

Module

4

Hydraulic Structures for Flow Diversion and Storage

Lesson

10

Gates and Valves for Flow
Control

Instructional objectives

On completion of this lesson, the student shall learn:

1. The different types of gates and valves used in water resources engineering
2. Difference between crest gates and deep seated gates
3. Classification of gates
4. Design criteria for important gates
5. Common hoists for gate lifting
6. Different types of valves for flow control

4.10.0 Introduction

Almost every water resources project has a reservoir or diversion work for the control of floods or to store water for irrigation or power generation, domestic or industrial water supply. A spillway with control mechanism is almost invariably provided for release of waters during excess flood inflows. Releases of water may also be carried out by control devices provided in conduits in the body of the dam and tunnels. In order to achieve flow control, a gate or a shutter is provided in which a leaf or a closure member is placed across the waterway from an external position to control the flow of water. Control of flow in closed pipes such as penstocks conveying water for hydropower is also done by valves, which are different from gates in the sense that they come together with the driving equipment, whereas gates require a separate drive or hoisting equipment.

Different types of hydraulic gates and hoists, working on different principles and mechanism are in use for controlled release of water through spillways, sluices, intakes, regulators, ducts, tunnels, etc. Right selection of gates and their hoisting arrangement is very important to ensure safety of the structure and effective control. A designer has to plan a gate and its hoisting arrangement together. Separate planning of gates or hoists, sometimes results in unsatisfactory installation. Though the choice for the gates and hoists depends on several factors, primarily safety, ease in operation as well as maintenance and economy are the governing requirements in the same order. It is essential for the water resources engineer to be aware of the different factors, which would largely affect the choice of gates and hoists and would help in selection of the same. In this lesson, an introduction is provided on different gates, specific purposes for which they may be used, possible locations in which to install, and suitable hoists with which to operate. A brief outline is also provided on the common types valves used to regulate flow in penstocks.

The Bureau of Indian Standards code IS 13623: 1993 “Criteria for choice of gates and hoists” provides the basic classification of gates, which may be done according to the following criteria.

1. Location of the gate with respect to reservoir water surface

2. Head of water over sill of gate
3. Operational requirement
4. Material used in fabrication
5. Mode of operation
6. Shape of gate
7. Discharge through gate
8. Type of flow passage with which connected and its location
9. Location of seal
10. Location of skin plate
11. Closing characteristics
12. Drive to operate

Hoists for raising gates are also classified based on certain characteristics, such as:

1. Drive operating mechanism
2. Mounting

Some of the important terminologies associated with gates are given below, which would help one to understand the operation of gates more closely.

1. Counter weight

A weight used for opposing the dead weight of a gate so as to reduce the hoisting capacity. A counter weight may also be used for making the gate 'Self closing'.

2. Frame

A structural member embedded in the surrounding supporting structure of a gate, which is required to enable the gate to perform the desired function.

3. Hanger

A device meant for suspending or supporting a gate in the open position when disconnected from its hoisting mechanism.

4. Gate groove or gate slot

A groove or slot is a recess provided in the surrounding structure in which the gate moves rests or seats.

5. Leaf

The main body of a gate consisting of skin plate, stiffeners, horizontal girders and end girders.

6. Lip

The lower most segment of a gate which is suitably shaped from hydraulic consideration.

7. Seal (Bottom, side and top)

A seal is a device for preventing the leakage of water around the periphery of a gate. A bottom seal is one that is provided at the bottom of the gate leaf. Side seals are those that are fixed to the vertical ends of gate leaf. A top seal is one that is provided at the top of a gate leaf or gate frame.

8. Sill

This is the top of an embedded structural member on which a gate rests when in closed position.

9. Guide

That portion of a gate frame which restricts the movement of a gate in the direction normal to the water thrust.

10. Guide rollers

Rollers provided on the sides of a gate to restrict its lateral and/or transverse movements.

11. Guide shoe

A device mounted on a gate to restrict its movement in a direction normal to the water thrust.

12. Horizontal and vertical girders

Horizontal girders are the main structural members of a gate, spanning horizontally to transfer the water pressure from the skin plate and vertical stiffeners (if any) to the end girders or end arms of the gate. Vertical girders (also called vertical stiffeners) are the structural members spanning vertically across horizontal girders to support the skin plate.

13. Hydraulic down-pull

The net force acting on a gate in vertically downward direction under hydrodynamic condition.

14. Hydraulic uplift

The net force acting on a gate in vertically upward direction under hydrodynamic condition.

15. Lift of a gate

The maximum vertical travel of a gate above the gate sill.

16. Lifting beam

A beam (with a gripping mechanism) suspended from a gantry crane or a traveling hoist and moves vertically in a gate groove for lifting or lowering a gate or a stop-log.

17. Lifting lugs

Structural members provided on a gate to facilitate handling of the gate during erection, installation or operation.

18. Air vent

A passage of suitable size provided on the downstream of the gate for venting / admitting air during filling / draining a conduit or for delivering a continuous supply of air to the flow of water from a gate.

19. Anchorage

An embedded structural member, transferring load from gate to its surrounding structure.

20. Bearing plate

A metal plate fixed to the surrounding surface of the frame to transfer water pressure to gate frame.

21. Gate Frame or Embedded Part of Embedment

A structural member embedded in the surrounding supporting structure of a gate, which is required to enable the gate to perform the desired function.

22. Thrust Pad or Thrust Block

A structural member provided on a gate leaf to transfer water load from the gate to a bearing plate. It could also be a structural member designed to transfer to the pier or abutment that component of water thrust on a radial gate, which is normal to the direction.

23. Skin plate

A membrane which transfers the water load on a gate to the other components.

24. Track Plate

A structural member on which the wheels of a gate move.

25. Trunnion axis

The axis about which a radial gate rotates.

26. Trunnion Pin

A horizontal axle about which the trunnion hub rotates.

27. Trunnion Tie

A structural tension member connecting two trunnion assemblies of a radial gate to cater to the effect of lateral force (normal to the direction of flow)

28. Block out

A temporary recess/opening left in the surrounding structure of a gate for installing the embedded parts of a gate.

29. Liner

Steel lining generally provided in the gate groove and its vicinity for a medium or high head installation.

30. Filling Valve

A valve fixed over a gate to create balanced water head conditions for gate operation.

4.10.1 Classification of gates based on location of opening with respect to water head

The different types of gates used in water resources projects may be broadly classified as either the Crest or Surface type, which are intended to close over the flowing water and the Deep-seated or Submerged type, which are subjected to submergence of water on both sides during its operation. The different types of gates falling under these categories are as follows:

Crest type gates**1. Stop-logs/flash boards**

A log, plank cut timber, steel or concrete beam fitting into end grooves between walls or piers to close an opening under unbalanced conditions, usually handled or placed one at a time (Figure 1). Modern day stop-logs consist of steel frames that may be inserted into grooves etched into piers and used during repair / maintenance of a regular gate (Figure 2). The stop logs are inserted or lifted through the grooves using special cranes that move over the bridge.

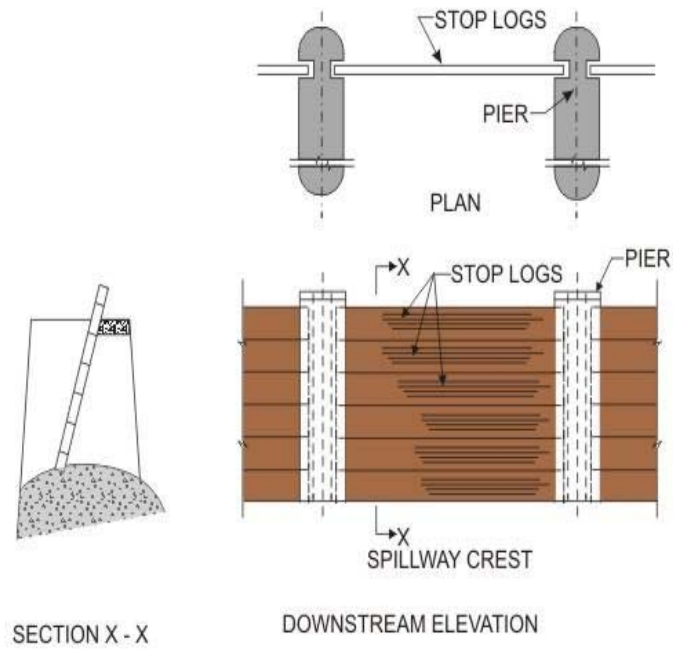


FIGURE - 1. STOPLOGS (NEEDLES)
INSERTED WITHIN GROOVES OF ADJACENT PIERS

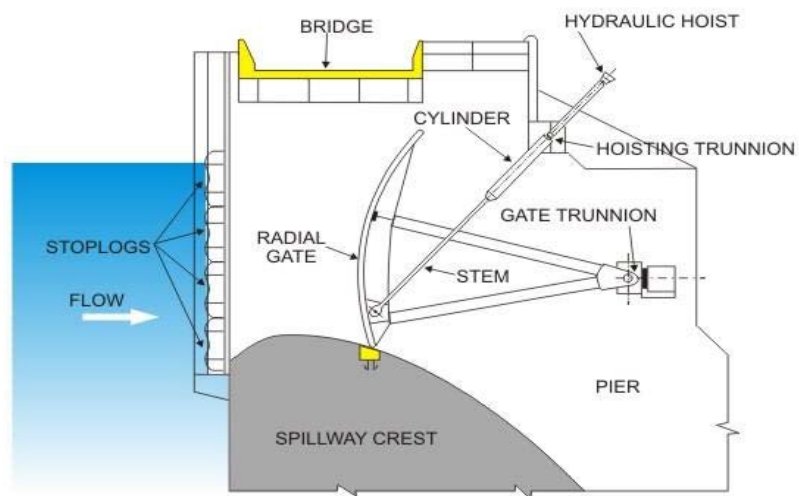


FIGURE - 2. MODERN DAY STOPLOGS SHOWN IN
COMBINATION WITH A RADIAL GATE
AND HYDRAULIC HOIST

2. Vertical lift gates

These are gates that moves within a vertical groove incised between two piers (Figure 3). The vertical lift gates used for controlling flow over the crest of a hydraulic structure are usually equipped with wheels, This type of gate is commonly used for barrages but is nowadays rarely used for dam spillways. Instead, the radial gates (discussed next) are used for dams. This is mostly due to the fact that in barrage spillways, the downstream tailwater is usually quite high during floods that may submerge the trunnion of a radial gate.

