

IV GATES AND VALVES

4.1. Introduction

Modern dams are frequently of very large size, requiring the control of great volumes of water under high head. The energies involved are often tremendous, whether the discharge be through outlet pipes, through penstocks, or over the dam spillway. The problems involved in the development of suitable control works for modern dams are many and complex.

The main operational requirements for gates are failure-free performance, water tightness, rapidity of operation, minimum hoist capacity, and convenience in installation & maintenance

The control equipments are usually required for conduits (including sluices and penstocks) and spillways. These include various types of gates and valves.

Hydromechanical control equipments are basically of two types.

1. Hydraulic gates
2. Hydraulic valves

4.2 Hydraulic Gates

Hydraulic gates are so constructed that the closing member is completely removed from the water passage when the gate is fully opened. In hydraulic valves the closing member remains in the waterway and therefore partially interferes with the water flow.

Hydraulic gates are, in general, classified as:

1. Vertical lift gates
2. Hinged type gates

Vertical lift gates are those in which the operating member moves vertically up and down to engage or discharge with the sealing element while the hinged gates are those in which the operating member rotates around a hinge for the same purpose.

4.2.1 Vertical Lift Gates

These are rectangular gates spanning horizontally between the grooves made in the supporting piers. The grooves are generally lined with rolled steel channel sections of appropriate size so as to provide a smooth bearing strength and are known as groove guides. These rectangular gates, consisting of steel members to which a skin plate of steel is attached on the upstream side, move between the groove guides and can be raised or lowered by a hoisting mechanism at the top.

Vertical lift gates can be classified as follows:

- i) Slide gates
- ii) Wheel or roller mounted gates
 - a) Fixed-wheel gates
 - b) Stony gates
- iii) High-pressure gates

4.2.1.1. Sliding Gates

Sliding gate is the simplest type of vertical lift gates. Since it has no rotating parts, it is an economical choice for low head installations of moderate size. Large frictional force due to sliding motion makes it unsuitable for big size and high heads.

When the gate is raised or lowered it slides over the groove surface. As a result heavy frictional resistance (sliding friction) have to be counteracted for lifting the gate against water pressure and hence large hoisting capacity will be required. The size of this type of gates is therefore limited by the available hoisting capacity. Moreover on account of these limitations sliding gates are seldom used.

4.2.1.2. Wheel or Roller Mounted Gates

For high head and large size openings wheel or roller mounted gates are employed in which the operating member or the gate leaf moves on wheels or rollers to engage with the sealing element.

a) Fixed Wheel Gates

Wheels are attached to the gate along each end and it travels on vertical tracks provided on the downstream surface of the gate grooves. Thus, as compared to sliding gates the frictional resistance is considerably reduced. However, both axle and rolling friction are developed

Figure

b) Stony Gate or Free Roller Gate

They have been frequently and successfully used for low-pressure intakes as well as for floodgates. A train of rollers is provided in between the gate and the groove on each side. The roller train is attached neither to the gate nor to the groove but rolls between the two as the gate moves. As a result, in this case, only roller friction is developed.

(Figure)

For both fixed-wheel and stoney gates rubber sheet or belting is used along the sides on the upstream face of the gate to seal the openings between the gate and the sides of the pier.

All vertical lift gates are counterbalanced by a counter weight beam, which is loaded to balance almost the entire dead weight of the gate. The lifting force is, therefore, required to balance only the frictional resistance.

These gates are operated from an overhead platform by winches, which can be worked manually, or by power.

4.2.1.3. High Pressure Gates

High-pressure gates are used as emergency gates or regulating gates in outlet works of dams, penstocks, or conduits against high heads. These gates are encased in closed frame embedded in concrete and covered by bonnet.

The following are the most common types of high-pressure gates:

- i Continuous skin plate gates /vertical lift gate/
- ii Ring follower gates
- iii Ring seal gates
- iv Jet flow gates

a) Continuous Skin Plate Gates

They are generally used in outlet works of dams. Commonly a combination of two gates, the upstream gate serving as an emergency gate and the downstream one as a regulating gate, is used. These gates can withstand a head of more than 80m as an emergency gate and more than 60 m as regulating gate.

These gates have rectangular gate leaf of box girder construction generally mounted on wheels or rollers in such a way that there is minimum friction. A high maintenance chamber around the gate allows easy inspection and replacement of parts. These gates are provided with air inlet connection on downstream side.

These gates are operated by hydraulic cylinder hoist using oil as medium. The gate leaf is raised vertically into the bonnet when oil is forced into the hydraulic cylinder above it, at pressure between 50 kg/cm^2 and 100 kg/cm^2 raising the piston to which the gate leaf is connected.

(Figure)

Solid rubber blocks mounted on the sides and top of a vertical lift gate are generally employed to provide a watertight seal.

For optimum condition, it is best to contract the pressure conduit upstream of the gate and to provide deflectors downstream to aid aeration as an anti-cavitation measure. The conduit face downstream of the gate slot should be protected against cavitation.

b) Ring Follower Gates

They are sliding type of gates. These are primarily used as emergency gates in closed conduits and are installed upstream of regulating or service gates.

Vertically movable rectangular gate leaf of height more than double the gate opening carries a circular opening (of inner diameter equal to that of conduit) in its lower portion. When the gate leaf is raised, the opening coincides with the conduit and an unobstructed flow is obtained. When the gate leaf is lowered, the portion carrying the opening moves below the conduit and the upper portion of the gate leaf stops the flow. The gate is kept either fully open or fully closed and is not suitable for partial opening.

