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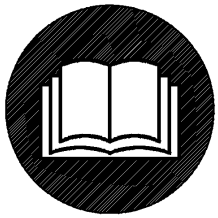
Total 17 Pages（Text 12 Pages）

EPFRCG-06-175-500-EX-10-S7

PROPORTIONAL SOLENOID OPERATED PRESSURE/FLOW CONTROL VALVE

INSTRUCTION MANUAL



Read the Instruction Manual

TOKIMEC

TOKIMEC INC.
CONTROL DIVISION Ⅱ

SAFETY PRECAUTIONS

Hydraulic equipment will perform as intended if used properly. However as hydraulic components involve pressurized vessels, incorrect use may cause bursting or other hazardous situations which may lead to accidental injuries or death. Carefully read this section " SAFETY PRECAUTIONS ", and observe the following points in order to avoid accidents.

The meaning of indicators for safety used in this manual is as follows.

⚠ DANGER — **Indicates an imminently hazardous situation which, if not avoided, may be LIFE-threatening.**

⚠ WARNING — **Indicates a potentially hazardous situation which, if not avoided, may result in death or serious injury and property damage.**

⚠ CAUTION — **Indicates a potentially hazardous situation which, if not avoided, may result in personal injury and property damage.**

1. Handling of products

⚠ CAUTION

(1) To prevent injury when handling products, protective gear should be worn depending on the situation.
(2) Care should be paid on how the work is carried out in order to prevent injuries, such as to hands and back, attributable to component weight and working posture.
(3) Do not step on, hit, drop or apply excessive external force to the component as it may affect function or cause damage, oil leakage, and other problems.
(4) Oil on the product or floor should be wiped clean to prevent dropping or slipping.

2. Mounting and Removal of product

⚠ DANGER

(1) There is much similarity in appearance of hydraulic components. Confirm correct product model code when making product replacements.

⚠ WARNING

(1) Confirm that power to equipment is OFF and that electric motor or engine has stopped movement prior to activities such as component installation , removal, and piping. Also confirm that pressure does not remain in the hydraulic system.
(2) Pumps, motors and other rotating shafts or components should be covered to protect against enmeshing hands or clothing.
(3) Tasks should be performed by technician competent in hydraulic systems..
(4) Insure that power is disconnected before performing any electrical wiring work to prevent shock and injury.

⚠ CAUTION

(1) Clean mounting holes and mounting interfaces. Improper tightening of bolts or damage to seals may result in product damage or oil leakage.
(2) Use specified bolts for mounting and tighten to specified torques as improper mounting may cause operational failures, product damage, or fire by oil leakage.

3. During operation

⚠ DANGER

(1) In explosive or flammable environments, insure that product used is suitable for such ambient conditions in order to prevent serious injury or death.

⚠ WARNING

(1) Pumps, motors and other rotating shafts or components should be covered to protect against enmeshing hands or clothing. Also, never operate with a cover removed.

(2) Before system is started up for the first time, check to insure correctness of the hydraulic circuit and electrical wiring and that joints are not loose.

(3) Immediately halt operation when an abnormal condition is detected (abnormal noise, oil leakage, smoke, etc.) and take appropriate action, as such condition may lead to equipment damage, fire, or injury.

⚠ CAUTION

(1) Products should be used in conformance with the specifications outlined in the product catalog, drawings, or specification sheets.

(2) Proper fluid should be used and recommended cleanliness(contamination) levels should be maintained in order to prevent operational failures or component damage.

(3) Components may become hot during operation due to increased oil temperatures and solenoid energization and cause injury if touched.

4. Maintenance and storage

⚠ DANGER

(1) As many fluids are flammable, never operate hydraulic equipment or machines near a fire source or welding work.

⚠ WARNING

(1) User SHOULD NEVER attempt to modify components. Do not disassemble or reassemble components, unless as directed by the manufacturer, as this may affect product function or lead to failures or accidents.

⚠ CAUTION

(1) When transporting or storing product, care must be paid to ambient conditions such as temperature and humidity to prevent dust accumulation and corrosion.

(2) After long periods of storage, component seals should be replaced before operating product.

PREFACE

This manual provides information on safety, specifications, storage, mounting, removal, piping, wiring, operation startup and adjustment, maintenance and checks, etc. User should familiarize himself with the contents for correct usage of the product.

Points to observe

⚠ WARNING In reading this manual, please pay attention to the following points.