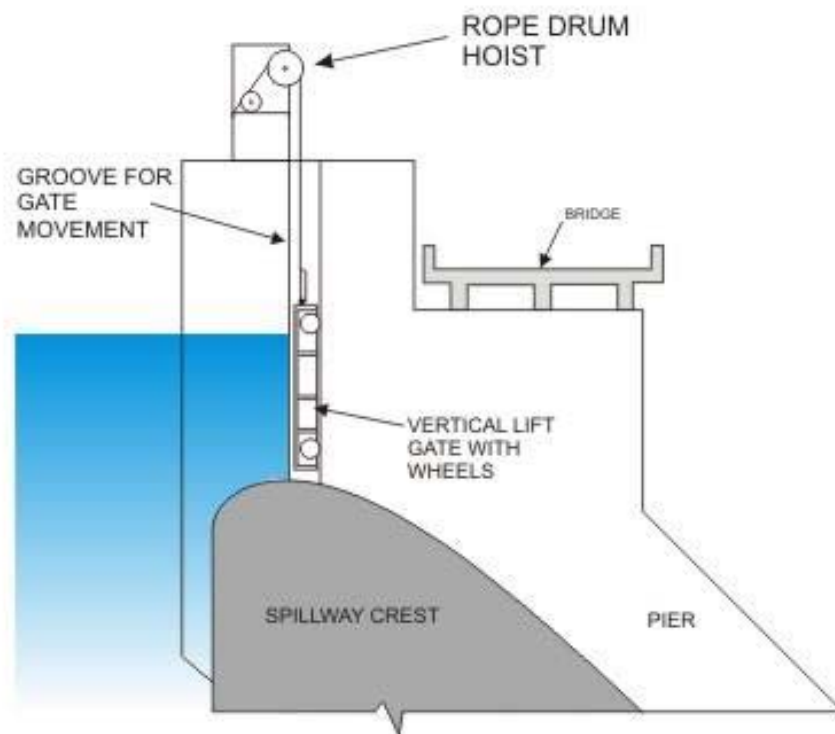


FIGURE 3 : VERTICAL LIFT GATE ARRANGEMENT FOR DAM SPILLWAY

3. Radial gates

These are hinged gates, with the leaf (or skin) in the form of a circular arc with the centre of curvature at the hinge or trunnion (Figure 4). The hoisting mechanism shown is that using a cable that is winched up by a motor placed on a bridge situated above the piers. Another example of radial gate may be seen in Figure 2, where a hydraulic hoisting mechanism is shown.

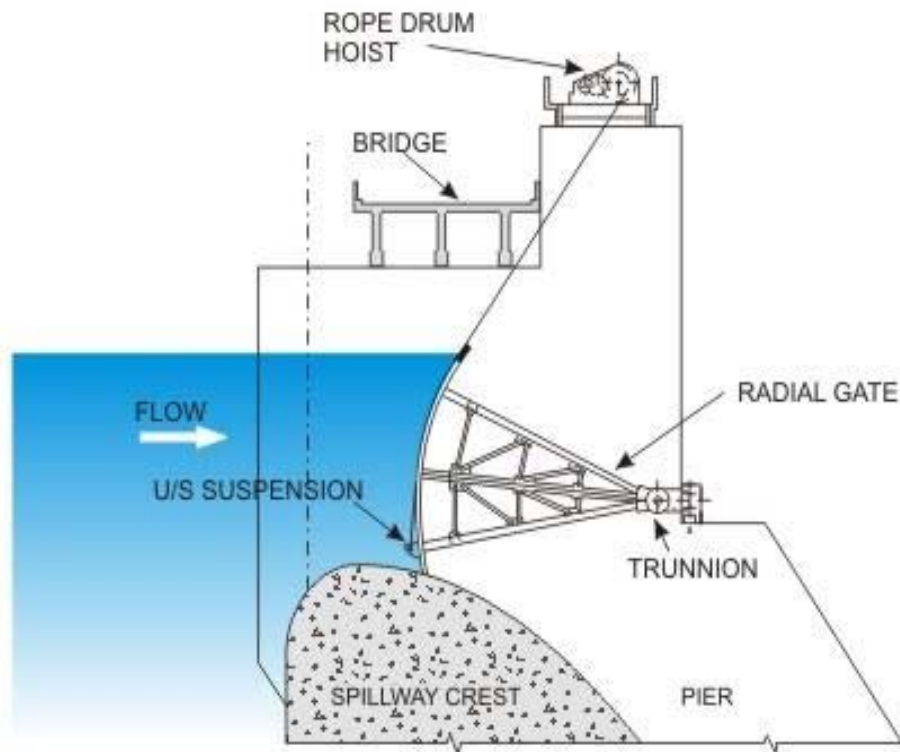


FIGURE 4 : RADIAL GATE SHOWN WITH ROPE DRUM HOISTING MECHANISM

4. Ring gates

A cylindrical drum which moves vertically in an annular hydraulic chamber so as to control the peripheral flow of water from reservoir through a vertical shaft (Figure 5).

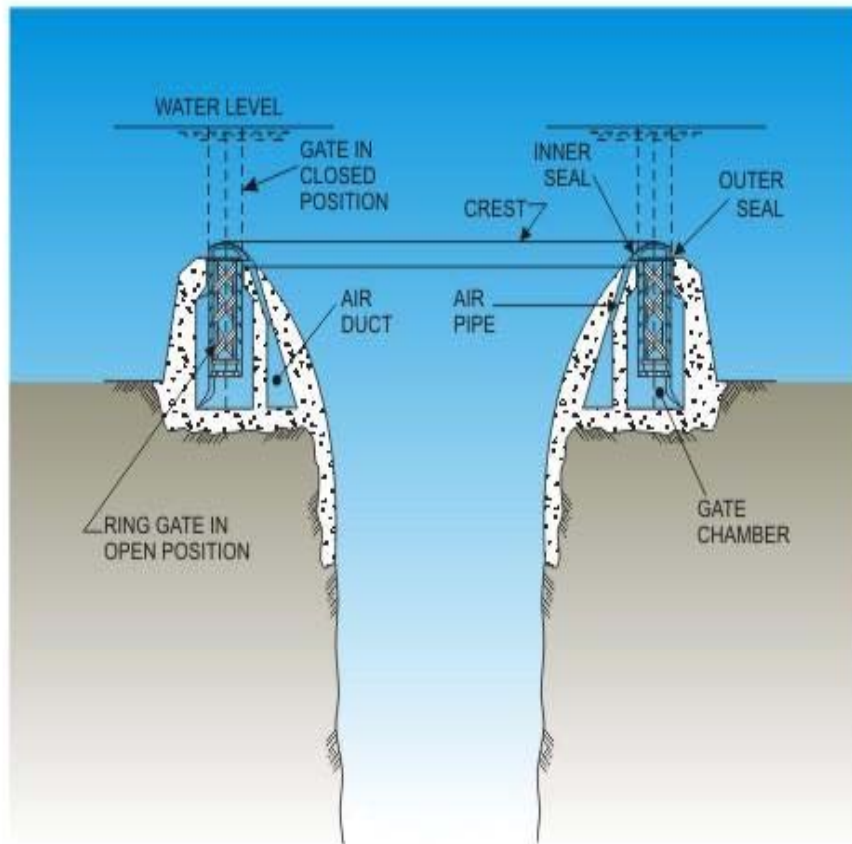


FIGURE 5 : RING GATE ARRANGEMENT
FOR A MORNING GLORY SPILLWAY

5. **Stoney gate**

A gate which bears on roller trains which are not attached to the gate but in turn move on fixed tracks. The roller train travels only half as far as the gate (Figure 6). This type of gate is not much in use now.

