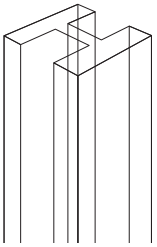


# G2 series 1.5-2t

Three-wheel Battery Counterbalanced
Forklift Trucks (For North American Market)

# OPERATION & SERVICE MANUAL

HELI 安徽合力股份有限公司
ANHUI HELI CO., LTD.

# FOREWORD

AC type three wheeled forklift truck with front drive is designed on the base of advantages of some trucks made by domestic and foreign manufacturers and developed in introduced technology from abroad to meet the market needs. These trucks are all suited for handling and stacking packed goods in stations, ports, goods yards, warehouses, food processing factory, light and textile industries and other factories. Because the AC type three wheeled forklift truck with front drive has small turning radius so it is more suitable for narrow working space such as supermarket and enterprise with high requirement on land usage rate. With some of attachments fitted, the trucks can be applied more and more.

These trucks feature a wide-visible hoisting system, full powered steering unit, drive axle with automatic brake, continuous speed control, overhead guard with opened port, high quality motor, battery, MOSFET electric controller and liquid crystal combined meter with large screen so they have a lot of advantages such as good performance, easy operation, wide visibility of operator, flexible steering, reliable braking, powerful and smooth power, low noise, no contamination to environment and beautiful contour.

This manual states the trucks' specifications, operation, maintenance, service, main assemblies' constructions and working principles so as to help operators to use the trucks correctly and attain the highest functions. It is necessary to read over the manual before they operate the trucks or service personnel serve these trucks. The rules and notices in the manual should be abided seriously by relative personals to enable trucks in optimized working state for long period and bring highest efficiency.

Because of the limit of space and editing, the figures, drawings, parts and such diagram illustration used in the manual do not have actual proportion. So size or mass can not be gained from diagram accurately.

This manual content might not correspond with the actual condition because of the improving of our products. Our products are subject to improvements and changes without notice.

# CONTENTS

## I. Safety Rules for Operation and Daily Maintenance of Forklift Truck

It is important that driver and manager for forklift trucks remember the principle of the "first safety" and ensure the safety operation as the description in《OPERATION AND SERVICE MANUAL》&《OPERATION MANUAL》.

### 1. Delivery of Forklift Truck

It must be pay attention to the following items when you deliver forklift trucks with container or trucks.

(1) Apply the parking brake.

(2) Fix the mast and the balance weight with steel wire. Wedge up all wheels.

(3) Sling points should be always at the positions specified in sling index plate when hoisting up the forklift truck.

### 2. Storage of Forklift Truck

(1) Drain off fuel completely. Don't drain off the cooling water containing antifreeze and rustproof agent.

(2) Apply antirust to the surface of the parts not painted. Apply lubrication oil to the lift chain.

(3) Lowing the mast to the lowest position.

(4) Apply the parking brake.

(5) Wedged up the wheels.

### 3. Precautions Before Operation

(1) Don't check fuel leakage and lever or instruments at the place where there is open flame. Never fill the fuel tank with the truck running.

(2) Check the tire inflation pressure.

(3) The forward-reverse lever should be in neutral.

(4) Check all the levers and pedals.

(5) Complete the provisions before starting.

(6) Release the parking lever.

(7) Make trying operation of the mast for lifting, lowing and Fwd/Bwd tilting and the truck for steering and braking.

**4. Operation of Forklift Truck**

(1) Only trained and authorized operator shall be permitted to operate the truck.

(2) Wear all the safety guards, such as shoes, helmet, clothing and gloves while operating the truck.

(3) Check all the control and warning devices before starting the truck. If any damages or defects are found, operate it after repairing.

(4) At the rated loading center, either overload or overload operation is strictly prohibited. The center of cargo should be in line with the frame center, not out of the line. The fork should insert completely under the cargo and make the cargo placed on it evenly. Do not raise an object with one fork end.

(5) The starting, turning, driving, braking and stopping operation of the truck should be done smoothly. When steering on the humid or low friction road, the truck should be decelerated.

(6) Travel with loads as low as possible and tilted backward.

(7) Be careful when traveling on a slope. When climbing grades with a slope of more than 10%, the truck should forward travel, and when descending so grades, backward travel. Never turning on a slope. Avoid loading and unloading operation when descending.

(8) Pay attention to pedestrian, obstacle and bumpy road when driving. Pay attention to the clearance over forklift truck.

(9) Never allow any persons to stand on the forks or the truck to carry persons.

(10) Never permit anyone to stand or walk under upraised forks.

(11) Don’t operate truck and attachment of it at any position out of the drive seat.

(12) On the high lift forklift truck, when the lift high more than 3m, it is noted that the goods on it should not fall down or the protection measures must be taken if

necessary.

(13) Tilt the mast of the high lift forklift truck as backward as possible while the truck working. Use minimum forward tilt angle and Min. reverse tilt when loading and unloading.

(14) Be careful and slowly driving over a dockboard or bridge-plate.

(15) Shut down the truck and don't stay on the truck when checking battery or fuel lever.

(16) The unloaded forklift truck with attachments should be operated as a loaded truck.

(17) Don't handle unfixed stacked goods. Be careful to bulky goods to be handled.

(18) If leaving the truck, lower the forks on the ground and let the shift lever to neutral, shut down the engine or cut down electric supply. If parking on a slope is unavoidable, apply the parking brake and block the wheels.

(19) Don't adjust the control valve and relief valve at will to prevent the damage of hydraulic system and its components because of excessive pressure passing them.

(20) Inflate a tyre according to it's stated air pressure. Never over inflate a tyre.

(21) According to the measure method specified in JB/T 3300, the max. noise at the outboard of the truck should be not more than 80dB(A).

(22) Be familiar with and pay attention to the functions of the decals on the forklift trucks.

**5. Application environment**

1) Environment temperature: -25℃ ~ +40℃;

2) Relative humidity: <90%;

3) Altitude: <1200m.

**6. Daily Maintenance of Forklift Trucks**

(1) Inspection before startup

a) Hydraulic oil volume: oil level should stay in the middle of oil meter scale;

b) Check piping, joints, pumps and valves for leaks or damages;

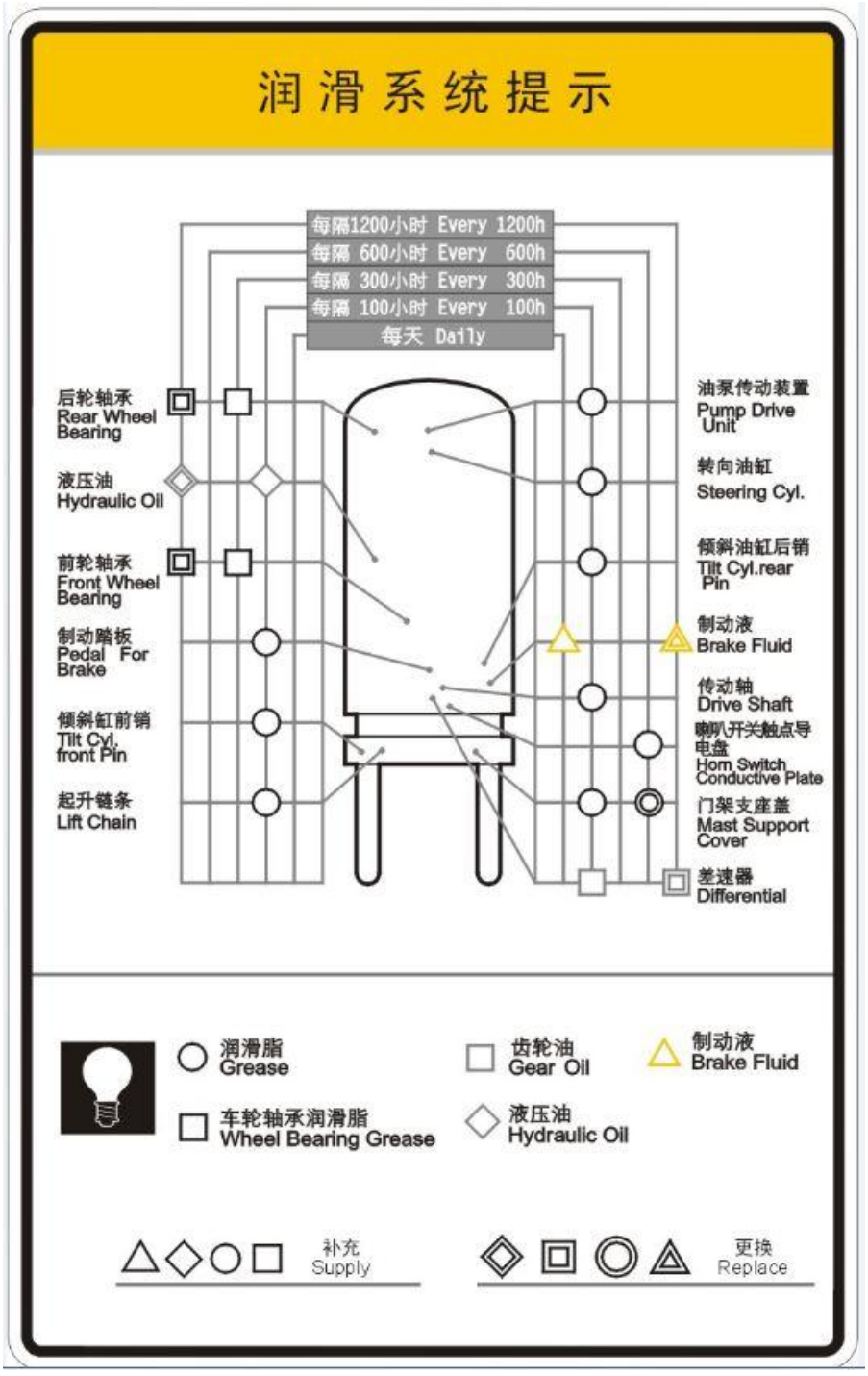
c) Check parking brake. The unladen truck can park on the 15% grade ramp, when the parking lever is pulled to the bottom;

d) Check instruments, lighting, switches and wiring to see if they work normally or not.

(2) Oil used for forklift trucks

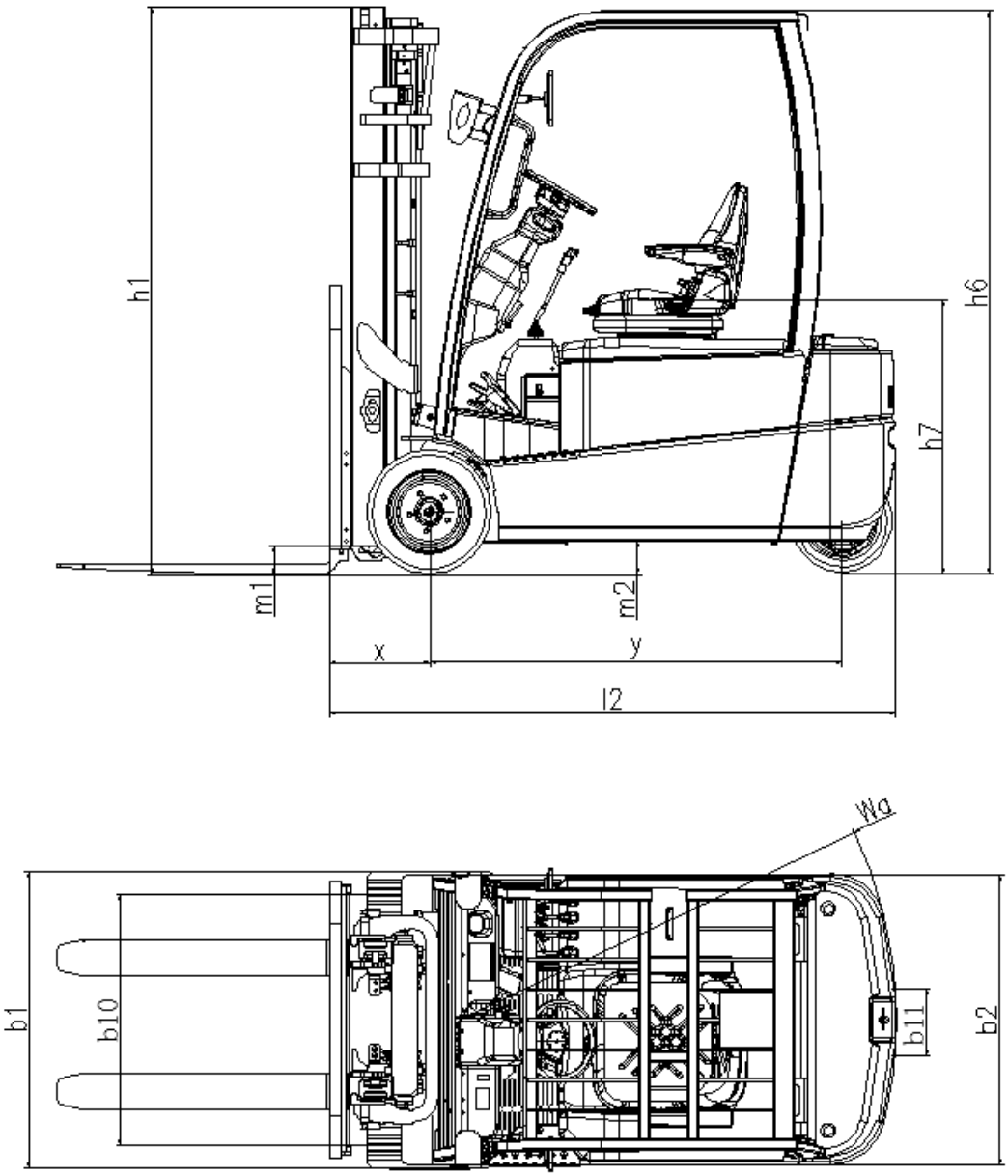
| Name | Recommended brand | Brand and temperature of using | | |
|---|---|---|---|---|
| Hydraulic oil | Chang cheng | Sticky grade | L-HM32 wearable hydraulic oil | L-HV32 low temp. wearable hydraulic oil |
| | | Temp. of using (℃) | ⩾-5 | ⩾-20 (cold region) |
| Lubricating grease | Chang cheng | 3# lithium base grease (-20℃～+120℃) | | |
| Gear oil of heavy-laden truck | Hai pai | Sticky grade | 85W/90GL-5 | 80W/90GL-5 |
| | | Temp. of using (℃) | -15～+49 | -25～+49 |

(3)Lubrication chart




Note: for the truck without brake liquid, it is not necessary to refer to the chart for relative operation.

## Ⅱ. Main Specifications of Forklift Truck




Enternal view of forklift trucks

Main specifications

| Model | Unit | | | CPD15SQ | | CPD18SQ | | CPD20SQ | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | GB | | GB | | GB | |
| Rated capacity | lb | kg | | 3000 | 1500 | 3500 | 1750 | 4000 | 2000 |
| Load center | in/mm | | | 24/500 | | | | | |
| Lifting height | in/mm | | | 130/3300 | | | | | |
| Free lifting height | in/mm | | | 3.5/90 | | | | | |
| Mast tilt angle(front/rear) (K/T) | deg. | | | 5/7 | | | | | |
| Fork size(L*S*E) | in/mm | | | 42.1×3.9×1.4/ 1070×100×35 | | | | 42.1×4.8×1.6/ 1070×122×40 | |
| wheel base F | in/mm | | | 51/1292 | | 55/1400 | | 55/1400 | |
| Front tread (b10) | in/mm | | | 35.8/910 | | 36.2/920 | | 36.2/920 | |
| Rear tread(b11) | in/mm | | | 6.4/163 | | 7.1/180 | | 7.1/180 | |
| Overall length (without fork)l2 | in/mm | | | 114.6/2912 | | 118.8/3020 | | 118.8/3020 | |
| Overall width (b1) | in/mm | | | 42/1060 | | 44/1120 | | 44/1120 | |
| Overall height （mast h1) | in/mm | | | 84/2160 | | 86/2175 | | 86/2175 | |
| Overall height （overhead guard h6) | in/mm | | | 80/2040 | | | | | |
| Seat height h7 | in/mm | | | 370/940 | | | | | |
| Underground clearance (at mast) m1 | in/mm | | | 3.3/85 | | 3.5/90 | | 3.5/90 | |
| Underground clearance(truck frame) m2 | in/mm | | | 3.9/100 | | 3.9/100 | | 3.9/100 | |
| Min. steering radius Wa | in/mm | | | 58/1477 | | 62/1585 | | 62/1585 | |
| Travelling speed(loaded/unloaded) | 36 V | mph | km/h | 8.7/8.7 | 14/14 | 8.7/8.7 | 14/14 | 8.7/8.7 | 14/14 |
| | 48 V | | | 9.9/10.5 | 16/17 | 9.9/10.5 | 16/17 | 9.9/10.5 | 16/17 |
| Lifting speed(loaded/unloaded) | 36 V | fpm | mm/s | 66.9/98.4 | 340/500 | 64.9/98.4 | 330/500 | 63/98.4 | 320/500 |
| | 48 V | | | 84.6/118 | 430/600 | 84.6/118 | 430/600 | 78.4/118 | 400/600 |
| Lowering speed(loaded/unloaded) | fpm | mm/s | | 98.4/78.4 | | | 400/500 | | |
| Gradeability (loaded/unloaded) | % | | | 20/33 | | | | | |
| Tyre size | Front | | | 18x7-8 | | 200/50-10 | | | |
| | Rear | | | 140/55-9 | | 140/55-9 | | | |
| Traction motor | HP | kW | | 4.7X2(AC) | | 4.7X2(AC) | | | |

| Oil pump motor | HP | kW | | 11 (AC) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Battery capacity | 36 V | Ah | Kwh | 880 | 30.6 | 1100 | 38.2 | 1100 | 38.2 |
| | 48 V | Ah | Kwh | 660 | 30.5 | 770 | 35.8 | 770 | 35.8 |
| Min. battery weight | lb | Kg | | 1700 | 772 | 2100 | 953 | 2100 | 953 |
| Service mass( with min. battery) | lb | Kg | | 6925 | 3144 | 7612 | 3456 | 8088 | 3672 |

Dimensions and weight of main removable parts

| Items | Truck model | Unit | CPD15SQ | CPD18SQ | CPD20SQ |
|---|---|---|---|---|---|
| | | | GB | GB | GB |
| Counterweight | Max. outline dimensions | mm | 425×1060×775 | | |
| | Weight | kg | 750 | 890 | 950 |
| Overhead guard | Max. outline dimensions | mm | 1238×1030×1541 | 1292×1030×1541 | |
| | Weight | kg | 65 | 75 | |
| Mast （lifting height 3300mm） | Max. outline dimensions | mm | 1267×1010×2075 | 1267×1086×2075 | |
| | Weight | kg | 577 | 604 | |

## Ⅲ. Construction, Principle, Adjustment and Maintenance of Forklift Trucks

### 1. Transmission system

### 1.1 General description

The transmission system of the three wheeled forklift truck includes transmission system we call traditionally and brake system. Front wheel dual driving motor structure makes the right and left wheel of three wheeled truck has drive axle, redactor, brake and driving motor independently to improve working efficiency. Transmission unit is assembled inside of drive axle housing while brake is assembled on motor shaft. The structure is compact.