(1) Read manual carefully.

This manual contains important information and should be thoroughly read.

(2) Maintain manual with care.

This manual is an important guide in the proper use of and care of the product. It should be kept at hand for easy reference and should be maintained at a prescribed location with a person assigned responsibility for its keeping.

(3) Manual should be available to those who actually will use and handle the product.

Intermediaries such as sales agents should ensure that this manual is provided to such personnel.

(4) Replace manual immediately if lost.

If manual is lost, contact the TOKIMEC office shown on the last page to order a replacement.

CONTENTS

Chapter 1 Introduction

This valve is a proportional solenoid operated pressure/flow control valve to adjust pressure and flow rate of hydraulic circuits with electric signal (current signal).

Two proportional solenoids are used in the valve driving electromagnetic actuator to be able to control pressure and flow rate of a hydraulic system in proportion to the input current.

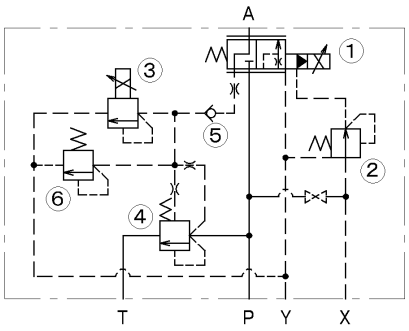
The stable pressure control is made by using the proportional solenoid operated relief valve "EPCG2-01" (pilot valve) and the balance piston type relief valve (main valve).

The proportional solenoid operated relief valve has excellent response characteristics and linearity, and is strong to contamination. Because of providing the manual adjusting function when no electric power is supplied, it is easy to inspect the equipment. The low noise balance piston type relief valve is used for the main valve, so it is possible to make the hydraulic system noise much lower.

In addition, the balance piston type relief valve operates as a pressure compensation valve when controlling the flow, and the supply ("P" line) pressure is controlled at the load pressure ("A" line) + the valve differential pressure to save energy of hydraulic circuits.

The flow control valve employs our unique position follow up technology using a nozzle flapper for driving a main spool, so very accurate spool positioning is possible. Because of the pilot-driven type, the main spool is not affected by external disturbances such as flow force, and accurate and quick response flow rate control is possible. The pilot section has a strong construction to contamination.

Graphical symbol



① Proportional solenoid operated flow control valve
② Pilot pressure reducing valve
③ Pilot pressure control valve (Proportional solenoid operated relief valve)
④ Main relief valve
⑤ Check valve
⑥ Safety valve

Chapter 2 Model code

EPFRCG – 06 – 175 – 500 – EX –10 – S7

1	2	3	4	5	6	7

1 Proportional solenoid operated pressure/flow control valve (with bypass type pressure compensator valve)

2 Valve size

3 Rated control prssure 175 : 17.5 MPa

4 Max. control flow rate 500 : 500 L/min.

5 Pilot EX : External pilot

6 Design number

7 Special features S7 : Refer to " Chapter 3. Specifications "

Chapter 3 Specifications

Operating pressure	P, A, X ports	max. 21 MPa
	T, Y ports	max. 0.1MPa Be sure to return Y port to the tank independently.
Rated control pressure		17.5 MPa
Rated control flow rate		500 L/min.
Pilot (X port)	Pressure	3 MPa or more
	Flow rate	approx. 2 L/min.
Hysteresis		3 % or less
Repeatability		1 % or less
Input current		max. 1 A
Coil resistance		14 Ω (at 20 ˚C)
Operating temperature range		0 ～ 60 ˚C
Operating oil viscosity		32 ～ 70 mm^2/s
Special features : S7		1) Modified main piston of the relief valve is used. 2) Orifice plate with check valve is used. 3) The safety valve "TGMCR-3" is used.

Chapter 4　Configuration and principle of operation

(The configuration of this valve is shown in page 11, Fig. 4.)

4.1　Pressure control valve

(1) Pilot pressure control valve

The proportional solenoid is used in the electromagnetic actuator and the pressure control in proportion to the input current is made.

The construction of pilot pressure control valve EPCG2-01 is shown in Fig. 1.

Main components are as follows.

① Seat　　⑤ Guide (bearing)
② Poppet　　⑥ Proportional solenoid
③ Spring　　⑦ Minimum pressure adjuster
④ Rod　　⑧ Manual pressure adjustment knob

(2) Main relief valve

This valve follows up the pilot pressure control valve to control the maximum pressure of the main circuit, and also functions as a pressure compensation valve when controlling the flow rate.

