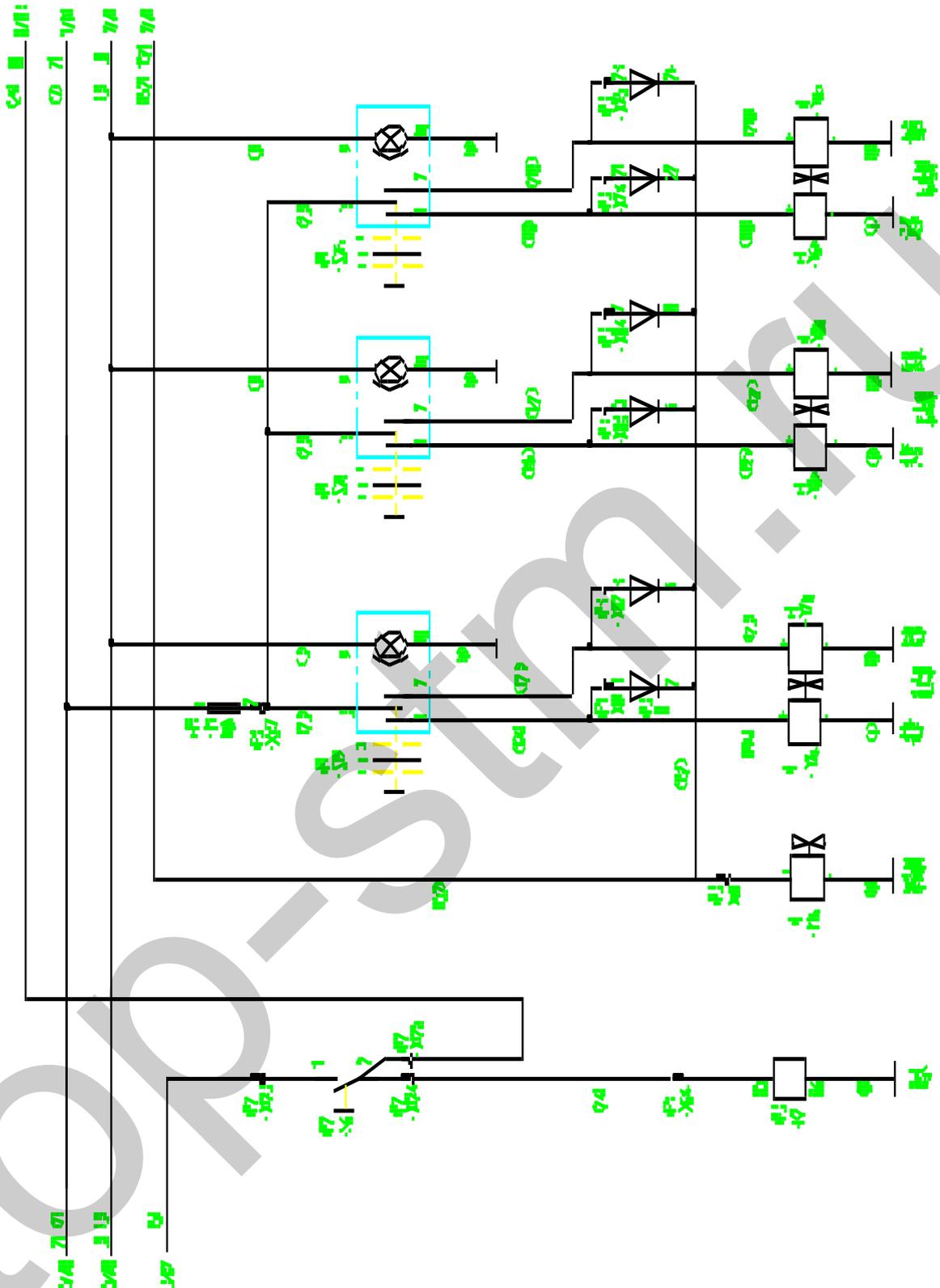


Figure 3 The 4<sup>th</sup> schematic diagram of electric system

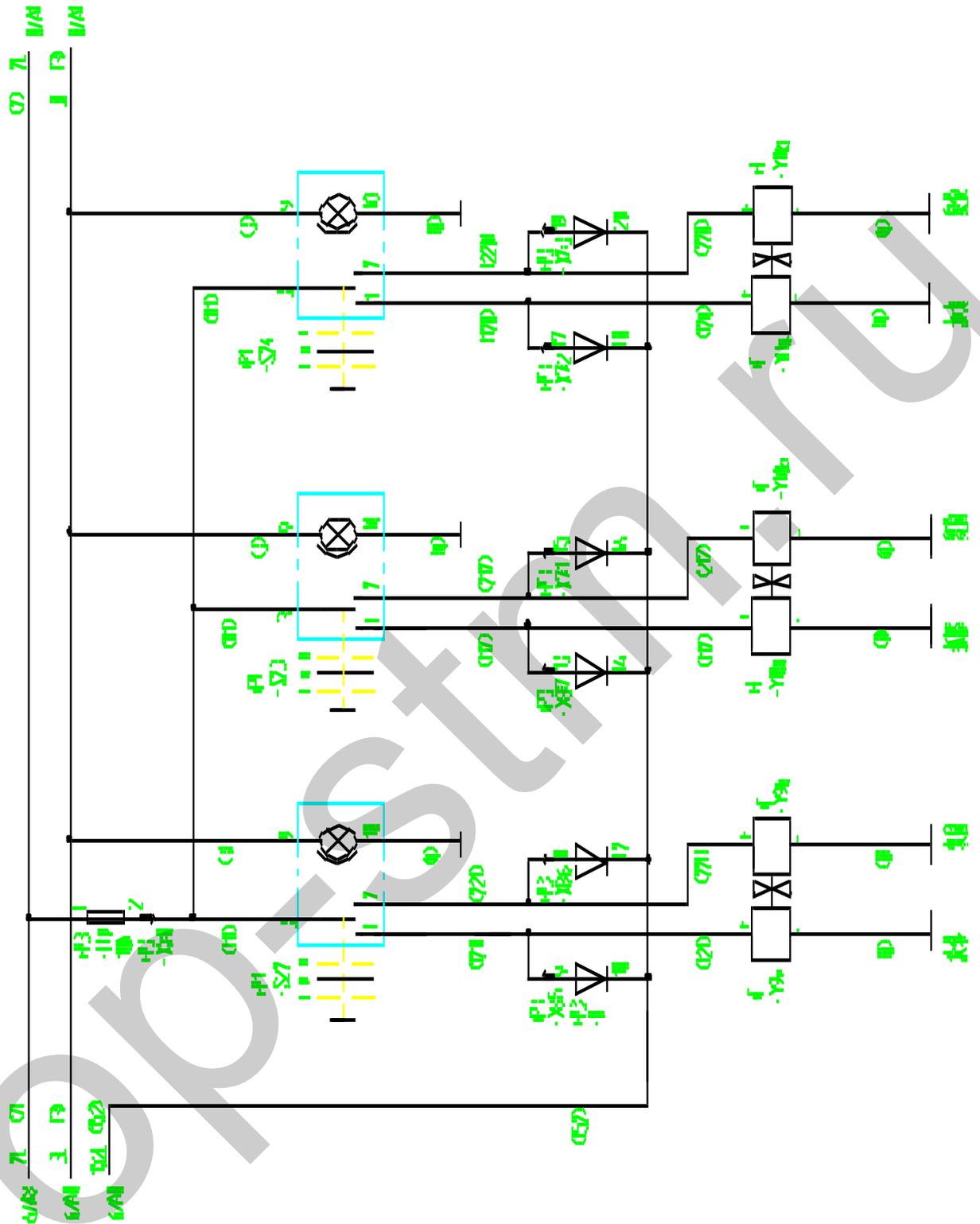


Figure 3 The 5<sup>th</sup> schematic diagram of electric system

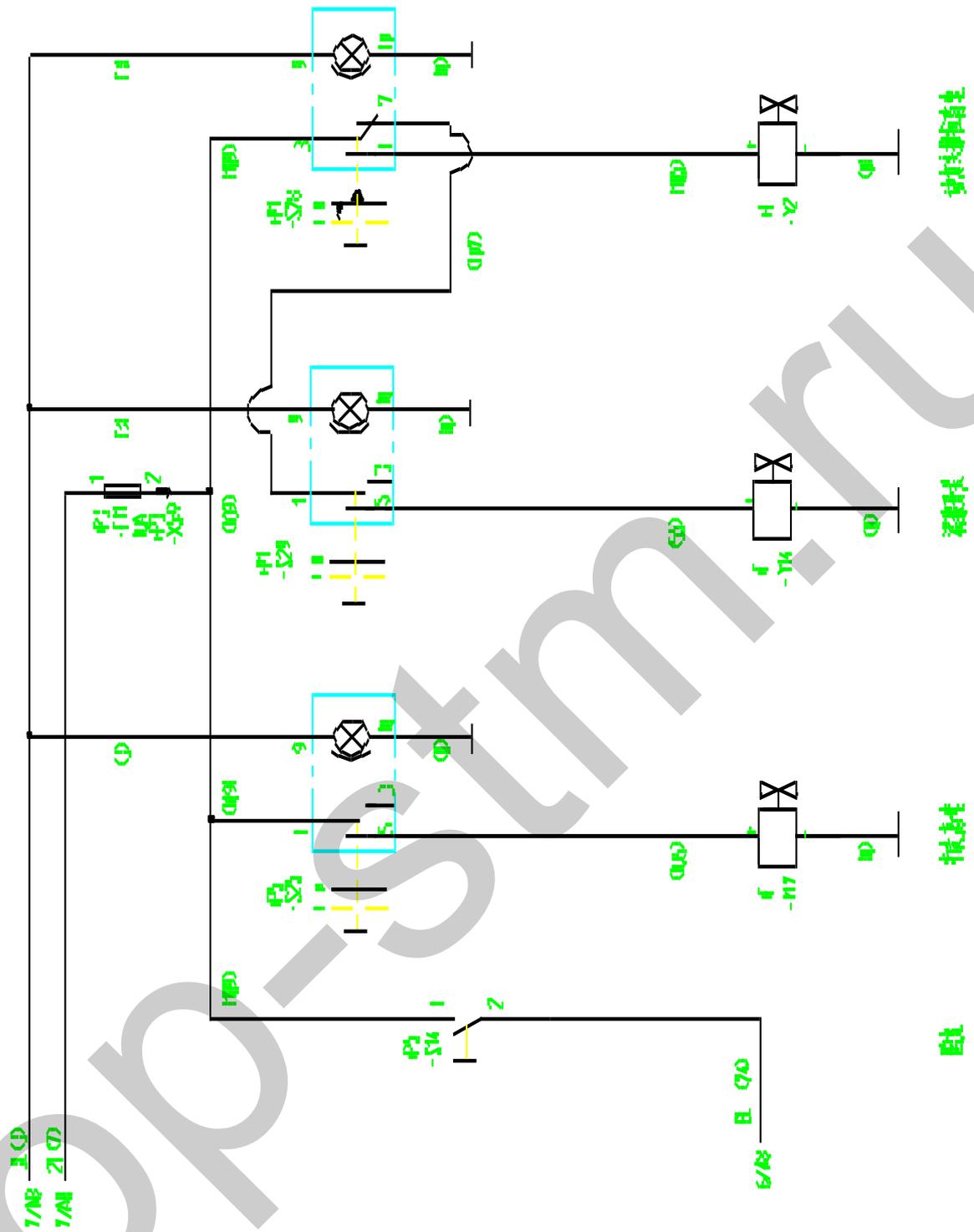


Figure 3 The 6<sup>th</sup> schematic diagram of electric system

## IV. Safety Requirements

Severe casualty may be caused if not abiding by danger, warning or Attention shown in the manual and safety label of drills.