Truck travelling speed is increased with the increase of motor speed; travelling direction is changed with motor rotation direction; The sensor installed on rear wheel sends information to drive motor controller on right and left front wheel, after receiving different information, right and left front wheel give out different speed and thus steering of the truck is realized. The steering of the three wheeled truck is realized through electric differential. The system has no bevel gear which thus not only improves working efficiency but also reduce bevel gear noise.

1.1.1 Front wheel assembly

Front wheel is made up of solid tyre and rim. Refer to the following for front wheel and rim model:

| Model / Tyre parameters | | CPD15SQ | CPD18SQ | CPD20SQ |
|---|---|---|---|---|
| Model | Super elasticity | 18×7-8 | 200/50-10 | 200/50-10 |
| | Rim | 4.33R | 6.50F | 6.50F |

## 1.2 Disassembling of transmission system

Disassemble the front wheel assembly and travelling motor first before disassemble transmission box. Then parts inside of the transmission box can be repaired or maintenance.

1.2.1 Removal of the wheels

Drain off the gear oil inside of the transmission box before disassembling. Loose 6 drive nut and remove drive wheel. Then loose the 7 bolts on frame (2 are M14 x1.5x 50 bolts and 5 are M14x1.5x100 hexagon socket bolts and remove transmission box connected with travelling motor from frame. Refer to figure 1-1.

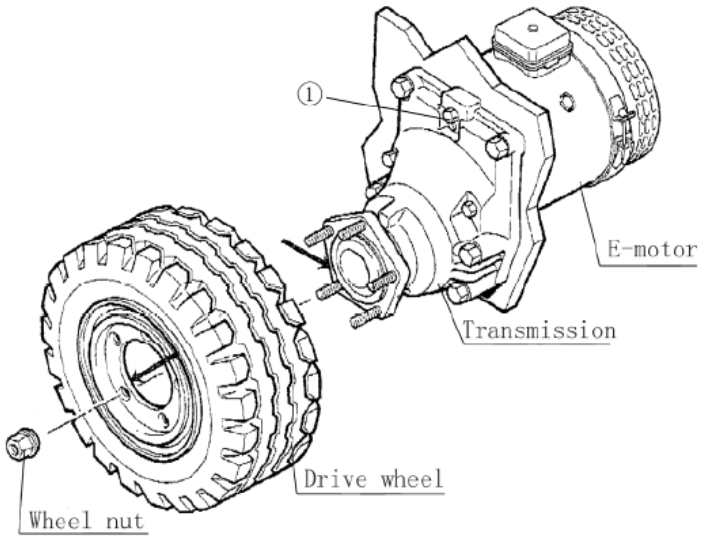



Figure 1-1

1.2.2 Removal of travelling motor

Refer to figure 1-2 to remove the bolts fixing travelling motor (one is M8 x50, and two are M8 x75).

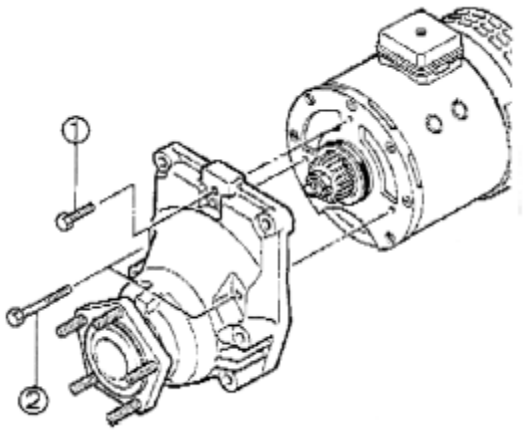



Figure 1-2

NOTE: Take care when removing motor from transmission box.

Take care not to damage the sealing surface for the O-ring in the housing! If only the motor is removed, the released transmission opening is to be sealed in order to avoid that dirt can get inside the transmission.

1.2.3 Disassembling and assembling of transmission box

It is not necessary to disassemble this part normally. If has to, please contact HELI sales company.

**1.3 Assembling of transmission system**

1.3.1 Assembling of travelling motor

Before assembling, clean the contacting face between transmission box and motor with cleanser (for example loctite 706 or alcohol) then make it dry. Check if the contactor is damaged, if there is slight damage, remove it with oil stone. Refer to figure 1-3.

Note: cleansers can not come into contact with the skin ,they must not be swallowed and their vapors must not be inhaled. Always use protective gloves and goggles. If a cleanser has been swallowed inadvertently, call medical help immediately. Pertinent instructions of the manufacturer should be duly noted.

(1) Clean motor shaft (part1) and taper bore of drive pinion (part 2) carefully

(2) Insert woodruff key (part 3) into motor shaft and push drive pinion on.

(3) Screw a new stopping nut (part 4) on and tighten with socket wrench. Tightening torque:55 Nm(M20 × 1,taper φ 25);68 Nm(M14 × 1.5,taper φ 20)

(4) Coat O-ring (part 5) slightly with transmission fluid and push it onto centering seat of motor.

(5)Place the motor carefully on the transmission and join the gearings of motor pinion and helical gear carefully.

**Attention: Do not knock with the drive pinion against the helical gear while installing the motor. This can cause knocking noise.**

(6) Turn motor to coincide bore pattern of transmission with bore pattern of motor.

(7)Screw motor to transmission with three hexagon bolts.(parts1 and 2)(1×M8×50 and 2×M8×75) Tightening torque: 23 Nm.

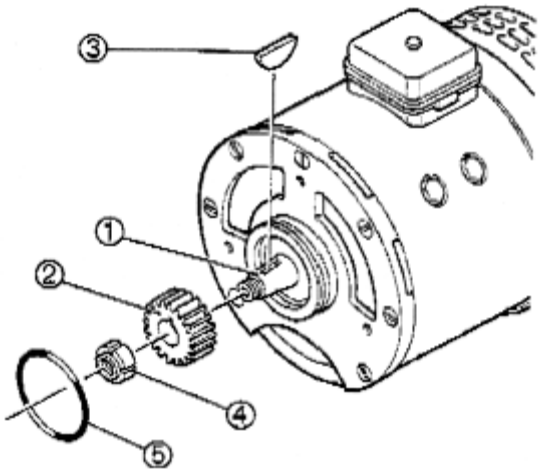



Figure 1-3

1.3.2 Mounting the transmission unit to the truck frame

Check the frame surface for damage and irregularities. The maximum admissible irregularity in the area of the transmission contour shall be no more than0.1mm.Screw drive unit with 7 hexagon bolts M14 and shims to frame. Refer to figure 1-1.

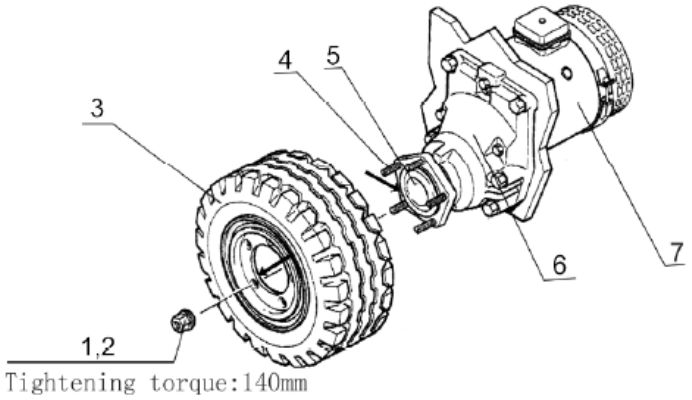
1.3.3 Assembling of wheels

The axle is applicable to solid tyre.

(1) Clean mating surfaces on wheel shaft and wheel thoroughly and check if it is damaged.

(2)The bore pattern in the rim should be in line with the bolts of the wheel shaft; then push the wheel on.

(3) Install hub nuts and tighten them. The tightening torque of it is 140Nm.(see Fig.1-4).




1. Bolt
2. Washer
3. Wheel
4. Nut
5. Wheel shaft
6. Transmission unit
7. Driving motor

Figure 1-4

1.4 Replenishing with Transmission Fluid

When a truck has been used for 1000 hours or one year, (The accurate time is according to the first reached time.) replace gear oil in differential and main reducer.

(1) Unscrew fluid filling plug (part 3) with sealing ring (part1), and let the gear oil out completely. Before screw fluid filling plug again, remove the dust on the plug. It is necessary to replace the sealing ring if it is damaged.

(2) Unscrew fluid filling plug (part 4) with sealing ring (part 2).

(3) Add gear oil to transmission box. During adding, air is not permitted to enter for bubble may be produced in the transmission box.

(4) Fluid capacity approx. 0.45 liters (standard value).The exact oil amount is determined by funnel.

(5) Gear oil model may be MOBIL ATF200 or ATF210 or ATF220；SHELL DONAXTM or ATFDEXRONⅡ D-21666 or DONAXTG PLUSD-22543 or DONAXTG

D-21126；ESSO TYPESUFFIXA or ATF　D-21065 or ATF　D-21611 or ATF D-22079.

(6)Screw fluid filling plug (part 1) with the sealing ring (part 2).Tightening torque: 22Nm. Refer to figure 1-5.

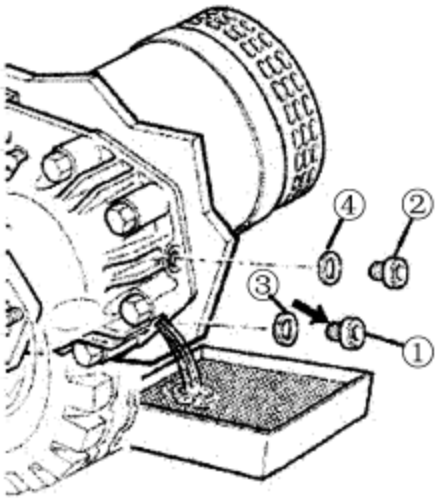



Figure 1-5

## 2. Brake system

### 2.1 General description

Brake system is made up of service brake and parking brake.

2.1.1Serivce brake

The service brake is made up of accelerating pedal, brake pedal, traction controller and traction motor.

During travelling, releasing the accelerating pedal slowly or quickly can reduce truck speed quickly and achieve brake effect. Brake effect in normal condition can be realized.

During travelling, Step the brake pedal (2) can achieve brake effect flexibly. Different brake effect can be achieved.

Note:

It is suggest for driver to getting familiar with the brake effect and functioning without load.

2.1.2 Parking brake

Electromagnetic parking brake which is installed on traction motor shaft is applied on three wheeled truck.

1) Automatic parking brake

When truck is braked or is stopped, electromagnetic parking brake is applied to lock traction motor output shaft. And thus the truck is stopped with parking brake.

When truck is stopped on a slope, the truck keep stopping through electric method ant then parking brake is started. And thus the truck is stopped with parking brake.

When operating direction switch and stepping on accelerating pedal at the same time, the electromagnetic parking brake is loosed automatically and truck can be operated normally.

2) Power-off parking brake

When key switch is turned off, emergency button is turned off or truck main power is disconnected, electromagnetic parking brake starts automatically. And thus the truck is stopped with parking brake.

**Danger:**

**Except under emergency case, it is prohibited to start electromagnetic parking brake through power-off parking brake. When electromagnetic parking brake is applied, do not tow the truck.**

## 3. Steering system

### 3.1 General Description

The function of steering system of forklift is to change the driving direction of the forklift or keep the forklift in straight line driving. The performance of steering system directly concerns with the driving safety, operation efficiency of forklifts and labor intensity of drivers. The steering system is divided into two categories of mechanical steering system (manual steering system) and power steering according to the power source of steering. The mechanical steering system is operated to overcome steering resistance moment fully by relying on the force and skill of driver, while in power steering system, the energy consumed to overcome the steering resistance moment is provided by prime mover and the driver can operate the system to control the turning direction with very small force.

As requested by the working characteristic of the forklifts, the operation site and driving pass are relatively narrow, changing-over is frequent and the minimum radius turnings are often needed, therefore, the steering system is required to be reliable and light in operation. Since the load of steering axle occupies about 60% of the vehicle weight in case of idling, G-series three-wheeled forklifts produced by our Co. adopt electric power steering system to alleviate the labor intensity of the driver.

### 3.2 Working Principle

When the truck is steering, the operator applies steering moment on steering wheel (steering operation mechanism) to make steering wheel produce rotation displacement which is transmitted to steering senor through steering axle. The sensor transmits the signal to steering control unit according to steering wheel’s rotation angle, rotation speed. And the steering control unit controls control motor to output corresponding steering speed and moment.

Electric steering device controls power transmitting to steering mechanism from steering motor by electric signal. Thus the truck has higher efficiency because hydraulic oil is not used as transmission medium. Meanwhile, the steering sensor has moment feedback function. The electric steering device will feed moment back according to truck travel speed, steering resistance and steering wheel rotation speed to ensure that the truck is safer and the operation is more comfortable.

### 3.3 Composition of Steering System

(1) Steering operation mechanism

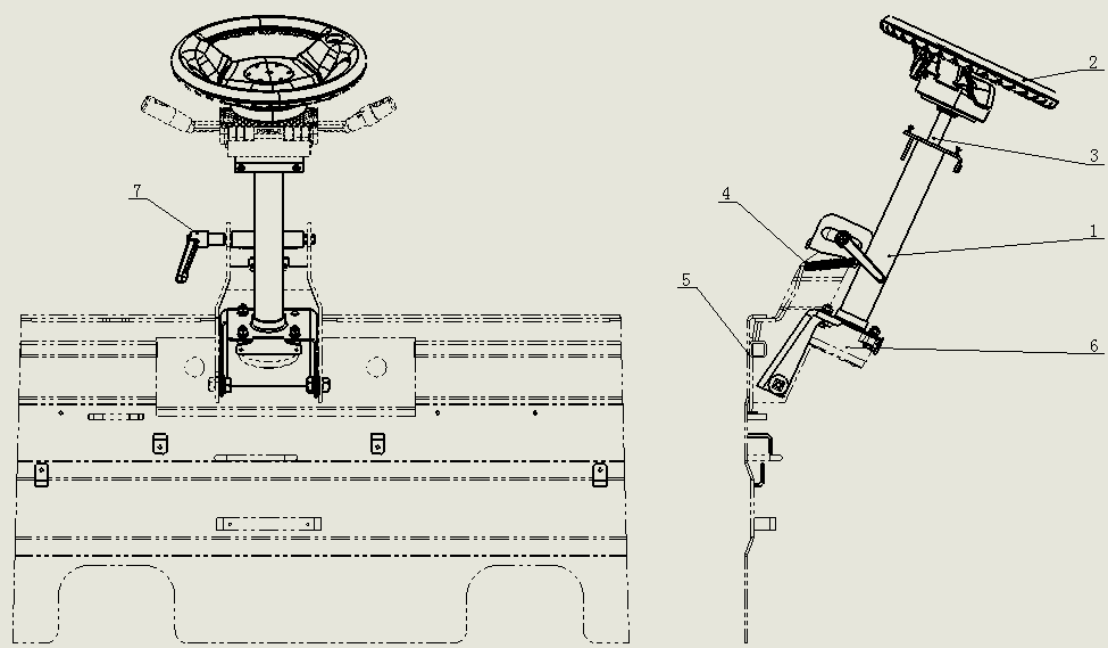



Figure 3-1 Steering unit

(1) Steering column (2) Steering wheel (3) Coupling shaft (4) Return spring
(5) Dashboard (6) steering sensor (7) lock handle

The operation mechanism of the truck mainly consists of steering wheel, tubular column, coupling, steering gear and mounting support etc (as shown in Fig.3-1). They are fixed on the instrument panel by mounting support, steering wheel, tubular column and coupling are connected together. The steering gear is fixed at the lower end of coupling and the rotation of steering wheel will bring along the steering gear. Adjustment of

handle can adjust the steering wheel to the comfortable position that drivers feel.

(2) Steering sensor

The steering sensor transmits steering signal to steering control unit according to steering wheel rotation angle and steering speed and meanwhile the steering sensor receives the feedback signal from steering control unit to adjust feedback moment.

(3) Steering transmission mechanism

The steering control unit makes steering motor output corresponding moment and speed according to signal transmitted by steering sensor. Then the moment and speed are transmitted to steer wheel through deceleration gear mechanism to make the steer wheel rotate with a certain angle.

The steering axle of the truck is made up of steering control unit, steering motor, deceleration gear mechanism, steering wheel axle, steer wheel and so on.