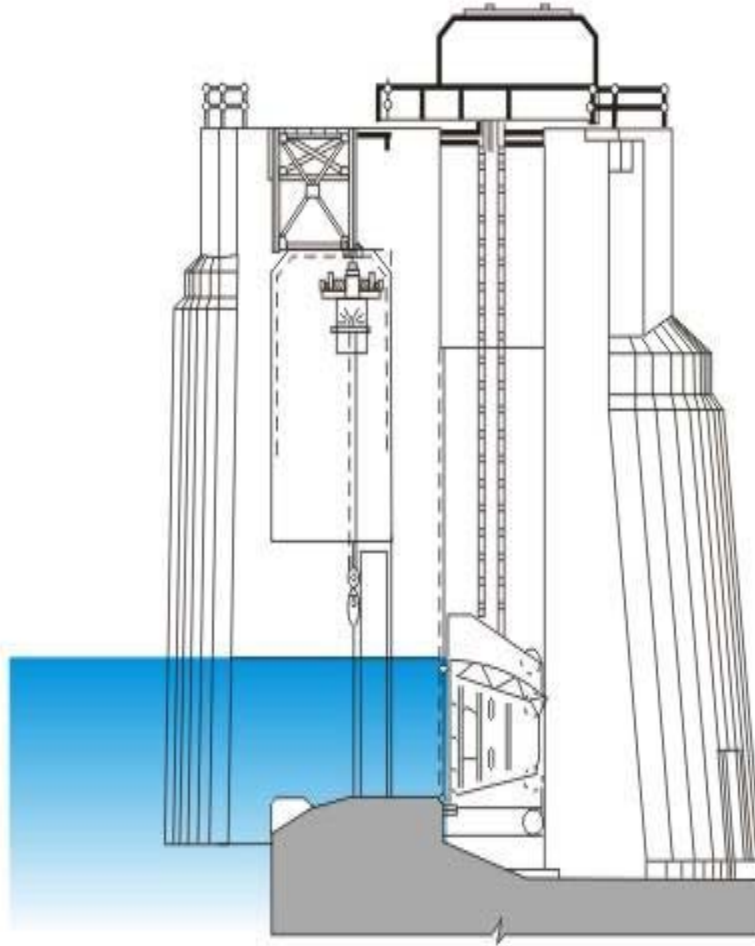


FIGURE 6 : TYPICAL INSTALLATION OF A STONEY GATE

6. Sector gates

A pair of circular arc gates which are hinged on vertical axis in a lock (Figure 7). These gates are used in navigation locks where ships pass from a reservoir with a higher elevation to one with a lower elevation.

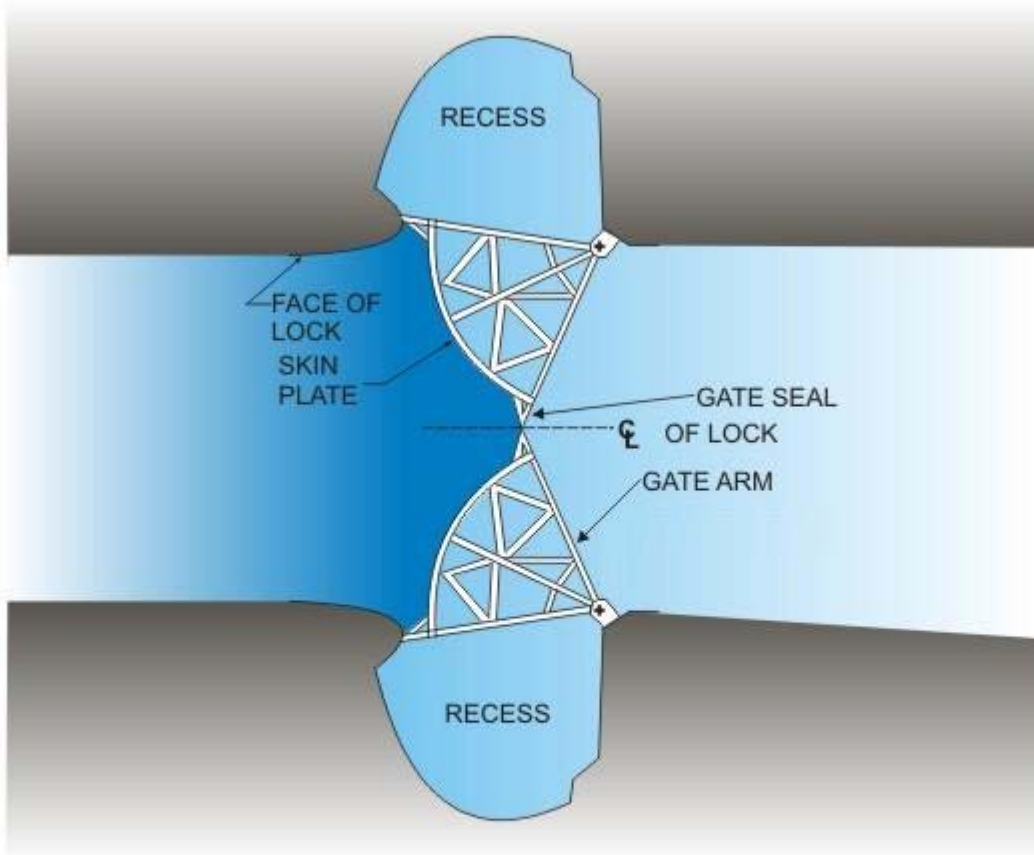


FIGURE 7 : PLAN OF A SECTOR GATE. LEFT SIDE CONTAINS WATER AT HIGHER ELEVATION

7. Inflatable gates

These are gates which has expandable cavities. When inflated either with air or water it expands and forms an obstruction to flow thus effecting control (Figure 8). Though these gates have not been commonly used in our country, it is used quite often in many other countries because of its simplicity in operation – However, they suffer from possible vulnerability from man-made damages.

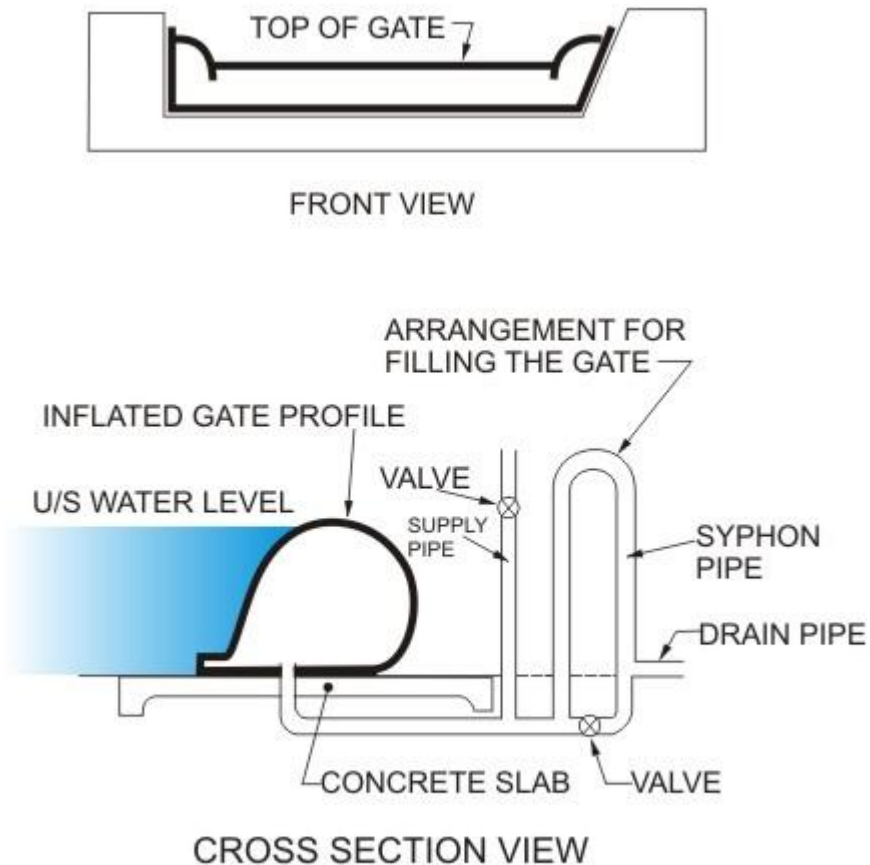


FIGURE 8 : INFLATABLE GATE

8. Falling shutters

Low head gates installed on the crest of dams, barrages or weirs (Figure 9) which fall at a predetermined water level. Generally these are fully closed or fully open, that is, fallen flat, which are shown to operate using a hoist. However, in some weirs, falling shutters have been provided earlier that are manually operated. In many of the older weir installations constructed during the pre-independence period were equipped with falling shutters, some of which are still in use today (Figure 10).