The gate is operated by a hydraulic cylinder having piston connected to the gate leaf by a stem passing through a packing in the gate housing body.

Figure

c) Ring Seal Gates

They are used either as emergency or service gates. These are installed upstream of turbines in penstocks or upstream of regulating valves in closed conduits. They are never used as regulating gates as they are not suitable for partially open positions.

The general arrangement of ring seal gate is similar to that of ring follower gate with the following differences.

- The gate leaf is mounted on wheels or rollers
- The upper portion of the gate leaf which stops the flow forms a bulkhead section, i.e. section not only suitable for emergency closure but strong enough to serve as service gate.
- Complete closure in closed position of the gate is obtained by proper placement of a movable ring seal. The ring seal is usually kept in a recess in the gate housing and is actuated hydraulically from the water pressure in the conduit to contact seat on the leaf.

(Figure)

d) Jet Flow Gates

Jet flow gates are used as regulating gates in conduits at their discharge end or at any intermediate point.

The main difference between this type of gate and other types is the fact that flowing water is kept away from gate slots by making it pass through the gate opening in the form of a jet. A jet is created by provision of a nozzle such that the issuing jet slips over the gate slots without touching downstream edge of the slot.

From a point approximately one diameter upstream of the face of the gate leaf the conduit is flared outward at a slope of 1 in 12 to a diameter of 120 percent. From this point the nozzle is

sloped at an angle of 45^0 with the axial centerline of the conduit to produce a jet. Hence water shoots out from the nozzle as in the case of an orifice, springs clear of the gate slots and strikes the bottom of the conduit somewhere downstream of the gate slot.

(Figure)

The gate leaf is similar to that of a fixed wheel gate. The leaf is mounted on wheels to reduce friction.

4.2.2 Hinged Gates

The following are the common types of hinged gates:

- i) Radial Gate
- ii) Drum Gate
- iii) Flap Gate

4.2.2.1. Radial Gates

They are also known as tainter gates or sector gates. Radial gates are the most widely used type of spillway crest gates and usually the most reliable and least expensive. The gate leaf consists of a curved skin plate shaped so as to form a sector of a curved surface of a horizontal cylinder. The skin plate is supported at the two ends of the gate span on end beams which are in turn supported on radial arms converging on pin bearing mounted on horizontal pins (trunnions) attached to the piers.

Radial gates are usually operated by means of hoisting cables provided at both span ends of the gate leaf and lead to winches on the platform above the gate. The winches are usually motor-driven. Close fitting rubber seals are provided on the gate sides and bottom.

Since skin plate that supports water is cylindrical, the resultant water pressure acting on it passes through its center and hence in this gate the resultant water pressure creates no moment against the lifting of the gate. Radial gates have the following advantages. Friction is concentrated at the pin and is much less than that for sliding gates. Since the trunnion bears part of the load, the hoisting load is nearly constant for all gate openings and is much less than for vertical lift gates of the same size.

(Figure)

Other advantages of tainter gate over vertical lift (sliding gates) are:

- Smaller hoist
- Increased speed of raising
- Higher stiffness
- Lower piers
- Absence of gate slot
- Less prone to vibration

However, they require longer and thicker piers.

4.2.2.2. Drum Gates

Consists of a segment of a cylinder, which fits, in a recess on the top of the spillway when the gate is in an open position. For lifting the gate in its closed position, water is admitted into the recess to create a buoyant force.

(Figure)

Because of the large recess (cavity) required by drum gates in the lowered position, they are not used for small (low) dams.

Drum gates on dam crests are usually of the upstream hinge type, with the hinge about $0.25H$ above the downstream gate sill and a radius of curvature $r \cong H$. The heads can be as high as 10m and the span 65m (long span gate).

Controlling device (for admitting or releasing water from the chamber) may be manual or automatic.

4.2.2.3. Flap Gates / Bottom Hinged Gates/

Simplest and most frequently used type of regulating gates used on their own or in conjunction with vertical lift gates. They were developed as a replacement for wooden flashboards.

Flap gates when used on their own, span up to 30m and used for heads as high as 6m. For larger spans several flaps connected to each other, but actuated by their own hydraulic hoist; may be used.

They provide fair level of regulation and easy flushing of debris.

(Figure)

4.3. Hydraulic Valves /Control Valves/

The distinguishing feature of valves from gates is that they are constructed in such a way that the closing member remains in the water passageway for all operating positions.

4.3.1. The Needle Valve

These are intended to operate at the downstream end of an outlet conduit under free discharge conditions and extremely high heads (up to 215m). The needle valve consists of an outer globular casting housing cylindrical inner mechanism consisting of a movable closed cylinder telescoping over a stationary cylinder.

(Figure)

The discharge end of the annular passage is closed when hydrostatic pressure is supplied to the proper chamber inside the cylinder. Needle points are provided at the upstream and

downstream face of the cylindrical mechanism to guide the water flow. The pressure required for operation is supplied by a compensating valve located beneath the body of the main valve. These types of valves are costly to install and maintain, are prone to cavitation damage and have low coefficient of discharge.

4.3.2. Tube Valve

It is essentially a needle valve with the tip of the downstream or movable needle eliminated. It was designed to minimize the cavitation erosion, which developed at the downstream end of the needle valve.