See table 3-1 for tyre and rim model of steering axle.

| Truck capacity | 1.5t、1.8t、2t |
|---|---|
| Tyre | 140/55-9 |
| Rim | 4.00 E-9 |

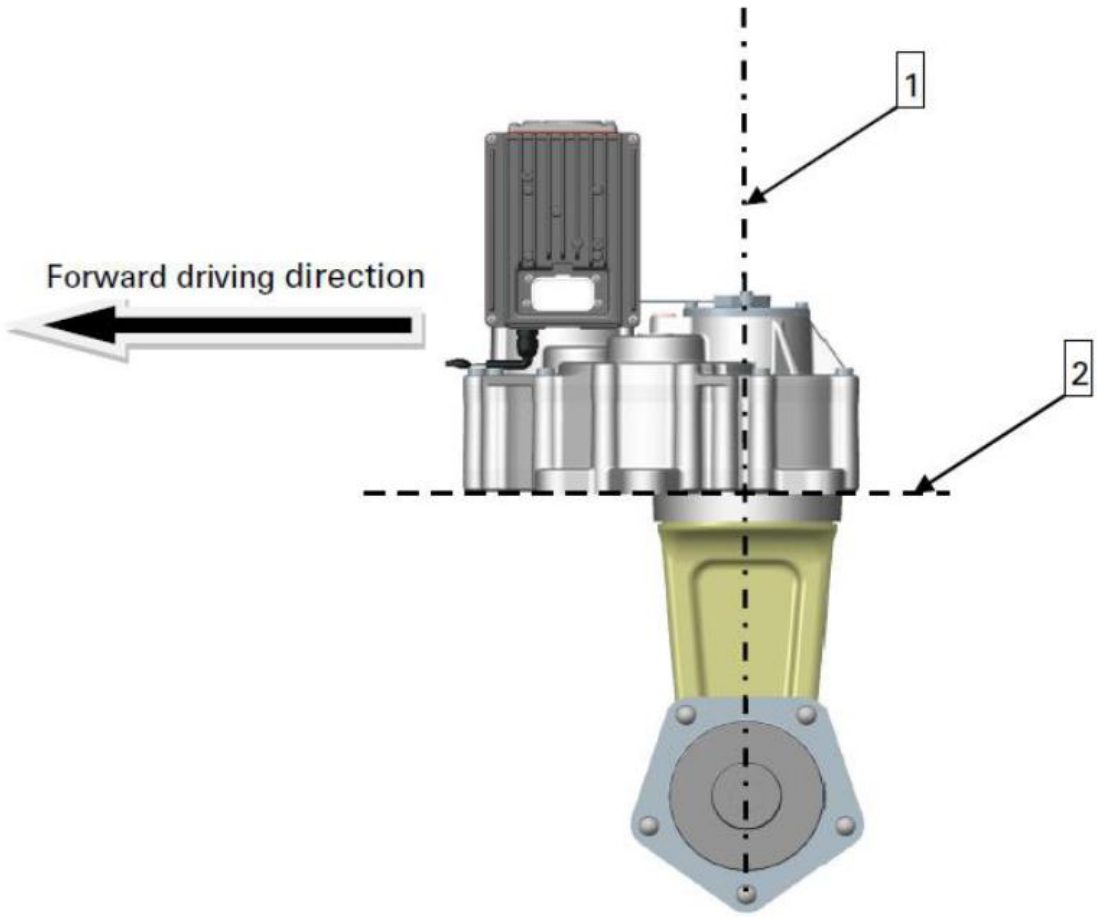



Figure 3-2 Steer axle

Position of EPS with vertical (1) and horizontal (2) reference plane of the vehicle.

### 3.5 Assembling

(1) See figure 3-3, first pre-tighten the 5 hub nuts;

(2) Tighten the hub nuts with regulated torque in a diagonal way.

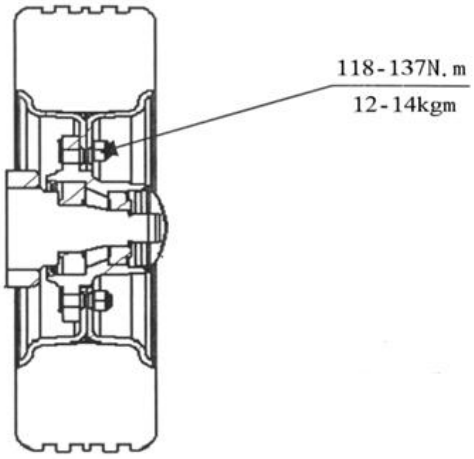



Figure 3-3 Assembling of steer wheel

**4. Electric system**

4.1 General description

The standard configuration of G2 series 1.5-2t is a full AC type control system. It can succeed in operating the forklift low-noisily, efficiently, smoothly and safety.

The electric system is composed of instrument, traction control system, lifting control system, steering control system, battery pack, control switch, lighting and wiring harness etc.

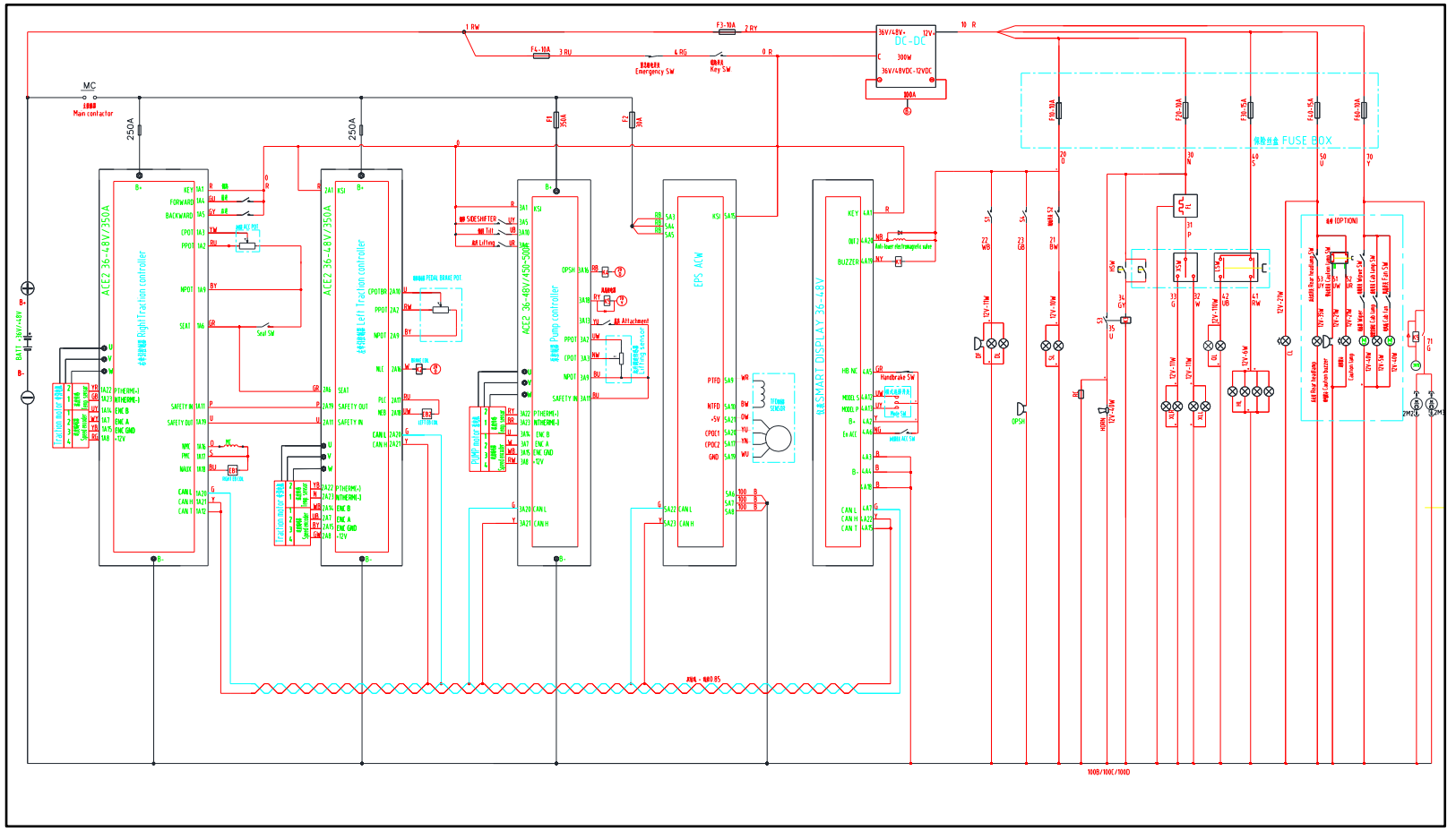
Thereinto, the traction control system is made up of direction switch, acceleration pedal, brake pedal, electromagnetic brake, traction motor and traction controller.

Lifting control system is made up of valve control switch, lifting motor and lifting controller.

The steering control system is made up of TFD sensor (to send order signal), steering angle sensor ( to feedback steering angle), steering control module and AC type steering motor and so on.

**Notice: Our Company has the right to improve on the production. Please contact with our company if there is any difference between the product and the manual.**

The circuit diagram of electric system are shown in the figure below.



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HL width lamp | QL head lamp | RC horn filter | SSW braking SW | SL brake lamp | CL caution lamp | FL flasher | LSW lamp switch |
| XLL turning lamp(left) | DL reverse lamp | Horn | XSW turning lamp SW | XLR Turning lamp (right) | DF reverse buzzer | HSW horn SW | OPSH warning buzzer |
| K1,S1 reverse relay | K2,S2 brake relay | K3, S3 horn relay | K4, S4 OPS relay | | | | |

Figure 4-1electric system principle diagram

## 4.2 Instrument

(1) Display of the instrument

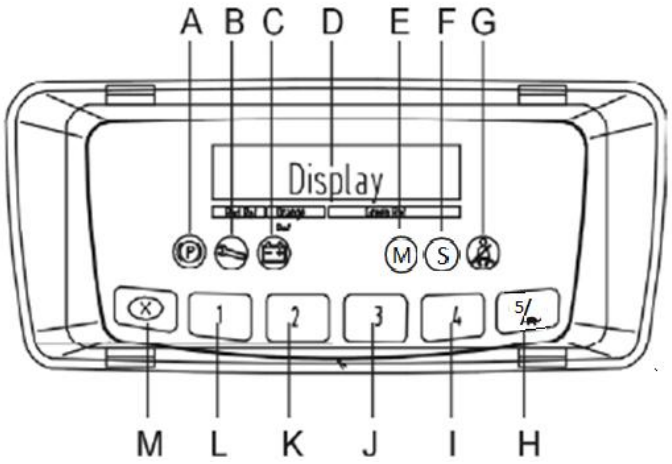



Fig. 4-2 Display of the ZAPI SMART instrument

(A) Hand brake condition indicator (B) Fault LED (C) Low state of battery LED (D) LCD (E) Moderate traction speed working indicator
(F) Low traction speed working indicator (G) Warning lights for seat switch
(H) High/moderate/low speed switch/Out button (I) Set down key
(J) Parameter setting key (K) Roll down key (L) Roll up key (M) Menu key

(2) Function and application

SMART DISPLAY is an intelligent dashboard connected to the truck system by CANBUS line. This dashboard provides the diagnostic and set-up of the whole truck system.

Connecting the ZAPI handset or PCWIN tool to SMART DISPLAY, it is possible to read and modify the setting of all the modules present on the CANBUS net. The display implements an interface to the operator through a main page and a number of submenus.

a) Turn on the key switch. When the instrument gets power “HELI AC SYSTEM” is displayed on the LED screen. After system self-testing, battery capacity, truck speed and traction hours will be indicated on the main page.

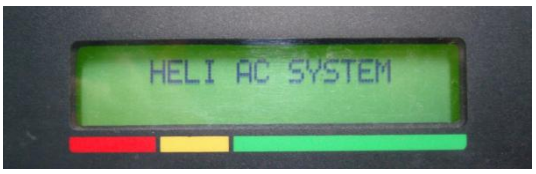



Fig. 4-3 Display of the ZAPI instrument when power on (fault-free)

b) Battery capacity display: There are 20 grids on the battery capacity indicator. After the truck is powered, the indicator is fully lit (20 grids) if the battery is fully charged. After battery discharge, the battery capacity is reducing, so are the grids of the indicator. When 20 grids of the battery capacity indicator are all off, the fault warning symbol and battery low symbol will flash at the same time and the travelling speed slow down, lifting action cut off. Charge the battery in time.

c) Traction travelling mode display: the driver can choose the mode through the switch except under hand console mode. When M indicator turns on, the truck is travel with medium speed; when S indicator turns on, the truck travels with slow speed; when both M and S are off, the truck travels with high speed.

d) Fault code display : If fault appears, is often on and refer to Table 4-2 for the fault code (the first line) displayed in the WINDOW， the control module No. (the second line) of CANBUS net where the fault happens and CANBUS net information of ZAPI.

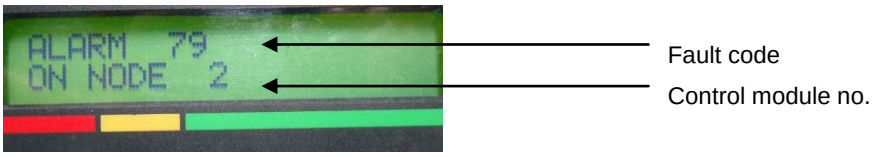



Fig. 4-4 Fault display interface of ZAPI instrument

Table 4-1 ZAPI CANBUS net information

| Number associated in CANBUS net | Module |
|---|---|
| 02 | TRACTION |
| 03 | TRACTION MASTER |
| 04 | TRACTION SLAVE |
| 05 | LIFTING |
| 06 | EPS-AC |
| 16 | SMART DISPALY |

## 4.3 Controller

### 4.3.1 General description

The three wheeled forklift of this series adoptsZAPI ACE2 motor controller imported from Italy, so it has advantages of advanced technology of high frequency

MOS tube, superior speed regulating performance, good safety, flexibility and first-class protection etc.

The controller assembly includes controllers for traction system, lifting controller, contactor, relay set, OPS warning buzzer and the related harness.

**4.3.2 control device**

技术要求:

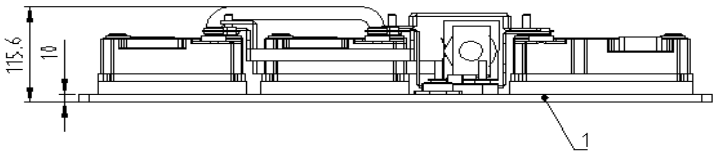
1.控制器总成各零部件表面应平整，不得有飞边，毛刺，铜排表面吹套黑色热缩套管;

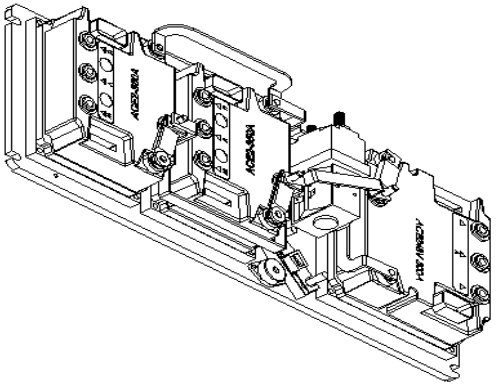
2.电控装置中的各部件必须安装牢固，部分部件拧紧力矩见表1，安装螺钉不得露出安装底板;

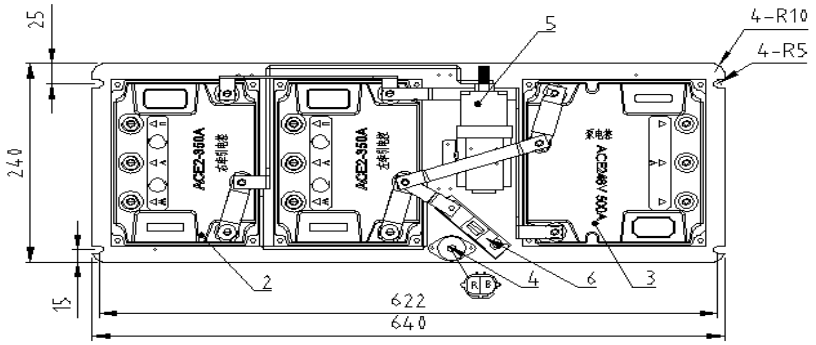
3.请在图示合理且明显位置粘贴相应标贴B+，B-；

4.电器元件按图示位置布置;

5.电控总成上所有接线桩头均加装烟斗护套或其它绝缘处理;






| | | | | |
|---|---|---|---|---|
| 6 | FUSE 30A | 30A 保险丝 | 1 | 部件 |
| 5 | AE772-41031 | 主接触器SW200-497 | 1 | 部件 |
| 4 | QLB2.041G.701 | OPS蜂鸣器 | 1 | 部件 |
| 3 | ACE2 36-48V/500A | 泵控制器 | 1 | 成品 |
| 2 | ACE2 36-48V/350A | 牵引控制器 | 2 | 成品 |
| 1 | QLB7.749.1D1 | 电控底板 | 1 | 铝 |

Figure 4-5 Electric control system

A) Traction and pump motor controller

Tractor motor controller type: ZAPI ACE2 48V/350A

Pump motor controller type: ZAPI ACE2 48V/500A

- ACE2 controller which is three phase AC asynchronism motor inverter controls traction motor and pump motor. It has regenerative brake function, CAN bus port and digital control function (based on motor speed feedback).
- Allowable working environment temperature: -30℃~+40℃， Max. allowable working temperature: 85℃.
- Protection function of the ACE2 traction motor controller:

a) battery polarity protection b) incorrect connection protection

c) over heat protection; overload protection; short circuit protection

d) controller protection degree:IP65;

e) out of control protection f) battery over discharging protection

g) Mis-starting protection

- The following functions can be realized through controller's hand console:

a) On line inspection and adjusting on traction and lifting control system

b) On line correction on travelling accelerator and lifting speed adjusting signal

c) Fault detection and inquiry on traction and lifting control system

**Important Note:**

◆ Test the truck with wheels raised after the controller being fixed, in that case there will be no danger even the connection is in error.

◆ A certain amount of voltage will remain in filter capacitance after the turn off of the electric switch. Cut off the battery and make the remained voltage short circuit by connecting the 10-100ohm resistance to the inverter before checking the inverter.

◆ The quality is assured by the producer. When there is a fault, inform the producer of the after-sale service. Do not repair as will unless getting the permission from the

producer. Or the user should bear the personal and property damage caused by the unauthorized repair by oneself.

### 4.4 Motor

#### 4.4.1 Specifications of motors

The motors used in each system are free-maintenance three phase AC induction motors.

Table 4-2 Motor specifications

| | Driving motor | Pump motor | Steering motor |
|---|---|---|---|
| Power | 4.7x2 | 11KW | 0.4KW |
| Voltage supplied by battery | 36V/48V | 36V/48V | 36V/48V |
| Rated current | 150A | 307A | |
| Speed | 4700 rpm | 1750rpm | 2500rpm |

**Notice: In case of backfire, one must shut off the power when checking and maintaining the motor.**

### 4.5 Battery

#### 4.5.1 Specifications of battery

Table 4-3 Specifications of battery (standard)

| Item \ Model | CPD15SQ-GB | CPD18～20SQ-GB |
|---|---|---|
| Model | E110 | E110 |
| Voltage | 36V/48V | 36V/48V |
| Capacity | 880Ah/660Ah | 1100Ah/770Ah |
| No. of cell | 18只/24只 | 18只/24只 |

#### 4.5.2 Use of battery

The correct use and daily maintenance of lead-acid battery have a great influence on the performance and service life of battery, therefore, the users must make maintenance and service by contrast with the actual condition and according to the maintenance instruction provided by manufacturer.

### 4.5.3 Maintenance of battery and matters for attention

(1) The surface of battery should be kept clean and dry. Its terminal and wiring parts should be frequently maintained and loosening or poor contact found should be timely eliminated.

(2) No conductive articles are allowed to put on battery to avoid its short circuit.

(3) The first charge of new battery before use is the initial charge and charges in the later use course are the common ones. The charging time of the common charge is different with battery capacity and discharging degree and usually discharging of 70%～100% needs continuous charge of about 8～12 hours.

