ACCUMULATORS

and

ACCUMULATOR CIRCUITS

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ACCUMULATORS and ACCUMULATOR CIRCUITS

Definition of Accumulator

An **Accumulator** is a **Device** that **Stores Potential Energy**
by means of **Gravity**,
Mechanical Spring,
or **Compressed Gases**.

The **Stored Potential Energy** in the **Accumulator** is a **Quick Secondary Source** Of **Fluid Power** capable of **Doing Useful Work** as **Required** by the **System**.

There are **Three Basic Types** of **Accumulators Used** in **Hydraulic Systems**.

They are **identified** as **Follows**:

1. **Weight-Loaded** or **Gravity Type**
2. **Spring-Loaded Type**
3. **Gas-Loaded Type**

Weight-Loaded Accumulator

The **Weight-Loaded Type** is historically the **Oldest**.

This type consists of a vertical, heavy-wall steel cylinder, which incorporates
A piston with packings to prevent leakage

A dead weight is attached to the top of the piston (see **Fig. 1**).

The **Force** of **Gravity** of the **Dead Weight provides**
The **Potential Energy** in the **Accumulator**

This **Type** of **Accumulator Creates** a **Constant Fluid Pressure** through out the full volume output of the unit **regardless** of the **Rate** and **Quantity** of **output**.

In the other types of **Accumulators**, the fluid output pressure decreases as a function of the volume output of the **Accumulator**.

The **Main Disadvantage** of this type of **Accumulator** is its
Extremely Large Size and **Heavy Weight**, which makes it
Unsuitable for **Mobile Equipment**.

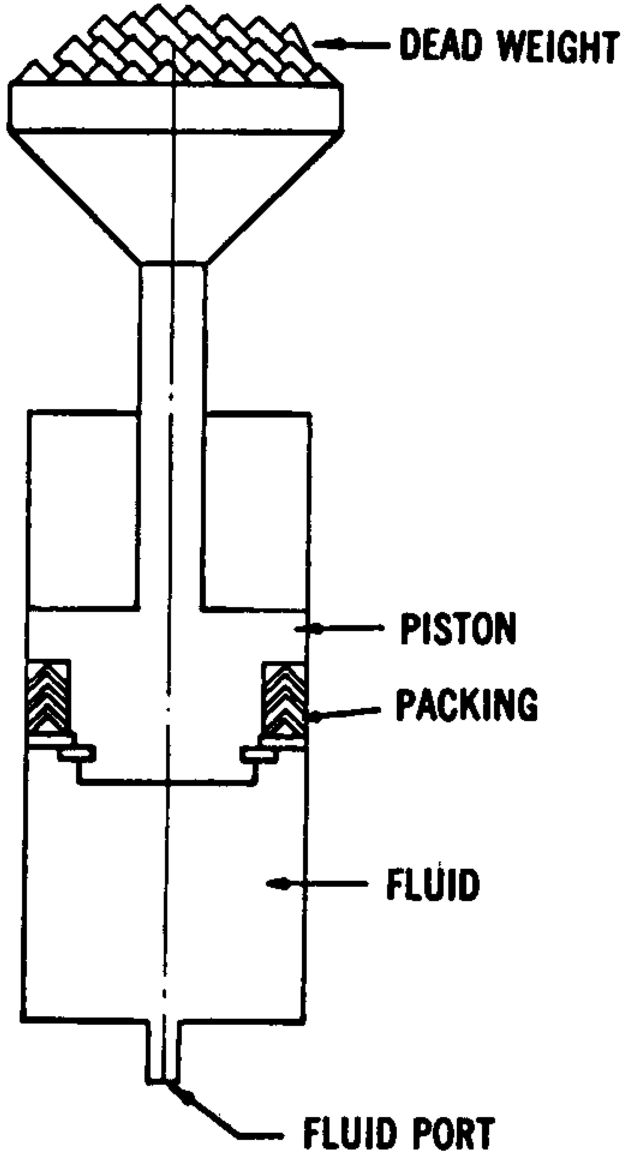


Fig. 1 Weight-Loaded Accumulator

Spring-Loaded Accumulator

A **Spring-Loaded Accumulator** is similar to the **Weight-Loaded Type** **except** that the **piston** is **preloaded** with a **spring**, as illustrated in **Fig. 2**.

The **spring** is the **source** of **energy** that acts against the **piston**, **forcing** the **fluid** into the **hydraulic system**.

The pressure generated by this type of **Accumulator** depends on the size and preloading of the spring.

In addition, the pressure exerted on the fluid is not a constant.

The spring-loaded **Accumulator** typically delivers a relatively small volume of oil at low pressures.

Thus, they tend to be heavy and large for high pressure, large-volume systems.

This type of **Accumulator** should **not** be used for applications requiring **high cycle rates** because the spring will fatigue and lose its elasticity.

The result is an inoperative **Accumulator**.

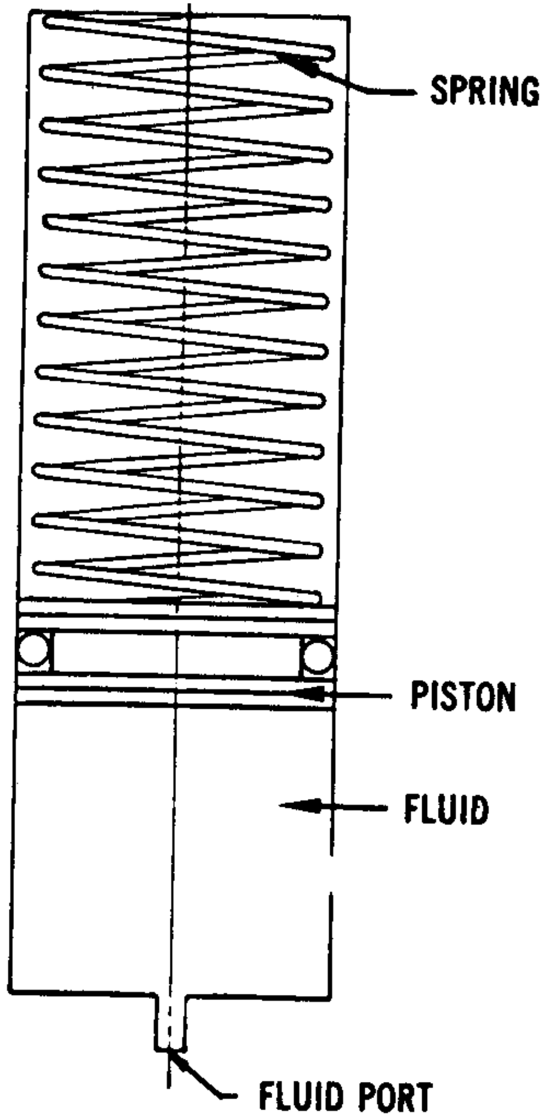


Fig. 2 Spring-Type Accumulator

Gas-Loaded Accumulators

Gas-loaded Accumulators (frequently called **hydro-pneumatic Accumulators**) have been found to be **more practical** than the **weight-** and **spring-loaded types**.