(Figure)

They are designed for discharge regulation for heads up to 90m. They have low coefficient of discharge. These valves are not satisfactory for all regulated openings as the jet is rough and unstable up to 35% openings. They also have problem of vibration at nearly full openings and nearly closed positions.

4.3.3. Hollow- Jet Valves

It is U.S.B.R's most recent and outstanding development in control valves. It is essentially a needle valve with the movable or closing needle pointed upstream and the downstream portion of the body eliminated, thus allowing the water to discharge from the bell-shaped body in a tubular or hollow part.

(Figure)

This is called hollow-jet valve because the jet as it leaves the valve is in the form of a longitudinal slotted tube or segmental jet having a hollow instead of a solid stem. These valves have better coefficient of discharge than needle or tube valves. They are intended for heads up to 305m. These valves should not be operated at openings less than 5% for long periods because of risk of cavitation.

4.3.4. Butterfly Valves

These are simple, rugged, economical valves used to shut off flow in a penstock or outlet conduit. It is essentially a circular leaf, slightly convex in form mounted on a transverse shaft carried by two bearings in the valve body.

(Figure)

Butterfly valves are occasionally installed as regulating controls for low head discharges, but their primary use is as service or guard gate in power penstocks immediately upstream from the turbine. Some of these valves have been designed to operate under a head greater than 300m. When used for emergency closure it operates either fully open or closed and not as partially open.

4.3.5. Fixed-Cone Valves (Howell-Bunger)

This is the most frequently used type of regulating valve installed at the end of outlets discharging into the atmosphere. It consists of a fixed 90° cone disperser, with the axis horizontal, upstream of which is the opening covered by a sliding cylindrical sleeve. A movable external horizontal sleeve controls the discharge by varying the opening between the sleeve and the cone. The discharge is in the form of a diverging hollow conical jet.

(Figure)

It has been used for heads up to 250m, and when fully open its discharge coefficient is 0.85-0.90. The fully opened valve area is about 0.8 of the conduit area. This type of valve is cheap but causes lots of spray. When the spray cannot be tolerated, a hood or discharge guide is installed to confine and redirect the discharge.

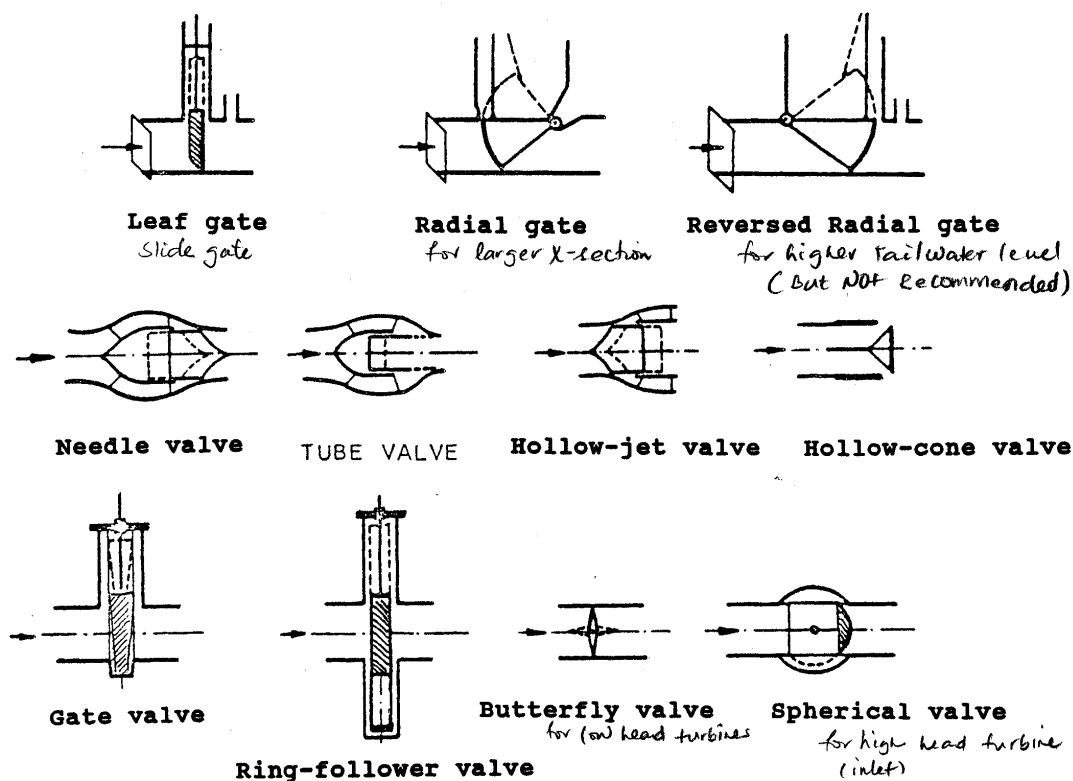
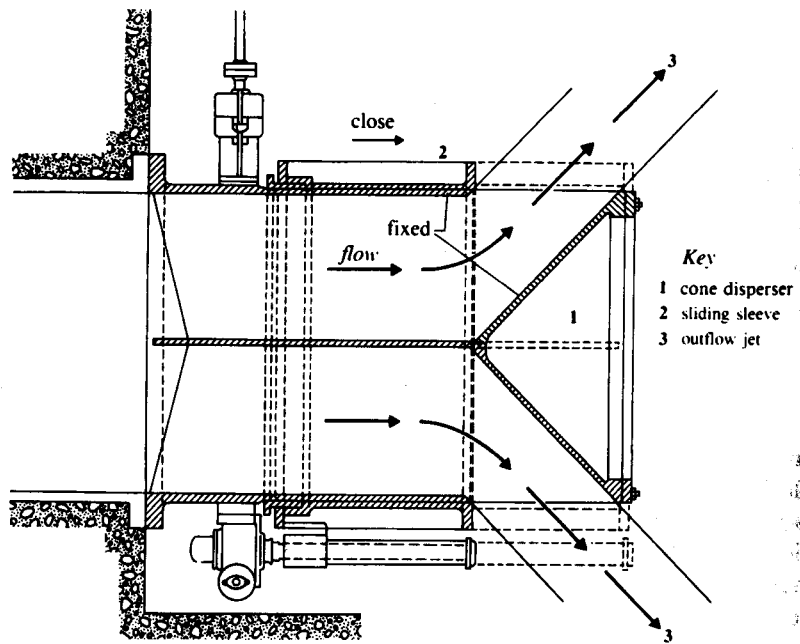