(4) Open the filling cap during battery charging and close it when charging is finished.

(5) Hydrogen and oxygen gas are separated out during battery charge, therefore, ensure good ventilation condition and prohibit the fire and smoke to prevent explosion.

(6) In use and charging course, the natural evaporation and electrolysis of water content in electrolyte will result in level decrease of electrolyte and increase of density, so distilled water should be frequently added in order to keep height and density of electrolyte normal.

(7) In the course of use, the excessive discharge (i.e. the voltage drop of monomer battery is lower than 1.70V) and excessive charge should be avoided, because, these would seriously affect the service life and performance of battery.

(8) Battery after use should be charged within 24 hours. Failure to charge the battery timely, undercharge, excessive discharge or unused for a long time without additional charging will vulcanize polar plate of battery and result in performance degradation and use difficulty when serious.

(9) In the course of use, equalizing charge should be made to the battery once a month so that all monomers of battery can reach well-balanced and good state when in use.

(10) For battery compartment without liquid leakage hole, check if there is hydrops inside of compartment every month. If there is electrolyte spillage caused by improper adding of distilled water, please clean the hydrops in the compartment with sucker in time.

### 4.5.4 Care and storage

(1) The battery should be stored in a warehouse which is dry, well ventilated and away from direct shinning. The temperature inside should stay between 5-40℃。

(2) Keep the battery from the heat source at least at a distance of 2m.

(3) The battery should not lie upside down or on the side. It should not bear any mechanical shock or any heavy load.

(4) Keep off any liquid and harmful foreign matter. Be care with the falling of the any metal impurity.

(5) Do not store the battery with electrolyte in. If it is necessary, charge the battery fully. Adjust the lever and density of the electrolyte well. Charge the battery once a month during its storage.

**Notice:**

**(1) During battery charging, the charge should be temporally suspended in the place where the temperature of electrolyte exceeds 40℃.**

**(2) In battery charging, the service life of battery will be affected if the temperature of electrolyte is more than 50℃.**

**(3) Do not charge the battery at low temperature (e.g. cold outdoor), this would affect the service life of battery.**

**Notice:**

**(1) The rated voltage of traction battery is not the safe voltage and there is electric shock injury danger if touched, so take safety precautions.**

**(2) Traction battery is lead-acid battery and electrolyte is dilute sulphuric acid. So when the battery is tested, fed and adjusted etc, wear safety device to avoid accident.**

**(3) The shell of charger is of metal conductor, therefore the reliable connection**

**of grounding protection line of charger should be ensured to prevent the electric shock accident.**

**(4) Pulling out battery connectors should be avoided when charger is not turned off. Special care should be taken as this will make battery undercharged which produces dangerous electric spark.**

### 4.5.5 Fault and troubleshooting

The causes that make the battery fault are various, except the quality manufacture and transport storage, mostly due to the improper maintenance. Find out faults and analyze the causation in time, take effective measure as soon as possible to exclude.

Table 4-4 Fault and troubleshoot of battery

| Fault | Characteristics | Causation | Repair measure |
|---|---|---|---|
| Pole plate sulfide | 1) Decrease of the battery capacity.<br>2) Low density of the electrolytic ( below the normal lever).<br>3) High battery voltage when beginning or finishing the charging.<br>4) Air bubble in the early time of charging or beginning.<br>5) High rising of the electrolytic temperature when charging. | 1) Inefficient first charging.<br>2) Inefficient charging for a long time.<br>3) Discharging for many times.<br>4) No timely charging after discharging.<br>5) High density of the electrolytic.<br>6) Low lever of electrolytic.<br>7) No timely balanced charging.<br>8) Too low or high discharging current.<br>9)Impure of the electrolytic.<br>10) Short inside or creepage. | 1) Adopt the measure of balanced charging when the actuality is not severity.<br>2) Adopt the hydrotherapeutics when the actuality is severity.<br>3) Do not over discharging.<br>4) The density of the electrolytic should below the regular lever.<br>5) The lever of the electrolytic and content of the impurity should be in the prescribed range. |
| Inside short circuit | 1) Low battery voltage or close to zero indeed when charging.<br>2) Few or no air bubble at the end of the charging.<br>3) High rising of electrolytic temperature or slow or no rising of electrolytic density.<br>4) Low battery voltage under the condition of open circuit or a quick drop to the limit value when discharging.<br>5)Serious self-discharging. | 1) Curve pole plate; expanded reactive matter; desquamated reactive matter.<br>2) Much precipitate.<br>3) Falling of conductor to the battery. | 1) Replace the plate.<br>2) Clean the precipitate and conductor.<br>3) Replace the plate. |

| | | | |
|---|---|---|---|
| Shedding off of the reactive matter | 1) Decrease of the battery capacity.<br>2) Turbid electrolytic.<br>3) Much precipitate. | 1) Being unsuitable to the electrolytic quality standard.<br>2) Frequent discharging and charging or over charging or discharging.<br>3)High electrolytic temperature when charging.<br>4) Outside short circuit when discharging. | 1) Clean the precipitate when the actuality is not severity.<br>2) Discard when severity. |

**4.6 Daily Maintenance**

(1) Check the wear condition of the contactor. Change it if necessary. Check the contactor every three months.

(2) Check the pedals or manual inching switch; measure the voltage drop between the inching switch ends; there is no resistance when the inching switch is closed; there is ringing sound when release. Check every three months.

(3) Check the main circuit, connecting cable among battery, converter and motor. Make sure the well insulation condition of the cables and circuits are tightly connected. Check it every three months.

(4) Check the mechanical moving of the pedal and knob; check if the spring is out of shape; check if the spring of the potentiometer can reach to the max. length or set length. Check it every three months.

(5) Check the mechanical moving of the contactor every three months; if there is any damage or condition affecting the safety, contact with ZAPI dealer.

**Notice: After chopper is installed, raise the wheel of vehicle (off the ground) for test. In this way, there will be no danger even connection is wrong.**

**After electric lock switch is off, there is a certain voltage left in filter capacitor within a period of time. Cut off the battery power first if the inverter is repaired at this time and then connect the resistance of 10～100Ω to the positive and negative poles of inverter to make the voltage on the capacitor short-circuited.**

**4.7 Hand brake switch**

When the truck is stopped and driver is away from the seat, apply parking brake manually. At this time, only hand brake light Ⓟ on the meter turns on all the time and truck can not travel.

When restarting the truck, release the parking brake manually, at this time, the brake light Ⓟ on the meter turns off. The track can travel again.

Figure 4-6 hand brake switch

**Danger:**

**Do not apply parking brake when travelling.**

**Under certain cases, if parking brake is applied suddenly, goods may falling down.**

**Parking brake can be applied only when the truck can not be stopped through braking pedal during travelling.**

### 4.7 Emergency power off device

Before operation, please turn on the emergency power off device.

When repair, transport, store the truck, please turn off the emergency power off device.

Figure 4-7 Emergency power off device

Danger

When the truck is working, please do not turn off the emergency power off device.

If the emergency power off device is turned off suddenly, goods will fall down from the fork that may cause goods damage or personnel injuries under certain conditions.

Turn off the emergency power off device manually only when the truck can not be stopped through other methods when it is working.

**4.8 Emergency button**

Release the emergency button before working.

Press the emergency button manually when the truck needs repair, transporting or will be store for a long time.

Figure 4-16 Emergency button

**Danger:**

**Do not press emergency button when travelling.**

**Under certain cases, if emergency button is pressed suddenly, goods may falling down.**

**Emergency button can be applied only when the truck can not be stopped with other methods during travelling.**

## 4.9Troubleshoot

The traction control system, lifting control system, steering control system and intelligent instrument system on the truck are all continuous monitoring microprocessor controller and they carry out a diagnosis program on main functions. The diagnosis program is made up of the following 4 points:

(1) Diagnosis when the electric lock is closed: check if the circuit for watch dog, current sensor, capacity charge, phase voltage, contactor drive, can-bus interface and switch operation order are correct; check if the output of accelerator is correct; check if the two microprocessors are synchronized; check if there are inputs of hardware related to safety.

(2) Check when it is under standby application: circuit of watch dog, phase voltage, drive of contactor, current sensor, CAN-BUS interface.

(3) Check when working: circuit of watch dog, drive of contactor, current sensor, CAN-BUS interface.

(4) Continuous check: inverter temperature, motor temperature

There are two ways to show the diagnosis: one is to use digital handhold unit; the other way is that fault code is transmitted by CAN BUS. The fault code and module node are shown on intelligent instrument.

Table 4-5 Common fault of traction system

| Fault Code | Implication | Note | Measures |
|---|---|---|---|
| 13 | EEPROM KO | EEPROM damaged | The fault is in the internal memory for storing and regulating parameters. When the fault appears, the machine automatically stops. If the fault still exists, when reconnecting it after switching off the electric lock, change the controller. If the fault disappears, the parameters previously stored will be replaced with default value. |
| 17 | LOGIC FAILURE #3 | Logic card failure 3 | Current protection function failure of logic card: change the controller. |
| 18 | LOGIC FAILURE #2 | Logic card failure 2 | Circuit failure of phase voltage feedback hardware on logic card. Change the controller. |
| 19 | LOGIC FAILURE #1 | Logic card failure 1 | The failure produced when the function of low or over voltage acts. In 24V system, the voltage detected by controller exceeds 45V or lower than 9V. In 48V system, the voltage detected by controller exceeds 65V or lower than 11V. Possible causes:<br>(1) Check if there is short circuit in the electric circuit system such as DC-DC and brake coils etc or if the input power supply contact of controller is good.<br>(2) If the battery voltage is excessively low or high.<br>(3) Check B+ and B and see if the power cable on the wiring terminal of contactor etc is tightly fixed.<br>(4) If the voltage calibration parameter of controller is in consistent with actual voltage.<br>(5) There is circuit fault of overvoltage protection hardware on logic card, change the controller. |
| 30 | VMN LOW | Low VMN | Cause：The high-end voltage of MOS during startup is 66% smaller than the capacitor voltage or this voltage is smaller than the required value in the operation of motor.<br>Possible causes:<br>(1) Wiring of motor is incorrect or there is circuit problem in motor. Check if three-phase connection of motor is correct, if there is any leakage of electricity on ground and |

| | | | |
|---|---|---|---|
| | | | circuit break of motor coil.<br>(2) If actuation of main contactor is rigid and if there is any wearing on contact?<br>(3) Change the controller . |
| 31 | VMN HIGH | High VMN | Cause：During startup, the low-end voltage of MOS tube is 10% higher than that of normal battery voltage or the phase voltage is higher than 1/2 of battery voltage.<br>Possible cause：<br>(1) The wiring of motor is incorrect or there exists problem in motor circuit . Check if three-phase connection of motor is correct, if there is any leakage of electricity on the ground and circuit break of motor coil. (2) Change the controller |
| 37 | CONTACTOR CLOSED | Adhesion of contactor | When the coil of main contactor is closed, the controller should first check if the contact of main contactor is adhered. Try to discharge the capacitance. If the capacitance voltage is reduced by 20% of the battery voltage, the fault possibly appears.<br>(1) Suggest to check if the contact of contactor is adhered or change the contactor. |
| 38 | CONTACTOR OPEN | Contactor open | Logic card drives the coil of main contactor, but the contactor does not close, possible causes:<br>(1) Mechanical fault and locking etc of contactor.<br>(2) Poor contact of contactor.<br>(3) If contactor works normally, change the controller. |
| 53 | STBY I HIGH | High standby current | The signal output by current sensor detected by micro-control system exceeds the scope allowed for non-operation current. The trouble has nothing to do with the peripheral parts, so the controller needs to be changed. |
| 60 | CAPACITOR CHARGE | Wrong capacitance charge | When the electric lock is switch on, inverter will charge the capacitance through power resistance and check if capacitance is fully charged within the time stipulated, otherwise, the capacitance voltage remains 20% lower than battery voltage, the inverter will give alarm and the main contactor will not close.<br>Possible causes：<br>(1) Peripheral equipment, e.g. DC-DC, motor or other equipment etc interfere with the charging process of controller and these interferences need to be eliminated.<br>(2) The charging resistance is disconnected, there is fault on charging circuit and power module ,so controller needs to be changed. |

| | | | |
|---|---|---|---|
| 62 | TEMPERAURE | Over-high temperature | In case that total power is allowed, the temperature of controller exceeds 85℃( it relates to the parameter " MAXIMUM CURRENT".)<br>Their corresponding relations are as follows: Parameter set alarm temperature<br>MAXIMUM CURRENT=50% 96℃<br>MAXIMUM CURRENT=60% 94℃<br>MAXIMUM CURRENT=70% 92℃<br>MAXIMUM CURRENT=80% 90℃ |

| | | | |
|---|---|---|---|
| | | | MAXIMUM CURRENT=90% 88℃<br>MAXIMUM CURRENT=100% 86℃<br>Now, the max. current of controller decreases with the increase of the max. current temperature. When the temperature is 105℃, the current of controller decreases to zero.<br>The fault appears if chopper is in the cold state:<br>(1) Temperature calibration parameter of logic card is incorrect, check parameters.<br>(2) The internal temperature sensor of controller has trouble and change the controller. |
| 65 | MOTOR TEMPERAT. | High motor temperature | If temperature digital switch of motor is turned on or analog signal exceeds the cutoff value, the trouble is produced. When the motor temperature reaches 120℃, the controller gives alarm, the vehicle can move at this time. But the max. current and performance are cut down. When the motor temperature reaches 125℃, motor stops working. Now try to lower the temperature of the motor.<br>If the fault still exists when motor is cooled, check the circuit and change the controller if he circuit is OK. |
| 66 | BATTERY LOW | Low capacity of battery | If parameter of "BATTERY CHECK" for battery test is not set as 0 and when charging capacity of battery is lower than 15% and there is no grid on instrument, fault alarm is given and the lifting function is locked, now charge it timely. In case the battery has electricity, check if the value of parameter "ADJUST BATTERY" of controller is consistent with battery voltage. |
| 74 | DRIVER SHORTED | Short circuit of driver | When electric lock is close, the microprocessor will detect if driver of main contactor is short-circuited and alarm will be given if yes. Check if there is short circuit on the positive pair A 16 of main contactor coil or negative pole. Change the controller if everything is OK. |
| 75 | CONTACTOR DRIVER | Fault of contactor driver | The coil of main contactor can not be normally driven and change the controller if the coil of main contactor has no fault. |

| | | | |
|---|---|---|---|
| 78 | VACC NOT OK | Accelerator error | Detection time : Standby state<br>The alarm indicates the voltage of accelerator is 1V larger than the min. value set in the signal scope （PROGRAM VACC）of accelerator.<br>Possible causes：<br>(1) The upper and lower voltage limit values of accelerator have not been collected and do it again when entering into PROGRAM VACC.<br>(2) Accelerator error: Accelerator pedal possibly fails to return or internal error of accelerator.<br>(3) The failure of controller |
| 79 | INCORRECT START | Incorrect starting sequence | Possible causes for incorrect starting sequence:<br>(1) Direction switch is closed before starting.<br>(2)Incorrect operation sequence.<br>(3)Incorrect wire joining.<br>(4)If the trouble still can not be eliminated, change the |

| | | | |
|---|---|---|---|
| | | | controller. |
| 80 | FORW+BACK | Forward and backward signals exist at the same time(adhesion of direction switch ) | The machine will keep on detecting. But when there are signals requesting operation from two directions at the same time, alarm is given. Possible causes:<br>(1) The wire is damaged.<br>(2) Direction switch fault.<br>(3)Improper operation.<br>(4) Change the controller if the trouble still can not be eliminated. |
| 82 | ENCODER ERROR | Encoder error | The controller detects the great difference between two consecutive speed readings of encoder. As the encoder in the system can not change great speed within very short time, so, the encoder may have the trouble (the circuits of one or two encoders are destroyed or broken). Check the mechanical and circuit function of the encoder. The alarm is possibly caused by the electromagnetic noise on the bearing of sensor. If not, change the controller. |
| 220 | PROG VACC NOT OK | Programming error of accelerator | If “2.5 POT” is set as “ON”, controller will check the max. and min values of potentiometer recorded during programming. If the min. value of forward is smaller than the max. value of backward or the min. value of backward is bigger than the max. value of forward, the fault will appear. Check if the potentiometer is correct, or make a data acquisition again. |
| 222 | WAITING FOR NODE | Waiting for node signal | In CAN communication network, a controller receives a signal that the other controller can not make normal communication and the controller always is always in the waiting state until CAN communication network is completely normal. Check why the wiring of the modules that fails to communicate is abnormal and see if the software edition or parameter setting is correct. |

| | | | |
|---|---|---|---|
| 223 | WATCHDOG #1 | Watchdog fault 1 | During startup, watchdog circuit is activated before software is started. The watchdog signal is invalid in standby or operation state( alarm state)<br>Fault analysis：Hardware circuit of watchdog or output of micro-controller is damaged. The above two cases have nothing to do with external parts, so change the controller. |
| 224 | COIL SHORTED EF | Short circuit of auxiliary coil | When the electromagnetic brake connecting to the output terminal of CNA#18IS or auxiliary coil is shorted, the fault signal is produced. Withdraw from the fault state through releasing brake after eliminating the overload condition so that the running request is valid.<br>Fault analysis：Generally, the fault code indicates that the trouble is on the harness or loading coil. So check the connection between controller output and load first. If there is no trouble of external load, the trouble is inside the controller and the controller needs to be changed. |
| 227 | WATCHDOG #2 | Watchdog fault 2 | Cause：During startup, the watchdog circuit is activated before software is started. The watchdog signal is invalid (alarm state)in case of standby or operation state.<br>Fault analysis: The hardware circuit of watchdog or |

| | | | |
|---|---|---|---|
| | | | output of micro-controller is damaged. The above two cases has nothing to do with external parts, so change the controller. |
| 228 | TILLER OPEN | TILLE off | When tiller input switch is off, about 30S later, the main contactor will be off and warning is given. The warning disappears for next operation. |
| 229 | SAFETY INPUT | Safety Input fault | When the safety input switch is off, so is the main contactor, meanwhile the electromagnetic brake or auxiliary output coil is driven. Check if the port of A11 is correctly connected. Change the controller if other parts are correct. |
| 230 | COIL SHORTED MC | Coil short circuit of main contactor | CAUSE: When the short circuit coil of main contactor is connected to the output port of CAN#16, the fault signal is produced. After overload is removed, it automatically withdraw from fault state through releasing brake and then the running instruction is valid.<br>Fault analysis：Generally, the fault code indicates that the trouble is on the harness or loading coil. So check the connection between controller output and load first. If there is no trouble of external load, the trouble is inside the controller and the controller needs to be changed. |
| 231 | COIL SHORTED HW KO | Fault of coil protection circuit | Short circuit fault of the coil protection circuit used to drive main contactor, electromagnetic brake or auxiliary devices<br>Fault analysis: Change the controller |