Refer to the graphical symbol (page 1) and Fig. 4.

4.1.1　Principle of operation of the pilot pressure control valve

The principle of operation of the pilot pressure control valve EPCG2-01 is explained first.　The construction is shown in Fig. 1.

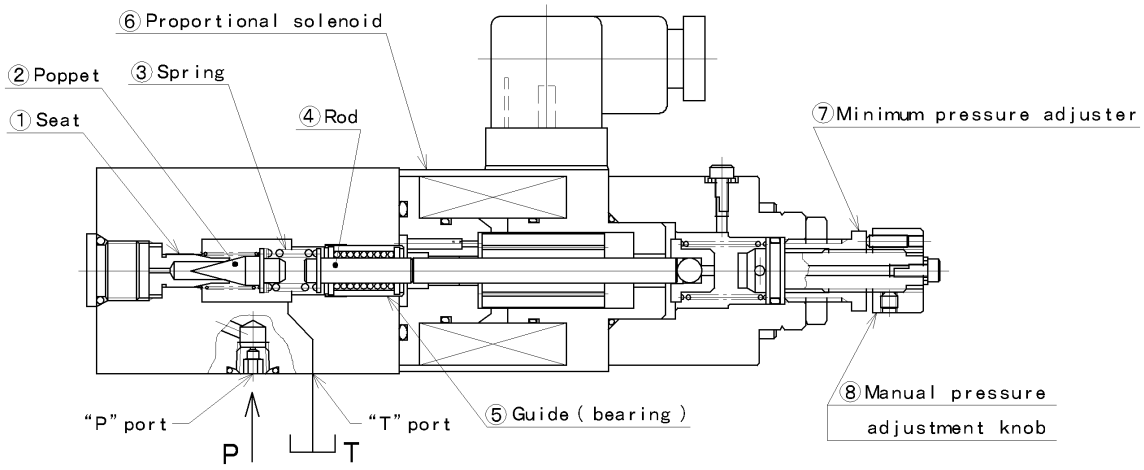


Fig. 1　Pilot pressure control valve (Proportional solenoid operated relief valve)

In Fig. 1, the operating oil flowed in from “P” port is restricted between the seat ① and the poppet ② and flows out from “T” port.　The oil from “T” port returns to the tank through “Y” port of EPFRCG valve.

When the current is applied to the proportional solenoid, the thrust in proportion to the current value generates.

In Fig. 1, the thrust generated in the proportional solenoid presses the poppet ② to the seat ① through the rod ④ and the spring ③.

When the poppet is pressed to the seat, the oil flow stops and the pressure of “P” port side rises.
When the force generated in the poppet section by this pressure exceeds the thrust of the proportional solenoid, the poppet is pressed back rightward to flow the oil to the tank and to prevent the pressure rising.
The stable point of the pressure is the point where the reaction force generated in the poppet and the thrust of the proportional solenoid are balanced, and this becomes the set pressure.

The formula of balance is as follows.

$$Fs = Pp \times A$$

The control pressure Pp equals to Fs/A.

Fs : Thrust of proportional solenoid
Pp: Control pressure
A : Pressure receiving area of seat, poppet section

Since the receiving area A is constant, any pressure can be obtained by variation of Fs.
Because the thrust Fs varies in proportion to the input current, the pressure control in proportion to the current value can be made.
The main relief valve is connected to “P” port of the proportional solenoid operated relief valve (pilot valve) through the vent line, and the main relief valve controls the main line pressure with following up the pressure of this pilot valve.

Not in the pressure control condition (when the line pressure does not rise to the relief valve set pressure while the hydraulic cylinder etc. is operating), the seat is being pressed to the poppet.

At this time, the control pressure is as follows.

$$P = Pp + f$$

P : Control pressure
Pp: Pilot valve control pressure
f : Pressure by main valve spring force

In this valve, the vent line of the main relief valve is connected to the secondary side of the proportional solenoid operated flow control valve, and the primary pressure (pump side pressure) is controlled with the secondary pressure (load pressure) + differential pressure of the valve.
The spring force of the pressure compensation valve is adjusted at approx. the double force of a usual relief valve to generate the differential pressure of the flow control valve.
As the result, the minimum control pressure is a little higher value (for the rated flow, approx. 1.3 MPa).