Fig. 22 BOTTOM OUTLET GATES AND VALVES



Cone dispersion valve

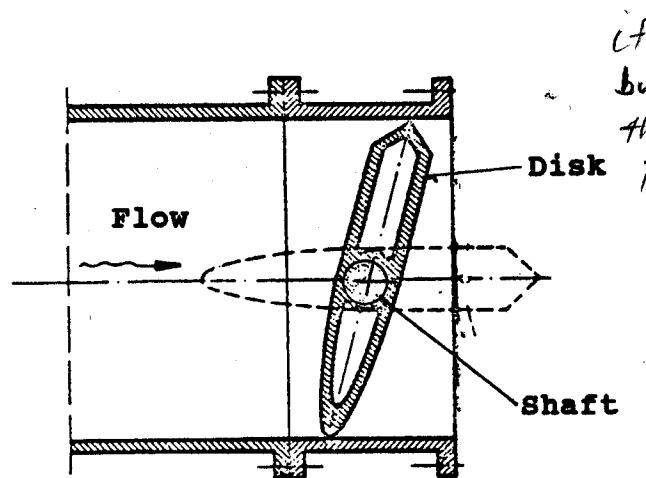
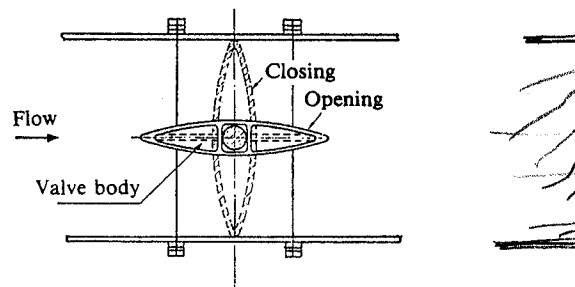


Fig. 35 BUTTERFLY VALVE

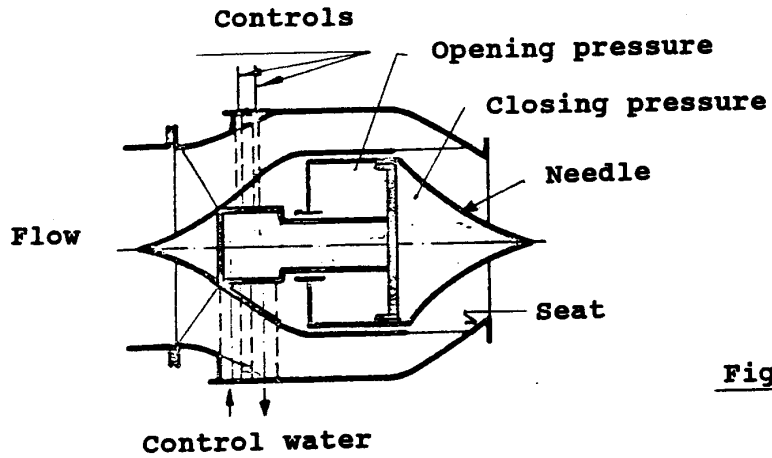
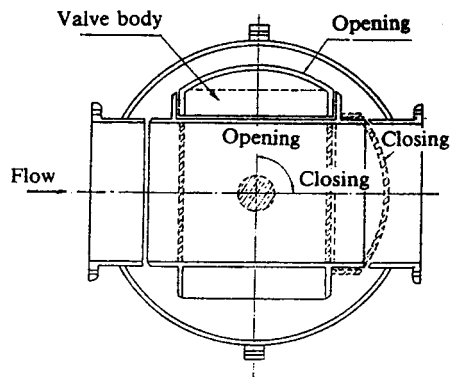


