CLAIMS

1. An electro-hydraulic actuator comprising:

a motor that outputs rotational power;

a pump operated by the rotational power of the motor;

a hydraulic actuator operated by hydraulic fluid pressurized by the pump;

a reservoir for storing the hydraulic fluid; and

a hydraulic circuit for hydraulically controlling operation of the hydraulic actuator,

wherein the hydraulic actuator reciprocates between a first operating state and a second operating state in response to a hydraulic pressure of the supplied hydraulic fluid, and is constantly biased in a direction returning to the first operating state;

wherein the hydraulic circuit includes:

a pressurizing flow path for supplying the hydraulic fluid pressurized by the pump to the hydraulic actuator;

a pressure reducing flow path that connects the hydraulic actuator and the reservoir via an unloading valve in an openably closable manner;

a pilot flow path for supplying hydraulic oil pressurized to a pilot pressure to the unloading valve in order to close the pressure reducing flow path;

a pilot pressure generating mechanism that generates the pilot pressure; and

a check valve disposed within the pressurizing flow path for allowing the hydraulic fluid to pass only in a forward direction from the pump to the hydraulic actuator,

wherein the pilot pressure generating mechanism generates the pilot pressure during operation of the pump,

the pilot flow path branches off midway from the pump to the check valve in the pressurizing flow path and reaches the

unloading valve, and

during operation of the pump, the pilot pressure is generated, causing the pump to transition to the second operating state, and when the pump stops, the pilot pressure disappears, the pressure reducing flow path is opened, and the pump returns to the first operating state,

wherein a throttle mechanism constituting the pilot pressure generating mechanism and the check valve are disposed, in that order, in the pressurizing flow path from the pump to the hydraulic actuator.

2. The electro-hydraulic actuator of claim 1, wherein the throttle mechanism is an orifice.

3.An electro-hydraulic actuator comprising:

a motor that outputs rotational power;

a pump operated by the rotational power of the motor;

a hydraulic actuator operated by hydraulic fluid pressurized by the pump;

a reservoir for storing the hydraulic fluid; and

a hydraulic circuit for hydraulically controlling operation of the hydraulic actuator,

wherein the hydraulic actuator reciprocates between a first operating state and a second operating state in response to a hydraulic pressure of the supplied hydraulic fluid, and is constantly biased in a direction returning to the first operating state;

wherein the hydraulic circuit includes:

a pressurizing flow path for supplying the hydraulic fluid pressurized by the pump to the hydraulic actuator;

a pressure reducing flow path that connects the hydraulic actuator and the reservoir via an unloading valve in an openably closable manner;

a pilot flow path for supplying hydraulic oil pressurized to a pilot pressure to the unloading valve in order to close the pressure reducing flow path;

a pilot pressure generating mechanism that generates the pilot pressure; and

a check valve disposed within the pressurizing flow path for allowing the hydraulic fluid to pass only in a forward direction from the pump to the hydraulic actuator,

wherein the pilot pressure generating mechanism generates the pilot pressure during operation of the pump,

the pilot flow path branches off midway from the pump to the check valve in the pressurizing flow path and reaches the unloading valve, and

during operation of the pump, the pilot pressure is generated, causing the pump to transition to the second operating state, and when the pump stops, the pilot pressure disappears, the pressure reducing flow path is opened, and the pump returns to the first operating state, wherein the pilot pressure generating mechanism is composed of an unloading relief valve having a parent valve and a child valve, and a throttle mechanism,

the parent valve has a built-in throttle valve, a parent valve primary port connected to the pilot flow path, a parent valve secondary port connected to a flow path communicating with the reservoir, a parent valve pilot port communicating with the parent valve primary port via the throttle valve, and has, with a predetermined direction being the up-down direction, a parent valve spool that is urged upward by hydraulic pressure at the parent valve primary port, and a parent valve spring that urges the parent valve spool downward,

the child valve has a child valve primary port connected to the parent valve pilot port, a child valve secondary port connected to a flow path communicating with the reservoir via