**Danger:** Death or severe injury may be caused due to direct dangers if not abiding by danger, warning or note shown in the manual and safety label of drills.

**Warning:** Death or severe injury may be caused due to potential dangers if not abiding by danger, warning or note shown in the manual and safety label of drills.

**Attention:** Slight or medium injury may be caused due to potential dangers if not abiding by danger, warning or note shown in the manual and safety label of drills.



**Warning:** Please read and master the manual before startup to operate equipment according to regulations. The manual shall be placed in convenient locations with timely supplementation or replacement if it is lost, damaged or difficult to read.

### 1 Please read following content carefully on the construction site before operating the equipment:

1.1 Only trained operators with rich experience can operate the drill. Be sure to read the manual and accept operation training before operation.

1.2 Please contact local utility pipe company before construction for assistance with position detection and mark of original underground pipes and cables along the route. Please contact relevant departments in a timely manner if pipes are damaged during construction.

1.3 Construction site shall be divided according to underground dangerous articles to select suitable tools, equipment, safety facilities and construction methods.

1.4 Construction scope shall be marked obviously and irrelevant persons can not enter into it within construction scope.

1.5 Construction staff shall wear suitable safety protection clothes such as rubber insulation gloves and shoes, etc.

1.6 Inspect underground dangerous articles, safety situations and emergency measures carefully before formal bootstrap. Responsibility of every worker also shall be defined definitely.

1.7 Equipment shall be operated carefully with instant shutdown for inspection under abnormal conditions.

1.8 Confirm all pipes are connected reliably to avoid severe casualty

caused by leakage of hydraulic oil, drilling liquid and washing system with high pressure.

1.9 Be sure not to operate the machine in locations with combustible gas or dangers may be caused.

1.10 Please contact local dealer if there is any doubt for equipment operation, maintenance and usage.

## **2 User's facilities**

### **2.1 Fire extinguisher**

Be sure that fire extinguisher can extinguish fire caused by oil or power.

### **2.2 Lighting lamp**

Other lighting lamps shall be provided if necessary.

## **3 Classification of underground dangerous articles**

3.1 Power wire

3.2 Natural gas pipe

3.3 Optic fiber cable

3.4 Water pipe

3.5 Blow-off pipe

3.6 Pipes to convey other chemicals, liquid or gas

## **4 Electric shock knowledge**

4.1 Current will be conveyed to underground by various ways besides channel of the minimum resistance.

4.2 Current also can be conveyed to equipment by cables of auger stem, hose and machine.

4.3 Casualty or death may be caused by low-voltage current.

4.4 Electric shock shall be assumed under following circumstances:

4.4.1 Power failure

4.4.2 Smoking

4.4.3 Explosion

4.4.4 Crack noise

4.4.5 Electric arc

## **5 Operation during electric shock:**

5.1 Remain on our respective positions on the drill or grounding cushion.

5.2 Anybody is strictly prohibited to contact or access drill.

5.3 Contact relevant power departments instantly.

5.4 Do not touch auger stem and drill body by hand or tool.

5.5 Drill operator can not leave the machine until power department confirms power cutoff and safety of work zone.

5.6 Re-drilling or entry into the site is not allowed without permission of power department.

## 6 Operation when fuel gas pipes are broken by drilling:

6.1 Close the engine and eliminate various fire sources instantly.

6.2 Leave the construction site as soon as possible.

6.3 Alarm other persons that fuel gas pipes are broken by drilling so that they can leave the site as soon as possible.

6.4 Contact local utility pipeline departments.

6.5 It is not allowed to enter into the site randomly without permission of utility pipeline departments.

## 7 Operation when optic fiber cables are broken by drilling:

7.1 Close the drill and contact local utility pipeline department instantly.

7.2 Do not look broken ends of optic fibers or unknown cables directly into our eyes to avoid impairment of vision.

## 8 Operation when tap water pipes are broken by drilling:

8.1 Close the drill and contact local utility pipeline department instantly.

8.2 Anybody is strictly prohibited to access the dangerous zone.

## 9 Division and precaution measures of construction site

9.1 Please refer to Table 2 for category division according to existing underground dangerous articles.

Table 2 Division List of Construction Site

Construction zone	Category
Within scope of 3m away from power wire	Power
Within scope of 3m away from natural gas pipes	Natural gas
Within scope of 3m away from other dangerous articles	Others

## 9.2 Detail precaution measures of various kinds of construction sites

### 9.2.1 Detail precaution measures of power site

#### **Take one or all methods as follows:**

9.2.1.1 Electric wires shall be exposed by manual excavation.

9.2.1.2 Power failure during construction: Power department shall inspect power wires before restoring power supply.

### 9.2.2 precaution measures of natural gas site

9.2.2.1 Drill shall be installed toward upwind direction of natural gas pipes.

9.2.2.2 Electric wires shall be exposed by manual excavation and bore track shall be traced by probe carefully.

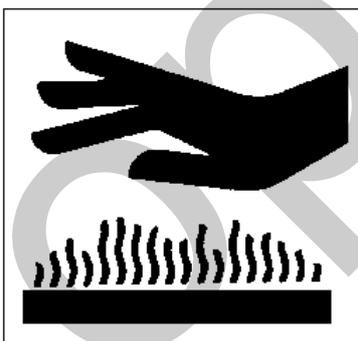
9.2.2.3 Gas supply cutoff during construction: Fuel gas department shall inspect pipes before restoring gas supply.

### 9.2.3 Other site protection measures

Different methods may be used to prevent us from other underground dangerous articles. Please contact responsible person of dangerous articles to define protection measures.

## 9.3 Safety warning classification

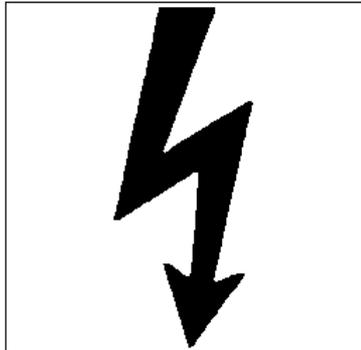
Such illustrations are used to prompt danger to you, surrounding persons and equipment. Please read such warnings or illustrations carefully with strict execution.



Do not touch it before cooling.



Keep far away from it due to possible severe winding and injury.



Keep far away from it due to possible casualty even death by touching electrified body.



Keep far away from it due to possible severe casualty caused by movable parts.



Use suitable process, procedure and facility or keep far away from it due to possible casualty even death caused by **protrusion**.

## V. Usage and operation

### 1 Functional instructions of switch, handle or instrument

1.1 Please refer to Figure 4 for operation panel of left console and Table 2 for detailed functions.

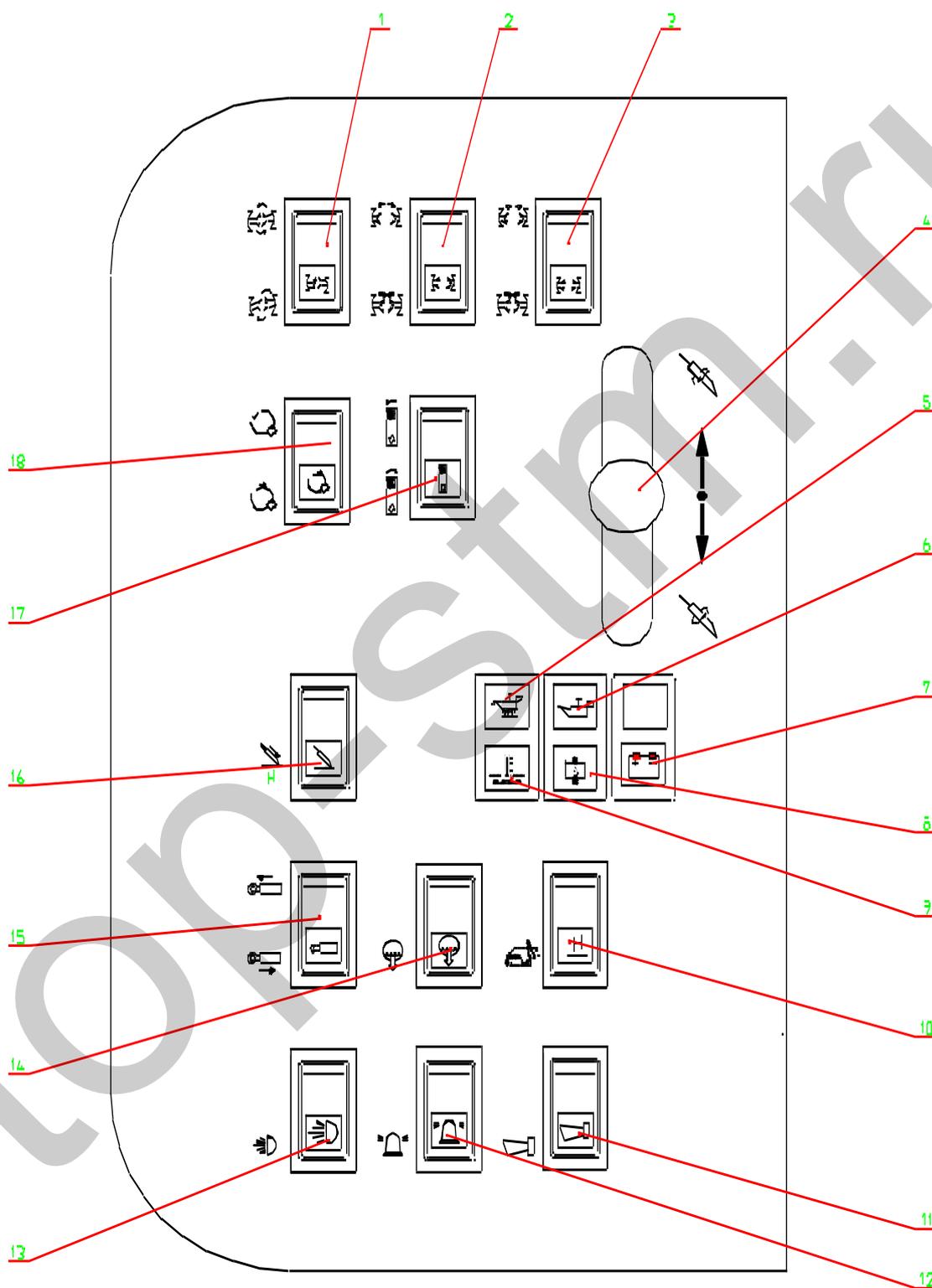


Figure 4 Operation panel of left console

Table 2 Left console switch

No.	Name	Function
1	Front jaw vice switch	To control clamping or loosening of front jaw vice
2	Post jaw vice switch	To control clamping or loosening of post jaw vice
3	Rotation switch of jaw switch	Used for rotation control of post jaw vice
4	Rotation handle	To control rotation of power head
5	Jamming alarm of hydraulic oil filter	Filter core of hydraulic oil filter shall be replaced if indicator lamp is on.
6	Machine oil warning lamp of engine	Machine oil shall be added if indicator lamp is on.
7	Charging indicator lamp of engine	Power generator shall supply power to battery if indicator lamp is off.
8	Hydraulic oil temperature alarm	Temperature of hydraulic oil is super-high if indicator lamp is on.
9	Water temperature alarm of engine	Cooling liquid temperature of engine is super-high if indicator lamp is on.
10	High-speed driving switch	Driving speed of drill will be doubled by pressing the switch.
11	Loudspeaker switch	To control operation and shutdown of loudspeaker
12	Rotation lamp switch	To control opening/closing of rotation lamp
13	Working lamp switch	To control opening/closing of working lamp
14	Mud pump switch	To control opening/closing of mud pump
15	Back tow switch with auxiliary power assistance	To control protrusion/shrinkage of oil cylinder with auxiliary power assistance
16	High-speed push-pull switch	Operation speed of power head will be doubled.
17	Lifting switch of auger stem	(Optional function) to control ascending/descending of auger stem
18	Tongs switch	(Optional function) to control opening/closing of tongs