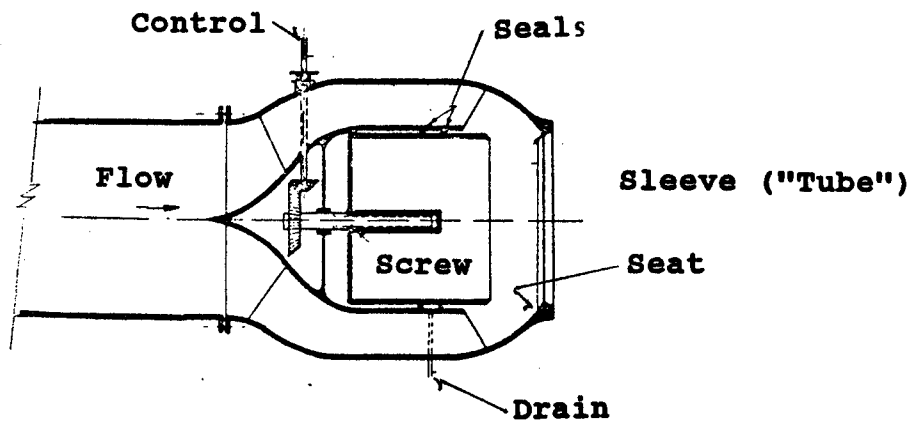
Fig. 29 NEEDLE VALVE

SECTION

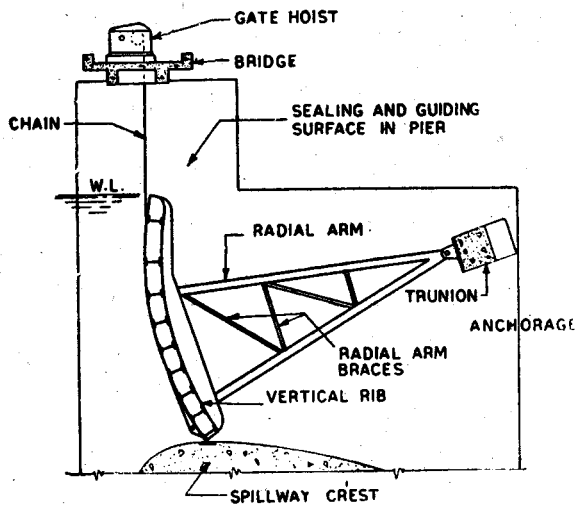
INSTALLATION



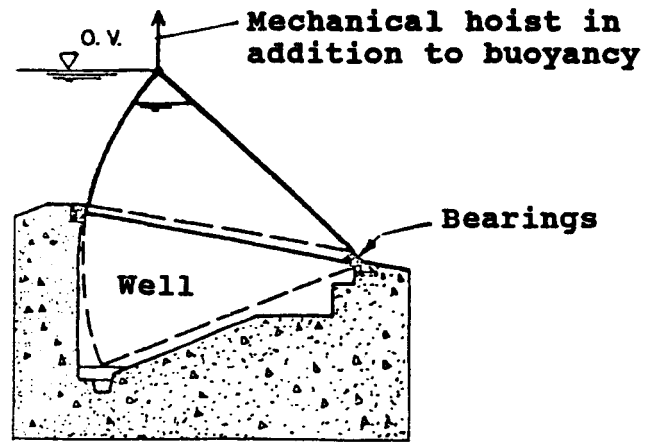
Spherical valve



Tube valve