| | | | |
|---|---|---|---|
| 232 | KEYOFF SHORTED | Short circuit of key switch | At start-up stage, if controller detects that there is low logic level signal when key switch is off, there is a fault.<br>Fault analysis: Most possibly is that the voltage is excessively low, suggest to check the followings :<br>(1) If the key switch is based on external load (e.g. the starting of DC-DC converter, the input signal of relay or contactor switch is lower than starting voltage).<br>(2) Check the positive and negative poles of power cable and cell end and the connection between –BATT and +BATT of main contactor and controller. It must be connected with screw and the torsion scope is 13NM~15NM..<br>(3) If no voltage drop has been detected on the power supply line, the fault signal is produced every time when the key switch is on. The fault may be possibly in the hardware of the controller; therefore, the controller needs to be changed. |
| 233 | POWER MOS SHORTED | Short circuit of power MOS | Software will check the power bridge before main contactor is closed: It converts into low-end power of MOS and the phase voltage value drops to –BATT (rise to +BATT). If the change of phase voltage value does not conform to the instruction, this fault signal is produced. Change the controller. |
| 235 | HANDBRAKE | Fault of handbrake switch | Handbrake input signal is valid when the running instruction is issued.<br>Resolution：Possible causes for the fault : |

| | | | |
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| | | | (1) Handbrake switch is damaged or wiring is wrong.<br>(2) Handbrake switch works normally. In TESTER menu, handbrake is always ON. This is a logic fault, so change the controller. |
| 236 | CURRENT GAIN | Fault of current gain | The maximum current gain parameter is a factory set value, which indicates that the max. current regulating parameter program has not be used.<br>Resolution: Correctly set program for current gain parameter by ZAPI technical personnel. |
| 237 | ANALOG INPUT | Fault of Analog Input | The fault signal is produced when A/D of all analog signals is converted into a fixed value and delay exceeds 400 millisecond. This function is used to check the fault of A/D converter or analog signal conversion.<br>Fault analysis: Change the controller if the fault always exists. |
| 238 | WRONG ZERO VOLTAGE | Wrong Zero Voltage | During startup, the feedback value of high end voltage of VMN is not at about 2.5V. The circuit of controller is damaged.<br>Fault analysis : The following checks are suggested:<br>(1) Internal connection of motor.<br>(2) Power cable connection of motor.<br>(3) Drain current between motor and vehicle casing.<br>(4) If the motor connection is good, the problem is inside the controller and changes it. |

| | | | |
|---|---|---|---|
| 239 | SAFETY OUTPUT | Failure of safety output | Driver short circuit of safety output.<br>Fault analysis: Check if there is short circuit or Low impedance push-pull output betweenA19 and -BATT. If it is the circuit trouble of driver of logic card, change the controller. |
| 240 | HARDWARE FAULT | Hardware circuit fault | Before driving the coil of main contactor, controller tests MOS driver or the auxiliary output drive is the invalid watchdog circuit signal. If it is not driven, there produces a fault signal.<br>Fault analysis: Change the controller. |
| 241 | FLASH CHECKSUM | Flash Memory fault | When key is switched on, the program is a positive value in flash memory and the fault signal is produced in case of negative value.<br>Fault analysis: The problem is on flash memory of microcontroller. The flash memory may be damaged or the program stored destroyed. Try to reset the program of logic card. The fault exists in the microcontroller if the fault still exists, Change the controller. |
| 242 | ENCODER LOCKED | Feedback signal fault of encoder | Under normal condition， if the target speed is greater than10 Hz and the rotation speed of motor higher than 1.5 Hz, the feedback signal of encoder checked by controller should exceed a threshold value. If not, the controller will give alarm. Test the motor encoder and see if motor or wiring is normal and if installation correct. Change the controller if periphery is normal. |
| 243 | SENS MOT TEMP KO | Fault of temperature sensor | Phenomenon：The output signal of temperature sensor of motor exceeds the scope. |

| | | | |
|---|---|---|---|
| | | | Solution: Check the value of sensor and connection of wires and the fault is inside the controller in case of no problem found. |
| 244 | SOFTWARE ERROR | Software error | During software testing, there are many reasons for such fault such as: CAN communication fault and EEPROM READ/WRITE ERROR etc. Check the parameter of “DEBUG MODE”, the value must be “OFF”. |
| 245 | WRONG RAM MEMORY | Dynamic memory fault | Wrong contents are found when testing the main memory: The registration address is “DIRTY” and the fault will restrict the operability of vehicle.<br>Fault analysis: Switch on the key after switching it off and change the controller if the trouble still exists. |
| 246 | AUX DRIVER OPEN | Auxiliary output drive fault | Auxiliary coil drive circuit can not drive load. The equipment or drive coil is damaged. Change the controller. |
| 247 | DATA ACQUISITION | Data acquisition | The fault will be hinted when calibrating the current gain. No treatment is needed and it will automatically disappear when calibration is finished. |
| 248 | NO CAN MESSAGE | NO CAN signal | CAN communication fault between pump and traction. Check CAN wiring, software setting and edition information. |
| 249 | CHECK UP NEED | Service time | It is the time for service and maintenance is needed. |

| | | | |
|---|---|---|---|
| 250 | THERMIC SENS KO | Temperature sensor fault | The output signal of temperature sensor of controller exceeds the range.<br>The fault has nothing to do with external parts and change the controller. |
| 251 | WRONG SET BATTERY | Wrong set of battery | During startup, the controller tests if the voltage of battery is within the nominal scope. Check if the value of BATTERY VOLTAGE parameter in the menu conforms to that on the voltmeter. If not, make them conform to each other with the function of ADJUST BATTERY.<br>Change the battery. |
| 253 | SLIP PROFILE | Slip fault | Wrong selection of SLIP PROFILE PARAMETERS. Check the setting of these values in the hardware setting parameters. |
| 254 | AUX DRIVER SHORTED | Auxiliary drive shorted | Short circuit of the driving electric circuit of the electromagnetic brake or auxiliary electric brake. Check if there is short circuit between the A16 and BATT.<br>Circuit ault of the drive unit of the logic card; change the controller. |

Table 4-6 Common fault of pump control system

| Fault Code | Implication | Note | Measures |
|---|---|---|---|
| 13 | EEPROM KO | EEPROM damaged | The fault is in the internal memory for storing and regulating parameters. When the fault appears, the machine automatically stops. If the fault still exists, when reconnecting it after switching off the electric lock, change the controller. If the fault disappears, the parameters previously stored will be replaced with default value. |
| 17 | LOGIC FAILURE #3 | Logic card failure 3 | Current protection function failure of logic card: change the controller. |
| 18 | LOGIC FAILURE #2 | Logic card failure 2 | Circuit failure of phase voltage feedback hardware on logic card. Change the controller. |
| 19 | LOGIC FAILURE #1 | Logic card failure 1 | The failure produced when the function of low or over voltage acts. In 24V system, the voltage detected by controller exceeds 45V or lower than 9V. In 48V system, the voltage detected by controller exceeds 65V or lower than 11V. Possible causes:<br>(1) Check if there is short circuit in the electric circuit system such as DC-DC and brake coils etc or if the input power supply contact of controller is good.<br>(2) If the battery voltage is excessively low or high.<br>(3) Check B+ and B and see if the power cable on the wiring terminal of contactor etc is tightly fixed.<br>(4) If the voltage calibration parameter of controller is in consistent with actual voltage.<br>(5) There is circuit fault of overvoltage protection hardware on logic card, change the controller. |
| 30 | VMN LOW | Low VMN | Cause：The high-end voltage of MOS during startup is 66% smaller than the capacitor voltage or this voltage is smaller than the required value in the operation of motor.<br>Possible causes:<br>(1) Wiring of motor is incorrect or there is circuit problem in motor. Check if three-phase connection of motor is correct, if there is any leakage of electricity on ground and circuit break of motor coil.<br>(2) If actuation of main contactor is rigid and if there is any wearing on contact?<br>(3) Change the controller . |
| 31 | VMN HIGH | High VMN | Cause：During startup, the low-end voltage of MOS tube is 10% higher than that of normal battery voltage or the phase voltage is higher than 1/2 of battery voltage.<br>Possible cause：<br>(1) The wiring of motor is incorrect or there exists problem in motor circuit . Check if three-phase connection of motor is correct, if there is any leakage of electricity on the ground and circuit break of motor coil. (2) Change the controller |
| 53 | STBY I HIGH | High standby current | The signal output by current sensor detected by micro-control system exceeds the scope allowed for |

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|---|---|---|---|
| | | | non-operation current. The trouble has nothing to do with the peripheral parts, so the controller needs to be changed. |
| 60 | CAPACITOR CHARGE | Wrong capacitance charge | When the electric lock is switch on, inverter will charge the capacitance through power resistance and check if capacitance is fully charged within the time stipulated, otherwise, the capacitance voltage remains 20% lower than battery voltage, the inverter will give alarm and the main contactor will not close.<br>Possible causes：<br>(1) Peripheral equipment, e.g. DC-DC, motor or other equipment etc interfere with the charging process of controller and these interferences need to be eliminated.<br>(2) The charging resistance is disconnected, there is fault on charging circuit and power module ,so controller needs to be changed. |
| 62 | TEMPERAURE | Over-high temperature | In case that total power is allowed, the temperature of controller exceeds 85℃( it relates to the parameter " MAXIMUM CURRENT".)<br>Their corresponding relations are as follows: Parameter set alarm temperature<br>MAXIMUM CURRENT=50% 96℃<br>MAXIMUM CURRENT=60% 94℃<br>MAXIMUM CURRENT=70% 92℃<br>MAXIMUM CURRENT=80% 90℃<br>MAXIMUM CURRENT=90% 88℃<br>MAXIMUM CURRENT=100% 86℃<br>Now, the max. current of controller decreases with the increase of the max. current temperature. When the temperature is 105℃, the current of controller decreases to zero.<br>The fault appears if chopper is in the cold state:<br>(1) Temperature calibration parameter of logic card is incorrect, check parameters.<br>(2) The internal temperature sensor of controller has trouble and change the controller. |
| 65 | MOTOR TEMPERAT. | High motor temperature | If temperature digital switch of motor is turned on or analog signal exceeds the cutoff value, the trouble is produced. When the motor temperature reaches 120℃, the controller gives alarm, the vehicle can move at this time. But the max. current and performance are cut down. When the motor temperature reaches 125℃, motor stops working. Now try to lower the temperature of the motor.<br>If the fault still exists when motor is cooled, check the circuit and change the controller if he circuit is OK. |
| 74 | DRIVER SHORTED | Short circuit of driver | When electric lock is close, the microprocessor will detect if driver of main contactor is short-circuited and alarm will be given if yes. Check if there is short circuit on the positive pair A 16 of main contactor coil or negative pole. Change the controller if everything is OK. |
| 78 | VACC NOT OK | Accelerator error | Detection time : Standby state<br>The alarm indicates the voltage of accelerator is 1V larger |

| | | | |
|---|---|---|---|
| | | | than the min. value set in the signal scope （PROGRAM VACC）of accelerator.<br>Possible causes：<br>(1) The upper and lower voltage limit values of accelerator have not been collected and do it again when entering into PROGRAM VACC.<br>(2) Accelerator error: Accelerator pedal possibly fails to return or internal error of accelerator.<br>(3) The failure of controller |
| 79 | INCORRECT START | Incorrect starting sequence | Possible causes for incorrect starting sequence:<br>(1) Direction switch is closed before starting.<br>(2)Incorrect operation sequence.<br>(3)Incorrect wire joining.<br>(4)If the trouble still can not be eliminated, change the controller. |
| 82 | ENCODER ERROR | Encoder error | The controller detects the great difference between two consecutive speed readings of encoder. As the encoder in the system can not change great speed within very short time, so, the encoder may have the trouble (the circuits of one or two encoders are destroyed or broken). Check the mechanical and circuit function of the encoder. The alarm is possibly caused by the electromagnetic noise on the bearing of sensor. If not, change the controller. |
| 221 | SEAT MISMATCH | Seat switch signal fault | If the parameter of the “SAFE OUT CONFIG” is 1, the fault may occur. If the traction seat switch signal is different from the pump controller sear switch signal, the fault may occur. Check the seat switch connecting. |
| 222 | WAITING FOR NODE | Waiting for node signal | In CAN communication network, a controller receives a signal that the other controller can not make normal communication and the controller always is always in the waiting state until CAN communication network is completely normal. Check why the wiring of the modules that fails to communicate is abnormal and see if the software edition or parameter setting is correct. |
| 223 | WATCHDOG #1 | Watchdog fault 1 | During startup, watchdog circuit is activated before software is started. The watchdog signal is invalid in standby or operation state( alarm state)<br>Fault analysis：Hardware circuit of watchdog or output of micro-controller is damaged. The above two cases have nothing to do with external parts, so change the controller. |
| 227 | WATCHDOG #2 | Watchdog fault 2 | Cause：During startup, the watchdog circuit is activated before software is started. The watchdog signal is invalid (alarm state)in case of standby or operation state.<br>Fault analysis: The hardware circuit of watchdog or output of micro-controller is damaged. The above two cases has nothing to do with external parts, so change the controller. |
| 229 | SAFETY INPUT | Safety Input fault | When the safety input switch is off, so is the main contactor, meanwhile the electromagnetic brake or auxiliary output coil is driven. Check if the port of A11 is correctly connected. Change the controller if other parts are correct. |

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|---|---|---|---|
| 232 | KEYOFF SHORTED | Short circuit of key switch | At start-up stage, if controller detects that there is low logic level signal when key switch is off, there is a fault.<br>Fault analysis: Most possibly is that the voltage is excessively low, suggest to check the followings :<br>(1) If the key switch is based on external load (e.g. the starting of DC-DC converter, the input signal of relay or contactor switch is lower than starting voltage).<br>(2) Check the positive and negative poles of power cable and cell end and the connection between –BATT and +BATT of main contactor and controller. It must be connected with screw and the torsion scope is 13NM~15NM..<br>(3) If no voltage drop has been detected on the power supply line, the fault signal is produced every time when the key switch is on. The fault may be possibly in the hardware of the controller; therefore, the controller needs to be changed. |
| 233 | POWER MOS SHORTED | Short circuit of power MOS | Software will check the power bridge before main contactor is closed: It converts into low-end power of MOS and the phase voltage value drops to –BATT (rise to +BATT). If the change of phase voltage value does not conform to the instruction, this fault signal is produced. Change the controller. |
| 237 | ANALOG INPUT | Fault of Analog Input | The fault signal is produced when A/D of all analog signals is converted into a fixed value and delay exceeds 400 millisecond. This function is used to check the fault of A/D converter or analog signal conversion.<br>Fault analysis: Change the controller if the fault always exists. |
| 238 | WRONG ZERO VOLTAGE | Wrong Zero Voltage | During startup, the feedback value of high end voltage of VMN is not at about 2.5V. The circuit of controller is damaged.<br>Fault analysis : The following checks are suggested:<br>(1) Internal connection of motor.<br>(2) Power cable connection of motor.<br>(3) Drain current between motor and vehicle casing.<br>(4) If the motor connection is good, the problem is inside the controller and changes it. |
| 239 | SAFETY OUTPUT | Failure of safety output | Driver short circuit of safety output.<br>Fault analysis: Check if there is short circuit or Low impedance push-pull output betweenA19 and -BATT. If it is the circuit trouble of driver of logic card, change the controller. |
| 240 | HARDWARE FAULT | Hardware circuit fault | Before driving the coil of main contactor, controller tests MOS driver or the auxiliary output drive is the invalid watchdog circuit signal. If it is not driven, there produces a fault signal.<br>Fault analysis: Change the controller. |
| 241 | FLASH CHECKSUM | Flash Memory fault | When key is switched on, the program is a positive value in flash memory and the fault signal is produced in case of negative value.<br>Fault analysis: The problem is on flash memory of microcontroller. The flash memory may be damaged or |

| | | | |
|---|---|---|---|
| | | | the program stored destroyed. Try to reset the program of logic card. The fault exists in the microcontroller if the fault still exists, Change the controller. |
| 242 | ENCODER LOCKED | Feedback signal fault of encoder | Under normal condition， if the target speed is greater than10 Hz and the rotation speed of motor higher than 1.5 Hz, the feedback signal of encoder checked by controller should exceed a threshold value. If not, the controller will give alarm. Test the motor encoder and see if motor or wiring is normal and if installation correct. Change the controller if periphery is normal. |
| 243 | SENS MOT TEMP KO | Fault of temperature sensor | Phenomenon：The output signal of temperature sensor of motor exceeds the scope.<br>Solution: Check the value of sensor and connection of wires and the fault is inside the controller in case of no problem found. |
| 244 | SOFTWARE ERROR | Software error | During software testing, there are many reasons for such fault such as: CAN communication fault and EEPROM READ/WRITE ERROR etc. Check the parameter of "DEBUG MODE", the value must be "OFF". |
| 245 | WRONG RAM MEMORY | Dynamic memory fault | Wrong contents are found when testing the main memory: The registration address is "DIRTY" and the fault will restrict the operability of vehicle.<br>Fault analysis: Switch on the key after switching it off and change the controller if the trouble still exists. |
| 247 | DATA ACQUISITION | Data acquisition | The fault will be hinted when calibrating the current gain. No treatment is needed and it will automatically disappear when calibration is finished. |
| 248 | NO CAN MESSAGE | NO CAN signal | CAN communication fault between pump and traction. Check CAN wiring, software setting and edition information. |
| 249 | CHECK UP NEED | Service time | It is the time for service and maintenance is needed. |
| 250 | THERMIC SENS KO | Temperature sensor fault | The output signal of temperature sensor of controller exceeds the range.<br>The fault has nothing to do with external parts and change the controller. |
| 251 | WRONG SET BATTERY | Wrong set of battery | During startup, the controller tests if the voltage of battery is within the nominal scope. Check if the value of BATTERY VOLTAGE parameter in the menu conforms to that on the voltmeter. If not, make them conform to each other with the function of ADJUST BATTERY.<br>Change the battery. |
| 253 | SLIP PROFILE | Slip fault | Wrong selection of SLIP PROFILE PARAMETERS. Check the setting of these values in the hardware setting parameters. |