1.2 Please refer to Figure 5 for operation panel of right console and Table 3 for detailed functions.

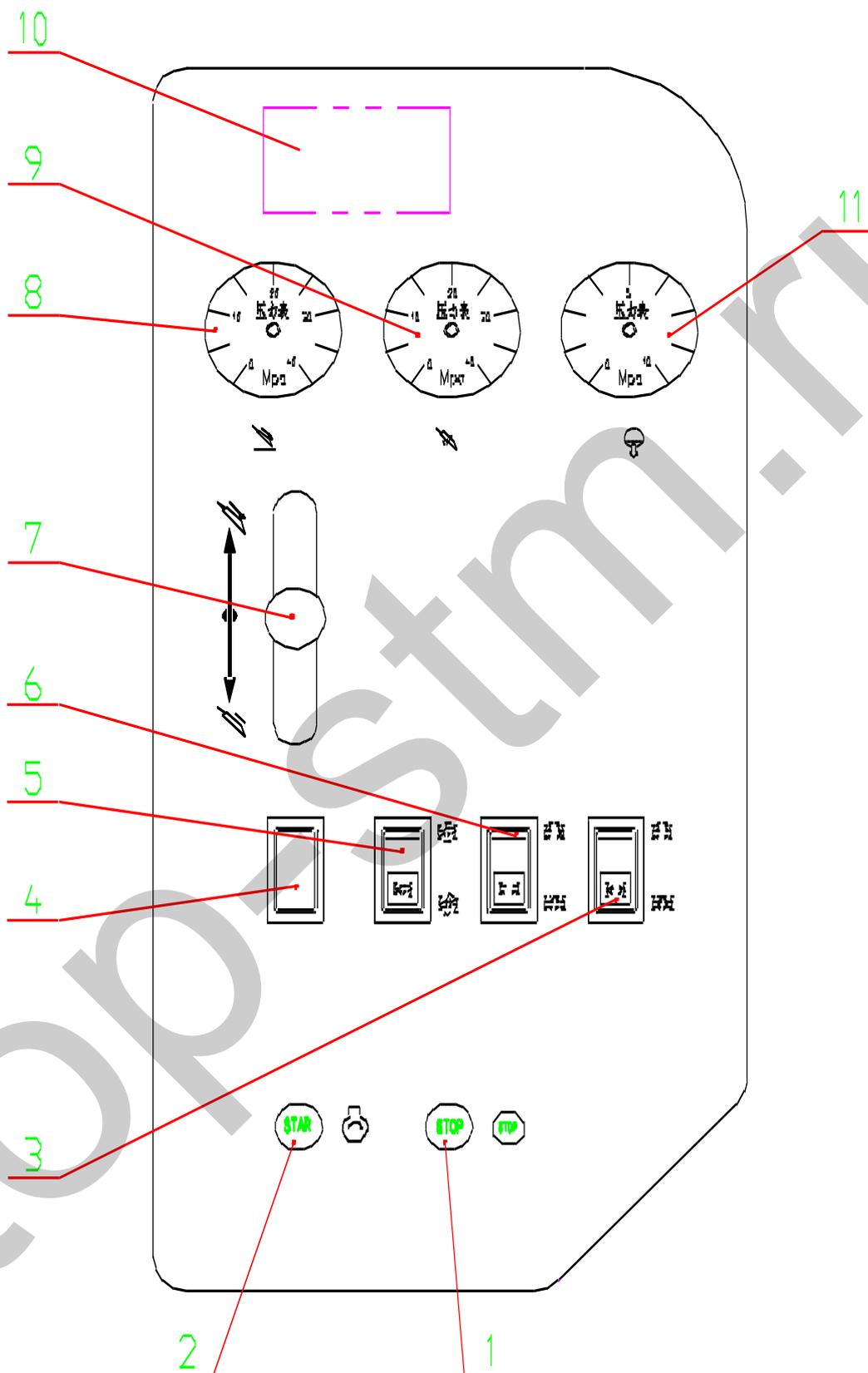
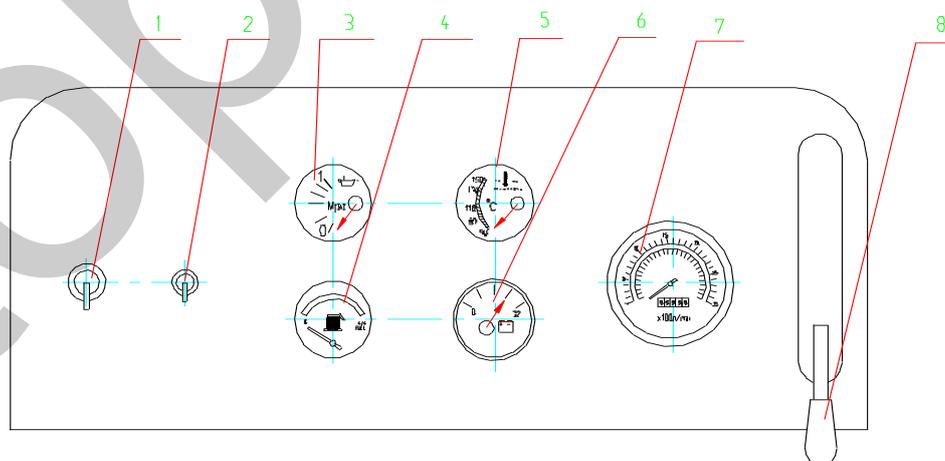


Figure 5 Operation panel of right console

**Table 3 Right Console Switch**

No.	Name	Function
1	Shutdown switch of engine	To control engine shutdown
2	Startup switch of engine	To control engine startup
3	Front jaw vice switch	To control clamping or loosening of front jaw vice
4	Backup switch	Backup switch
5	Rotation switch of jaw vice	Used for rotation control of post jaw vice
6	Post jaw vice switch	To control clamping or loosening of post jaw vice
7	Pushing handle	To control push-pull of auger stem
8	Push-pull pressure gauge	To display pressure of push-pull motor
9	Rotary pressure gauge	To display pressure of rotary motor of power head
10	Installation plate of guide instrument	Guide instrument shall be installed here.
11	Mud pressure gauge	To display pressure of mud system

1.3 Please refer to Figure 6 for operation panel of auxiliary console and refer to Table 4 for detailed functions.



**Figure 6 Operation panel of auxiliary console**

Table 4 Function of auxiliary console

No.	Name	Function
1	Power switch	Main power switch of the system
2	Key switch	Used for engine startup and system electrification
3	Machine oil pressure gauge	To display engine oil pressure
4	Fuel oil gauge	To display fuel oil quantity
5	Water temperature gauge	To display temperature of cooling liquid of engine
6	Voltmeter	To display system voltage
7	Hourly rotation speed list of engine	To display rotation speed and working hours of engine
8	Control handle of accelerator	To control engine accelerator

1.4 Please refer to Figure 7 for operation panel of post console and refer to Table 5 for detailed functions.

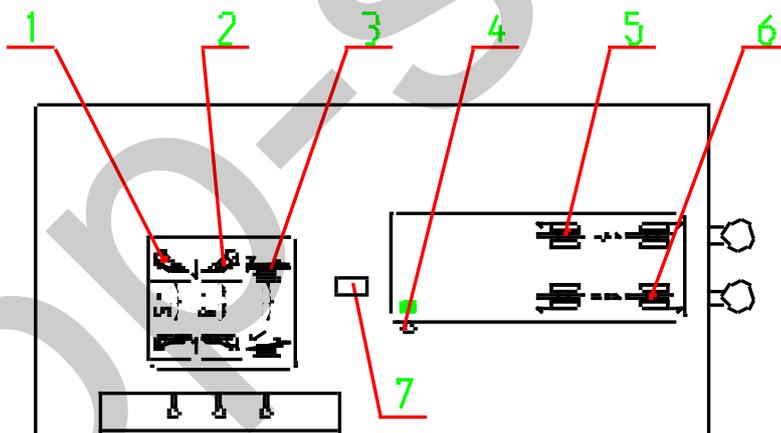


Figure 7 Operation panel of post console

Table 5 Operation panel of post console

No.	Name	Function
1	Liquid control handle of left leg	To control expansion/retraction of left leg
2	Liquid control handle of right leg	To control expansion/retraction of right leg
3	Inclined liquid control handle of drilling frame	To control expansion/retraction of inclined oil cylinder of drilling frame
4	Crash stop switch	Crash stop switch of engine
5	Right driving liquid control handle	To control forward/backward motion of right crawler
6	Left driving liquid control handle	To control forward/backward motion of left crawler
7	Driving acceleration switch	To control driving speed

Note: Driving acceleration position must be in non-acceleration position after finishing movable machines or power head can not be pushed or pulled.

## 2 Preparation

### 2.1 Data collection

**Successful construction begins from bore and existing documents of the project and construction site shall be read firstly.**

2.1.1 Contact utility pipeline company to position and mark existing underground utility pipes.

2.1.2 Ask for pipe sample and detect weight and rigidity. Contact material manufacturing department to consult to bending radius. Check if we have suitable back tow facilities or not.

2.1.3 Contact local management department and discuss with relevant safety measures if construction site is close to highway or other traffic

zones.

2.1.4 Provide phone numbers of local rescuing and medical departments as well as phones.

## **2.2 Site exploration**

**Construction site shall be inspected as follows before equipment positioning:**

2.2.1 Overall flatness and slope of construction site

2.2.2 Height drop of construction site such as hill and valley, etc;

2.2.3 Obstacles such as building, railway and river, etc;

2.2.4 Mark of underground pipelines (shown in Safety Protection Part)

2.2.5 Traffic circumstances

2.2.6 Entry route

2.2.7 Soil quality and geologic conditions

2.2.8 Water supply situations

2.2.9 Trace and position disturbance source such as reinforcement iron bar and steel rail, etc of the system.

2.2.10 Select points and collect soil samples along bore track to define drill bits for drilling and re-expanding.

## **2.3 Verification of dangerous articles**

**Please refer to “Safety Protection” for verification of underground dangerous articles and division of site category.**

**Note:** Use equipment by abiding by operation regulations accurately and maintain necessary safety protection facilities because underground dangerous articles may cause death or casualty.

## **2.4 Position selection of perforation and final hole**

**Consider following circumstances when selecting perforation positions.**

2.4.1 Slope

Mud mixing station shall be in horizontal position and perforation angle shall be considered to avoid influence to drill installation and prevent mud from flowing out of the hole due to bent auger stem.

2.4.2 Traffic

Locomotives and pedestrians must be out of safety distance of

construction site with buffer zone of at least 3m away from equipment.