The **gas-loaded type operates** in accordance with **Boyle's law** of **Gases**, which states that for a **constant temperature process**, the **pressure** of a **Gas varies inversely with** its **volume**.

The **compressibility** of **gases accounts** for the **storage** of **potential energy**.

This **energy forces** the **oil out** of the **Accumulator when** the **gas expands due** to the **reduction** of **system pressure when**, an **actuator rapidly moves** a load.

Nitrogen is the gas used in accumulators because (unlike air) it contains no moisture.

In addition, **nitrogen** is an inert gas and thus will not support combustion.

Gas-loaded **Accumulators** fall into two main categories: **1- Non-separator type**
2- Separator type

Non-Separator Type Accumulator

The **Non-Separator Type** consists of
A fully enclosed shell containing an oil port on the bottom
and a gas charging valve on the top (see **Fig. 3**).

The gas is confined in the top and the oil at the bottom of the shell.

There is no physical separator between the gas and oil, and thus
the gas pushes directly on the oil.

The **Main Advantage** of this type is its **ability** to **Handle Large Volumes** of **Oil**.

The **Main Disadvantage** is **absorption** of the gas in the oil due to
the lack of a separator.

This type must be installed vertically to keep the gas confined
at the top of the shell.

This Type is **Not Recommended for use** with **High-Speed Pumps** because
The **Entrapped Gas** in the oil **could cause Cavitation** and **Damage** to the **Pump**

Absorption of **gas** in the **oil** also **makes** the **oil Compressible**,
resulting in spongy operation of the **hydraulic actuators**.

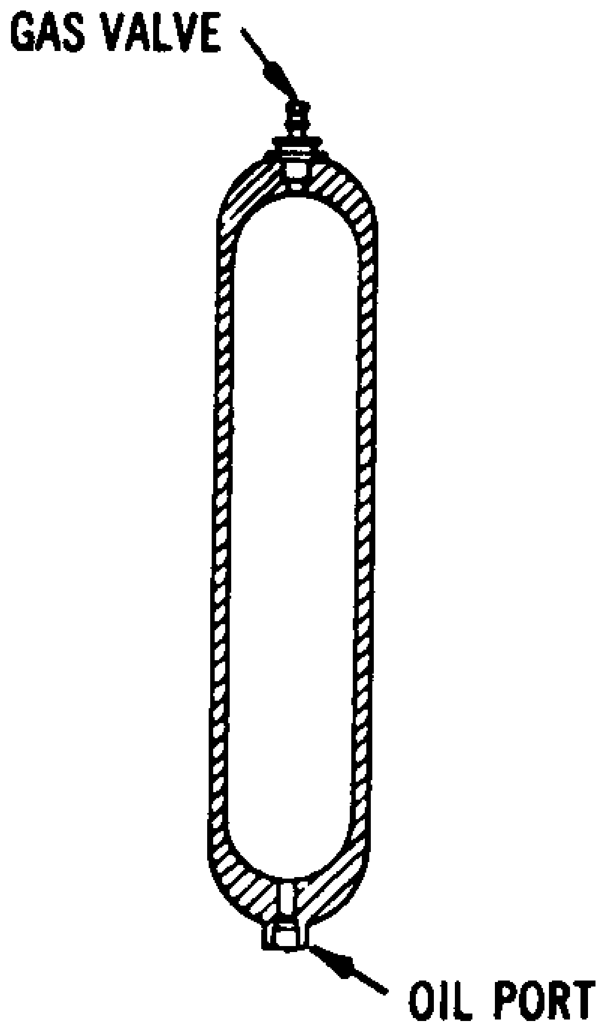


Fig 3 Non-Separator-Type Accumulator

Separator Type Accumulator

The commonly accepted design of gas-loaded **Accumulators** is the separator type.

In this type there is a physical barrier between the gas and the oil.

This barrier effectively utilizes the compressibility of the gas.

The **Three Major Classifications** of the **Separator Accumulator** are

1- **Piston Type**

2- **Diaphragm Type**

3- **Bladder Type**

Piston Accumulator

The piston type consists of a **Cylinder** containing a freely floating **Piston** with proper **Seals**, as illustrated in **Fig. 4**.

The piston serves as the barrier between the gas and oil.

A threaded lock ring provides a safety feature, which prevents the operator from disassembling the unit while it is precharged.

The **Main Disadvantages** of the piston type are that They are expensive to manufacture and have practical size limitations.

Piston and seal friction may also be a problem in low pressure systems.

Also, appreciable leakage tends to occur over a long period of time, requiring frequent precharging.

Piston accumulators should not be used as pressure pulsation dampeners or shock absorbers because of the inertia of the piston and the friction of the seals.

The **Principal Advantage** of the piston accumulator is **Its** ability to handle very high or low temperature system fluids through the utilization of compatible O-ring seals.

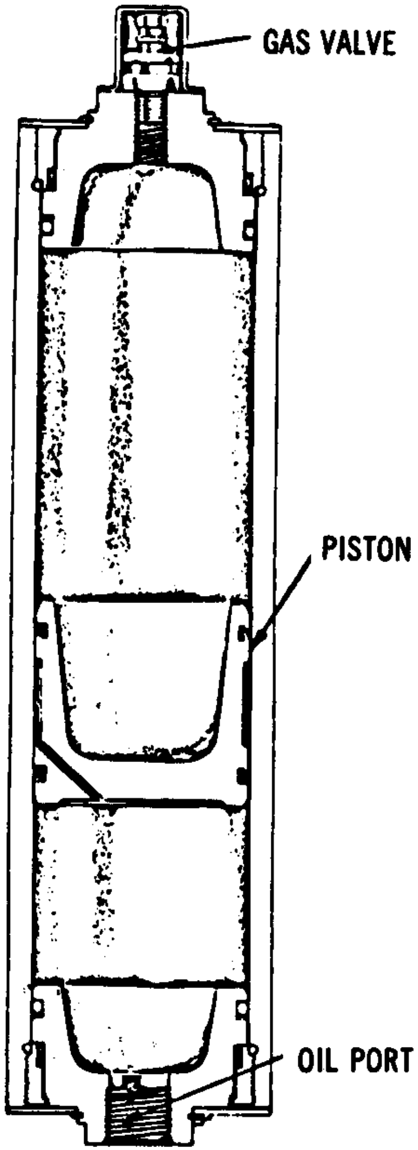


Fig. 4 Piston-Type Accumulator

Diaphragm Accumulator

The **Diaphragm-Type Accumulator** consists of a **Diaphragm**, secured in the shell, which serves as an elastic barrier between the **Oil** and **Gas** (see **Fig. 5**).