Radial gate



Sector gate

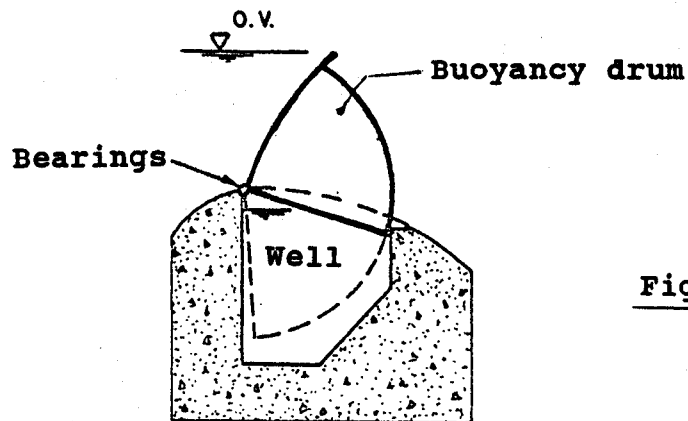
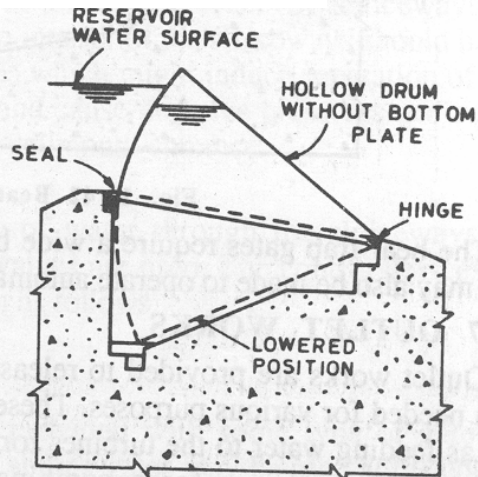
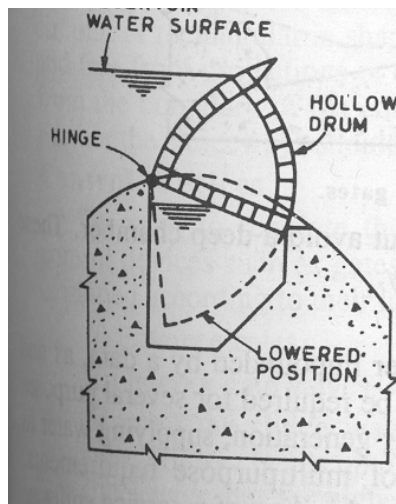
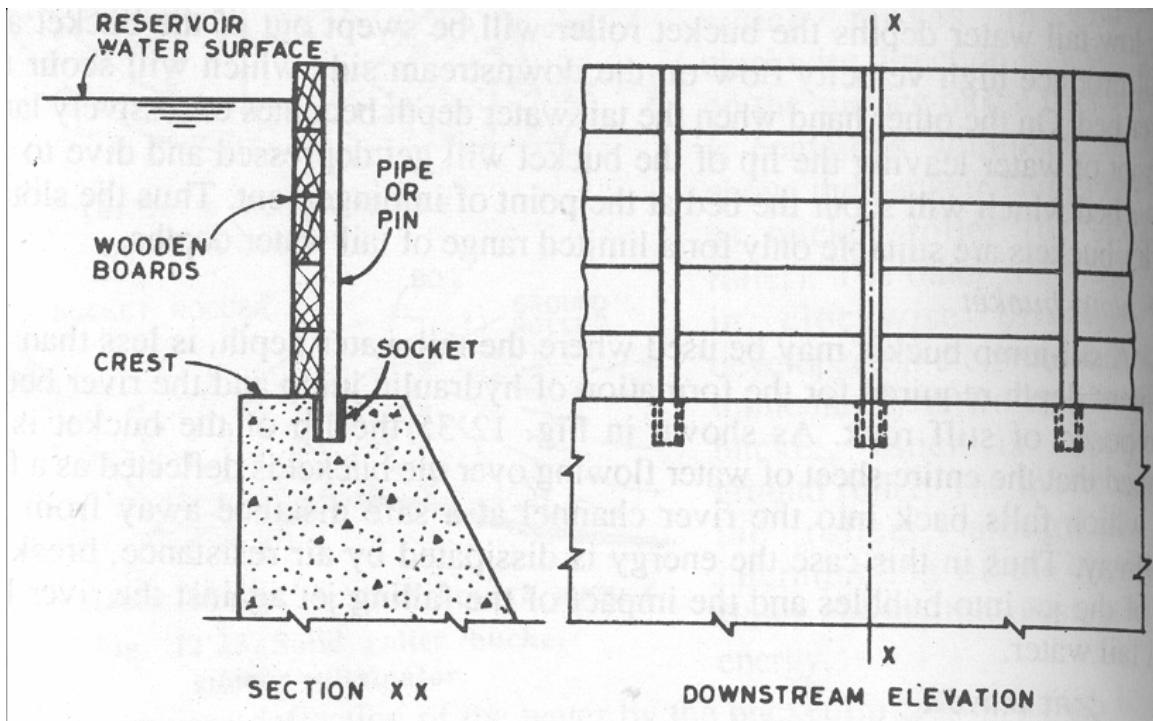