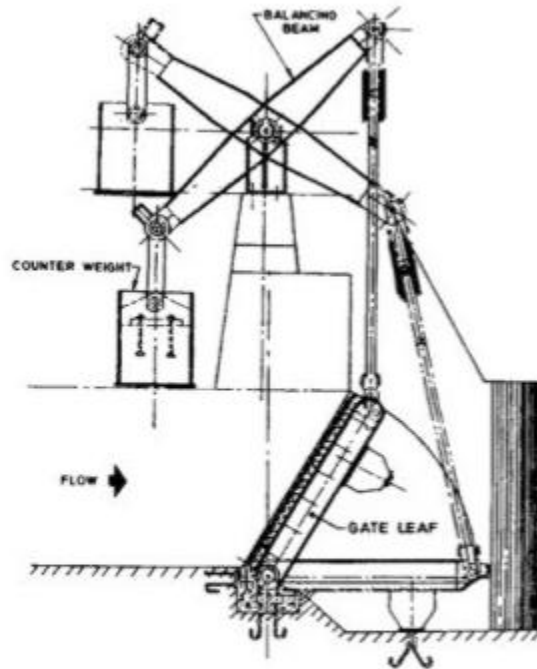


Figure 9. Automatic falling shutter

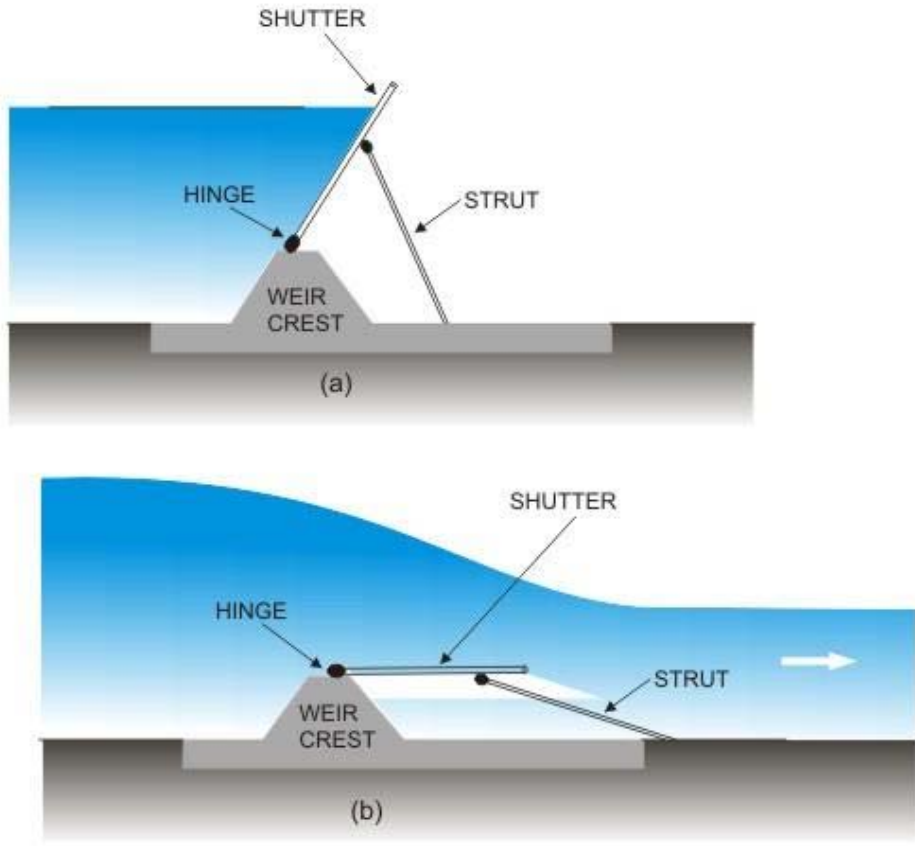


Fig.10: Manually operated falling shutter (a) Closed Position, (b) Open Position

9. *Float operated gates*

A gate in which the operating mechanism is actuated by a float that is pre-set to a predetermined water level (Figure 11). These may be used as escape in canals or even in dams to release water if it goes above a certain level considered dangerous for the overall safety of the project.

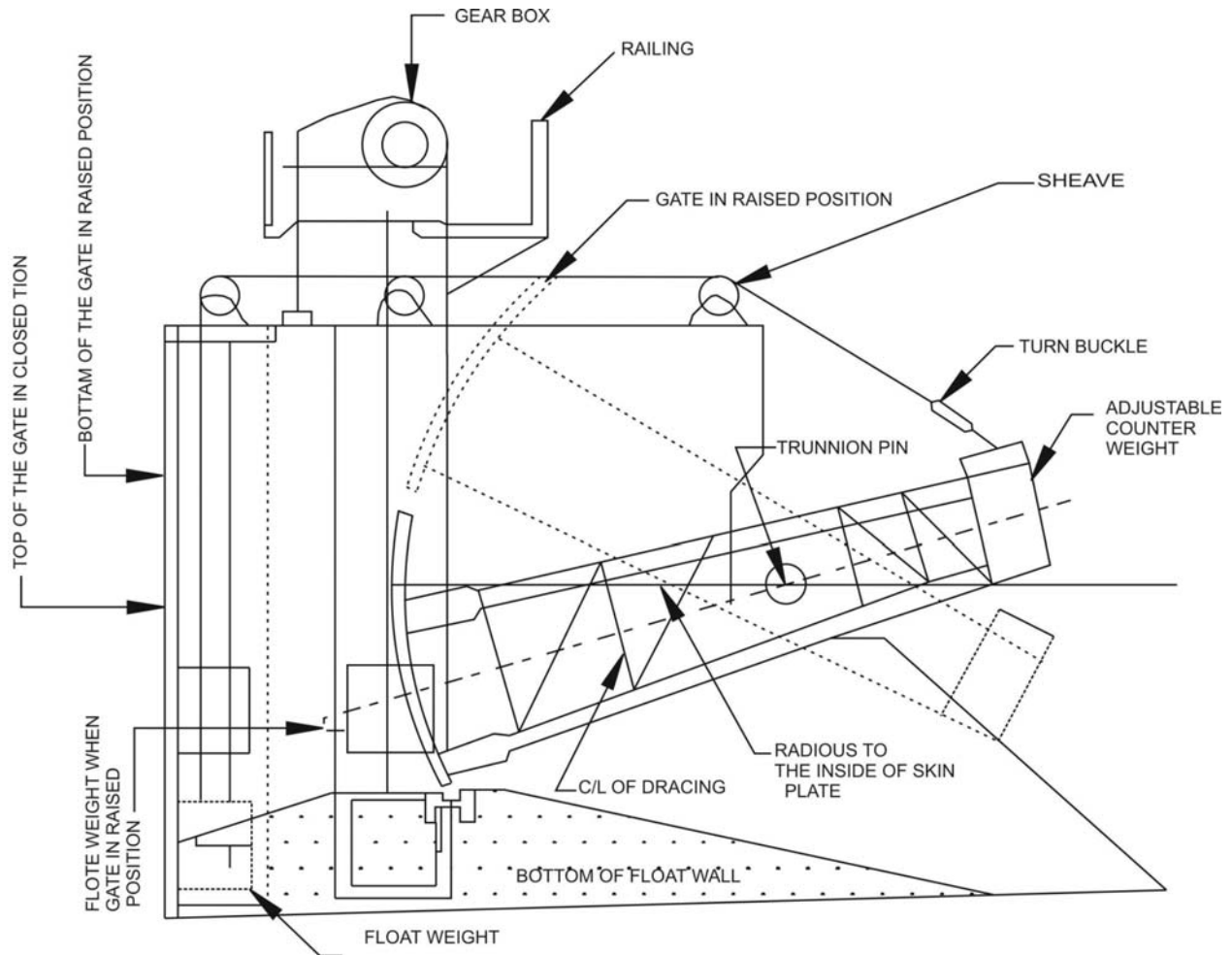


FIGURE 11. AUTOMATIC FLOAT OPERATED RADIAL GATE

10. Two-tier gates

A gate used in two leaves or tiers which can be operated separately, but when fully closed act as one gate. These types of gates are used to reduce the hoist capacity or the lift of the gate (Figure 12). Such a gate has been installed in the canal head regulator of the Farakka barrage.

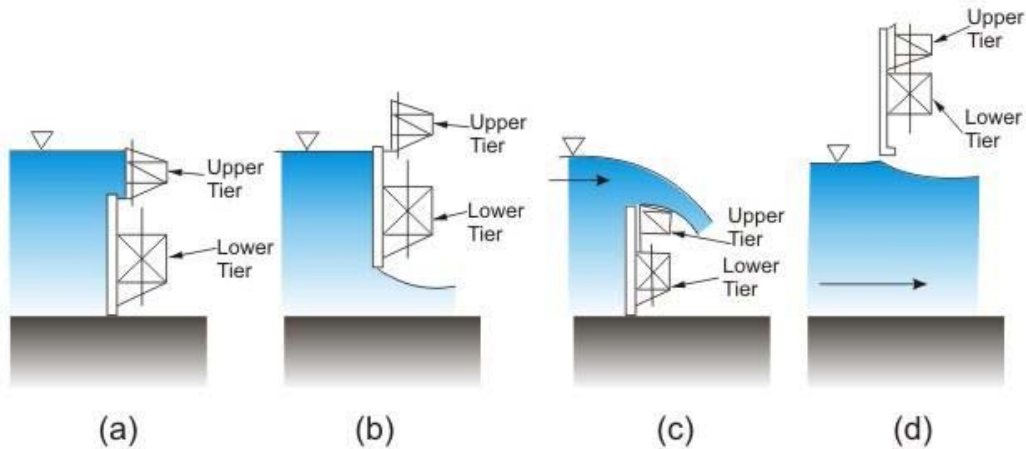


FIGURE 12. Two tier gate at different positions
(a) Closed; (b) Underflow
(c) Overflow; (d) Freeflow

Deep seated gates

1. Vertical gate

Similar to that used for crest type gates (Figure 1), but usually for deep-seated purposes like controlling flow to hydropower intake either the ones with roller wheels (Figure 13), or the sliding-type without any wheels (Figure 14), are used.