A shutoff button, which is secured at the base of the diaphragm, covers the inlet of the line connection when the diaphragm is fully stretched.

This prevents the diaphragm from being pressed into the opening during the precharge period.

On the gas side, the screw plug allows control of the charge pressure and charging of the accumulator by means of a charging and testing device.

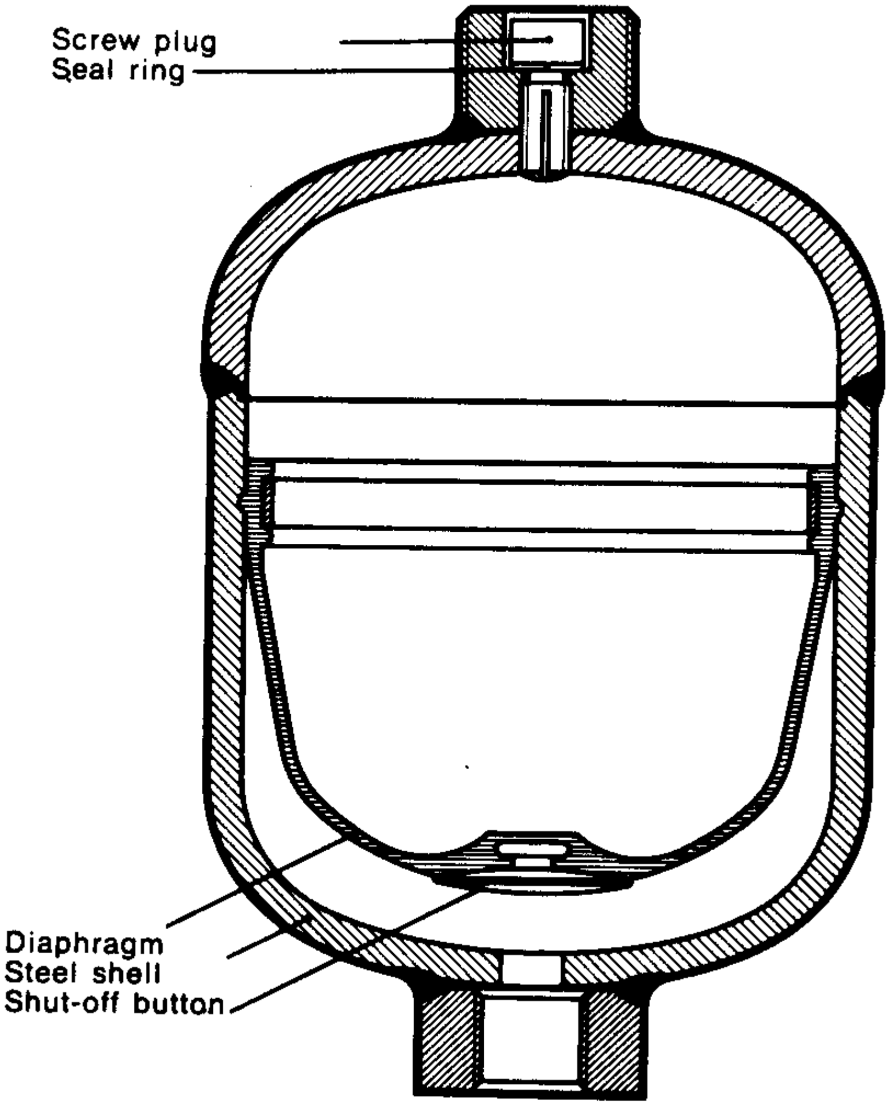


Fig. 5 Diaphragm-Type Accumulator

Fig. 6 illustrates the operation of a diaphragm-type accumulator.

The hydraulic pump delivers oil into the accumulator and deforms the diaphragm.

As the pressure increases, the volume of gas decreases, thus storing hydraulic energy.

In the reverse case, where additional oil is required in the circuit, it comes from the accumulator as the pressure drops in the system by a corresponding amount.

The primary advantage of this type of accumulator is its small weight-to-volume ratio, which makes it suitable almost exclusively for airborne applications.