Table 4-7 Common fault for instrument system

| Fault Code | Implication | Note | Measures |
|---|---|---|---|
| 13 | EEPROM KO | EEPROM damaged. | Trouble is in the internal memory to store and regulate the parameters. Machine will automatically stops in case of trouble. The controller should be changed if the trouble still exists after reconnection when the electric lock is turned off. If the trouble disappears, the parameters stored before will be replaced with default value. |
| 18 | LOGIC FAILURE #2 | Logic card failure 2 | Circuit failure of A19 or A20 output port，change the instrument if it has nothing to do with external components. |
| 76 | COIL SHORT | Coil short | Drive coil short circuit: Test if there is short circuit on the device connecting with output port of the instrument, otherwise, change the instrument. |
| 102 | CAN BUS KO MASTER | CAN communication failure | Instrument no longer receives the data from CAN BUS data wire. In case that the fault code and other alarm signal are displayed together, the fault may possibly be on the CAN interface of the instrument, because the instrument can not receive any message. So, suggest to check the wiring and connection of CAN , or the CAN interface fault of other modules will appear in the CAN network. |
| 103 | SERVICE REQUIRED | Maintenance is Needed. | It is the time for maintenance (service). |
| 104 | HYDRAULIC OIL | | The input of hydraulic oil level is valid during startup.<br>Trouble Diagnosis：<br>Check if the related digital input on instrument（A9）is valid（Refer to TESTER MENU）<br>Check the effective level form（+VB or GND）of the input end (Refer to SET OPTION MENU).<br>(1) If the input is valid, check the relating switch, circuit and oil level.<br>(2) If the input is invalid, there might have an input circuit trouble in the intelligent instrument. |

Table 4-8 Fault code of main controller of EPS steering system

| **MASTER** | |
|---|---|
| CAN CODE | ALARM |
| 8 | WATCHDOG |
| 13 | EEPROM KO |
| 16 | LOGIC FAILURE #4 |
| 17 | LOGIC FAILURE #3 |
| 32 | VMN NOT OK |
| 48 | MAIN CONT. OPEN |
| 53 | STBY I HIGH |
| 60 | CAPACITOR CHARGE |
| 61 | HIGH TEMPERATURE |
| 65 | MOTOR TEMPERAT. |
| 70 | HIGH CURRENT |
| 71 | POWER FAILURE #3 |
| 72 | POWER FAILURE #2 |
| 73 | POWER FAILURE #1 |
| 84 | STEER SENSOR KO |
| 85 | STEER HAZARD |
| 91 | DRIVER 2 KO |
| 98 | INPUT ERROR #2 |
| 205 | SELFCHECK #2 |
| 206 | SELFCHECK #1 |
| 207 | WRONG HW SET |
| 209 | W.D. SYNCRO |
| 210 | WRONG SLAVE VER. |
| 211 | TFD FEEDB. ERROR |
| 212 | WRONG RAM MEM. |
| 213 | PARAM RESTORE |
| 214 | SP JERK |
| 215 | CAN BUS KO M/S |
| 216 | TFD WRONG RESIST |
| 217 | S.P OUTRNG WARN. |
| 218 | CONTROLLER MISM. |
| 219 | STEPPER MOT MISM |
| 220 | MOTOR LOCKED |
| 221 | M/S PAR CHK MISM |
| 222 | FB POT LOCKED |
| 223 | FB JERK |
| 224 | EMERGENCY |
| 225 | CURRENT GAIN |
| 226 | STOP TRAC WAR |

| | |
|---|---|
| 227 | OUTRNG-TURN ST01 |
| 228 | POSITION ERROR |
| 229 | LOOK. FOR PATH |
| 230 | PARAM CONFIGURAT |
| 231 | LATERAL OUT |
| 232 | ANGLE |
| 233 | LOSING PATH |
| 234 | LOSING STRAIGHT |
| 235 | TFD SHRT/VOLT KO |
| 236 | TFD STB I HIGH |
| 237 | SLAVE ALARM |
| 238 | EPS NOT ALIGNED |
| 239 | WAITING FOR TRAC |
| 240 | LOGIC SUPPLY ERR |
| 241 | FB SENSOR LOCKED |
| 242 | Q LINE SENSOR KO |
| 243 | D LINE SENSOR KO |
| 244 | PARAM TRANSFER |
| 245 | DATA ACQUISITION |
| 247 | CAN BUS KO |
| 248 | S.P OUT OF RANGE |
| 249 | F.B OUT OF RANGE |
| 251 | INIT VMN NOT OK |
| 252 | TWIN POT MISMAT. |
| 253 | ANALOG |
| 254 | NO SP REFRESH |

Table 4-9 fault code of slave controller of EPS steering system

| **SLAVE** | |
|---|---|
| CAN CODE | ALARM |
| 8 | WATCHDOG |
| 13 | EEPROM KO |
| 16 | LOGIC FAILURE #4 |
| 17 | LOGIC FAILURE #3 |
| 32 | VMN NOT OK |
| 48 | MAIN CONT. OPEN |
| 53 | STBY I HIGH |
| 60 | CAPACITOR CHARGE |
| 61 | HIGH TEMPERATURE |
| 65 | MOTOR TEMPERAT. |
| 70 | HIGH CURRENT |
| 71 | POWER FAILURE #3 |
| 72 | POWER FAILURE #2 |
| 73 | POWER FAILURE #1 |
| 84 | STEER SENSOR KO |
| 85 | STEER HAZARD |
| 91 | DRIVER 2 KO |
| 98 | INPUT ERROR #2 |
| 205 | SELFCHECK #2 |
| 206 | SELFCHECK #1 |
| 207 | SP MISMATCH |
| 208 | OUTPUT MISMATCH |
| 209 | W.D. SYNCRO |
| 210 | WRONG SLAVE VER. |
| 211 | TFD FEEDB. ERROR |
| 212 | WRONG RAM MEM. |
| 213 | PARAM RESTORE |
| 214 | SP JERK |
| 215 | CAN BUS KO M/S |
| 216 | TFD CURRENT MISM |
| 217 | S.P OUTRNG WARN. |
| 218 | CONTROLLER MISM. |
| 219 | STEPPER MOT MISM |
| 220 | MOTOR LOCKED |
| 221 | M/S PAR CHK MISM |
| 222 | FB POT LOCKED |
| 223 | FB JERK |
| 224 | EMERGENCY |
| 225 | CURRENT GAIN |

| | |
|---|---|
| 226 | STOP TRAC WAR |
| 227 | OUTRNG-TURN ST01 |
| 228 | POSITION ERROR |
| 229 | LOOK. FOR PATH |
| 230 | PARAM CONFIGURAT |
| 231 | LATERAL OUT |
| 232 | ANGLE |
| 233 | LOSING PATH |
| 234 | LOSING STRAIGHT |
| 235 | TFD SHRT/VOLT KO |
| 236 | TFD STB I HIGH |
| 237 | WAITING MASTER |
| 238 | EPS NOT ALIGNED |
| 239 | WAITING FOR TRAC |
| 240 | LOGIC SUPPLY ERR |
| 241 | FB SENSOR LOCKED |
| 242 | Q LINE SENSOR KO |
| 243 | D LINE SENSOR KO |
| 244 | PARAM TRANSFER |
| 245 | DATA ACQUISITION |
| 247 | CAN BUS KO |
| 248 | S.P OUT OF RANGE |
| 249 | F.B OUT OF RANGE |
| 250 | INPUT MISMATCH |
| 251 | INIT VMN NOT OK |
| 252 | TWIN POT MISMAT. |
| 253 | ANALOG |
| 254 | NO SP REFRESH |

# 5 Hydraulic System

## 5.1 General Description

The hydraulic system consists of oil pump, control valve, priority valve, lift cylinder, tilt cylinder, high & low pressure oil pipe an joint etc.. The pump is driven directly by the electromotor. The hydraulic oil flow to control valve through the pump and are distribute to cylinders by the control valve.

### 5.1.1 Oil pump

The main parts of the gear oil pump for forklift are a pair of external gears mutually

meshed and their working principle is as shown in Fig. 5-1.

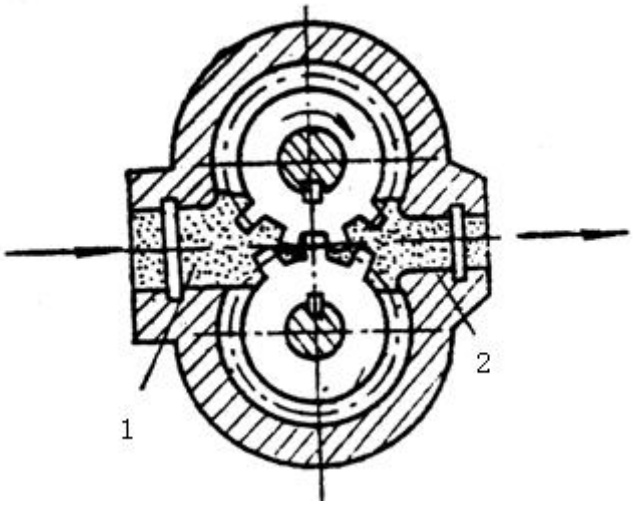



Fig 5-1 Working principle of gear pump
(1) Oil suction cavity (2) Oil pressing cavity

A pair of meshed involute gear is mounted inside the housing, the two end face seals of gear and gear separate the pump housing into two sealing oil cavities as shown 1 and 2 in the Fig. When the gear of gear pump rotates in the direction shown in the Fig, the volume of space shown by 1 (engaging part for gear disengagement) changes from small to big and forms vacuum. The oil in the oil tank enters into oil suction cavity under the action of atmospheric pressure to fill the intertooth space through the oil suction pipe of pump. While 2 indicates that the volume of space (engaging part for gear entering) changes from big to small and press the oil into pressure oil circuit, i.e.1 is oil suction cavity, 2 is oil pressing cavity and they are separated by meshing point of two gears. With constant rotation of gear, the suction and discharge outlets of the pump continuously absorb and drain oil.

Oil pump is to turn the mechanical energy of motor into hydraulic energy, so the oil pump is the actuating unit of hydraulic system of the forklift.

The main pump consists mainly of a pump body, a pair of gears, lining plates and oil seals. This pump uses pressure-balance type bearings and a special lubrication method so as to minimum the clearance of the gear face. (See Fig. 5-2)

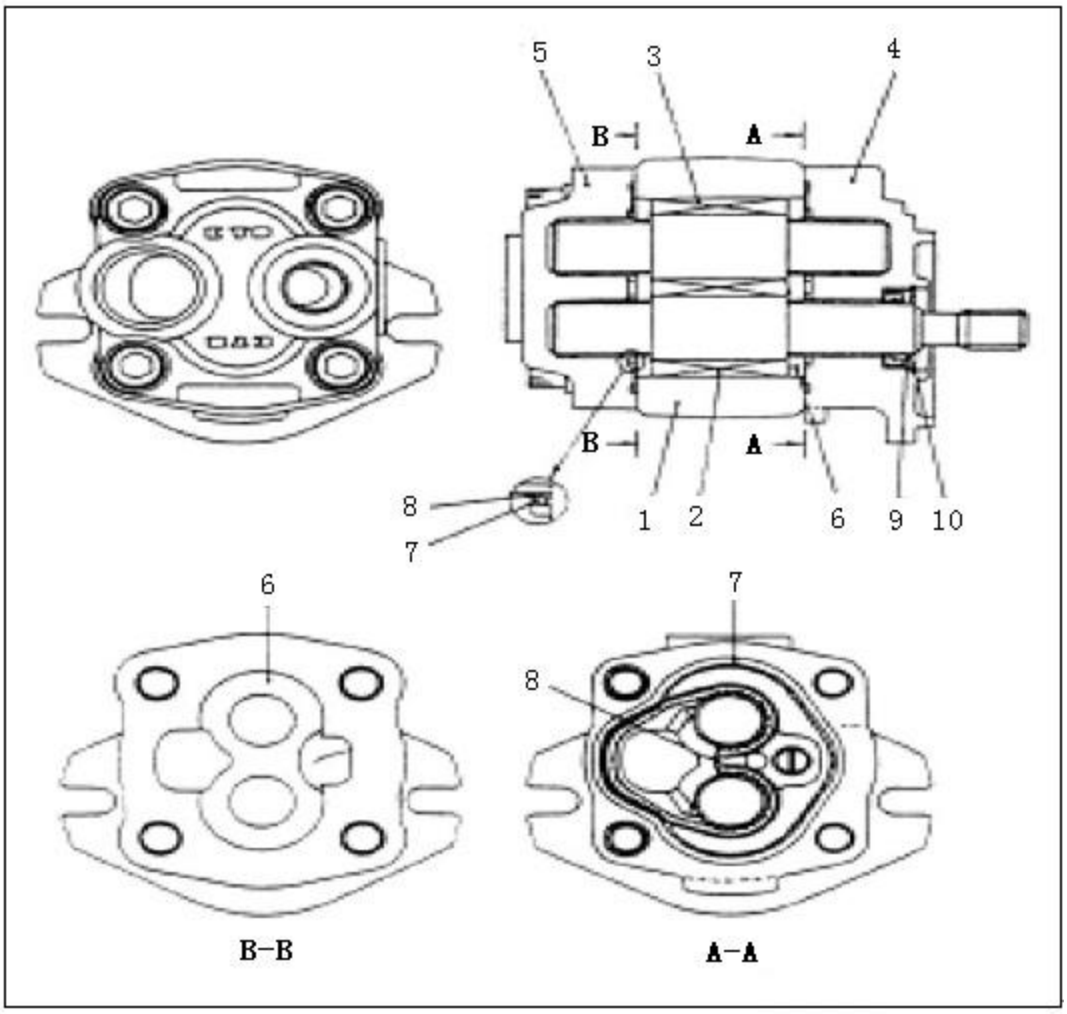



Fig. 5-2 Gear pump

(1) Pump body (2) Driving gear (3) Driven gear (4) Front cover (5) Rear cover
(6) Lining plate (7) Seal ring (8) Ring (9) Oil seal (10) Snap ring

### 5.1.2 Control Valve

The external of the control valve as shown in Fig. 5-3.

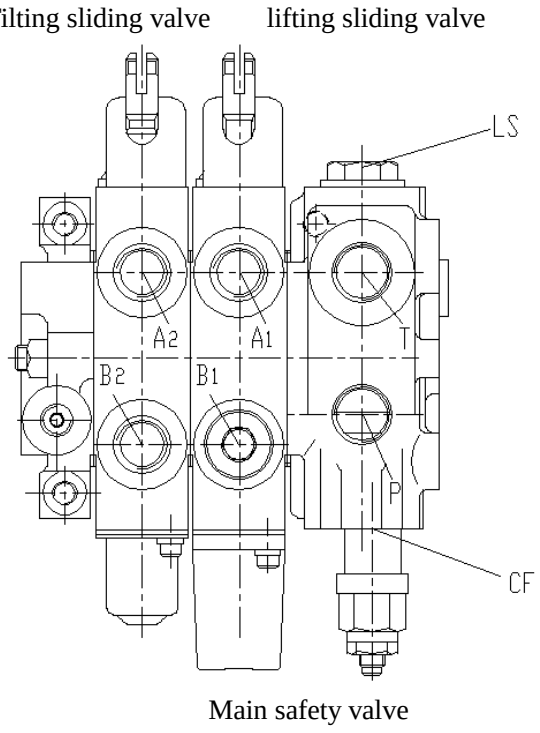



Figure 5-3 Control valve

The control valve adopts two pieces and four body type. The hydraulic oil from working pump distributes the high-pressure oil to the lifting cylinder or tilting cylinder through the control of valve stem. There are safety relief and tilt-locking valves inside the control valve. The safety relief valve is at the top of oil inlet of control valve to control the pressure of the system. The tilt-locking valve is on the tilt valve block and is mainly used to prevent the serious consequence due to wrong operation of control rod when the tilt cylinder has no pressure source. The check valve is mounted between oil inlet and inlet port of lifting valve block and between oil inlets of lifting and tilt valve blocks.

(1) Spool operation (take the tilt spool valve for example)

a) Neutral position (See Fig. 5-4)

The high-pressure oil from lift pump returns to the oil tank through the mid-passage.

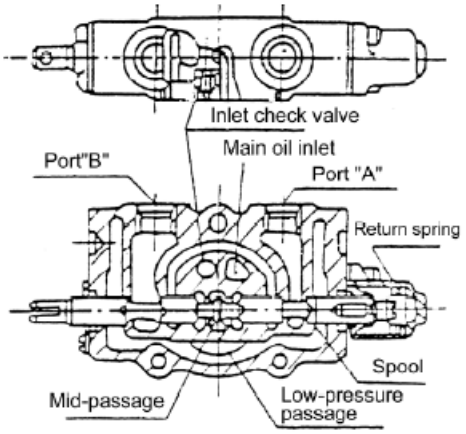



Fig. 5-4 Neutral position

b) Pushing-in of spool (See Fig. 5-5)

In this time, the spool is pushed in to close the mid-passage. This causes the oil from the main oil-inlet to push up the inlet check valve and to flow into the port “B”. The return oil from the port “A” flows through the low-pressure passage to the tank and the spool is restored to its neutral position by the return spring.

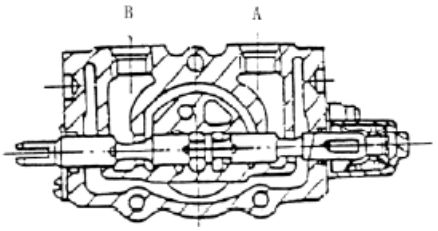



Fig. 5-5 Push in spool

c) Drawing-out of spool (See Fig. 5-6)

With the mid-passage closed, the oil from the main oil-inlet pushes up the check valve and flows into the port “A”. The return oil from the port “B” flows through the low-pressure passage to the tank. The spool can be restored to its neutral position by return spring.

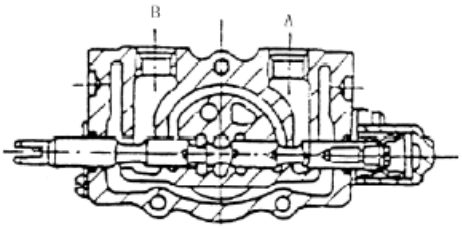



Fig. 5-6 Draw out spool

(2) Motion of safety relief valve

The relief valve is mounted between “HP” nozzle of oil pump and “LP” passage. Oil passing through lifting valve C acts on different areas of diameters “A” and “B”, thus, “K” of check valve and “D” of overflow lift valve are on the valve seat as shown in Fig. 5-7. When the pressure regulated in “HP” passage of oil pump acts on the spring of pilot valve, the check valve “E” will open. The oil flows into “LP” side through holes around the valve as shown in Fig. 5-8.