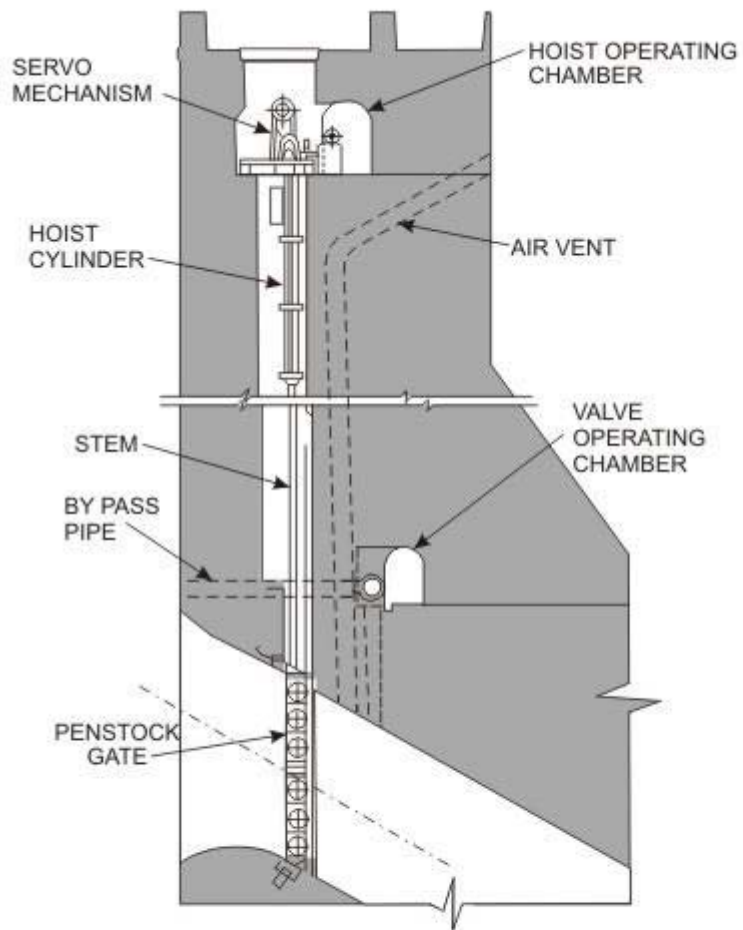


FIGURE 13. TYPICAL ARRANGEMENT OF VERTICAL LIFTGATE WITH WHEELS WITH HYDRAULIC HOIST

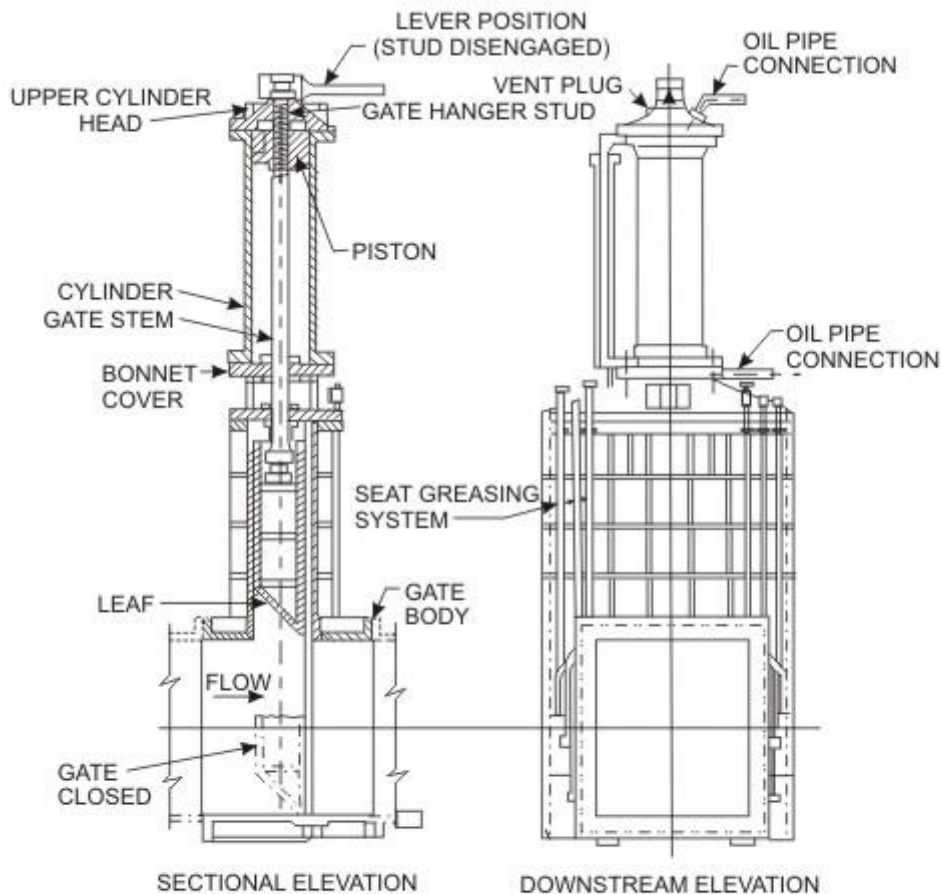


FIGURE 14. SLIDE GATE (VERTICAL LIFT) WITH HYDRAULIC HOIST MECHANISM

According to the Bureau of Indian Standards code IS: 5620 “Recommendations for structural design criteria for low head slide gates”, slide gates may be classified into the following three types depending upon their service conditions.

- (i). **Bulk head or stop-logs**
 These are usually located at the upstream end of river outlet conduits or penstocks where in addition some other equipment is used to cut off flow and are subjected to relatively high heads.
- (ii). **Emergency or guard gates**
 These are designed to be operated under unbalanced head, that is, with water flowing through the conduit or sluice but are not meant for regulation. These are kept either fully opened or fully closed and are not operated at part gate opening.

(iii). **Regulating gates**

These are used for regulating flow of water. These are also operated under unbalanced head condition and are designed to be operated at any gate opening.

2. Deep-seated radial gates

These are low level radial outlet gates. These gates have sealing on top apart from on all sides. They are located at sluices in the bottom portion of dam (Figure 15). The hoisting arrangement is usually at the top but could also be provided near the elevation of top seal to reduce hoist stroke.

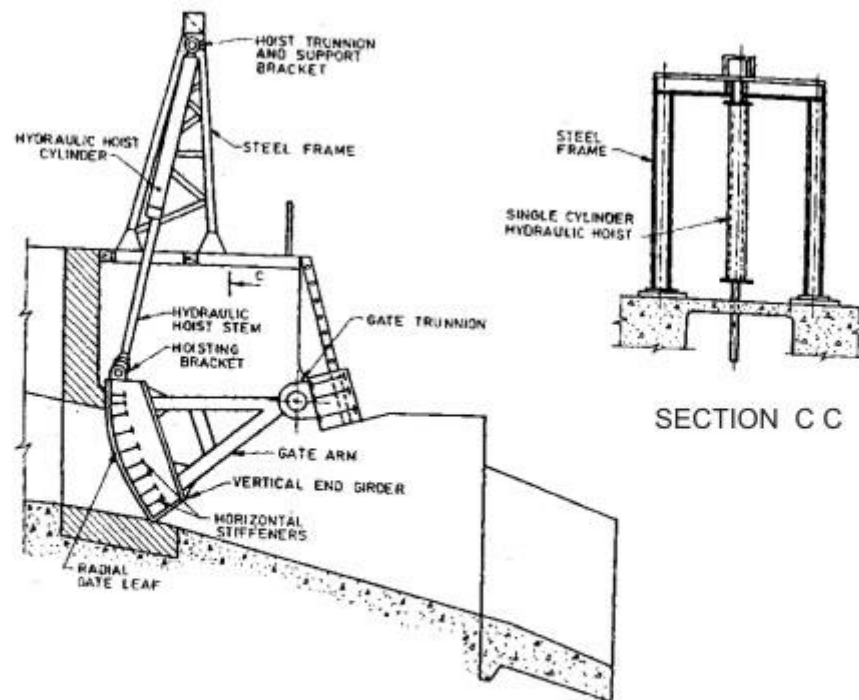


FIGURE 15. DEEP SEATED RADIAL GATE WITH HYDRAULIC HOIST

3. Disc gates

A gate, which is in the form of disc, and rotates about an axis of its plane to control the flow of water.

4. Cylindrical gates

A gate in the form of a hollow cylinder placed in a vertical shaft. These gates are used usually for intake towers, upstream of dams for shutting off the water to

penstocks and control valves. These may also be used in outlet works (Figure 16).