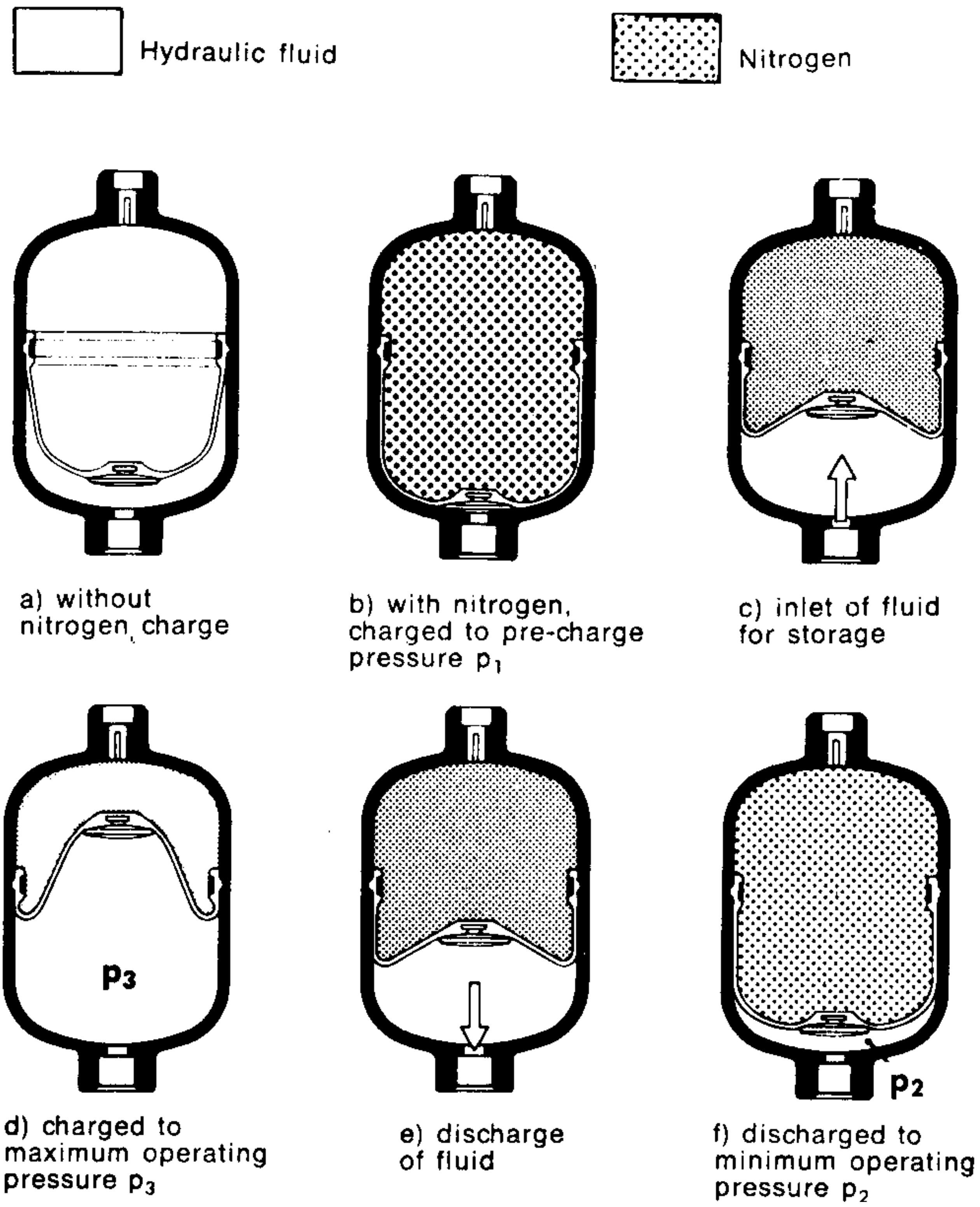


Fig. 6 Operation of A Diaphragm-Type Accumulator

Bladder Accumulator

A **Bladder-Type Accumulator contains** an **Elastic Barrier** (**Bladder**) between the **Oil** and **Gas**, as illustrated in **Fig. 7**.

The bladder is fitted in the accumulator by means of a vulcanized gas-valve element and can be installed or removed through the shell opening at the poppet valve.

The poppet valve closes the inlet when the accumulator bladder is fully expanded. This prevents the bladder from being pressed into the opening.

A shock-absorbing device protects the valve against accidental shocks during quick opening.

The greatest advantage of this type of accumulator is the positive sealing between the gas and oil chambers.

The light- weight bladder provides quick pressure response for pressure regulating, pump pulsation, and shock-dampening applications.