### 2.4.3 Space

Check if perforation and final hole have sufficient space to guarantee gradual bending of auger stem. Please refer to “The minimum angle buildup distance” in the chapter to check if there is sufficient operation space or not.

### 2.4.4 Amenity

Strive to drill toward downslope direction by considering shade, wind direction, smoke, smog and other site characteristics so that mud will not flow to drill.

## 2.5 Design bore track

**Bore track shall be designed from perforation to final hole before drilling.**

Bore track can be marked on the ground by painting, flagging or marking on the paper for operator’s reference.

### **For complex bore:**

Consult to engineers for site evaluation and calculation of bore track. Be sure to notify engineer of the minimum perforation angle, bending extreme of auger stem, back tow materials, length of auger stem and positions of various underground pipelines.

**Four parameters shall be considered before drilling for simple bore.**

It is suggested to consider bending extreme of auger stem, perforation angle, the minimum angle buildup distance and the minimum depth. Suggested bending extreme shall be considered for every bent auger stem besides perforation.



**Attention: Auger stem can be bent but invisible damage may be caused if exceeding suggested bending extreme. Auger stem may be invalid suddenly after long-term damage accumulation.**

### 2.5.1 Definition of perforation angle

Perforation angle refers to relative included angle between drill and ground. It can be gained by following methods:

2.5.1.1 Deviation survey probes shall be placed on the ground and drill respectively to measure ground inclination and drill inclination. Difference of drill inclination and ground inclination is equal to perforation angle.

2.5.1.2 “A” and “B” refer to height of carrier front end and post end to the ground. “C” refers to horizontal distance of front and post ends and formula of perforation angle is follows:  $((B-A) / C) \times 100$

(Please refer to Figure 8.)

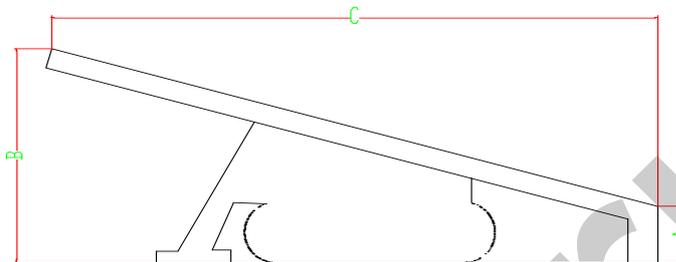


Figure 8 Definition of perforation angle

Bore can be under the horizontal status as early as possible by little bore bending if perforation angle is relatively smaller. Bore track and depth will be increased if perforation angle is relatively larger.

#### 2.5.2 Definition of the minimum angle buildup distance

The minimum angle buildup distance refers to horizontal projected distance of bore from drilling to horizontal status. Bore slope will exceed bending extreme of auger stem with damage if angle buildup distance is excessively small.

The minimum angle buildup distance can be defined by known perforation angle according to bore depth requirements to the ground.

#### 2.5.3 The minimum hole location depth

Auger stem must be bent stably so bore depth to the ground under horizontal status shall be defined by perforation angle and bending extreme of auger stem. Depth is in inverse proportion of perforation angle. Depth will be increased by increasing perforation angle and angle buildup distance.

Corresponding angle buildup distance and perforation angle can be calculated by required hole location depth.

### 2.6 Equipment preparation

**Note: Inspect equipment carefully before daily or shift equipment startup.**

2.6.1 Inspect liquid level and volume including fuel oil, hydraulic oil, cooling liquid of engine, electric quantity of storage battery and machine oil.

2.6.2 Check if status and function of equipment parts are normal without

loose bolts or not.

2.6.3 Check if there is oil, water or gas leakage or not.

2.6.4 Check if display of various manipulation instruments is normal or not.

2.6.5 Check if assorting facilities are complete or not.

2.6.5.1 2 sets of new batteries shall be provided for receiver, transmitter or tracer.

2.6.5.2 Probe shall have new and backup batteries.

2.6.5.3 Wireless interphone shall have new and backup batteries.

2.6.5.4 Quick wrench

2.6.5.5 Backup drill bit, filter net and nozzle

2.6.5.6 Small flag or paint for mark

2.6.5.7 Water and backup hose

2.6.5.8 Fuel oil (according to engineering quantity)

2.6.5.9 Bentonite, polymerizer, water processor and other additives

2.6.5.10 Fuse

2.6.5.11 Re-expanding probes, rotary connectors and back tow facilities;

2.6.5.12 Hose and water gun for washing

2.6.5.13 Pipe tape

2.6.5.14 Thread dope and brush

2.6.5.15 Insulation shoes and gloves

2.6.5.16 Tally book and pen

## **2.7 Site preparation**

**Note: Such sites shall be classified into power type site if there is any doubt for category division or there are possible power wires without mark. Cables shall be cut off and exposed to facilitate monitoring before drilling.**

2.7.1 Bore track mark

Design bore track or original underground pipelines shall be marked by small flag or paint.

### ***Bore preparation point***

As shown in Figure 9, the 1<sup>st</sup> auger stem must be straight to guarantee successful drilling. Please excavate a beginning hole on the ground to

avoid bending and distortion of auger stem.

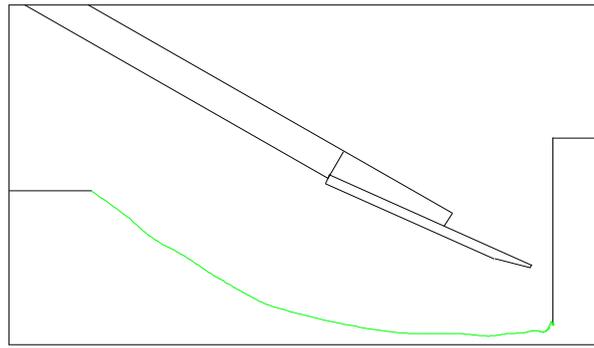


Figure 9 Beginning pit

### 2.7.2 Bore path record

Record actual bore path after construction. List skewness, depth of every auger stem and describe the construction process integrally. In addition, construction sketch shall be mapped to record back tow depth and approximate position.

## 2.8 Machine startup

2.8.1 Various manipulation rods and switches shall be placed in the middle position before engine startup.

2.8.2 Switch on power switch and rotate key switch or press startup button then start up the engine.

Please refer to engine manual for startup and usage of engine.

2.8.3 Low-speed no-load operation for 5 minutes is required after engine startup for pre-heating.

## 2.9 Drill positioning

2.9.1 Drill shall be positioned according to soil insertion pint.

2.9.2 Rack shall be inclined to reach required soil insertion angle according to demand.

2.9.3 Post leg shall be lowered to the ground.

## 2.10 Assembly of drilling rig

2.10.1 Selection of nozzle and drill bit.

2.10.1.1 Selection of nozzle and drill bit: There are many kinds of nozzles and drill bits and they shall be selected according to detailed construction conditions and required mud flow.

2.10.1.2 The nozzle shall be installed on the probe container tube.

2.10.1.3 (As shown in Figure 10), the probe shall be connected to container tube.

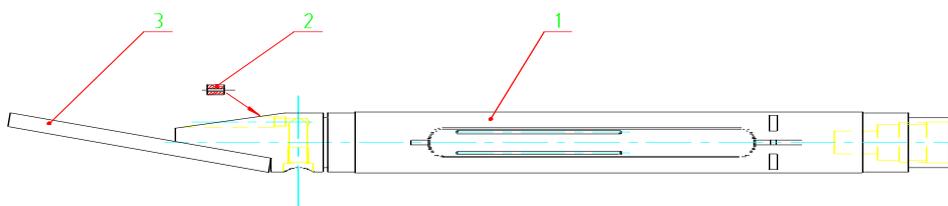


Figure 10 Assembly of drilling rig

2.10.1.4 Transmitter installation:

Replace old battery, place signal rod in its accurate position and use guide instrument accurately according to manual.

**Note: Battery of signal rod must be replaced before daily operation.**

2.10.2 Connection of buffer rod

2.10.2.1 Slide bushing components of auger stem shall be detached.

2.10.2.2 Buffer rod shall be placed in the front jaw vice.

2.10.2.3 Close the jaw vice.

2.10.2.4 Lubricate the connector.

2.10.2.5 Connector shall be tightened by machine torque.

2.10.3 Connect probe container tube.

2.10.3.1 Drilling rig shall be placed in the front jaw vice.

2.10.3.2 Close the jaw vice.

2.10.3.3 Connector shall be tightened by machine torque.

2.10.4 (Optional) connection of drilling rig by combination pliers

2.10.4.1 Drilling tool shall be connected to the 1<sup>st</sup> auger stem and tightened by hand.

2.10.4.2 Special combination pliers shall be connected in the accurate positions.

·(As shown in Figure 11), combination pliers shall be placed around pipes after opening special pliers(2).

·Pipes shall be clamped by the combination pliers (1).

·As shown in the figure, special pliers(2) shall be placed in the other end of pipes.

- Pull-rod axles (3) (4) shall be screwed down to rotation body (5).
- Rotate special pliers to insert pull-rod axles (3) (4) into special pliers (1) (2) then into elastic pins (6) (7) respectively.
- Pipes shall be clamped by rotating special pliers (2).

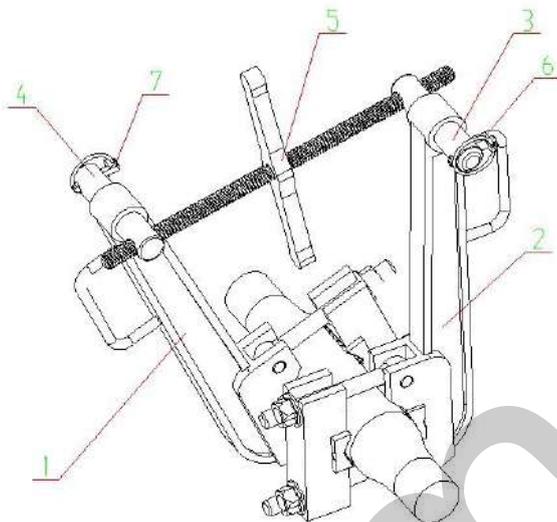


Figure 11 (Optional) special pliers

2.10.4.3 Connector shall be tightened by marking-on process.

2.10.4.4 Screws shall be tightened for 2 circles inversely to release pressure then components of combination pliers shall be detached.

2.10.5 Marking-on process (shown in Figure 12)

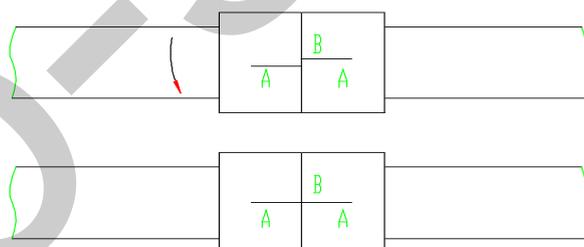


Figure 12 Marking-on processes

2.10.5.1 Slag shall be removed from wrench and connector thoroughly.

2.10.5.2 A line shall be marked to divide 2 ends of partition line.

2.10.5.3 The 2<sup>nd</sup> line shall be marked to be about 9.5mm away from the 1<sup>st</sup> line toward inverse tightening direction in one end of movable connector.

2.10.5.4 Rotate the handle and tighten connector so that the 2<sup>nd</sup> line is connected to the 1<sup>st</sup> line.