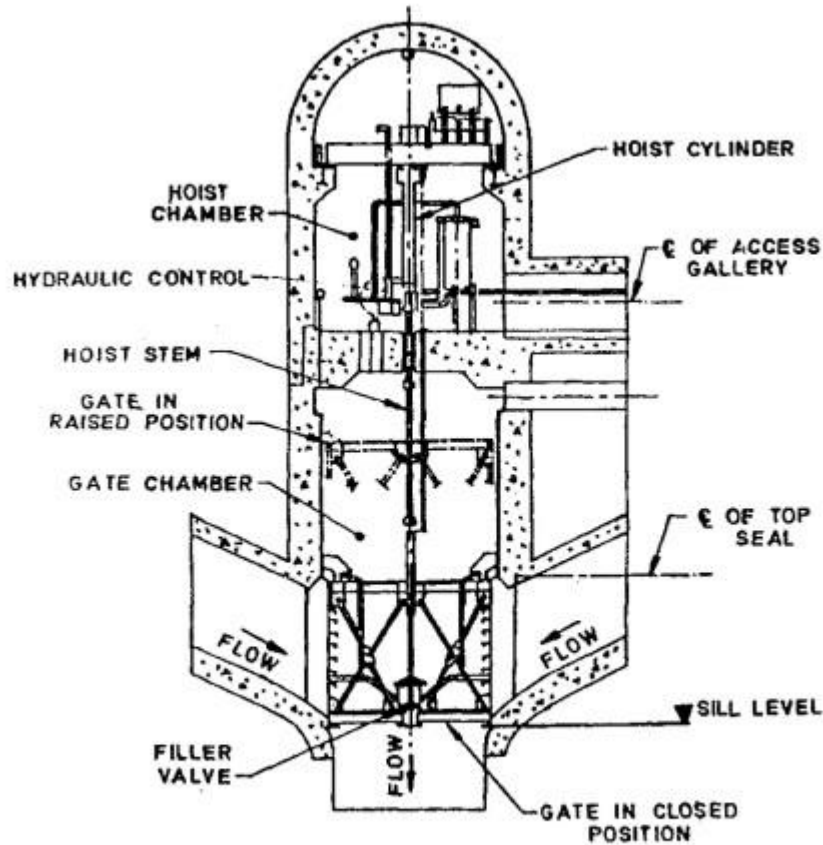


FIGURE 16. CYLINDRICAL GATE WITH HYDRAULIC HOIST

5. Ring follower gates

These are gates with a slide gate with a circular ring (a leaf with a circular hole) extending below the gate leaf. The diameter of the circular hole is equal to the diameter of the conduit. When the gate leaf is raised above the conduit, the circular hole forms an unobstructed passage for the flow of water in the conduit. When the gate is lowered to shutoff the flow, the circular ring fits into a recess below the invert of the conduit. It is used as emergency gate upstream of a regulating or service gate and is operated either in fully closed or fully open position (Figure 17).

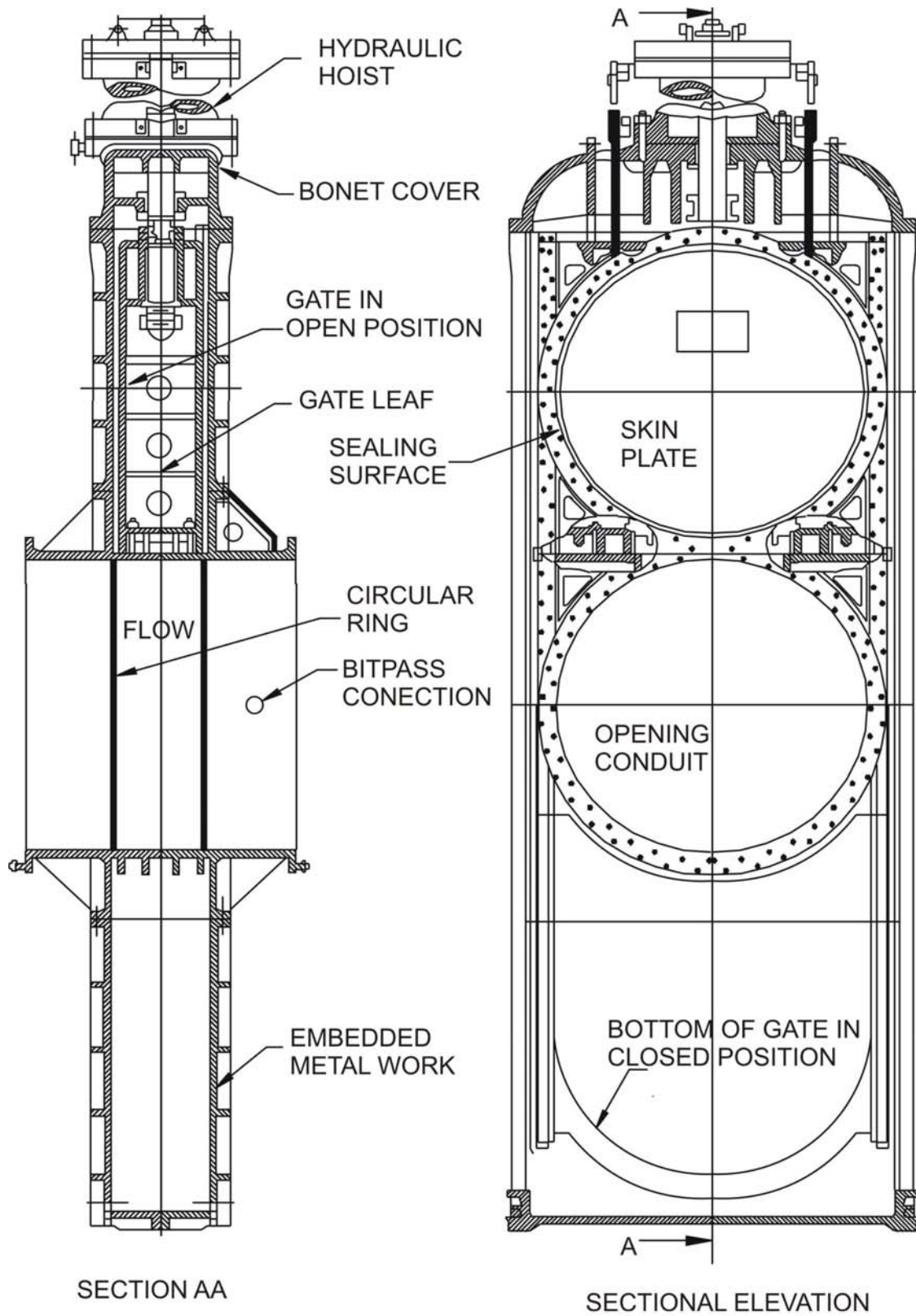


FIGURE17. RING FOLLOWER GATE

6. Jet flow gates

A high pressure regulating gate in which the leaf and the housing are so shaped as to make the water issue from the orifice in the form of a jet which skips over the gate slot without touching the downstream edge of the slot (Figure 18). They are adopted when very fine control of discharge is desired.

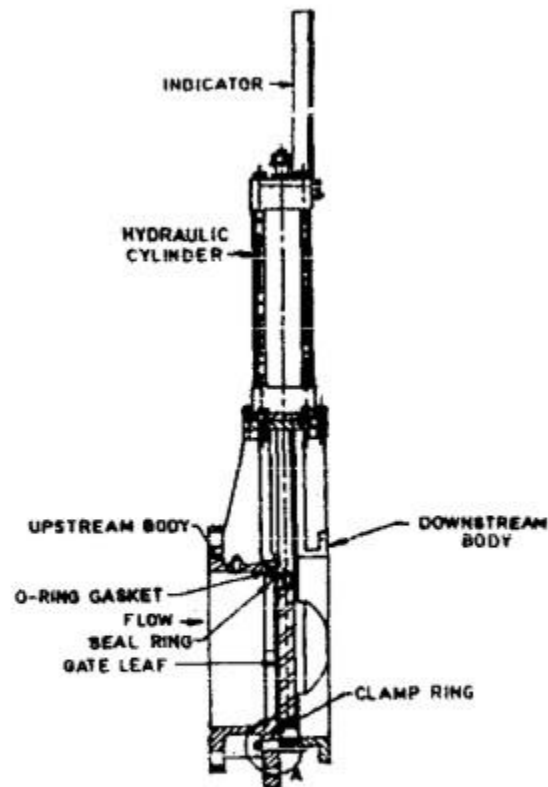


FIGURE 18. JET FLOW GATE

7. Ring seal gates

A roller or wheel mounted gate in which the upper portion of the gate leaf forms a bulkhead section to stop the flow of water and the lower portion forms a circular opening of the same size as the conduit so as to produce an unobstructed water passage with the leaf in the open position. Complete closure of the leaf in the lower position is made by extending a movable ring seal actuated hydraulically from the water pressure in the conduit to contact a seat on the leaf. This type of gate is usually used as either service or emergency gates in the penstocks or other conduits (Figure 19).

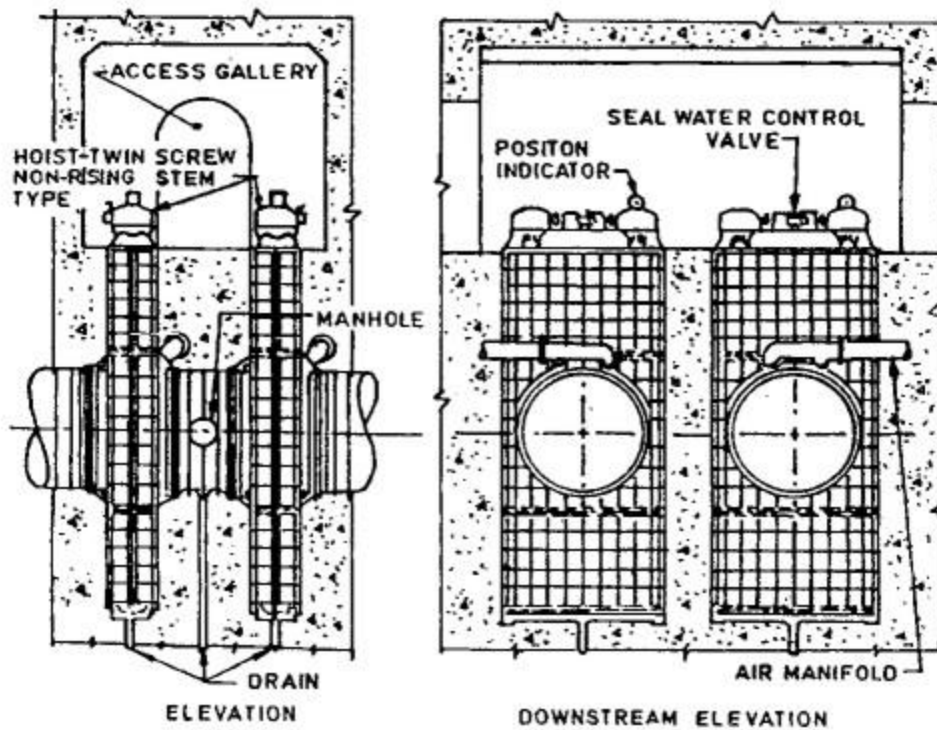


FIGURE 19. RING SEAL GATE (INSTALLATION OF 2 GATES)

4.10.2 Classification of gates based on the type of flow passage with which connected and its location

Gates are a part of most of the openings provided in any water resources project. They may be used to regulate flow through spillways, sluices, intakes, regulators, ducts, tunnels, etc., to name a few. The following list provides classification of gates based on its association with a particular water passage. The gates associated with hydropower have only been briefly described here. They are described in more detail in the next module.