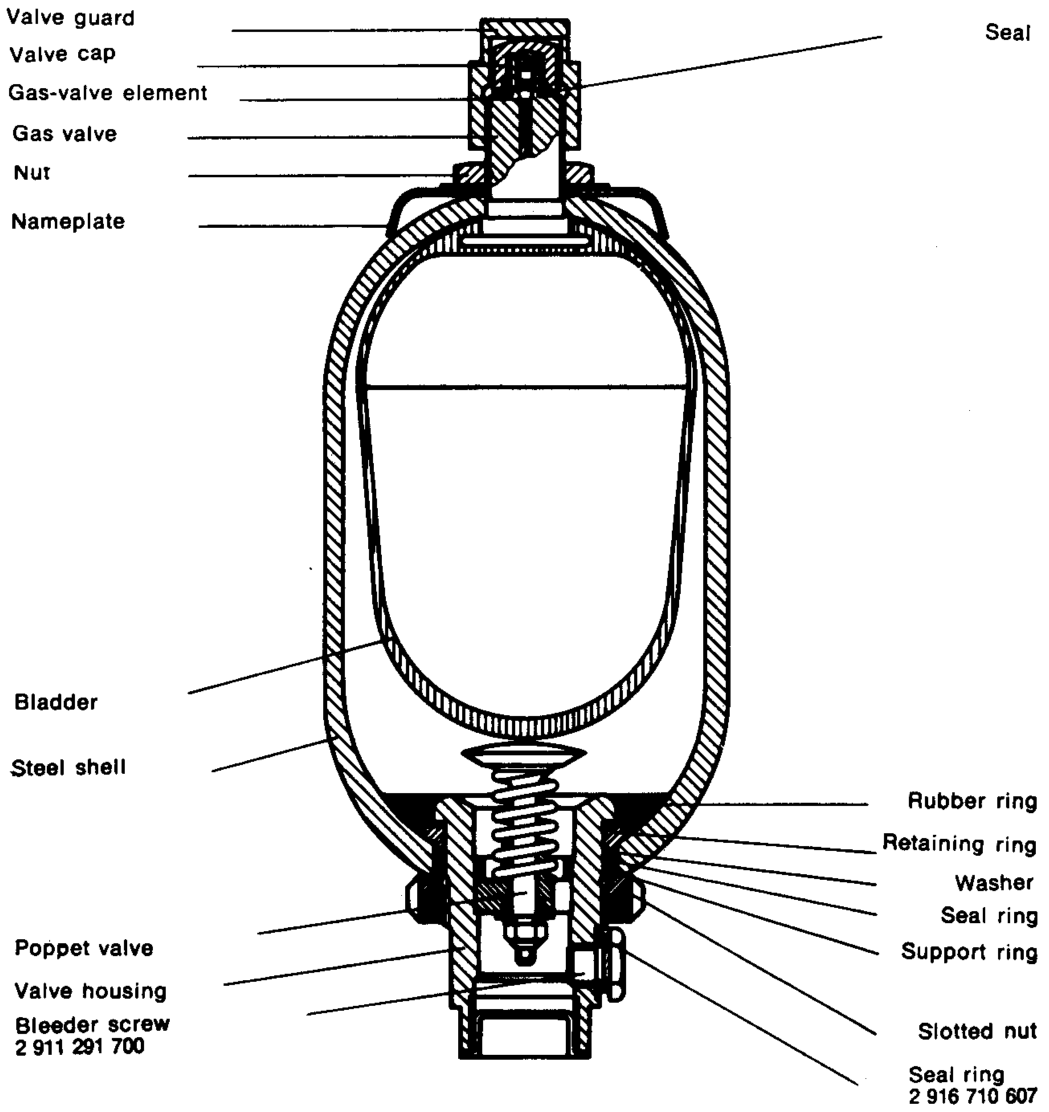


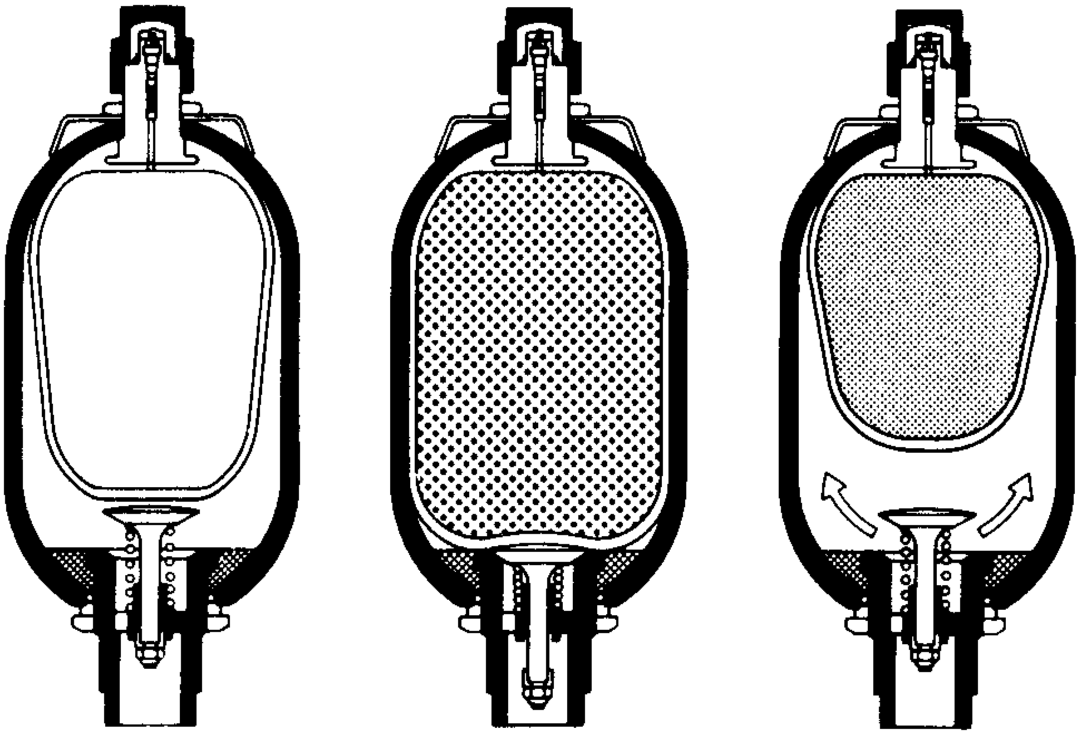
Fig. 7 Bladder-Type Accumulator

Figure 8 illustrates the operation of a **Bladder-Type Accumulator**.

The hydraulic pump delivers oil into the accumulator and deforms the bladder.

As the pressure increases, the volume of gas decreases,
thus storing hydraulic energy.

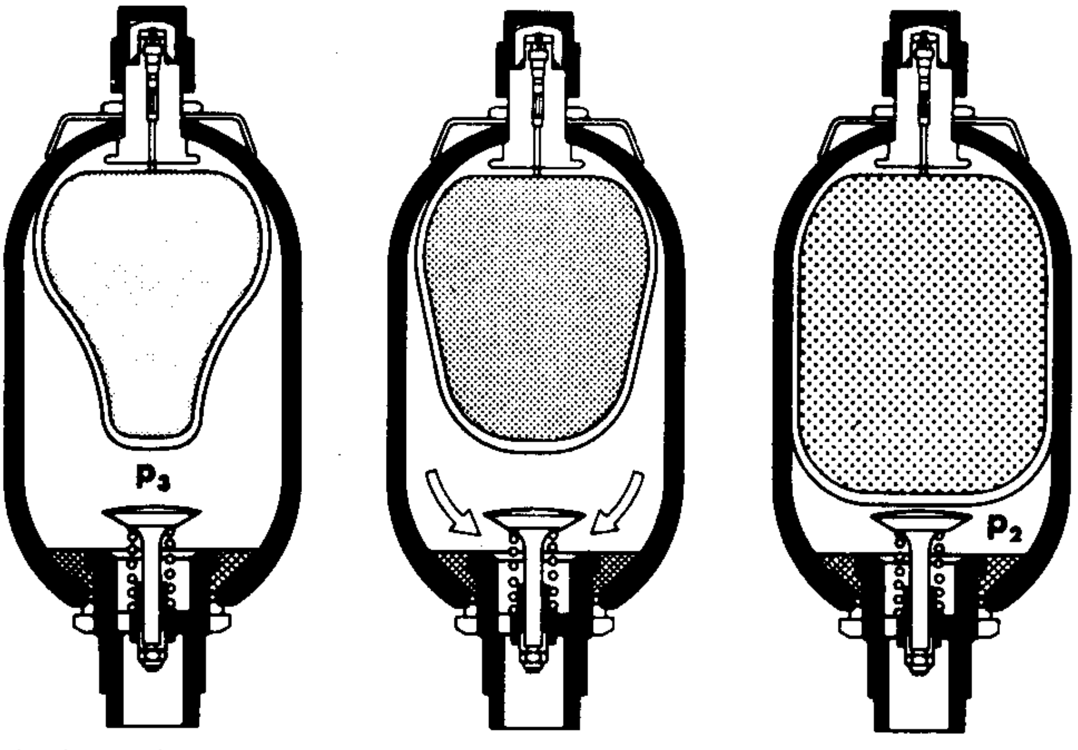
In the reverse case, where additional oil is required in the circuit,
it comes from the accumulator as pressure drops in the system
by a corresponding amount.



a) without nitrogen charge

b) with nitrogen, charged to pre-charge pressure p_1

c) inlet of fluid for storage



d) charged to maximum operating pressure p_3

e) discharge of fluid

f) discharged to minimum operating pressure p_2

Fig. 8 Operation of A Bladder-Type Accumulator

Applications

Of

Accumulators

Applications of Accumulators

There are Four Basic Applications where **Accumulators** are used in **Hydraulic System**:

1- An Auxiliary Power Source

2- A Leakage Compensator

3- An Emergency Power Source

4- A Hydraulic Shock Absorber

The **Following** is a **Description** and the **Accompanying Circuit Diagram** of **Each** of **These Four Applications**.