2.10.6 Connect the 1<sup>st</sup> auger stem.

2.10.6.1 Start up the engine.

2.10.6.2 Align buffer rod of the front wrench.

2.10.6.3 Clamp the drilling rig by front wrench.

2.10.6.4 Load the auger stem.

2.10.6.4.1 Lubricate main axle connector thread of power head.

2.10.6.4.2 Lubrication front threads of auger stem.

2.10.6.4.3 Lifting device switch of auger stem shall be used to convey auger stem to the main axle. Pay attention to relative position of auger stem to front jaw vice and drill collar (and mark clamping positions of every auger stem) to guarantee accurate position of auger stem.

2.10.6.5 Connection of auger stem

2.10.6.5.1 Power head shall move forward until main axle connector is closed to threads of auger stem.

2.10.6.5.2 Power head shall continue to move forward until auger stem is inserted into main axle connector.

2.10.6.5.3 Power head shall move forward until auger stem terminal is aligned to thread of buffer rod.

2.10.6.5.4 Use the pushing/rotation controller to rotate the main axle and auger stem slowly then install them to threads of the buffer rod.

2.10.6.5.5 Open the holder clamp.

2.10.6.5.6 Decline the lifting device of auger stem to the greatest extent.

2.10.6.6 Screw down the auger stem.

2.10.6.7 Loosen the front jaw vice then move power head to the rear of drill rack.

2.10.6.8 Power off the engine.

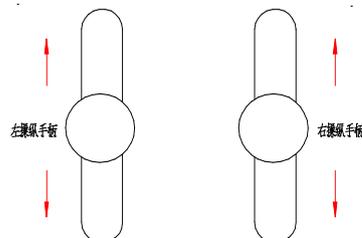
2.10.7 Connection of mud system

Mud hose shall be connected from mud mixing system to mud pump.

Guide drilling



**Warning: Inaccurate operation may cause death or casualty. Shutdown is required for inspection if failing to operate according to manual.**



**Note:** Drills shall be anchored accurately before perforation.

### 3.1 Operation of feeding & revolution handle

**Feeding & revolution handle has 2 operation locations to allow complex effect of 4 basic motions. Please refer to Figure 13 for function and position of operation handle.**

Please refer to following figure for possible functions when control handle is in the composite position.

Auger stem will rotate positively (and shackle) when power head moves forward.

Auger stem will rotate inversely (and shackle) when power head moves forward.

Auger stem will rotate inversely (and shackle) when power head moves backward.

Auger stem will rotate positively (and shackle) when power head moves backward.

### 3.2 Drilling the 1<sup>st</sup> rod

#### 3.2.1 System startup

3.2.1.1 Start up drill and mud device to pre-heat 2 engines. Please refer to usage manual of mud mixing system for operation.



**IMPORTANT:** Be sure that mixed liquid can meet drilling conditions.

**Auger stems, drilling rigs and short connectors of different factories can not be mixed.**

3.2.1.2 Adjust accelerate switch of engine so that it can be opened completely.

3.2.1.3 Pressure the charging mud pump switch so that auger stem is full of mud with increased mud pressure.

**Note:** Everybody shall be at least 3m away from rotary auger stem. Feeding auger stem can not operate forcefully or it may be bent. Do not use bent auger stems.

3.2.2 Inspect flow of drilling liquid by visual observation.

3.2.3 Select position of time clock.

3.2.4 Power head shall move forward slowly. Strive to drill the 1<sup>st</sup> auger stem straightly.

3.2.5 Monitor various surveying meters.

### 3.3 Add auger stems



**Warning:** Please keep far away from rotary axle due to possible death or casualty.

3.3.1 Adjust accelerator switch so that rotation speed of engine can be about 1,900 r/min.

3.3.2 Cut off auger stem connector in main axle thread.



**Attention:** Do not hold recessed end of auger stem to avoid damage. Strive to be close to front jaw vice (2) and close the mud pump if connector is between jaw vices.

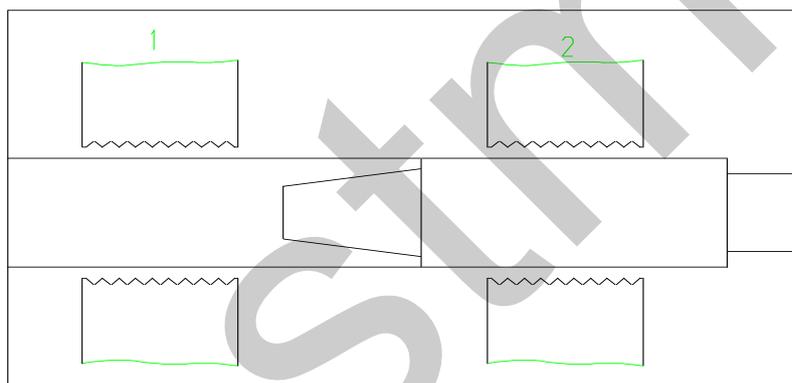


Figure 14 Holding the auger stem

3.3.2.1 Loosen the manipulation rod when auger stem connector in main axle thread is between front jaw vice (2) and post jaw vice (1).

3.3.2.2 Start up the front jaw vice (2) until auger stem is clamped with increased pressure.

3.3.2.3 Main axle shall be rotated counter-clockwise until threads are loosened.

3.3.2.4 Lubricate the main axle thread.

3.3.2.5 Stop rotation and move the power head to the rear end of rack.

3.3.3 Add auger stems.

3.3.3.1 Decline the lifting device of auger stem then open the clamp switch of holder.

3.3.3.2 Place one auger stem in the clamp.

3.3.3 Close clamp switch of holder.

3.3.4 Rotate the lifting device to move the auger stem to its axle.

3.3.5 Lubricate front threads of auger stem.

**Note: Thread oil shall be brushed on threads of auger stem and short connector when installing the auger stem.**

3.4 Connect the auger stem.

3.4.1 Power head shall be pushed forward until main axle thread contacts auger stem.

3.4.2 Continue to push power and rotate main axle until main axle thread is installed on the auger stem.

3.4.3 Power head shall move forward slowly until new auger stem contacts front auger stem threads.

3.4.2 Push the power head and rotate the main axle until new auger stem is tightened with front auger stem.

3.4.3 Loosen the front jaw vice.

3.4.4 Press the holder switch then open the holder.

3.4.5 Rotate lifting device switch for declination.

**Note: Be sure that lifting device of auger stem is in the lowest position before pushing power head forward. Guarantee sufficient free motion distance between power head and carriage during loading/unloading of auger stem.**

3.5 Pressure the charging mud pump switch so that auger stem is full of mud with increased mud pressure.

**Note: Adjust speed control handle of mud pump and set pressure suitably. Gear can not be changed during operation of mud pump.**

Gear variation operation of mud pump: It is the easiest to change gears within 10 seconds after closing the mud pump because transmission gear is still in operation.

Please refer to operation manual of mud pump for operation.

3.6 Rotate the main axle and drill slowly then adjust rotation speed according to dimension of drill bit and soil conditions.



**Attention: Be sure to rotate it clockwise unless connector of auger stem is cut off. Connector will be loosened by counter-clockwise rotation.**

3.7 Monitor various surveying instruments and shutdown is required for inspection if any is any problem.

3.8 Drill bit shall be positioned by guide instrument after drilling for at least half of length of auger stem.

#### 4 Correction direction

4.1 Correction direction is operator's technique gained by experience to equipment and soil conditions.

Basic operation steps are as follows:

4.1.1 An operator shall position drill bit by guide instrument and issue operation instructions to drill operator during directional drilling.

4.1.2 Drill bit shall be traced during correction to compare current position with drilling plan and steer drill bit according to demand.

4.1.3 Basic principle to consider during correction is as follows:

4.1.3.1 Steering ability depends on soil conditions, used drill bit, nozzle, surveying data of drill bit and non-rotation pushing distance.

4.1.3.2 All machines shall be corrected gradually. Please refer to bending extreme of auger stem. Excessive correction may damage auger stem and cause difficult drilling and back towing so it is required to straighten as early as possible for correction.

4.1.3.3 Do not push the entire auger stem into the ground if it does not rotate because auger stem may be damaged by exceeding the bending radius.

#### 4.2 Positioning of drill bit

4.2.1 Drill bit parameters which can be gained by guide instrument include depth, inclination, angle of tool and temperature, etc.

4.2.2 Compare with positions shown in drilling plan to define direction of drill bit.

4.2.3 Rotate the power head until required time clock position is displayed on the guide instrument;

#### 4.3 Steering steps:

4.3.1 Adjust angle of drill bit.

4.3.2 Push the auger stem if power head does not rotate.

4.3.3 Check if direction can meet requirements or not by display data of guide instrument. Stop operation then drill with rotation once reaches required angle. (Steering of auger stem can not exceed permissible

bending angle of single auger stem or it may be damaged.)



**Attention: Stop operation and find out reasons instantly if single auger stem has larger angle variation within shorter distance. Auger stem, drill bit, beginning rod, pivot plate even probe rod may be damaged if continuing to operate the machine.**

**Do not push the power head forcefully if it is difficult to change pushing direction of auger stem to avoid bending. Auger stem can be close to steering direction for slow rotation and pushing within scope of 45° sector.**

## 5 Design notice of guide hole

Guide holes shall be designed to evade underground pipelines and remain sufficient safety distance. Measured depth of underground pipes deviates from actual depth and detected and measured values are different especially under large disturbance. Therefore, sufficient safety distance shall be remained when designing the guide hole. In general, safety distance shall be 1m during actual construction and it must reach 0.5m.

Guide hole below the water level shall be designed to horizontal hole as practicable as possible when passing across the river. In general, guide hole shall be at least 3m away from bottom of river bed because pipes may float due to super-small distance. In the meanwhile, guide hole is difficult to construct due to small distance of river bottom and complex soil quality.

Guide hole shall be at least 4m away from road base when passing across railway or highway. Depth shall be increased if expanding diameter is larger. Various conditions on the site shall be collected completely when passing railway and highway to guarantee safety of guide operators.

In general, depth of guide hole shall be not lower than 5m when setting pipes below floors. Depth of guide hole shall be increased if expanding diameter is large with soft stratum.

Points shall be set when passing across routes for construction site with poor vision to control guide precision and define soil exit hole positions.

Auger stems of every factory have different bending radius and they may be invalid due to early rupture even major loss if actual bending radius exceeds permissible bending radius.

Be in accordance with three requirements at the same time when designing the guide hole. That is, it is required to meet owner's requirements and construction process and evade underground hidden articles. Coordinate with entrusting party to check if construction route can be changed or not if construction location can not meet above conditions at the same time. Project of which route can not be changed is preferred to

reject due to super-low success rate.

## 6 Soil exit of drill bit

Drill bit shall be led to target pit or protrude out of the ground upward. Pay attention that deformation of auger stem shall be within the minimum bending radius. Mud pump switch shall be closed instantly once drill bit is exposed.



**Warning: Ask drill operator to close the engine then replace the drilling tool when using the combination pliers. It is strictly prohibited to start up the engine when connecting and replacing drilling rigs.**

## 7 Re-expanding and back towing

Bore can be expanded and materials shall be drawn after finishing directional drilling.



**Warning: All persons shall keep far away from materials and movable parts which are in installation. Re-expanding or back towing is not allowed until confirmation that re-expanding head is installed and relevant persons are far away from them. Back towing is required firstly until drill bit begins to enter into the soil then it shall be rotated slowly.**

### 7.1 Re-expanding steps

7.1.1 Selection of re-expanding device: Selection of re-expanding drill bit may be influenced by dimension of pivot hole, back towing materials and soil conditions so please contact dealer or factory for details.