1. Crest gates

A gate mounted on a crest for the purpose of controlling the discharge flowing over the crest of the spillway of a dam or a barrage (Figure 20). As mentioned in Section 4.10.1, it is common to find radial gates to regulate flow over dam crests and vertical lift gates for barrage spillways.

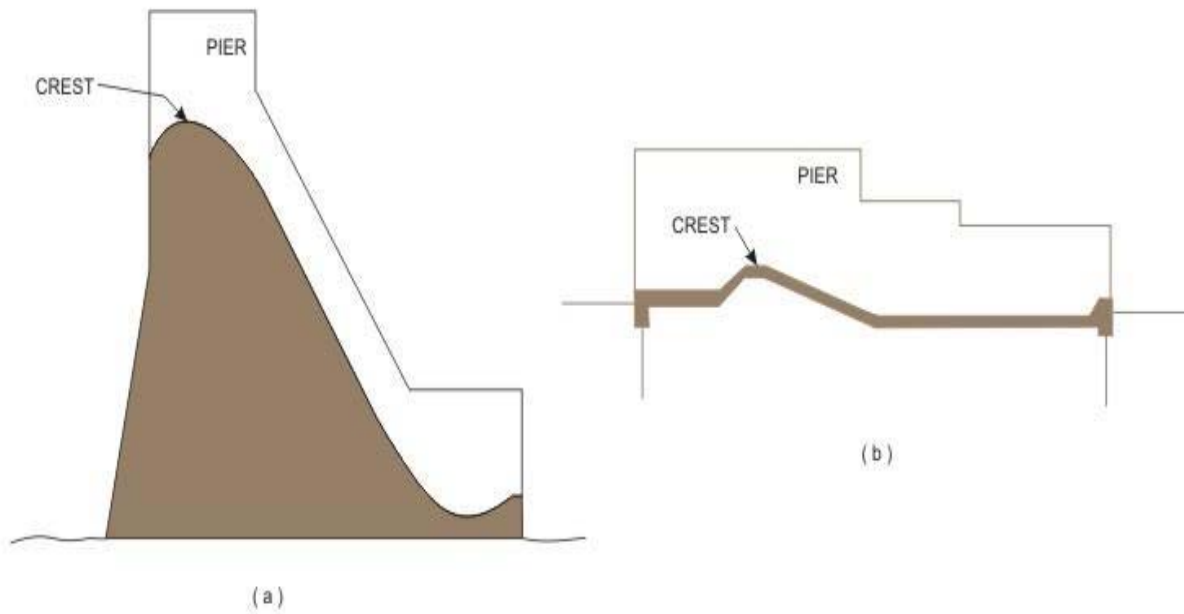


FIGURE 20. SPILLWAY BAYS SHOWING CRESTS OF (a) DAM AND (b) BARRAGE SHOWING CRESTS

2. Sluice gates

These are gates which controls or regulates flow through an opening or sluice in the body of the dam where the upstream water level is above the top of opening as shown for gates at the entry to the penstock of a hydropower intake in Figure 21.

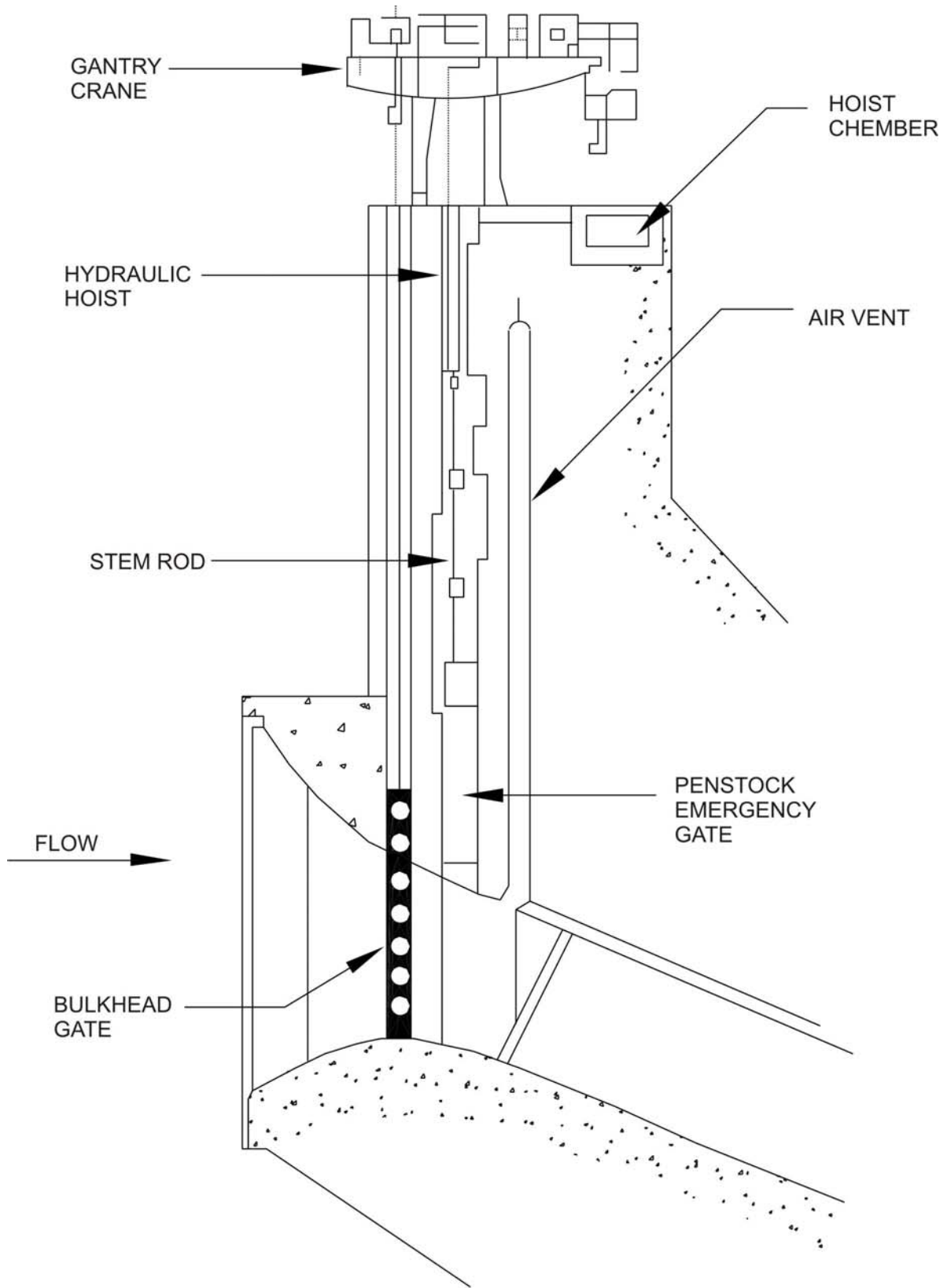


FIGURE 21. PENSTOCK EMERGENCY GATE

3. Depletion sluice gates

A gate located at lowest level in the body of the dam to deplete the reservoir in the event of distress. It may be either wheel mounted type or sliding type.

4. Construction sluice gates

This gate is meant for closing a construction sluice which is normally plugged after construction.

5. Diversion tunnel gates

This gate is meant for making diversion tunnel dry, when it has to be plugged after construction (Figure 22). Service gates are lowered for plugging the diversion tunnel and emergency gates are provided to take care of any eventuality resulting from malfunctioning of the service gates. Usually, such gates are meant for one time operation while plugging the tunnel.