Accumulator as an Auxiliary Power Source

One of the **Most Common Applications** of **Accumulators** is as
An **Auxiliary Power Source**

The **Purpose** of the **Accumulator** in this **Application** is to **Store Oil**
Delivered by the **Pump** **During** a **Portion** of the **Work Cycle**

The **Accumulator** then **Releases** this **Stored Oil** **Upon Demand**
to **Complete** the **Cycle**, thereby **Serving** as
A **Secondary Power Source** to **Assist** the **Pump**

In Such a System Where **Intermittent Operations** are **Performed**,
The **Use** of an **Accumulator** **results** in being
able to **use** a **Smaller-Sized Pump**.

This **Application** is depicted in **Fig. 9** in which
A **Four-Way Valve** is **Used** in **conjunction** with an **Accumulator**.

When the **Four-Way Valve** is **Manually Actuated**,
Oil flows from the **Accumulator** to the **Blank End** of the **Cylinder**.

This **extends** the **piston** until it reaches the end of its stroke.

While the **Desired Operation** is **Occurring**
(The **Cylinder** is in the **Fully Extended Position**),
The **Accumulator** is being **Charged** by the **Pump**.

The **Four-Way Valve** is then **Deactivated** for the **Retraction** of the **Cylinder**.

Oil Flows from the **Pump** and **Accumulator** to **Retract** the **Cylinder Rapidly**.

The **Accumulator Size** is **Selected** to **Supply Adequate Oil**
During the **Retraction Stroke**

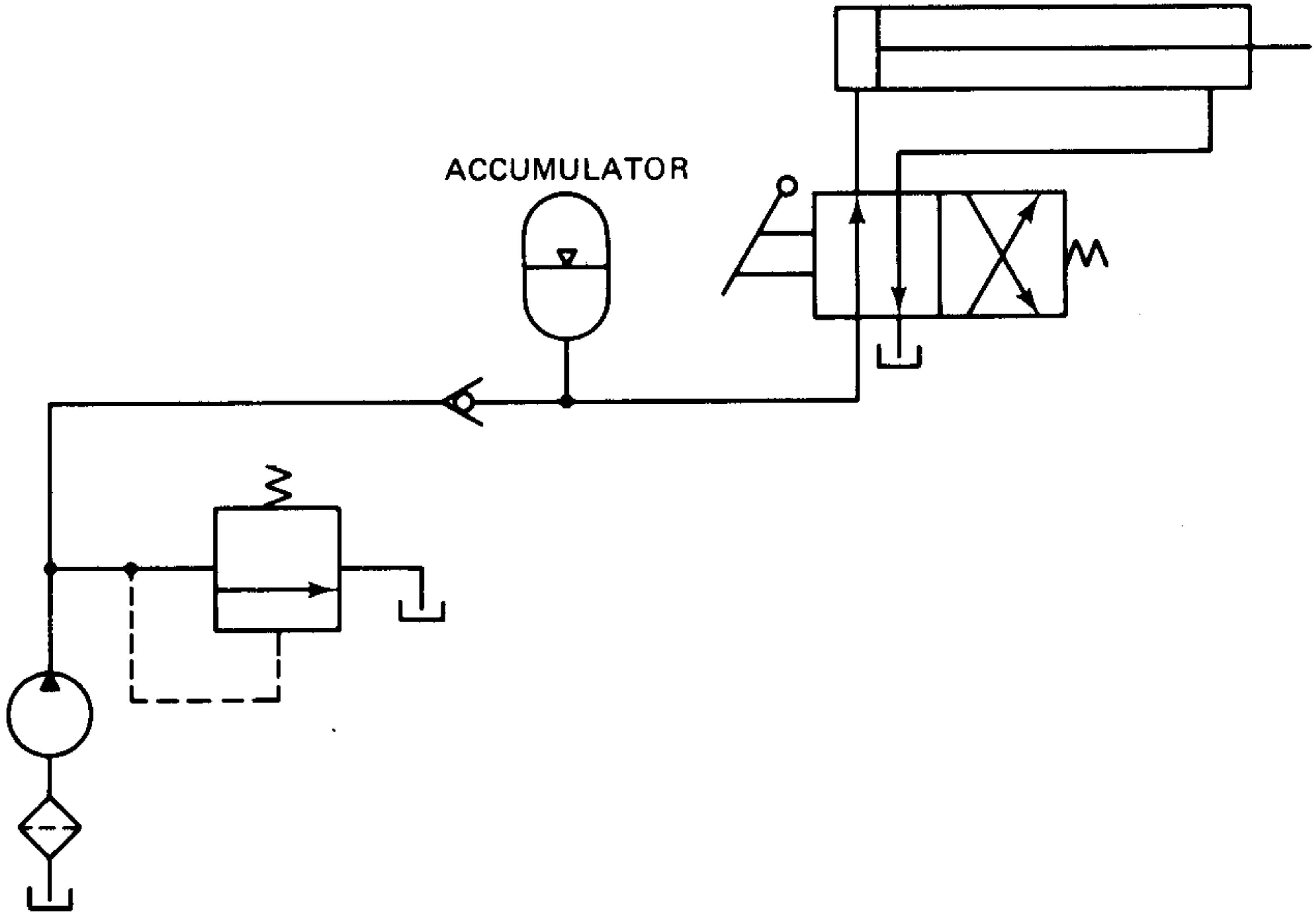


Fig. 9 Accumulator as an Auxiliary Power Source

Accumulator as a Leakage Compensator

A second application for accumulators is as a compensator for internal or external leakage during an extended period of time during which the system is pressurized but not in operation.

As shown in **Fig. 10**, for this application the pump charges the accumulator and system until the maximum pressure setting on the pressure switch is obtained.

The contacts on the pressure switch then open to automatically stop the electric motor that drives the pump.

The accumulator then supplies leakage oil to the system during a long period of time.

Finally, when system pressure drops to the minimum pressure setting of the pressure switch, it closes the electrical circuit of the pump motor (not shown) until the system has been recharged.

The use of an accumulator as a leakage compensator saves electrical power and reduces heat in the system.