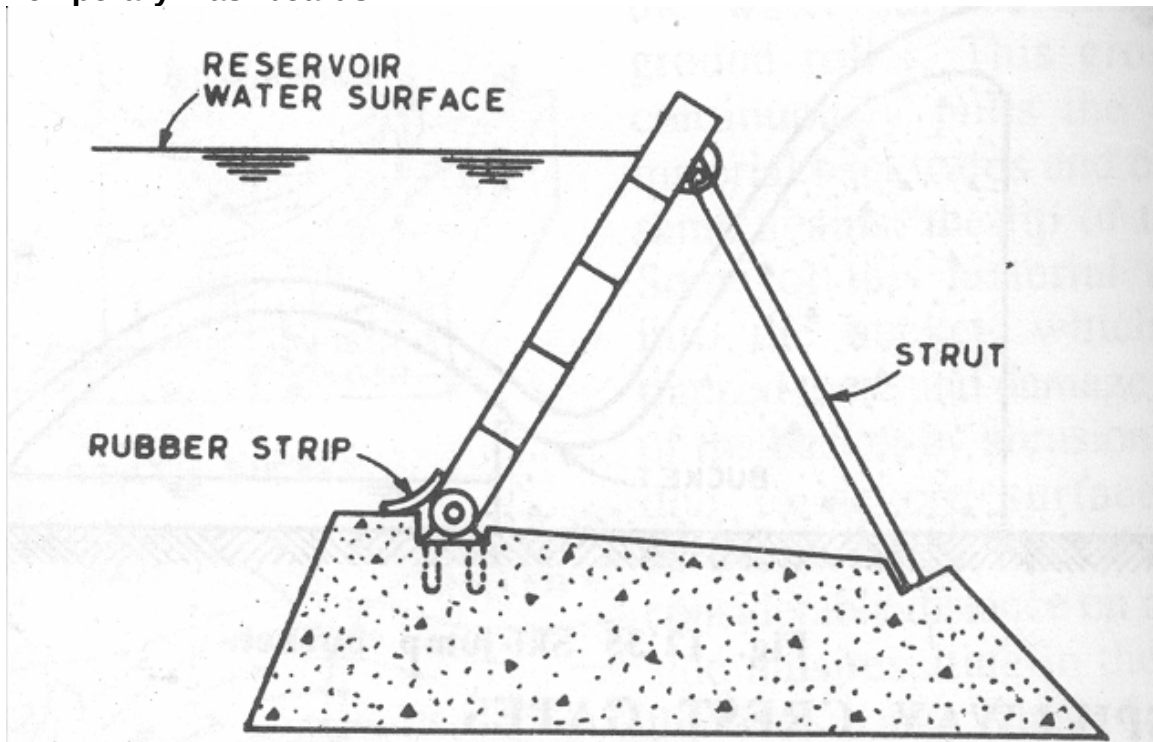
Fig. 2 DRUM GATE



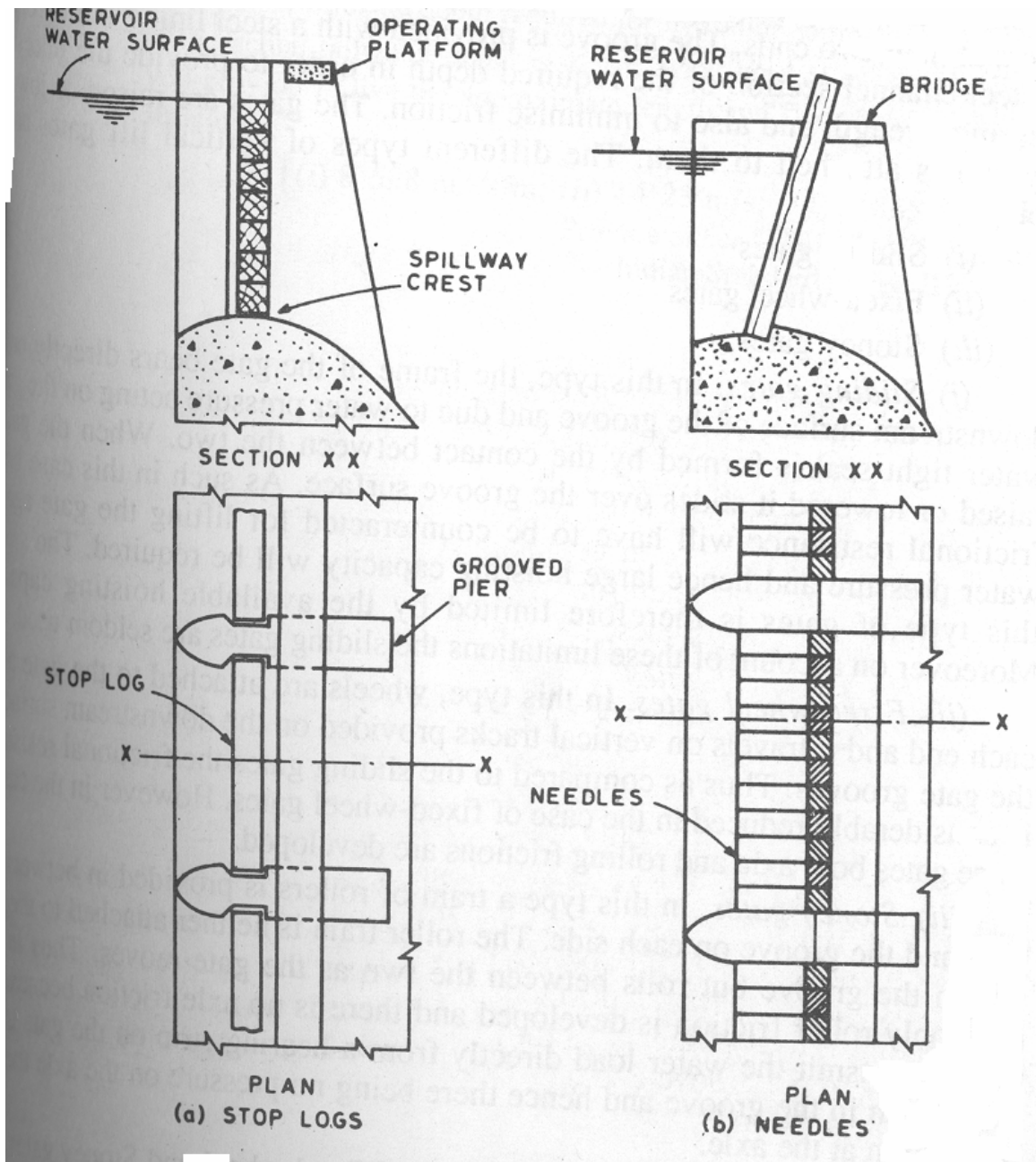
Drum Gates



Temporary Flashboards



Permanent Flashboards



Stop logs and Needles