the throttle mechanism, and a child valve pilot port connected to a flow path from the check valve to the hydraulic actuator, and has, with a predetermined direction being a vertical direction, a valve body that is urged upward by hydraulic pressure at the child valve primary port, a child valve spool that is urged upward by hydraulic pressure at the child valve pilot port, and a child valve spring that urges the valve body downward,

the child valve distributes hydraulic pressure P1 at the child valve primary port into hydraulic pressure P2, which presses the valve body upward, and hydraulic pressure P3, which presses the child valve spool downward, with P2>P3, and when the hydraulic pressure P1 reaches a predetermined cutout pressure, the valve body is pressed in one direction, opening the child valve primary port and the child valve secondary port to enter an unloaded state,

the parent valve spool is pressed upward by a pressure difference between the hydraulic pressure P1 on the parent valve pilot port side, which has been reduced in association with the unloaded state of the child valve, and hydraulic pressure P5 on the parent valve primary port side, thereby opening the parent valve primary port and the parent valve secondary port and putting the parent valve in an unloaded state,

when the child valve is in an unloaded state, the unloaded state is maintained by hydraulic pressure P4 at the child valve pilot port,

when both the parent valve and the child valve are in the unloaded state, the hydraulic pressure P5 is maintained at the pilot pressure by the hydraulic pressure P1 generated by the passing resistance of the throttle mechanism and the hydraulic pressure generated by the parent valve spring urging the parent valve spool downward, and the hydraulic actuator is maintained in the second operating state by the hydraulic pressure P4.

4. The electro-hydraulic actuator of claim 3, wherein the unloading relief valve is a single integrated unit in which the parent valve and the child valve are attached to a metal block in which the flow path for the hydraulic fluid is formed, and

the parent valve and the child valve are cartridges configured to be attachably detachable from the metal block.

5. The electro-hydraulic actuator according to claim 4, wherein the throttle mechanism is interposed midway through a flow path formed in the metal block, and

the unit constitutes the pilot pressure generating mechanism.

6. The electro-hydraulic actuator of claim 1, wherein the hydraulic circuit includes a flow path that branches from the pilot flow path, passes through the throttle mechanism, and reaches the reservoir, and

the throttle mechanism has a flow path resistance higher than a flow path resistance of the pilot pressure generating mechanism when the pump is in operation, and eliminates residual pressure of the hydraulic fluid remaining in the flow path from the pump to the pilot pressure generating mechanism in the pressurizing flow path and in the pilot flow path when the pump is stopped.

7. The electro-hydraulic actuator according to any one of claims 1 to 6, wherein the hydraulic actuator is a direct-acting hydraulic actuator,

the first operating state is attained when a piston of the direct-acting hydraulic actuator is at bottom dead center;

the second operating state is attained when the piston is at top dead center, and

the piston is biased in a direction toward bottom dead center by an external mechanism connected to a tip of a piston rod.

8. The electro-hydraulic actuator according to any one of claims 1 to 6,

the hydraulic actuator is a direct-acting hydraulic actuator,

the first operating state is attained when a piston of the direct-acting hydraulic actuator is at bottom dead center;

the second operating state is attained when the piston is at top dead center; and

a spring mechanism is provided to constantly bias the piston toward bottom dead center.

9. A brake device comprising the electro-hydraulic actuator according to claim 7,

wherein the brake device is provided with a braking mechanism that presses or separates brake linings against both sides of a disc-shaped brake disc,

the braking mechanism is constantly biased in a direction to be in a braking state, and

when the electro-hydraulic actuator is in the second operating state, the brake disc is released from the braking state, and when the electro-hydraulic actuator is in the first operating state, the brake disc is in a braking state.

10. A brake device comprising the electro-hydraulic actuator according to claim 8,

wherein the brake device is provided with a braking mechanism that presses or separates brake linings against both sides of the disc-shaped brake disc, and

when the braking mechanism is in the second operating state, t

he braking state for the brake disc is released, and when the braking mechanism is in the first operating state, the brake d isc is in a braking state.