4.1.2 Manual pressure adjustment knob of the pilot pressure control valve

This pilot valve can set the pressure by manual operation even when no electric power is supplied. Refer to Fig. 2 and Fig. 3.

And our unique mechanism is employed for easy and accurate returning to the original point after manual operation by providing a separate minimum pressure adjusting mechanism.

Fig. 2 shows the state of shipment from the factory and Fig. 3 shows the state of manual operation.

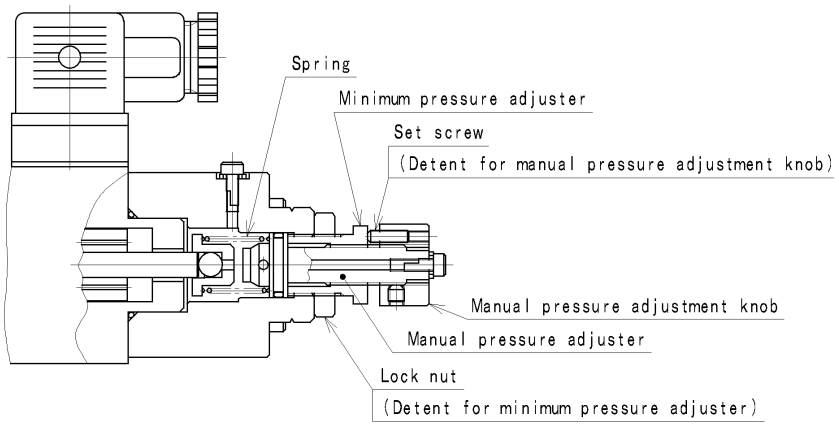


Fig. 2　The state of shipment from factory

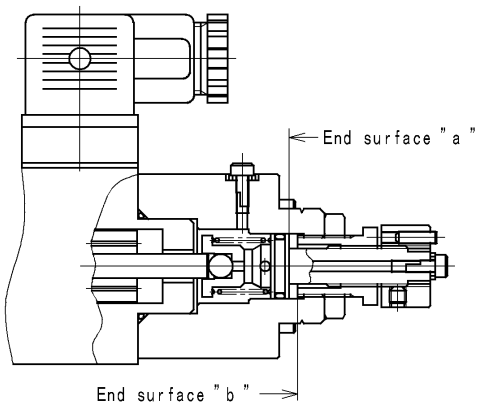


Fig. 3　The state of manual operation

The manual operating procedure is as follows.

(1) Loosen the set screw.

(2) Rotate the manual pressure adjustment knob clockwise (C.W.) gradually to raise the pressure. The maximum control pressure of manual operation is obtained where the left end of the adjustment knob touches the right end of the minimum pressure adjuster.

Note) Be careful not to tighten the manual pressure adjustment knob too much as the pressure by manual operation may become higher than the maximum pressure by the proportional solenoid operated control.

(3) Fix the manual pressure adjustment knob by the set screw when the desired pressure is obtained.

Operate with keeping to the following cautionary points.

Note 1) The pressure rises rapidly from where the manual pressure adjuster touches the spring. Operate the adjusting shaft gradually.
2) The minimum pressure adjuster has been adjusted when shipment. Do not change the adjustment.
3) The manual pressure adjustment knob has been fixed to the manual pressure adjuster after the adjustment. Do not loosen it.
4) It may be damaged if the manual pressure adjustment knob is rotated clockwise (C.W.) over the stroke end with a strong force. Do not screw in forcibly.

The procedure returning to the original point is as follows.

(1) Loosen the set screw.
(2) Rotate the manual pressure adjustment knob counter clockwise (C.C.W.).
(3) The end surface “a” and end surface “b” in Fig. 3 are close together and can not rotate any more.
(4) Fix the manual pressure adjustment knob with the set screw.

Now the operation is completed.

4. 2 Flow control valve

This valve consists of the following three units.

(1) Pilot pressure reducing valve
(2) Proportional solenoid operated flow control valve
(3) Pressure compensation valve (main relief valve combined use)

The proportional solenoid operated flow control valve consists of the following components.

(1) Proportional solenoid
To generate the thrust in proportion to the input current.