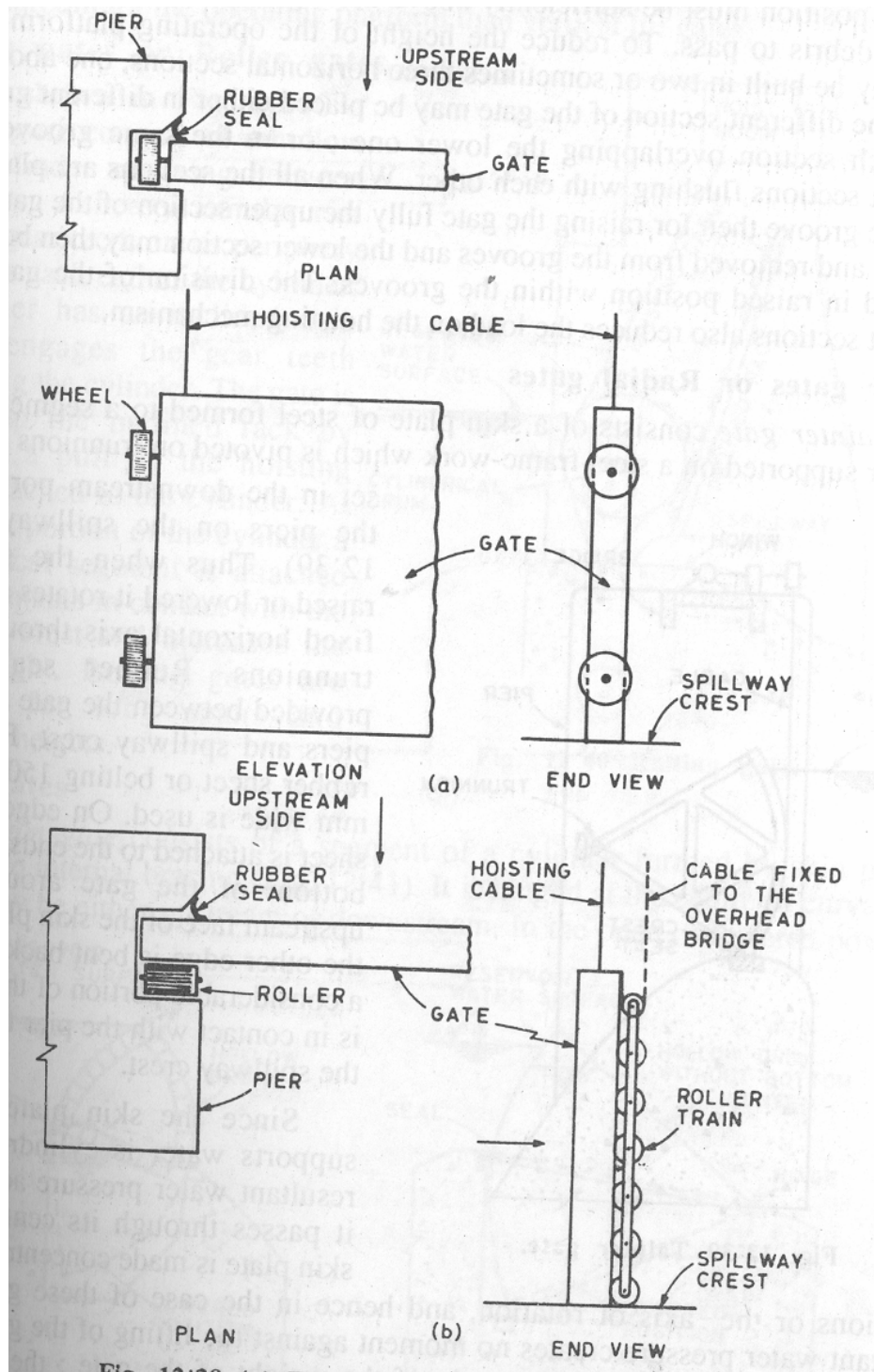
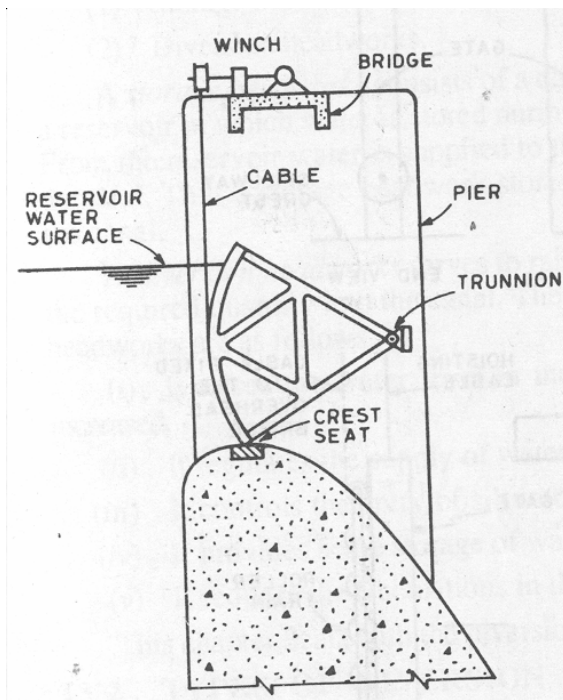
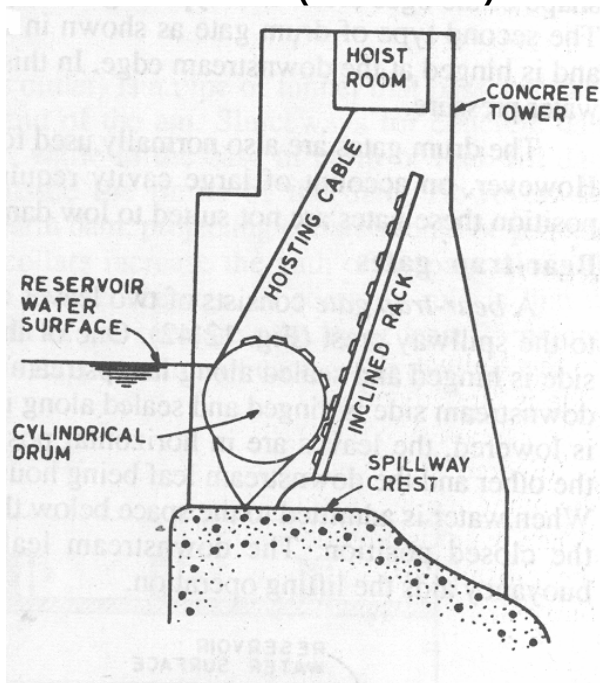


Fig. 12.28 (a) Fixed wheel Gate; (b) Stoney Gate.



Tainter Gate (Radial Gate)



Rolling Gate