Ideal final bore aperture is approximately 1.3 to 1.5 times of pipe diameter or sum of pipe diameter and 200mm. Suggested expanding aperture is sum of pipe diameter and 200mm if pipe diameter exceeds 600mm. Re-expanding head is suggested to be the smaller value of 1.2 to 1.5 times of outer diameter or sum of outer diameter and 200mm during practice to form a circular space, remove mud or drilling debris and reduce resistance of back towing pipes with suitable bending for pipes.

7.1.2 Define mud flow requirements.

7.1.3 Select the back towing device.

7.1.4 Transmitter installed in the re-expander shall be used for re-correction if re-expanding hole is traced by transmitter.

7.1.5 Set mud flow reasonably.

7.1.6 Ensure that mud can be jetted from all nozzles.

7.2 Re-expanding prompt

7.2.1 Strive to straighten drilling route during plan.

Inspect bending extreme of back towing materials for gradual bending. Mud quality is important for re-expanding so it is required to know soil quality, underground water, additive and mixed mud. Re-expanding needs more mud by comparing with pivot hole drilling.

7.2.2 Definition of mud requirements

Re-expanding is not successful until there is sufficient mud. Required mud consumption depends on dimension of re-expanding hole, drawn materials and soil conditions.

The section is to describe how to define the minimum mud consumption under ideal conditions. Mud consumption during actual construction shall be larger than suggested consumption or re-expanding hole may be dry and unsuccessful.

7.2.2.1 Define dimension of re-expanding hole and outer diameter of drawn materials shall be defined and required mud consumption can be known according to Appendix A.

For instance, a re-expanding hole of 15.2 cm (namely, 6 inches) needs at least 19L/m (1.47 gallon/foot) while a back towing material of 7.6cm needs at least 5L/m (0.37 gallon/foot).

7.2.2.2 Mud consumption required by every foot or meter of re-expanding can be calculated by difference of mud consumption required by re-expanding hole and volume of back towing materials. For instance, drilling for 1m needs at least 14L mud (and every foot needs 1.1 gallons).

7.2.2.3 Mud consumption required by the hole can be estimated by multiplying result by re-expanding length.

7.2.2.4 Pressure estimation

Required mud flow and pressure can be defined according to nozzle diameter shown in Appendix B.

Actual mud flow and pressure relate to nozzle quantity of re-expanding heads.

8 Disassembly of auger stem



Warning! Do not hold the head of auger stem or it may be damaged. Hold the auger stem and strive to close to front jaw vice (2) when connector is between wrenches. Please refer to

Figure 15 for clamping.

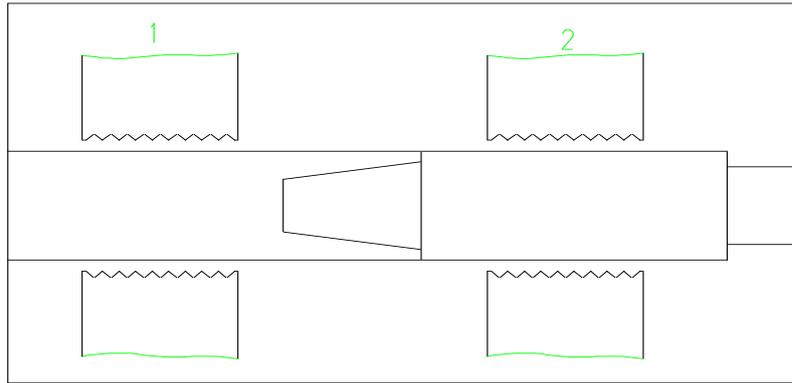


Figure 15 Clamping diagram of auger stem

8.1 Stop the power head and hold the auger stem when connector is between front and post jaw vices.

Press clamping switch of front jaw vice (2) until auger stem is clamped with certain pressure.

Press clamping switch of post jaw vice (1) until auger stem is clamped with certain pressure.

8.2 Cut off the front connector.

Press rotation switch of post jaw vice (1) and rotate the post jaw vice counter-clockwise then cut off the connector.

Open the post jaw vice then rotate it clockwise so that it can return to its original position.

8.3 Separate the front connector.

8.3.1 Clamp the auger stem by post jaw vice;

8.3.2 Rotate the power head counter-clockwise and loosen the connecting thread;

8.3.3 Rotate auxiliary loading/unloading device of auger stem and clamp the auger stem so that post jaw vice can loosen the auger stem;

8.3.4 Rotate the main axle slowly and counter-clockwise, move power head backward, detach the auger stem then rotate auxiliary loading/unloading device of auger stem and detach the augers tem. (Pay attention to relative position of auger stem and jaw vice to avoid collision of rotary auger stem and jaw vice or bonding with connecting thread of drill collar.)

8.4 Connect it to the next auger stem.

8.4.1 Move the power head forward until main axle pin contacts auger

stem.

8.4.2 Rotate the main axle and move the power head forward. Connect main axle pin to the box of auger stem then screw down the connector.

8.4.3 Open the front jaw vice to loosen the auger stem.

8.4.4 Open the mud pump for continued re-expanding or back towing.

## 8.5 Shutdown

8.5.1 Low-speed no-load operation for 5 minutes is required for engine before shutdown for cooling.

8.5.2 Toggle key switch to shutdown position or pressure the button then remove the startup switch key.

8.5.3 Power off the main switch then remove the power switch key.

## 9 Technical difficulties during construction

### 9.1 Jamming of a drilling tool

Jamming of a drilling tool is a common technical difficulty during re-expanding and reasons shall be defined for troubleshooting.

9.1.1 Retract the drill bit, auger stem and move drill to drill the guide hole again if there is jamming with underground pipelines.

9.1.2 Jamming of bricks or stones in the soil: Loosen the torque and rotate the drill bit for slow expanding. Jamming of large stone or concrete in the soil: Strive to retract the drill bit and move drill for re-drilling or excavate stones for continued expanding. Do not operate forcefully or auger stem may be broken and drill is lost in the hole.

9.1.3 Slow down expanding speed and increase mud consumption if there is frequent jamming for large-diameter expanding in hard clay layers. Sometimes 40 minutes shall be required for back towing of an auger stem.

9.1.4 Loosen the torque and re-expand slowly if jamming is caused by collision of drill bit and root. Root shall be crushed to avoid obstacles if re-expanding is required.

### 9.2 Hole shrinkage

Hole shrinkage may be caused in the hole during re-expanding in soft soil layer. Water in the hole will flow out of the auger stem inversely after disassembling the auger stem to indicate severe hole shrinkage. Pipes may be protruded with deformation even jamming under severe hole shrinkage.

Solid mud protective wall shall be selected for severe hole shrinkage to

maintain balanced pressure in the hole or drill bit of larger diameter shall be adopted for expanding, borehole cleaning and pipe layout. PE or PVC tubes with higher hardness and strong resistance pressure shall be used and pipes with slight hole shrinkage generally can be set after borehole cleaning.

### 9.3 Hole collapsing

Expanding holes in sandy clay, sand and loose backfill soil layers are easy to collapse and pavement crack may sink due to hole collapsing, burial or jamming of a drilling tool.

Solid mud or heavy gum solid mud protective wall can be selected to avoid hole collapsing effectively. Continued expanding is not allowed until removing rock blocks if hole collapses in storage yard of rock blocks.

### 9.4 Bore expansion

Clay expands after water absorption so set pipes are easy to be flat with increased debris and reduced aperture after forming.

High-quality solidfree protective wall can be adopted to reduce contact between hole wall and water and reduce water loss. Expanding diameter can be added with multiple borehole cleaning to avoid stratum expansion and protrusion to set pipes effectively.

### 9.5 Mud loss

Mud in loose backfill soil layers such as sandy silt, clay, sand layers and soft soil layers on the bottom of river bed will lose from the hole due to lower underground water level.

Mud concentration and viscosity can be added to form a skin on the hole wall to avoid mud loss effectively. Mud still will lose when hole passes across the river.

### 9.6 Mud effusion

Mud will effuse from hole to ground during expanding and back towing of pipes and reasons are as follows:

9.6.1 Bore will be jammed due to excessive debris in the expanding hole and mud will effuse from the ground due to high pressure in the hole.

9.6.2 Loose stratum will reserve an effusion channel for mud.

In general, it is insignificant if mud effuses from the ground. Pay attention to it under specific conditions.

9.6.3 Mud can not effuse from residential houses, fish, shrimp or crab ponds.

#### 9.6.4 Mud effusion prevention measures

9.6.4.1 Design bore depth shall be added from 6m to 9m and original depth can be added from 9m to 12m.

9.6.4.2 Improve the drill bit structure to strive to mix mud in the bore into mud.

9.6.4.3 Add mud viscosity, concentration, flow and floating and debris removal ability of protective wall properly. A complete channel shall be formed in the bore so that mud can effuse from the hole freely.

#### 9.7 Continue to pump mud even if drill stops operation.

Drill stops operation due to various reasons during back towing and pipe layout. Pipes which shall be welded and protective layers which shall be repaired in the halfway may be disturbed by municipal administration. Mud can not be pumped if drill bit stops operation if back towing and pipe layout are required. Mud shall circulate in the hole to prevent from increasing back towing force of set pipes and avoid burial. Mud pumping can not be stopped especially for sandy stratum. Stop pumping dense mud before drill stops operation under emergency conditions then mud shall be pumped for 10 minutes after re-drilling so that mud can exit the hole for back towing and pipe layout.

#### 9.8 Expanding efficiency

Torque and rotation speed of drill are in direct proportion of expanding efficiency. Expanding efficiency relates to expanding soil layer, drill bit, mud quality and mud consumption directly under rated torque and rotation speed of drill. Clarify soil layer structure and soil quality composition, select high-efficiency drill bit to cut the soil layer, mix mud and define mud consumption to increase expanding efficiency.

#### 9.9 Quick sand

Complete holes can not be formed after expanding of quick sand layer. Quick sand has absorption force to bring resistance to set pipes. Heavy gum solid mud will be used to slow down expanding speed so that mud and quick sand can emulsify thoroughly. Quick sand will be floated in the hole to eliminate absorption force. Quick sand will flow out of the bore with mud during pipe layout.

#### 9.10 Pipe deformation

Clay will form blocks for residue in the hole in high-viscosity stratum and it is difficult to mix into mud. Mud blocks will be protruded and pipes will be protruded with deformation during pipe layout. Pipes shall be set before layout after multiple borehole cleaning to guarantee little deformation.

Pipes with large deformation shall be repaired or they shall be rejected.

#### 9.11 Pipe jamming

Pipes may be jammed in the hole due to many residual mud blocks, hole collapsing and hole shrinkage. Back tow pressure gauge will increase gradually before jamming. Back towing speed shall be paused or reduced and mud consumption shall be added when reading increases to avoid pipe jamming. Pipes can be retracted by bulldozer and excavator for re-borehole cleaning and pipe layout.

#### 10 Add antifreeze fluid into the drill

Drill can operate in the night under low temperature by using approved antifreeze fluid.