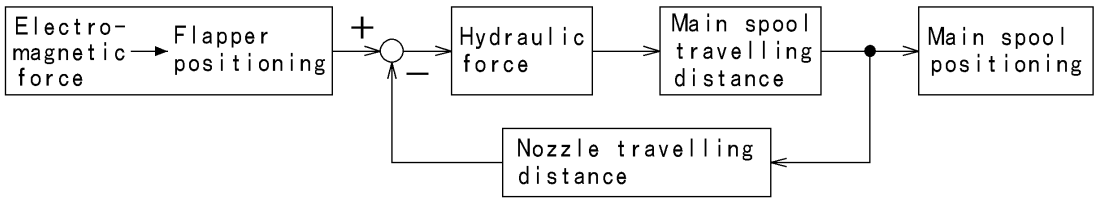
(2) Flapper and spring section
To do the flapper positioning in proportion the proportional solenoid thrust.

(3) Nozzle and main spool section
To do the main spool positioning with following up the flapper position.

(4) Manual flow adjustment knob
The same operation as that of the manual pressure adjustment knob of the pilot pressure control valve.

4.2.1 Main spool positioning

The main spool positioning is made as follows.



(1) When no pilot pressure is applied, the main spool is closed by the return spring force.

(2) The ratio of the left side pressure receiving area “A” and the right side pressure receiving area “B” of the main spool is as follows.

A : B = 1 : 2 (B = 2A)

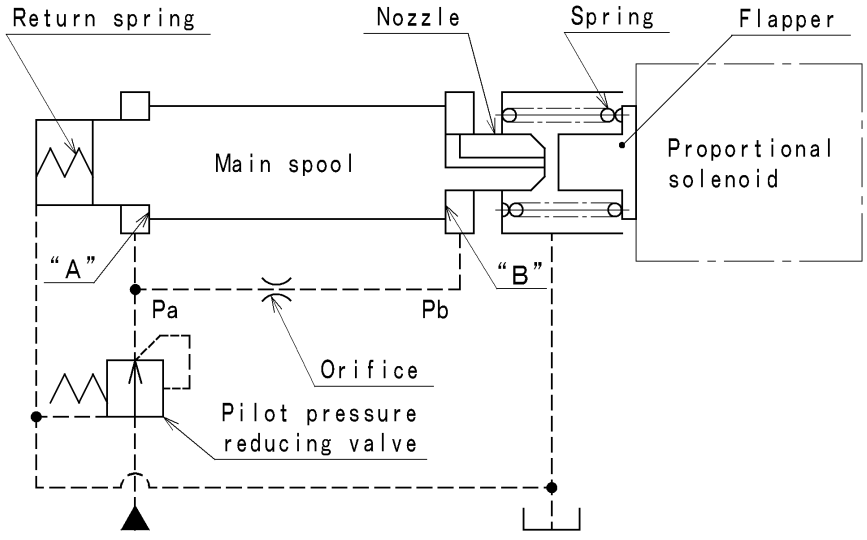
To the area “A”, the set pressure (approx. 3 MPa) is applied.
The force balance of the main spool is as follows.

Pa x A = Pb x B

(3) When the current is applied to the proportional solenoid, the flapper moves leftward, and the gap between the nozzle and the flapper becomes small. Pb gets large.

Pa x A < Pb x B

As the result, the main spool moves leftward.



(4) The gap between the nozzle and the flapper gets larger and Pb gets smaller until Pa x A gets equal to Pb x B.
In this way, the forces applied to the main spool are balanced for the main spool positioning.

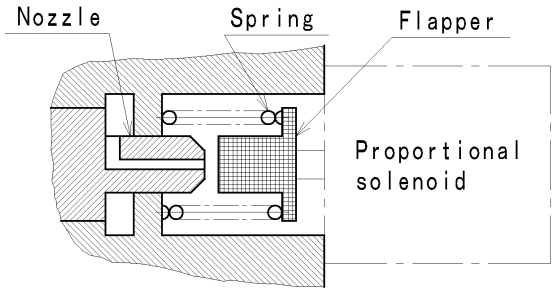
(5) The travelling distances of the main spool and the flapper are the same because the gap between the nozzle and the flapper is controlled to be constant.

4.2.2 Flapper positioning

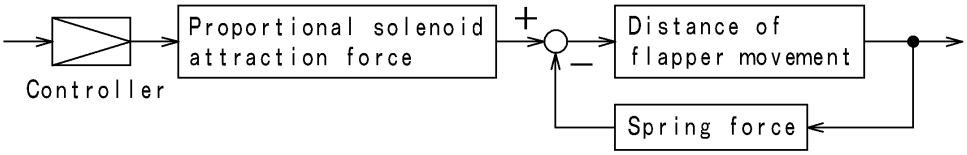
(1) The flapper positioning is made by the following construction and the formula.