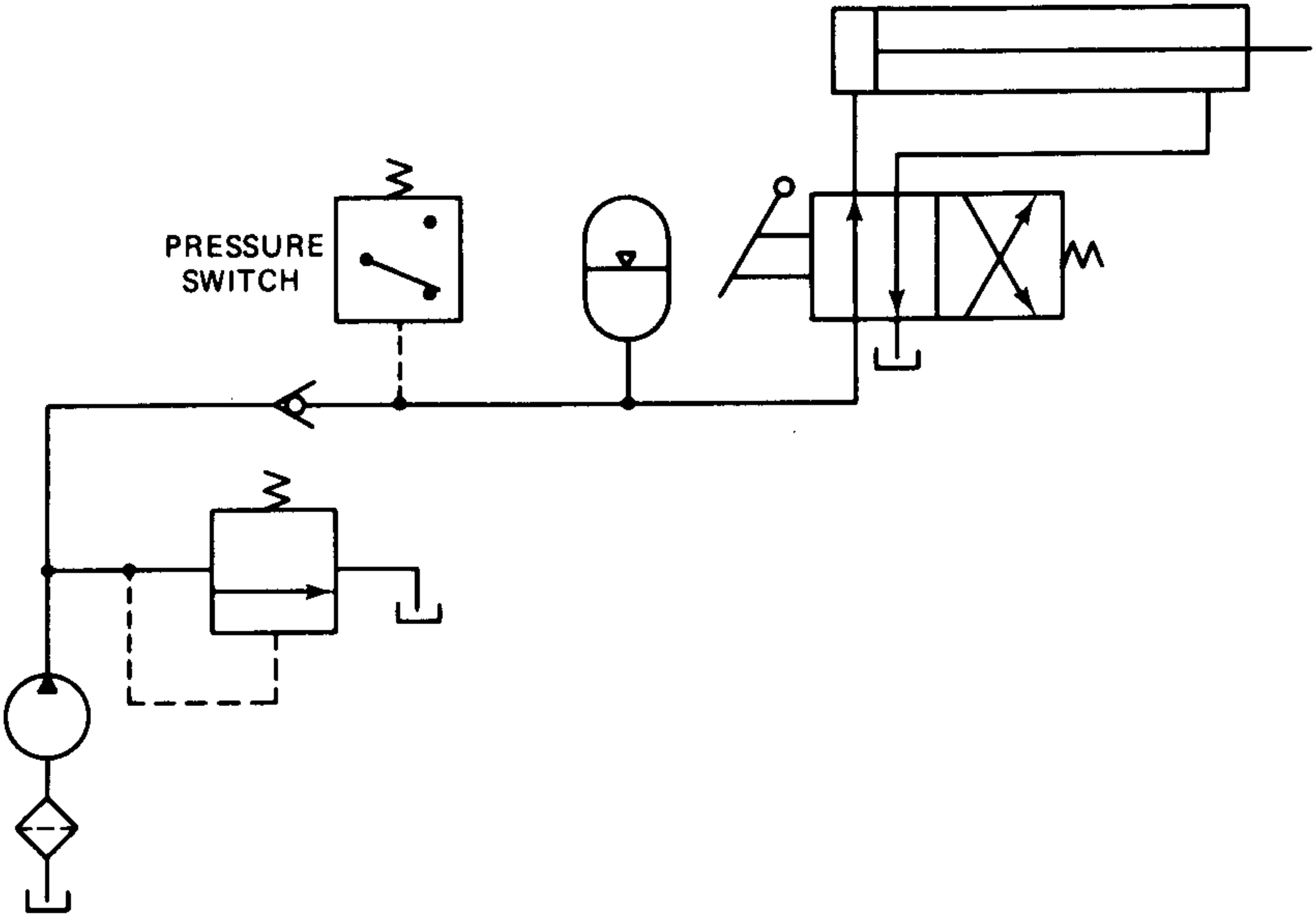


Fig. 10 Accumulator as a Leakage Compensator

Accumulator as an Emergency Power Source

In some hydraulic systems, safety dictates that a cylinder be retracted even though the normal supply of oil pressure is lost due to a pump or electrical power failure.

Such an application requires the use of an accumulator as an emergency power source, as depicted in **Fig. 11**.

In this circuit, a solenoid actuated three-way valve is utilized in conjunction with the accumulator.

When the three-way valve is energized, oil flows to the blank end of the cylinder and also through the check valve into the accumulator and rod end of the cylinder.

The accumulator charges as the cylinder extends.

If the pump fails due to an electrical failure, the solenoid will de-energize, shifting the valve to its spring offset mode.

Then the oil stored under pressure is forced from the accumulator to the rod end of the cylinder.

This retracts the cylinder to its starting position.