#### **Steps to add antifreeze fluid:**

10.1 Connect one end to mud pump by a hose and the other end shall be placed into the antifreeze fluid.

10.2 Adjust the mud pump to the minimum flow gear.

10.3 Start up the device and set the accelerator to the slow speed position.

10.4 Open the mud pump switch and start up the mud pump.

10.5 Until antifreeze fluid flows out of main axle.

10.6 Close the mud pump.

10.7 Remove the hose and keep it properly.

## **VI. Lubrication, repair and maintenance**

### **1 Operation and maintenance of rubber crawler**

#### **1.1 Tension force of rubber crawler**

Tension force of rubber crawler must be adjusted before operation of driving device. (Rubber crawler has been adjusted before leaving the factory.) It must be adjusted if crawler has large pendant length during operation. Adjustment method is as follows: Grease shall be added into the tension device by grease gun until rubber crawler can meet tension standards.

Tension standard of rubber crawler is as follows: The maximum pendant length of rubber crawler between 2 upper supports is less than or equal to 10mm.

#### **1.2 Ground**

Rubber crawler is strictly prohibited to use for following pavement because texture may be damaged. Sharp turn shall be evaded with super-low speed for operation under following conditions:

##### **1.2.1 Grit road**

##### **1.2.2 Stone road**

##### **1.2.3 Steps**

#### **1.3 Warning:**

1.3.1 Driver shall drive it slowly and carefully on the rough pavement to avoid damage to wheel and crawler.

1.3.2 Strive to avoid abrasion between rubber crawler and cement wall during driving to avoid rim crack of rubber crawler.

1.4 Driving technique of driver will influence service life of rubber crawler greatly.

1.4.1 Driver shall turn in times with low speed during operation. Driving speed shall be changed gradually during driving to avoid crash and emergency stop.

1.4.2 Avoid sharp turn on the cement pavement and avoid damage to wheel or crawler.

1.4.3 Driving rubber crawler shall not contact salt or salt fog because it may influence bonding of rubber and metal parts. It shall be washed by water after contacting salt.

1.4.4 Driving rubber crawler shall not contact fuel oil or hydraulic oil. Stain

shall be removed instantly or service life of crawler may be damaged.



Warning: Rubber crawler damaged by improper operation is not within regulated scope of “three warranties” of the machine.

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## 2 Equipment lubrication and maintenance

- Check if various connectors are tightened and pipelines are damaged or not before operation of lubrication system.
- Leakage of hydraulic oil is difficult to inspect by visual observation. It is preferred to inspect by a hard paperboard or wooden pieces.
- Wear protection clothes and glasses.
- Cure injured anybody instantly.



**Attention! Maintenance and repair shall be under closing status of engine unless otherwise specified.**

### 2.1 Engine maintenance shown in Table 7

Table 7 Engine maintenance

<b>Task</b>	<b>Period (hour)</b>	<b>Oil product</b>
Inspection of machine oil	10	Please refer to engine operation instructions.
Replacement of machine oil and filter (for the 1 <sup>st</sup> time)	50	Please refer to engine operation instructions.
Replacement of machine oil and filter	100	Please refer to engine operation instructions.

### 2.2 Sliding rack lubrication shown in Table 8

Table 8 Sliding rack lubrication

<b>Task</b>	<b>Period (hour)</b>	<b>Grease</b>
Lubrication chain	10	SAE 30W
Grease nozzle of lubrication jaw vice	10	Calcium soap grease
Sliding rail of lubrication power head	If necessary	Calcium soap grease
Sliding rod axle of lubrication jaw vice	If necessary	Calcium soap grease

2.3 Maintenance of power head shown in Table 9

Table 9 Maintenance of power head

Lubrication item	Hour	Lubrication oil
Inspection of lubrication oil in power head	50	L-CKD220
Inspection of driving speed reducer oil (in 2 locations)	50	SHELL OMALA EP150 Caltexoils Meropa 150
Replacement of lubrication oil in power head	1000	L-CKD220
Replacement of driving speed reducer oil (in 2 locations)	1000	SHELL OMALA EP150 Caltexoils Meropa 150

2.4 Maintenance of hydraulic system shown in Table 10

Table 10 Maintenance of hydraulic system

Item	Hour	Hydraulic oil
Inspection of hydraulic oil	10	L-HM46
Replacement of oil filter (for the 1 <sup>st</sup> time)	50	
Replacement of oil filter	250	
Replacement of hydraulic oil and filter core	1000	

2.5 Maintenance of mud pump shown in Table 11

Table 11 Maintenance of mud pump

Lubrication item	Hour	Lubrication oil
Inspection of machine oil in mud pump	50	SAE30W
Replacement of machine oil in the pump	250	

2.6 Maintenance of drilling tool

Joint threads shall be used for drilling rig connectors and lubrication auger

stem with special lubrication grease before usage for the 1<sup>st</sup> time and after drilling.

2.7 Ordinary inspection shown in Table 12

Table 12 Ordinary inspection

Interval (hour)	Item
Ordinary	Inspection of tensivity of feeding chain
	Inspection of tensivity of crawler
10	Inspection of various pipes
	Leakage inspection of gear box and motor
25	Inspection of radiator
50	Inspection of storage battery
	Belt inspection
	Replacement of oil filter (for the 1 <sup>st</sup> time)
100	Inspection of drilling tool
250	Replacement of oil filter
2000	Washing & cooling system
If necessary	Replacement of air filter
	Replacement of sliding plate of power head or clamp holder
	Replacement of wearing parts such as short connector of auger stem, power divider, re-expander and torque sleeve, etc
	Muffler inspection

2.8 Ordinary maintenance shown in Table 13

Table 13 Ordinary maintenance

Item	Interval (hour)
Pipeline inspection	10
Inspection of radiator	25
Inspection of storage battery	50

Belt inspection	50
Replacement of short connector	If necessary
Replacement of sliding plate of power head	If necessary



Warning! Close engine and manipulate various handles for unloading and descend, lock or support various ascending devices before cutting off hydraulic pipes. Various connectors shall be covered by thick cloth and loosened by connector nuts to release residual pressure. Discharged hydraulic oil shall be contained by container.

### 2.8.1 Storage battery



Attention! Storage battery shall be cut off during repair, welding and long-term storage. It shall be inspected every 50 hours.

Keep the storage battery clean without corrosion and brush a layer of lubrication grease in the cable connectors.

### 2.8.2 Pipeline inspection

All pipelines shall be inspected every 10 hours to check if there is leakage or loose connection or not.

### 2.8.3 Engine belt

The transmission belt drives AC power generator, cooling fan and water pump. Operating conditions of tension device and idle pulley shall be inspected every 50 hours to check if belt is in accurate position with abrasion or not.

### 2.8.4 Radiator

Check if there are sundries, weeds or sundries or not by inspection every 25 hours. It shall be cleaned by compressed air or water spraying gun if necessary. Pay attention to not damage cooling fins by high-pressure air or water. It also shall be inspected constantly during construction under dirty or weedy conditions.

It shall be cleaned by compressed air or sprinkling every 50 hours. Do not damage vanes by high-pressure air flow or water flow. Screws can be detached to remove weeds and dirt in the cover. Dirty engine end of heat dissipater can be cleaned by cleaner of radiator.

Cooling liquid level of radiator shall be inspected every year or every 600 hours. Please refer to operation manual for engine operation.

## 2.8.5 Short connector

2.8.5.1 Replace short connector of drill collar if necessary.

2.8.5.2 Unload thread connection of drill collar and short connector.

2.8.5.3 Replace old short connectors and brush thread adhesive on threads.

2.8.5.4 Install new short connectors with tightening by jaw vice.

Note: Short connectors and jaw vices are wearing parts so they shall be replaced in a timely manner after abrasion. Backup parts shall be supplied to avoid influence to construction schedule.

## 2.8.6 Power head pulley

Check if power head pulley is abraded or not with replacement if necessary. It can be adjusted by removing adjustment gaskets in phases. Removed gaskets shall be reserved and installed again during pulley replacement.

## 2.9 Maintenance of filter core shown in Table 14

Table 14 Filter maintenance

<b>Item</b>	<b>Period (hour)</b>
Replacement of machine oil filter	Shown in "Lubrication" chapter
Replacement of fuel oil filter (for the 1 <sup>st</sup> time)	50
Replacement of fuel oil filter	150
Muffler inspection	If necessary
Replacement of air filter	If necessary

### 2.9.1 Oil filter

Filter shall be replaced for every 50 hours for operation period and after future 150 hours. Filter shall be replaced constantly if added oil comes from oil bucket.

### 2.9.2 Air filter

Air filter shall be replaced if yellow strip in repair indicator reaches red line position or operation for 1,000 hours. It also shall be replaced constantly during construction in dirty environment.

### 2.9.3 Muffler

It shall be replaced if necessary.

## 2.10 Inspection of power head shown in Table 15

Table 15 Inspection of power head

Item	Period (hour)
Feeding inspection of feeding chain	Every day
Tensity inspection and operating conditions of crawler	Every day

### 2.10.1 Crawler tensity

Crawler tensity shall be inspected if necessary. Calcium soap grease can be added by oil nozzle to adjust tensity.

### 2.10.2 Tensity of feeding chain

Tensity of feeding chain shall be adjusted as follows if necessary:

2.10.2.1 Move power head to the rear end of sliding rack.

2.10.2.2 Loosen connecting rod nut below head support of drilling frame.

2.10.2.3 Screw down nuts clockwise to tighten chain then lock it by nuts.

## 2.11 Gear box and motor

Inspect gear box and motor every 10 hours to check if there is leakage or not.

## 2.12 Maintenance of auger stem

Auger stem is important for drill so it shall be maintained periodically.

2.12.1 Please install the protective cover cap before long-term storage of auger stem.

2.12.2 Threads shall be cleaned by high-pressure water and soap according to demand. Do not use gasoline or similar solvent. Lubricate threads and base by thread oil after cleaning. Special protective cap shall be installed if it is not used for a long time.

## VII. Transportation, Storage and Protection

### 1. Transportation notice

Drill shall be transported by truck during distance transfer. It has a driving chassis so it can move onto the vehicle by support (welded by owner) without relying on crane.

Please refer to Figure 15 for support dimension.