X = F/K

X: Flapper travelling distance
K: Spring sensitivity
F: Proportional solenoid thrust



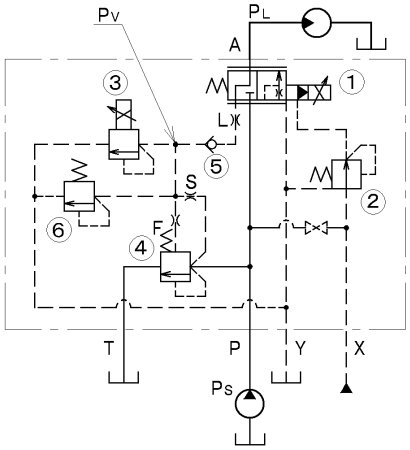
(2) The block diagram of the flapper positioning procedure is shown below. This pilot driving method is our unique system and the precise flow control is possible.



4.2.3 Pressure compensation valve

The main relief valve has the function combined with the pressure compensation valve. Refer to Fig. 4.

The valve operates with the meter-in bleed-off circuit as shown below.



① Proportional solenoid operated flow control valve
② Pilot pressure reducing valve
③ Pilot pressure control valve
(Proportional solenoid operated relief valve)
④ Main relief valve (Pressure compensation valve. Pressure receiving area: D)
⑤ Check valve
⑥ Safety valve

L : Orifice “L” (load side)
S : Orifice “S” (pump side)
F : Spring force “F”
Ps : Pump side pressure
PL : Load side pressure
Pv : Vent line pressure (spring force)

(1) The vent line is connected to the load side when no current is supplied to the proportional solenoid operated flow control valve.
Under this condition, when the current is supplied to the pilot pressure control valve of which system line is fully blocked, the pump side (“P” line) pressure rises slower depending on system volume because of the leakage from vent line to system line (“A” line).
In the case of none blocked, not fully closed, the pump pressure dose not reach to the setting pressure of relief valve.

(2) When the flow control valve is opened, the vent line is connected to the load side.

Formulas of balancing at this time are as follows.

$Ps \times D = Pv \times D + F$
$Ps - Pv = F/D$ (Constant)
$\Delta p1 = Ps - Pv$ = Constant

$\Delta p1$: Differential pressure of orifice “S”

As the result, the constant vent flow “q” flows to the load side through the orifice “S”, “L” and the check valve ⑤ because of the constant differential pressure ($\Delta p1$) at the orifice “S”.

(3) By this vent flow “q”, the pressure loss ($\Delta p2$) generates at the orifice “L”. This can be shown by the following formula.

$\Delta p2 = (Ps - Pv) \times (Ss/SL)^2$ = Constant

Ss: Area of orifice “S”
SL: Area of orifice “L”

In addition, the check valve cracking pressure (Pc) is added to the vent flow passed through the orifice when the flow passes the check valve ⑤. (Pc is approx. 0.1 MPa)
That is, the differential pressure of the proportional solenoid operated flow control valve is
Δp1 + Δp2 (constant) + check valve cracking pressure.

The pump side pressure is higher than the load side pressure by (Δp1 + Δp2 + Pc).

$$Ps = PL + (\Delta p1 + \Delta p2 + Pc)$$

As mentioned above, the primary pressure is controlled by the load pressure + the valve differential pressure in this meter-in bleed-off circuit, and this saves energy.

Chapter 5 Special features

Special features code: S7

- Modified main piston of the relief valve is used.
  This modification reduces peak pressure at the moment of conversion from flow control mode to pressure control mode.
- The orifice plate with check valve is used.
- Safety valve
  When some abnormality occurs in the pilot relief circuit, this valve protects the circuit from abnormal pressure.