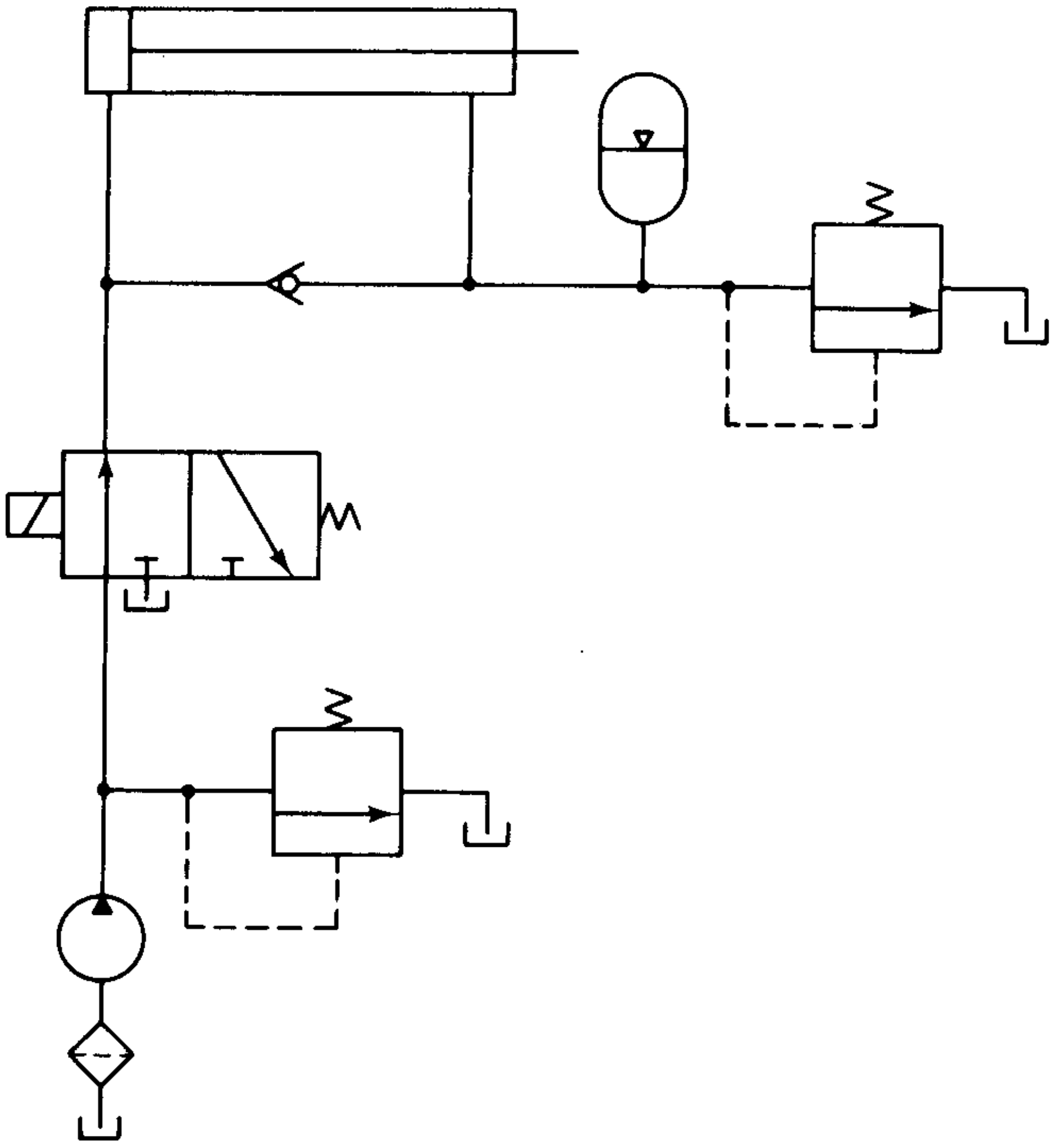


Fig. 11 Accumulator as an Emergency Power Source

Accumulator as a Hydraulic Shock Absorber

One of the most important industrial applications of accumulators is the elimination or reduction of high-pressure pulsations or hydraulic shock.

Hydraulic shock (or water hammer, as it is frequently called) is caused by the sudden stoppage or deceleration of a hydraulic fluid flowing at relatively high velocity in a pipeline.

This hydraulic shock creates a compression wave at the source, where the rapidly closing valve is located.

This compression wave travels at the speed of sound upstream to the end of the pipe and back again, causing an increase in the line pressure.

This wave travels back and forth along the entire pipe length until its energy is finally dissipated by friction.

The resulting rapid pressure pulsations or high-pressure surges may cause damage to the hydraulic system components.

If an accumulator is installed near the rapidly closing valve, as shown in **Fig. 12**, the pressure pulsations or high-pressure surges can be suppressed.

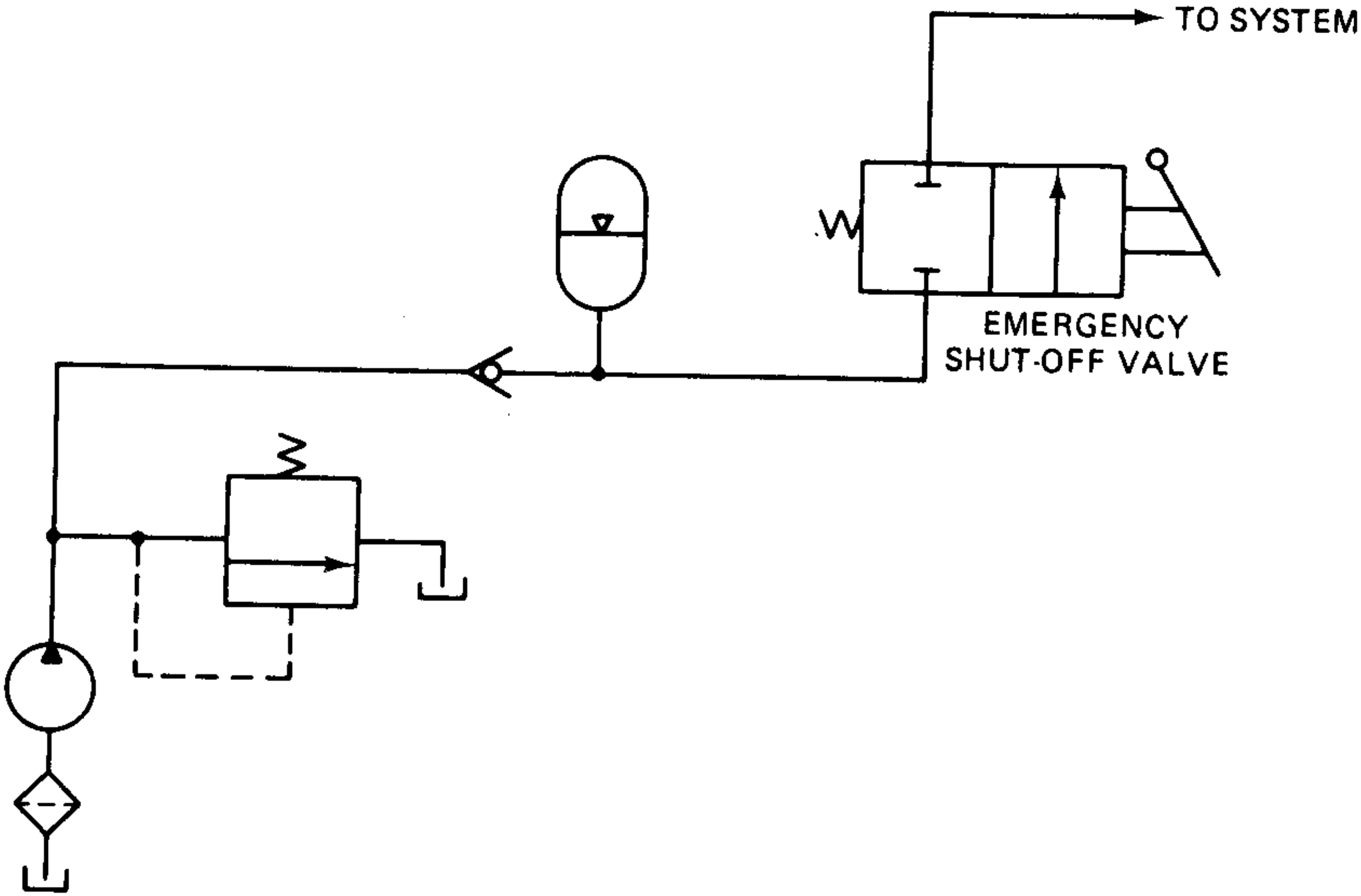


Fig. 12 Accumulator as a Hydraulic Shock Absorber