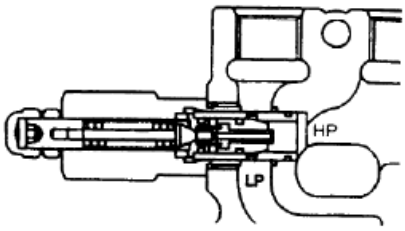



Fig. 5-7

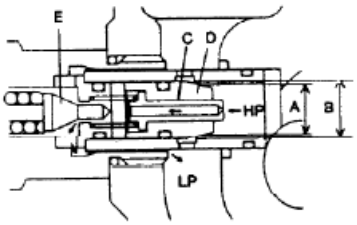



Fig. 5-8

Once the pilot valve “E” opens, the pressure inside valve “C ” will drop, valve “E” and valve “C” are on the valve seat. The liquid flowing to the rear of the valve “D” will be closed, so the pressure inside will be decreased. (See Fig. 5-9)

The “HP” passage pressure and inside pressure of oil pump are not even, the valve “D” opens with the action of pressure difference and oil directly flows into the low pressure circuit “LP”. (Refer to Fig. 5-10).

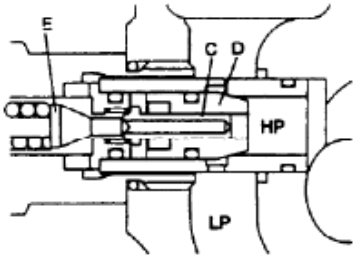



Fig. 5-9

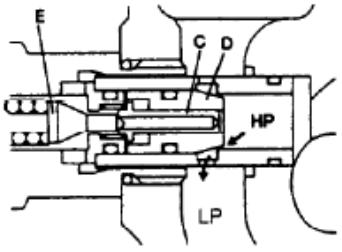



Fig. 5-10

(3) Action of tilt-lock valve

Tilt spool valve housing contains a tilt-lock valve. The tilt lock valve is intended to prevent vibrations of the mast resulting from the negative pressure in the tilt cylinder and also to avoid danger incurred from mishandling of the spool. When the lift motor isn't running, the mast doesn't be tilted forward by push the tilt lever.

See Fig. 5-11, when the spool is pushed in. See Fig. 5-12, when the lift motor stops.

a) The spool is pushed in

The pressure oil flows through the port "B" to tilt cylinder and moves the tilt-lock valve to let the port "A" connect with the low-pressure tank. The tilt cylinder and the mast is tilted forward.

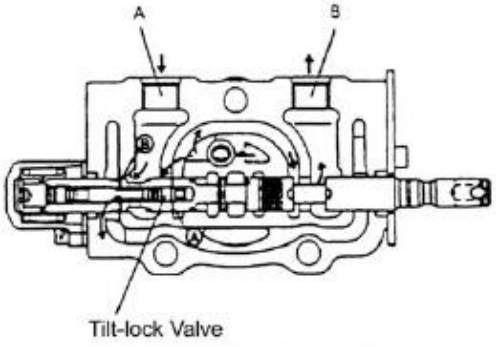



Fig. 5-11

b) The spool is pushed in (when the lift motor stops)

When the lift motor stops, no pressure oil flows to the tilt-lock valve. The port "A" can't connect with the low-pressure tank and the mast doesn't be tilted forward.

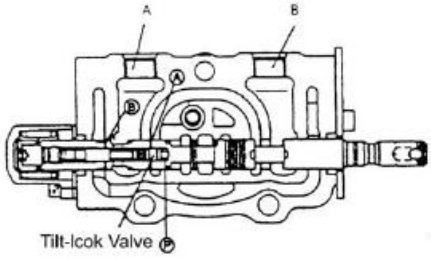



Fig. 5-12

(4) Operation of the control valve

The control valve is operated with the valve levers. All valve levers are assembled

together with a shaft and the shaft is assembled on the valve joint plate with the bracket. The valve levers operate the control valve with the joints. (See Fig. 5-13)

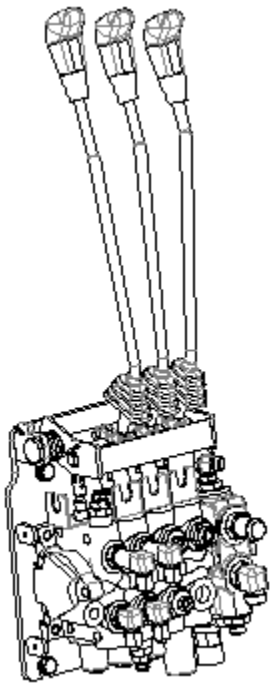


Figure 5-13 Control valve

As you see in Fig. 5-14, the mast lift up when you push the lift lever forward, the mast fall down when you pull the lift lever backward. The mast tilt forward when you push the tilt lever forward, the mast tilt backward when you pull the tilt lever backward.

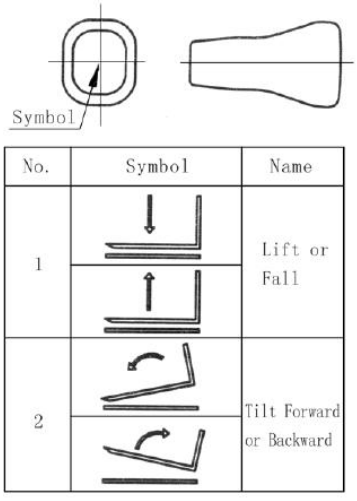



Fig. 5-14 The symbol on the operation lever

(5) Setting pressure of the control valve (See Fig. 5-15)

The pressure of the safety valve shall not be adjusted by non-professional personnel. The adjustment shall follow following procedures:

a) Screw off the plug of the measuring hole on the inlet of the control valve. Install an oil pressure gauge capable of measuring 25MPa.

b) Operate tilting lever and measure the pressure at the end of the cylinder stroke.

c) If the oil pressure is different with the specified value, loosen the locking nut of the relief valve and turn the adjusting screw left and right until the pressure reaching the specified value. Turn left when the pressure is high and turn right when the pressure is low.

d) Tighten the nut after adjusting.

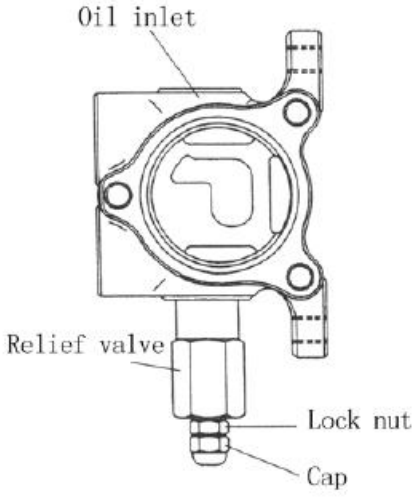
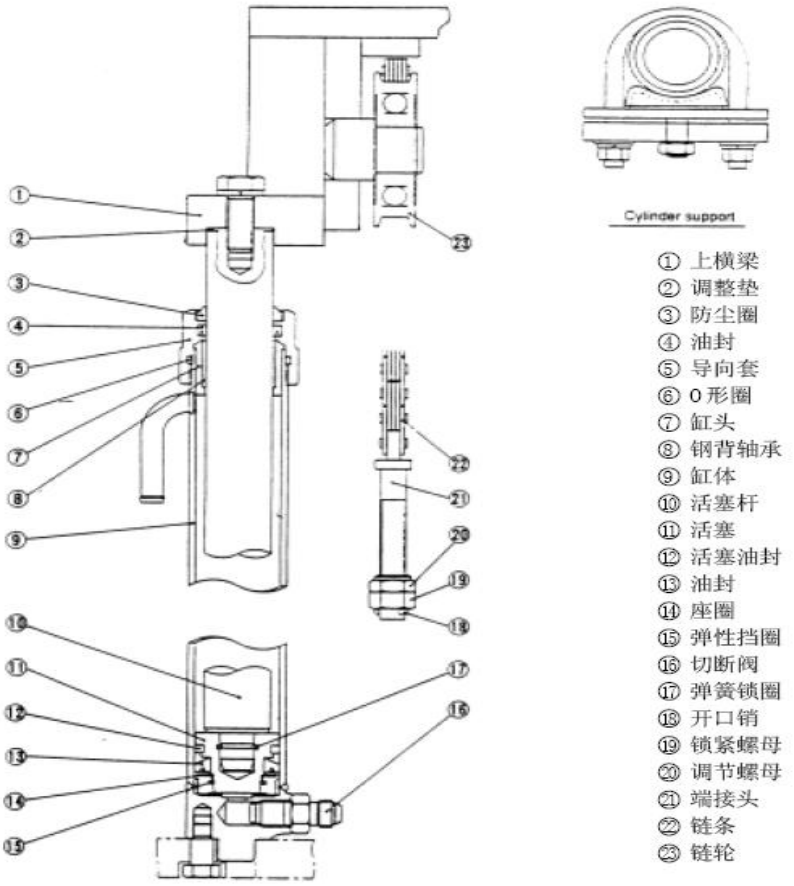



Fig. 5-15

### 5.1.3 Lift cylinder

The lift cylinder is of single-acting piston type. It consists of cylinder body, piston, piston rod, cylinder cap, cut-off valve and oil seals. The cylinder head is equipped with bushing and oil seal and the bushing supports the piston rod and the oil seal keeps dust off. (See Fig. 5-16)

When the hoist valve of control valve is placed at lifting position, hydraulic oil enters into the lower part of piston of hydraulic cylinder from pressure-gradient control valve to selector valve to push rising of piston and lifting of the goods. When the hoist valve of control valve is placed at descending position, the piston rod drops with the action of goods, mast, fork bracket and piston itself, the hydraulic oil is pressed back to oil tank. If the cut-off valve is mounted at the bottom of cylinder (See Fig. 5-17), it can play the role of protection if the mast rises when high-pressure pipe cracks.

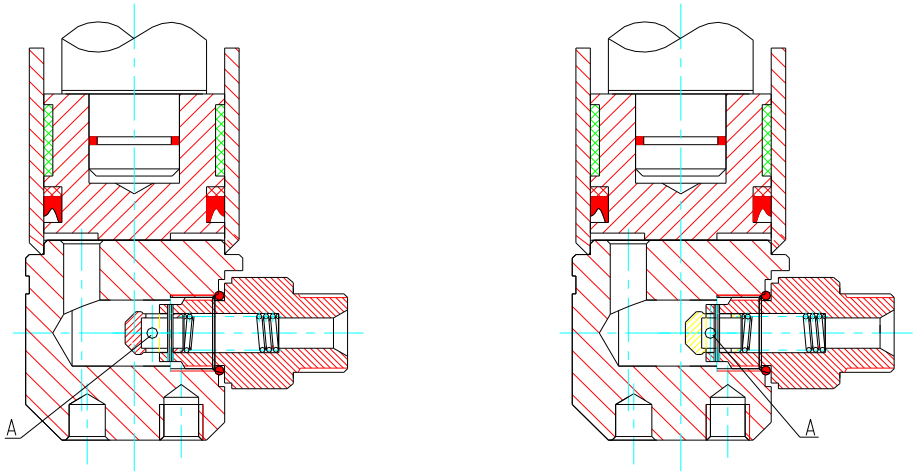



1. upper beam 2. Adjusting shim 3. Dust proof ring 4. Oil seal
5.Guide sleeve 6. O ring 7. Cylinder head 8. Bearing
9. Cylinder body 10. Piston rod 11. Piston 12. Piston oil seal
13. oil seal 14. Seat ring 15. Snap ring 16. Cut-off valve
17. spring lock ring 18. Collar pin 19. Lock nut 20. Adjusting nut
21. end connector 22.chain 23. Chain wheel

Figure 5-10 lifting cylinder

### 5.1.4 Cut-off valve

The cut-off valve is mounted at the bottom of the cylinder (See Fig. 5-17) to prevent the goods from falling suddenly when the high pressure pipe is broken. The oil from hoist cylinder passes through the hole A on the outer circumference of the spool when returning to oil tank, if flow rate of oil through the hole is less than the setting value of the valve and the pressure difference before and after spool smaller than spring force, the spool will not move at this time and slide valve does not work. If the flow rate through the spool hole exceeds the setting value due to high pressure pipe cracking or other reasons, the pressure difference before and after spool will be larger than the spring force and move the spool to the left. In this way, hole A is closed, only small amount of oil flows out from the small clearance of spool and valve bush and the goods descends slowly.




When flow is lower than set value  when flow is higher than set value

Figure 5-17 working principle of cut-off valve

### 5.1.5 Flow regulator valve

The flow regulator valve, located in the lift cylinder circuit to limit the descending speed of loaded forks, has the construction as shown in Fig. 5-18.

When the lift spool is placed in the “lift” position, the oil from the control valve flows through the oil chambers A and B, oil holes C, D, E and F, and the chamber G to the lift cylinder without any regulation. When the lift spool is placed in the “down” position, the oil pusses the orifice plate and a pressure difference generates between

the chambers A and B, the pressure difference overcomes the force of the spring and moves the valve core right, thus the oil flow being decreased by narrowing of the hole D and C, and reduces the oil flow passing through the orifice plate.

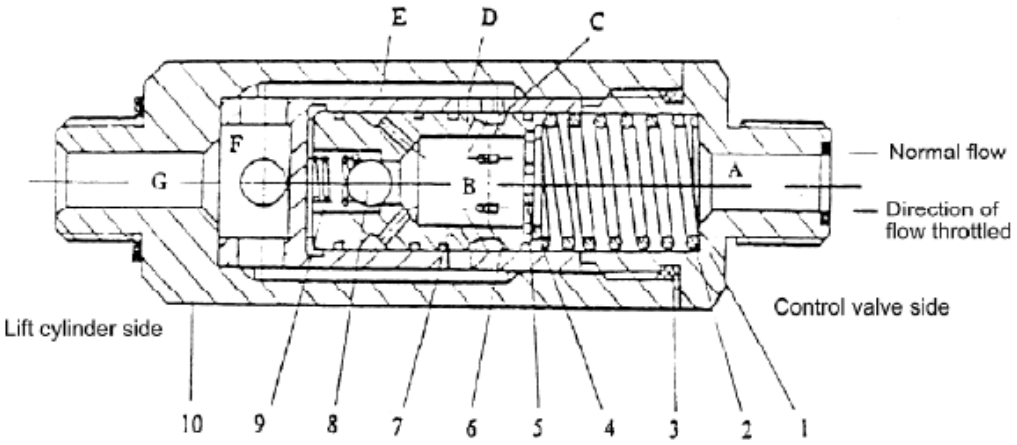



Fig. 5-18 Flow regulator valve

(1) Nipple (2) Spring (3) Ring seal (4) Snap ring (5) Spool (6) Sleeve
(7) Steel ball (8) Spring of the check valve (9) Valve body

### 5.1.6 Tilt cylinder

The tilt cylinder is of double-action and piston type hydraulic cylinder and is mounted at both sides of mast with its piston rod end connecting with mast. The bottom of tilt cylinder is connected through dowel with connecting end of frame and mast and the forward and backward tilting of the mast are fulfilled by the motion of tilt cylinder.

The tilt cylinder consists primarily of piston, piston rod, cylinder body, cylinder base, guide sleeve and seals. The piston, welded to the piston rod, is fitted with two Yx-rings and one wear ring on its circumference. A bushing press-fitted to the inner side of the guide sleeve supports the piston rod. The guide sleeve is with dust seal, snap ring, Yx-ring and O-ring to prevent oil leakage and keep dust off. Fitted with them, the guide sleeve is screwed into the cylinder body. When piston moves, oil enters from one port and exits from the other. The piston rod is furnished with adjusting threads to adjust the difference between the dip angles. (See Fig. 5-19)

When the tilt lever is pushed forward, the high-pressure oil enters into the

cylinder body from the cylinder tail, moving the piston forward and causing the mast assembly to tilt forward until 6 degrees. When the tilt lever is pulled backward, high-pressure oil enters into the cylinder body from the guide sleeve and moves the piston backward, tilting the mast assembly backward.

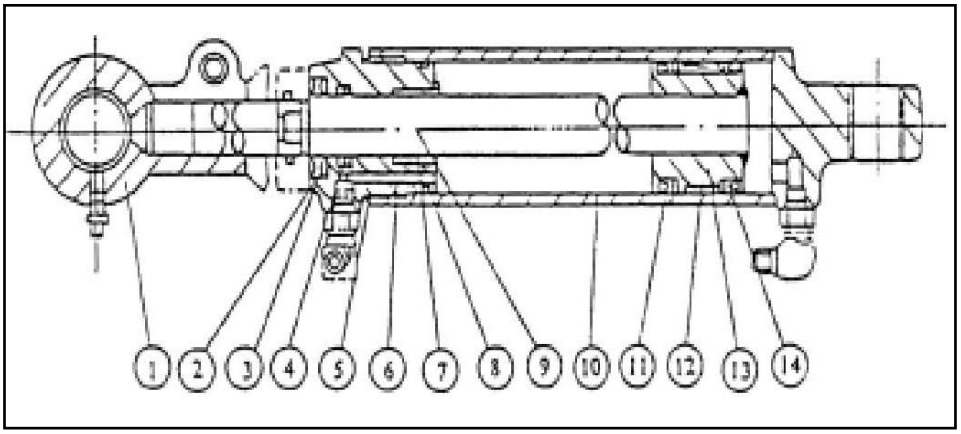



Fig. 5-19 Tilt cylinder

(1) Ear ring (2) Dust ring (3) Snap ring (4) Yx-ring (5) O-ring (6) Guide sleeve (7) Bushing (8) O-ring (9) Piston rod (10) Cylinder body (11) Yx-ring (12) Wearing
(13) Piston (14) Yx-ring

### 5.1.7 Oil tank

Oil suction filter is fixed in the oil tank while the return oil filter is fixed in the oil returning pipelines to make sure the cleanness of the supplied oil.

### 5.1.8 Hydraulic oil circuit

The hydraulic system principle diagram see Fig. 5-20 and the hydraulic oil circuit see Fig. 5-21.