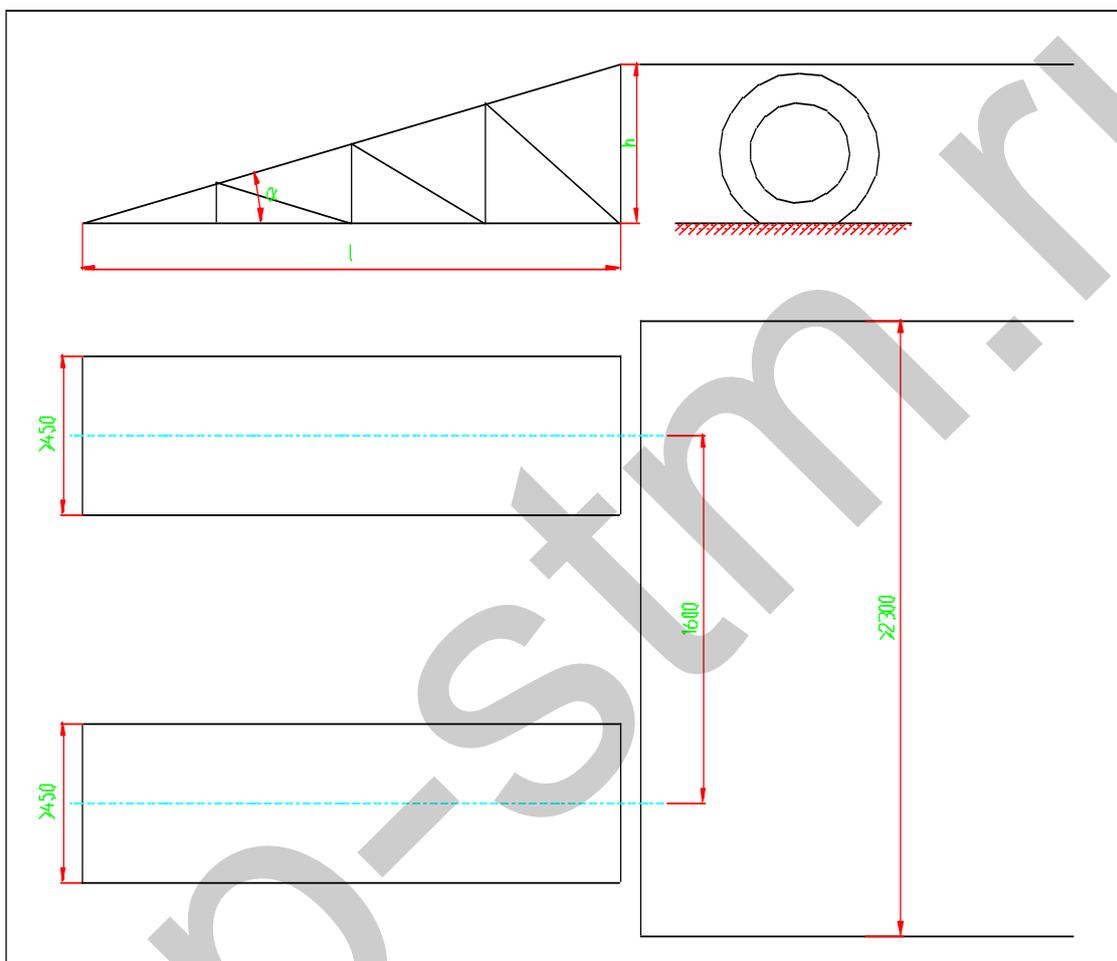


Figure 15 Support dimension diagram

In the figure: "h" refers to height of transportation platform of vehicle to the ground.  $\alpha \leq 16.7^\circ$  (namely,  $l \geq 3.3 \times h$ ).

Support shall bear weight of the entire drill with certain safety coefficient.

### 2. Drill transportation



Warning! Drill operator or other persons can not stay on the drill to avoid falling off or accidents.

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Warning! Drill shall move forward during motion on the horizontal ground or downslope pavement and retreat during upslope or moving to tow truck to strengthen safety precaution measures and facilitate operation.

Please operate as follows when entering into the site or finishing drilling;

2.1 Remove residual mud in mud supply system by clean water then detach the mud mixing device.

2.2 Wash equipment and auger stem by clean high-pressure water if possible.

2.3 Retract anchor piles.

2.4 Separate all assorting devices such as mud mixing system and pipe connector, etc.

2.5 Overturn the operation seat to the transportation position.

2.6 Rotate the guide rail to the horizontal position.

2.7 Engine shall operate with low speed so that drill can move to the tow truck or auto truck with low speed.



Warning: Drill shall move forward during motion on the horizontal ground or downslope pavement and retreat during upslope or moving to tow truck to strengthen safety precaution measures and facilitate operation.

2.8 Guarantee firm fixation when transporting drills by truck or tow truck.



**IMPORTANT:** Anchorage seat must be put down during transportation (to avoid damage to angle adjustment oil cylinder). It can not be tied by hoisting ring on left and right sides of crawler support by chain or rope after placing on the carriage floor of tow truck or truck stably.



Warning: Engine shall be under low-speed operation status when drill moves toward tow truck or truck!

## **VIII. Daily Storage and Protection**

Anchorage seat must be placed on the ground thoroughly during drill storage so that angle adjustment oil cylinder is not under the stress status. Manipulation rods of various valve blocks shall be in middle positions. Retract the key and power off main power switch then keep the key properly.

### **Short-term storage**

Short-term storage refers to storage period which does not exceed 2 months. Drill shall be kept in a garage with excellent ventilation and it shall be far away from combustible, explosive and volatile articles. It must be covered by firm and durable coverage if there is no garage.

Please refer to engine usage manual for maintenance.

Please refer to usage manual of mud pump for maintenance.

## Appendix A Mud Consumption

Guarantee sufficient mud in the hole during drilling and re-expanding for smooth construction. Mud demand shall be determined according to dimension of re-expanding hole, back towing materials and nozzle dimension.

Please refer to following list for the minimum mud consumption required by drilling under complete soil layer conditions. Mud consumption during actual construction shall be larger than value in the list or construction may be invalid due to poor cooling or lubrication in the hole.

Diameter of re-expanding drill bit (or back towing pipe)		Gallon/foot	Liter/meter
5'	12.70 cm	1.02	12.67
5.5'	13.97 cm	1.23	15.33
6'	15.24 cm	1.47	18.24
6.5'	16.51 cm	1.72	21.41
7'	17.78 cm	2	24.83
7.5'	19.05 cm	2.29	28.50
8'	20.32 cm	2.61	32.43
8.5'	21.59 cm	2.95	36.61
9'	22.86 cm	3.30	41.04
9.5'	24.13 cm	3.68	45.73
10'	25.40 cm	4.08	50.67
10.5'	26.67 cm	4.5	55.86
11'	27.94 cm	4.94	61.31
11.5'	29.21 cm	5.4	67.01
12'	30.48 cm	5.88	72.97
12.5'	31.75 cm	6.37	79.17
13'	33.02 cm	6.9	85.63

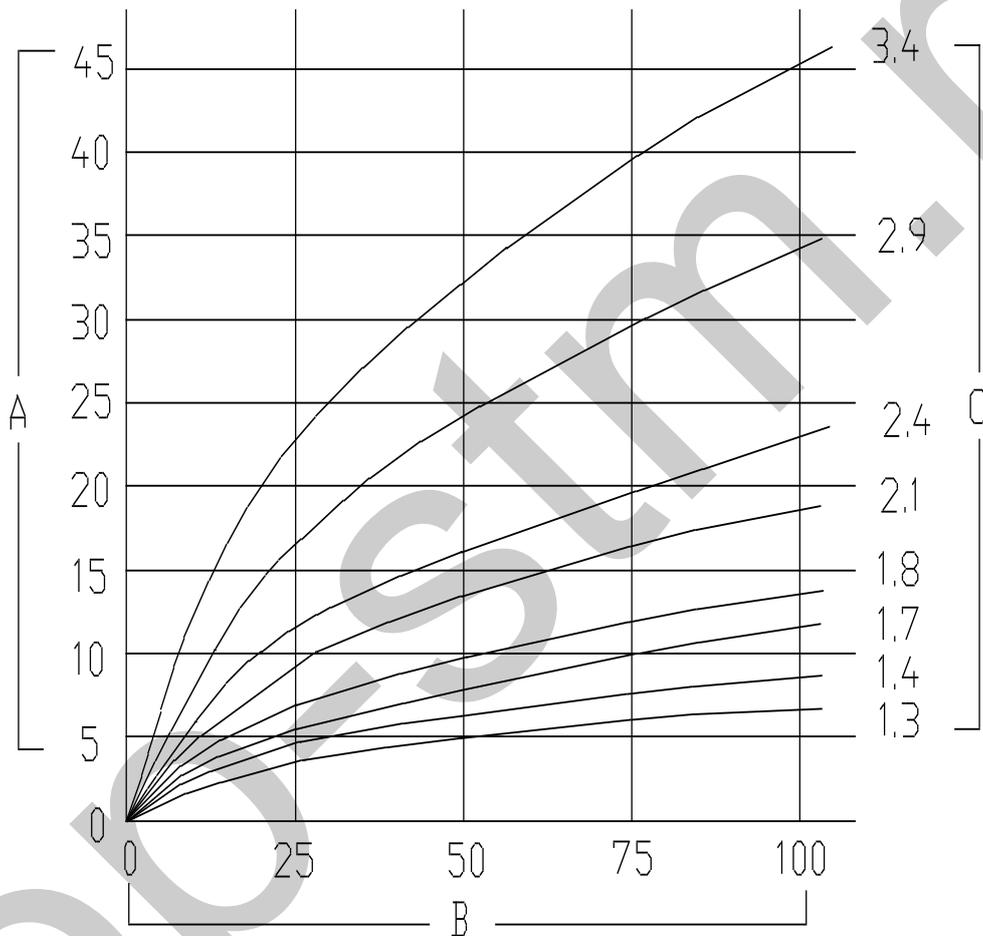
Diameter of re-expanding drill bit (or back towing pipe)		Gallon/foot	Liter/meter
13.5'	34.29 cm	7.44	92.35
14'	35.56 cm	8	99.31
14.5'	36.83 cm	8.58	106.54
15'	38.1 cm	9.18	114.01
15.5'	39.37 cm	9.8	121.74
16'	40.64 cm	10.44	129.72
16.5'	41.91 cm	11.11	137.95
17'	43.18 cm	11.79	146.44
17.5'	44.45 cm	12.79	155.18
18'	45.72 cm	13.22	164.17
18.5'	46.99 cm	13.96	173.42
19'	48.26 cm	14.73	182.92
19.5'	49.53 cm	15.51	192.68
20'	50.8 cm	16.32	202.68
20.5'	52.07 cm	17.15	212.94
21'	53.34 cm	17.99	223.46
21.5'	54.61 cm	18.86	234.23
22'	55.88 cm	19.75	245.25
22.5'	57.15 cm	20.65	256.52
23'	58.42 cm	21.58	268.05
23.5'	59.69 cm	22.53	279.83
24'	60.96 cm	23.5	291.86
24.5'	62.23 cm	24.49	304.15
25'	63.5 cm	25.5	316.69
25.5'	64.77 cm	26.53	329.49

26'	66.04 cm	27.58	342.53
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**Appendix B Nozzle Flow**

Nozzle dimension shall be selected according to mud pressure and the minimum mud flow per minute. Actual mud flow shall be larger then the minimum mud flow per minute.

Please refer to Figure 16 for pressure and flow curve with different nozzle



diameters.

Figure 16 Relation diagram of pressure and flow

In Figure 15: A:Flow of every nozzle; Unit: Liter/minute;  
 B:Nozzle pressure; Unit: Kilogram/centimeter<sup>2</sup>;  
 C:Nozzle diameter; Unit: Millimeter;

**Appendix C The Maximum and Length of Tow Pipes**

Please refer to following list for the maximum operating capacity of XZ320

## *Manual of XZ320 Horizontal Directional Drill*

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horizontal directional drill. (Actual capacity relates to soil quality and mud greatly and the list is only for reference.)

Diameter of drill bit and the maximum length of tow pipe (or steel tube)

Diameter of drill bit and the maximum length of tow pipe (or plastic tube)

Diameter of drill bit, $\varphi$ (mm)	The maximum length of tow pipe (m)
152	840
159	785
168	730
173	715
180	675
194	655
203	644
219	558
245	525
273	494
299	470
325	447
351	425
377	407
402	390
426	375
480	346
530	300
630	262
720	237
820	213
920	179
1020	133

Diameter of drill bit, $\varphi$ (mm)	The maximum length of tow pipe (m)
63	1076
75	1068
90	1057
110	1038
125	1027
140	1006
160	982
200	927
225	891
250	853
315	756
400	636
500	514
630	392
800	281
1000	210
1200	205



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