Chapter 6 Caution in use

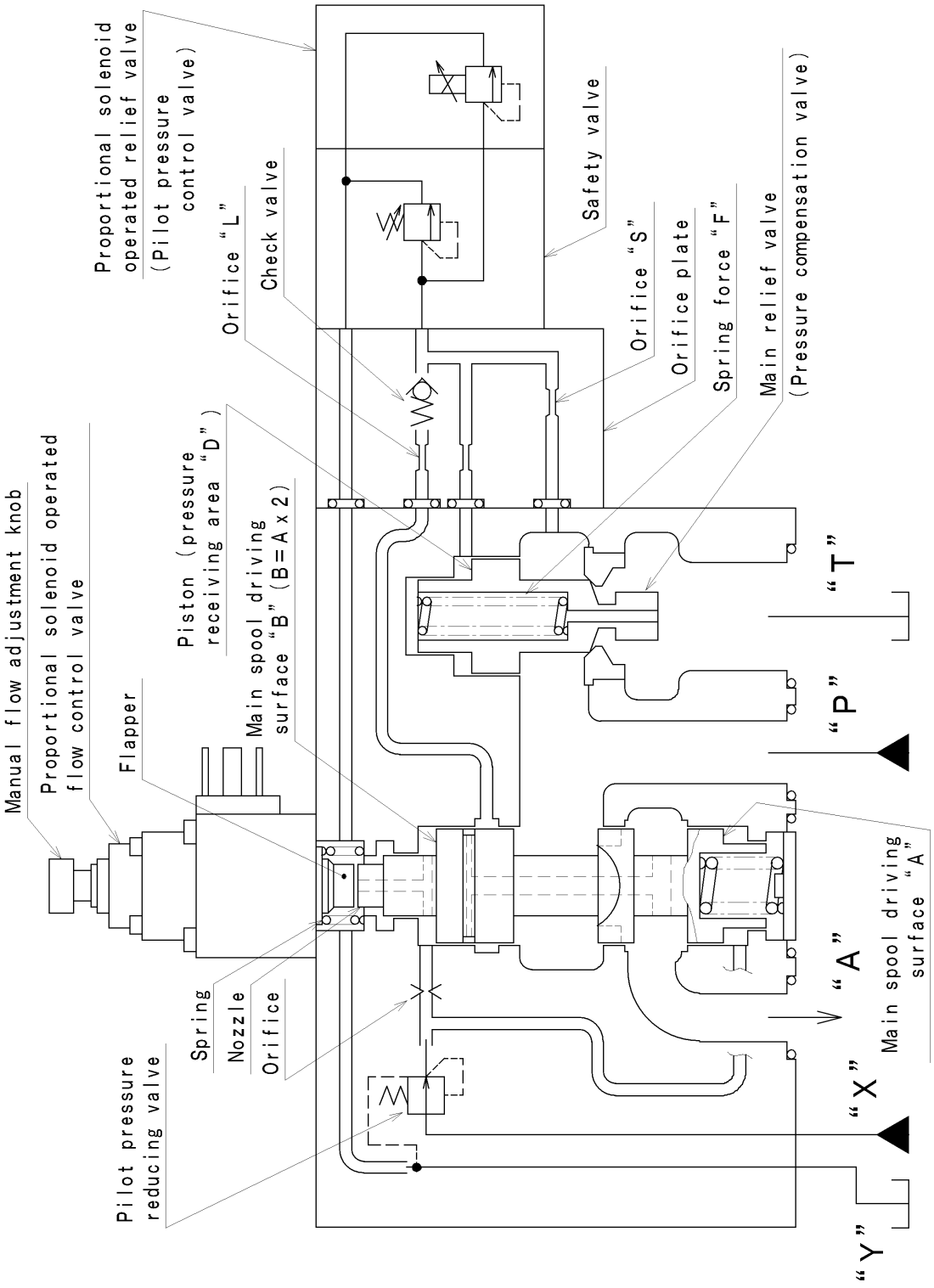
(1) Refer to Note in page 6 for the pilot pressure control valve.

(2) This valve is of pilot-driven type.
Higher than 3 MPa is necessary for the pilot line pressure.

(3) The zero adjusting screw of the flow control valve has been adjusted when shipment.
Do not operate with loosening the lock nut.

(4) The solenoid coil has no polarity.

Chapter 7　Configuration drawing (Fig. 4)



TOKIMEC INC. OFFICE TO CONTACT

- The office to contact for repair is as follows.

Name	TEL	FAX	Location
TOKIMEC INC. Head office	+81-3-3737-8631	+81-3-3737-8666	2-16-46. MINAMI-KAMATA, OTA-KU, TOKYO, 144-8551, JAPAN

- Contents of this manual are subject to change without notice.
- Contact us if you require clarification on any contents of this manual.

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