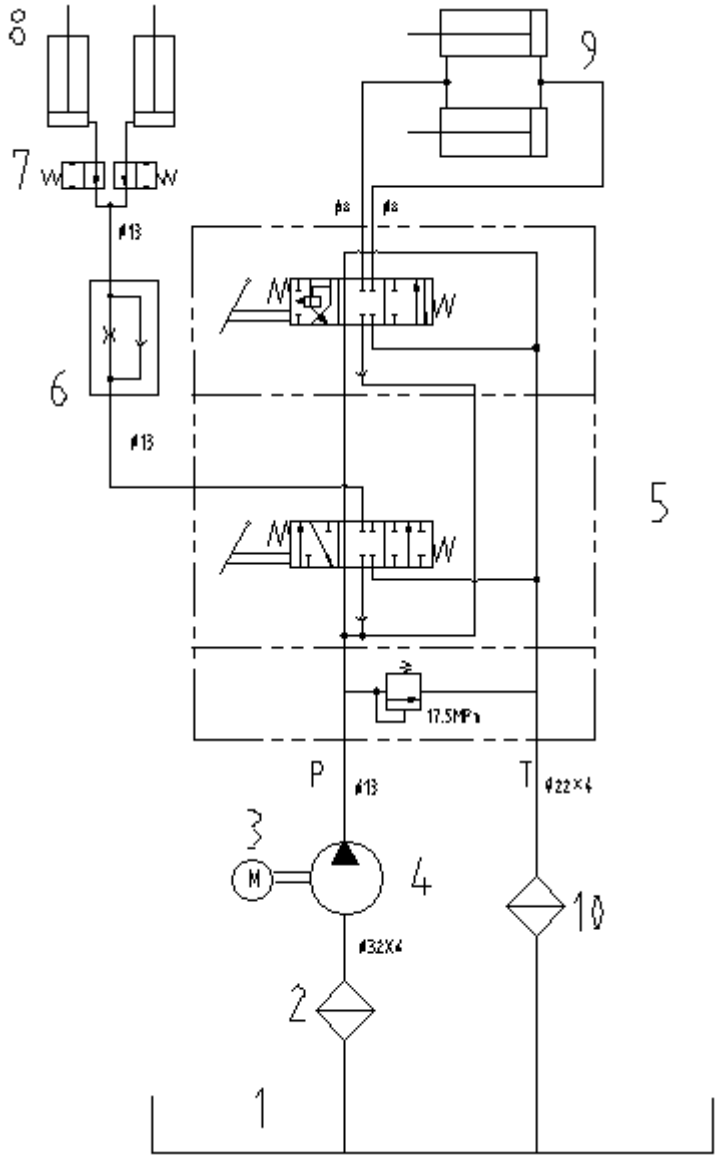



Fig. 5-20 Hydraulic system principle diagram

(1) Oil tank (2) Oil suction filter (3) Pump motor (4) Gear pump (5) Control valve (6) Flow regulator valve (7) Cut-off valve (8) Lift cylinder (9) Tilt cylinder (10) Return oil filter

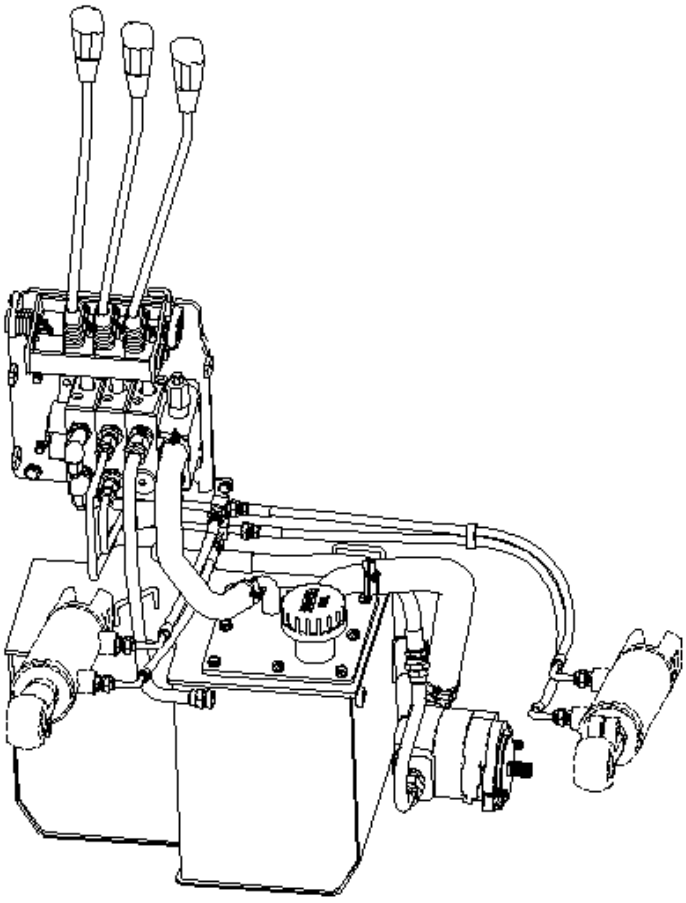


Figure 5-21 Hydraulic pipeline

## 6. Lifting system

### 6.1 Normal type lifting system general description

Normal type lifting system is of two stage roller type with veritical up and down moving. It is made up of inner mast, outer mast, two rear lifting cylinder and fork brakcet.

### 6.2 Inner mast and outer mast

Inner mast and outer mast are welded parts. Refer to figure 6.1. The weight is beared by frame. The middle part of the outer mast is connected with frame throught tilting cylinder and it can tilt forward and backward under the action of tilting cylinder. The steel channel of outer mast is of C type. There is one pair of combined roller on top of the end. The steel channel of inner mast is of H type and there is one pair of

combined roller at the lower end. The inner mast keeps a fixed ralative position between inner mast and outer mast during moving through main roller and side roller.

The maintenance of the roller and the side rollers on the inner and outer masts is very important. Please be careful.

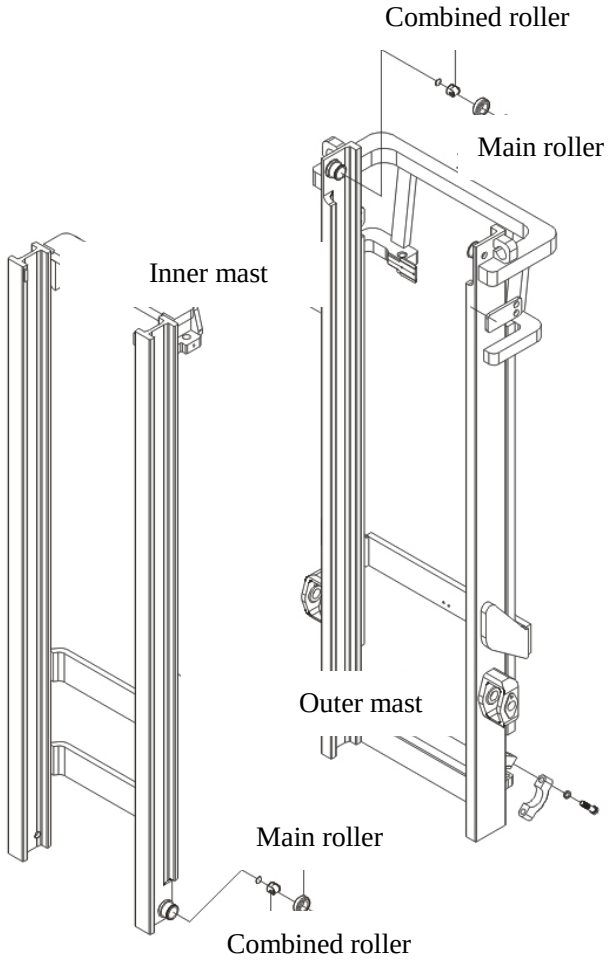



Figure 6-1 inner mast and outer mast

### 6.3 Fork bracket

The fork bracket runs inside of the iner mast through main roller. The main roller is installed on main roller shaft with snap ring. The main roller is welded on fork bracket. The side roller of upright plate is fixed on forkbracket with bolt. The longitudinal load is beared by main roller. When the fork is lifted to the highest position, the upper roller comes out form the mast upper end. The transverse load is

beared by side roller.

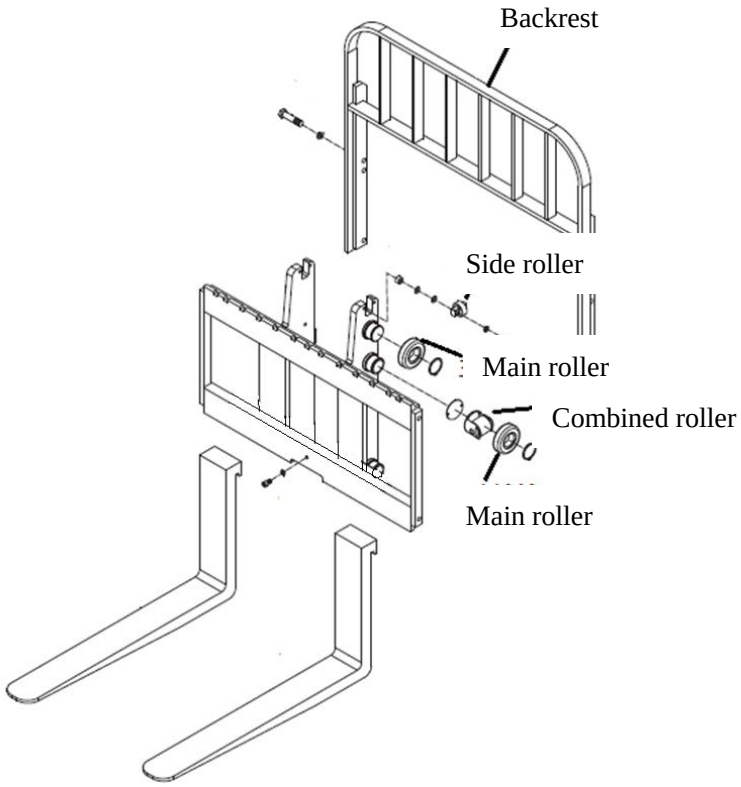



Figure 6-2 Fork brakcet

**6.4 Roller adjusting method**

There are 10 main rollers which are installed on outer mast upper end (2), inner mast lower end (2) and two sides of forkbracket upright plate (6) respectively.

There are 8 combined rollers which are installed on outer mast upper end (2), inner mast lower end (2) and fork bracket (4) respectivily.

The using of main roller and combined roller makes inner mast and fork bracket move smoothly.

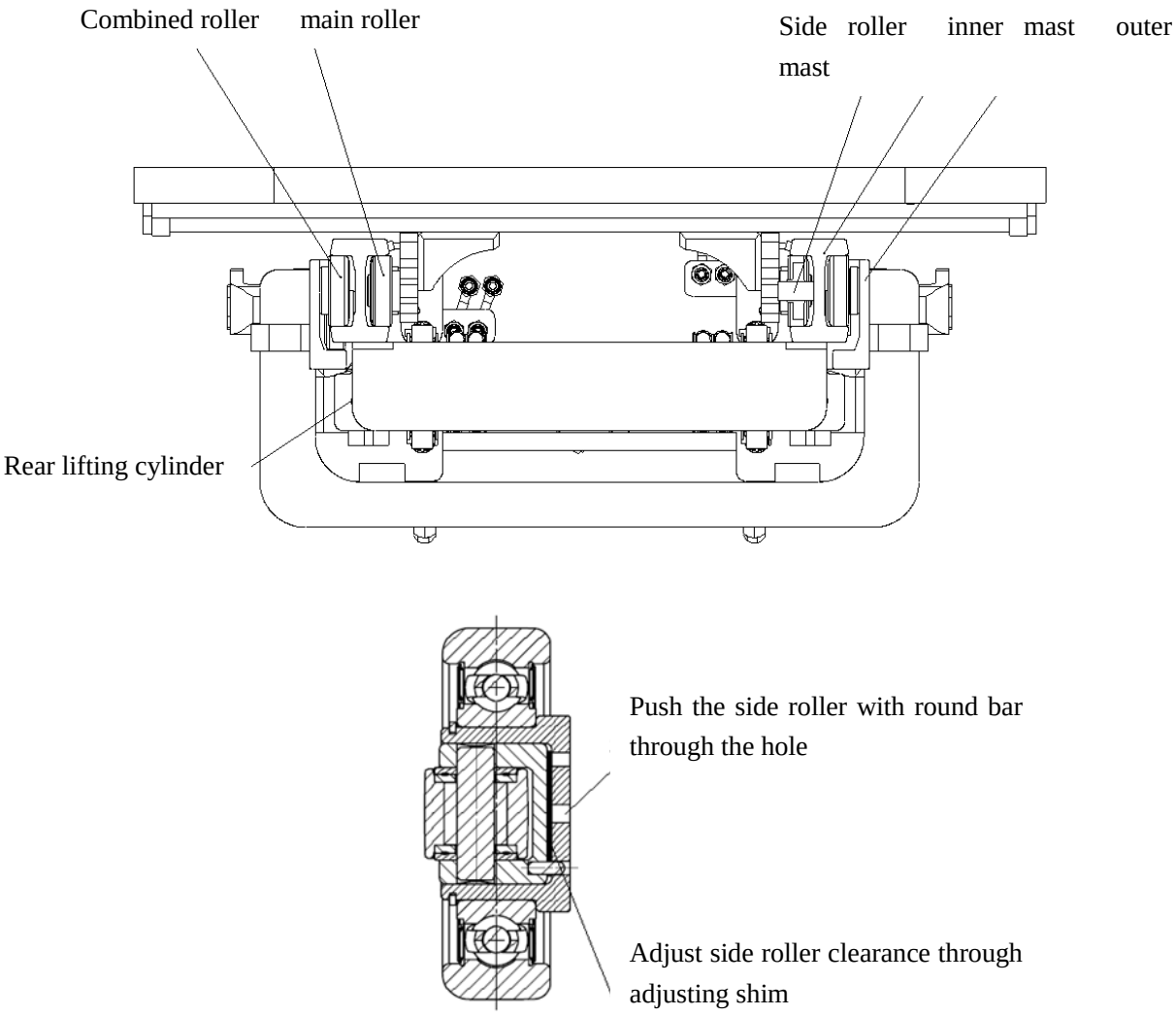



Figure 6-3 roller layout

Note: (a) side roller clearance is between 0 and 0.5mm.

(b) Apply grease on main roller surface and mast conntacting surface.

## 6.5 Repair

### 6.5.1 Lifting cylinder adjusting

When dismounting or changing lifting cylinder, inner mast or outermast, rear lifting cylinder needs readjust. (refer to figure 6-5). Adjusting method is followed:

(1) Install piston rod head into inner mast top beam without adjusting shim.

(2) Lift the mast slowly to cylinder max. stroke. Check if two cylinders are synchronous. If the two cylinders do not stop at the same time, it means the cylinder stokes are not the same. Adjust the stoke to be the same through asjuting shim (0.2mm

and 0.5mm).

(3) Lower the inner mast slowly and check if two cylinders stroke are synchronous. Refer to the method above to adjust.

(4) Adjust chain tensioning.

Lifting cylinder adjusting is very important, please take care.

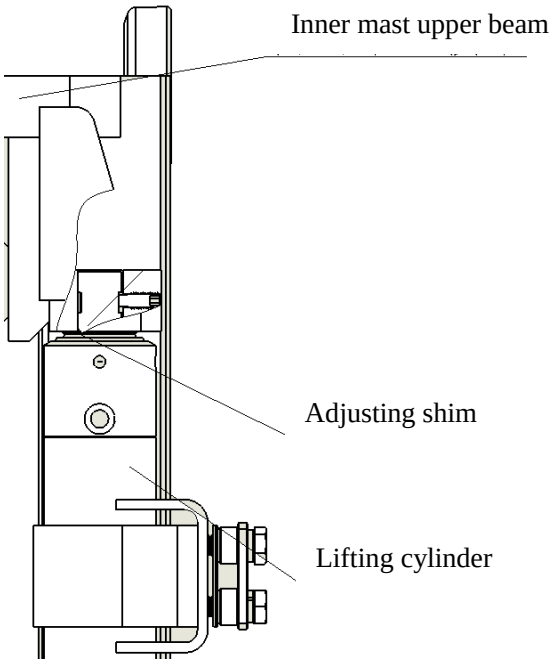



Figure 6-4

### 6.5.2 Adjust lift bracket's height

(1) The truck should be stopped on horizontal ground. And ensure the masts erect.

(2) Lower the forks on the ground, adjust the set nut of tie-in on the upper of chains to make the distance A between main rollers and the lift bracket.

(3) Make the mast assembly tilt backward when forks descended to the ground, adjust the pulling force of lift chains and let the tightness of lift chains be equal.

| Truck type | A mm |
|---|---|
| 1-1.8t | 36-41 |
| 2-2.5t | 24-29 |
| 3-3.5t | 19-24 |

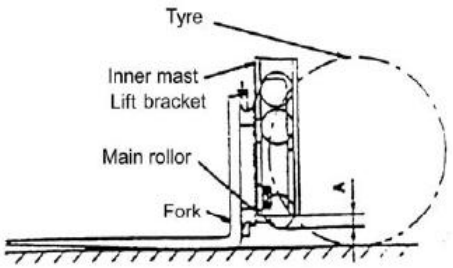



Fig. 6-5 Adjust lift bracket's height

### 6.5.3 Replacing rollers of the lift bracket

(1) Place a salver on the forks and make the forklift stop on the horizontal ground.

(2) Make the forks and salver descend to the ground.

(3) Take down tie-in on top of the chains. And take out chains from sheave. (See Fig. 6-7)

(4) Make the inner mast rise.

(5) The forklift can be reversed when the lift bracket disengaged from the outer mast.

(6) Replacing main rollers

(a) Take apart all of snap ring from the lift bracket and take out main rollers.

(b) Fit the new main roller (the same type as the old one) on the lift bracket and fastened with snap ring.

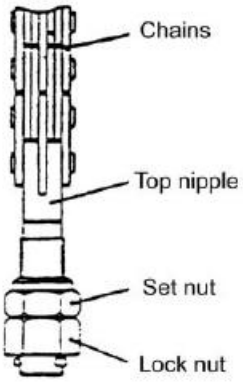



Fig. 6-6

### 6.5.4 Replacing rollers of masts

(1) Take apart the fork bracket from the inner mast, then replace the main roller follows the way as 6.5.3.

(2) Park the truck on the horizontal ground and lift up the front-wheel 250～300mm from the ground.

(3) Pull parking brake level fully, and use a wedge to make back-wheel stationary.

(4) Take apart bolts which fastened lift cylinders and the inner mast. Hang up the inner mast without losing shims of the piston rod heads carefully.

(5) Take apart bolts which jointed lift cylinders and the bottom of outer mast and take apart the oil-pipe between two lift cylinders without loosing the nipple.

(6) Let down the inner mast and dismantle inner mast lower end main roller.

(7) Main rollers on the upper outer mast will be showed on the top of the inner mast, then main roller can be removed.

(8) Replacing main rollers

a) Take apart the upper main rollers without losing shims.

b) Fit the new main roller and shims together on the outer mast.

(9) Hang up the inner masts and let all rollers in the inner mast.

(10) Assembly the lift cylinder and the lift bracket as disassembly contrarily.

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