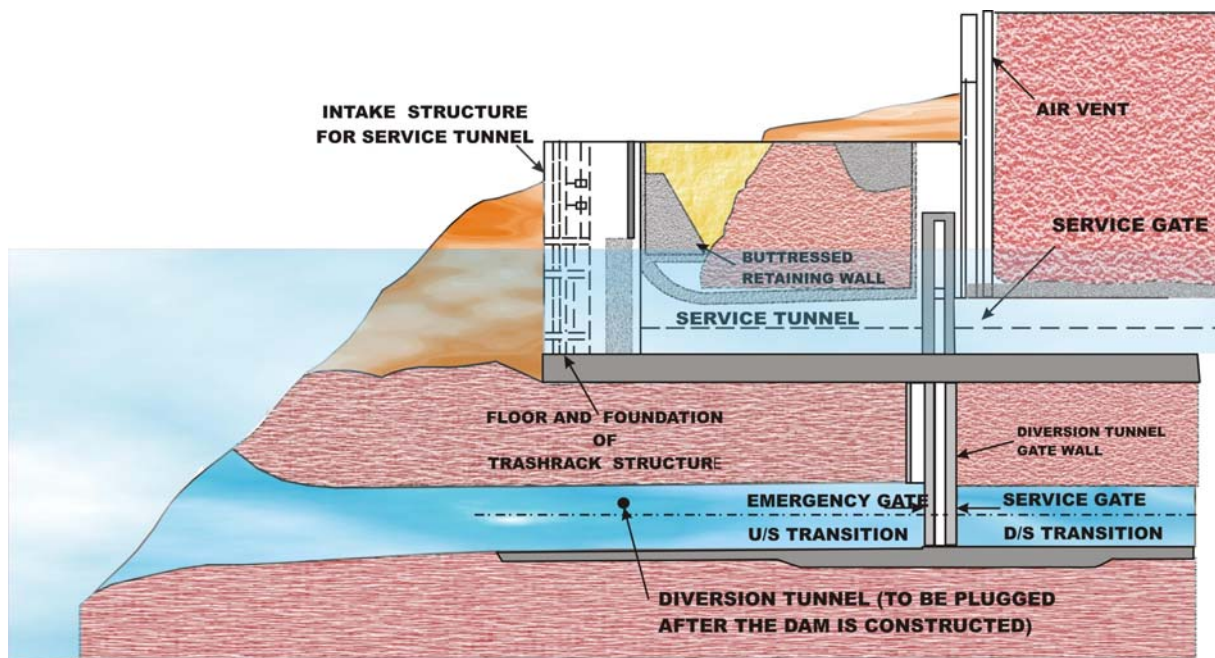


FIGURE 22. DIVERSION ON TUNNEL AND GATE , WHICH CONTROL, FLOW DURING DIVERSION

6. Head regulator and Cross regulator gates

The Head regulator gates are used for regulating water from reservoir to main canal. These are generally wheel mounted vertical lift gates. The Cross regulator gates are used in an irrigation channel for the purpose of raising the water level. Usually, vertical lift gates are commonly used, but radial gates are also being adopted.

7. Desilting chamber gates / Silt flushing gates

These gates are located at the exit of desilting chamber of a hydroelectric plant to flush out accumulated silt.

8. Head race tunnel gates

A gate installed at the entrance of head race tunnel of hydroelectric project. It is generally a wheel mounted gate.

9. Surge shaft gates

Surge shaft gate is used for inspection of tunnel / penstock and is located in the vicinity of surge shaft and tunnel junctions.

10. Penstock gates / Intake gates

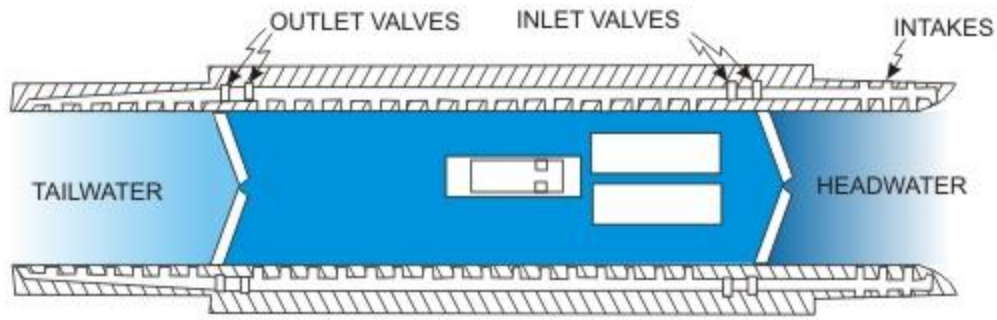
A gate provided at the upstream end of the penstock.

11. Draft tube / Tail race gates

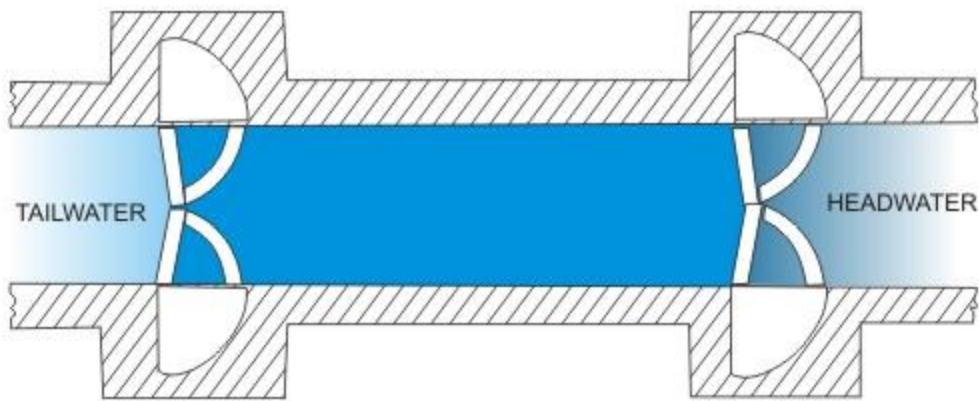
A bulkhead gate used to permit dewatering of the draft tubes for inspection and repair of turbine parts and draft tubes.

12. Navigation lock gates

These are gates provided on navigation locks. Commonly used in India is the Mitre gate, which is a lock gate comprising of two hinged symmetrical leaves which meet at the centre of the lock channel when in the closed position and fit into recesses in the side walls of the channel when open (Figure 23).



(a)



(b)

FIGURE 23. PLAN OF NAVIGATION LOCK

13. Balancing gates

A gate used for the purpose of balancing water levels on either side.

4.10.3 Classification of gates based on other criteria

The Bureau of Indian Standards code IS: 13623-1993 "Criteria for choice of gates and hoists" has recommended certain selection criteria for gates under specific conditions, since this has a great impact on the safety of the structure and effective control of water flow. Further, a designer has to plan a gate and its hoisting arrangement together. Separate planning may sometimes lead to unsatisfactory installation. Though the choice for the gates and hoists depends upon several factors, primarily safety, ease in operation as well as maintenance and economy are the governing requirements. Some of the salient points, taken from IS: 13623 – 1993 are presented below.

Classification based on head over Sill

1. Low head gate: head less than 15 m
2. Medium head gate: head between 15 m and 30 m
3. High head gate: head more than 30 m

Classification based on operational requirements

1. Service gates (main gate): To be used for regulation and routine operation such as main gate for regulation of flow through spillway sluices, outlets, etc.
2. Emergency closure gates: To close the opening in flowing water condition in case of emergency such as emergency penstock gate.
3. Maintenance gate: Bulkhead gate, emergency gate, stop-logs, which are used for maintenance of service gates.
4. Construction gates: Required to shut off the opening during construction or to finally close the opening after construction such as construction sluice gates, diversion tunnel gates, etc.

Classification based on material used in fabrication

1. Steel gates
2. Wooden gates
3. Reinforced concrete gates
4. Aluminium gates
5. Fabric (plastic) gates/Rubber gate
6. Cast iron gates.

Classification based on mode of operation

1. Regulating gates: Operated under partial openings. Generally the main regulating gates are the service gates.
2. Non-regulating gate: Gates not suitable as well as not intended for operation under partial gate openings.

Classification based on shape

1. Hinged gates: Such as radial gates, Sector gates, hinged leaf gates, falling shutters.
2. Translatory gates: Rolling gates such as fixed wheel gate, Stoney gate, slide type gate, etc.

Classification based on discharge through the gate

1. Free discharging gate: Flow past the gate is in open air that is the tail water level is below the sill level of the gate and there is no submergence.

2. Gates for submerged flow: Where the tail water level is above the sill level of the gate such as deep radial gate.

Classification based on location of seal

1. Upstream seal gate,
2. Downstream seal gate, and
3. Seals both upstream and downstream.

Classification based on the location of skin plate

1. Gates with upstream skin plate, and
2. Gates with downstream skin plate.

Classification based on closing characteristics

1. Self closing gates
2. Gate requiring positive thrust for closure

Classification based on drive to operate

1. Manually operated gates
2. Electrically operated gates
3. Semi automatic gates
4. Automatic gates, like:
 - i) Float operated gate,
 - ii) Water powered automatic gates
 - iii) Solar powered gate
 - iv) Computer controlled gates

4.10.4 Design of important gates

The important types of gates used for water resources projects are the following:

1. Fixed wheel type vertical lift gates
2. Radial gates
3. Sliding gates

The following paragraphs mention the salient features of these gates, the detailed design of which are available in the respective Bureau of Indian Standards codes as mentioned.

Fixed wheel type vertical lift gates

The fixed-wheel vertical lift gates comprise of, in general, a structural steel frame consisting of end vertical girders with properly spaced horizontal girders between them. The spacing depends on the design water pressure and on dimensions of the gate. The frame is held a piece by secure welding or riveting. Skin plate protects the structural framework from damage due to ice and heavy debris, minimizes downpull, reduces corrosion and facilitates maintenance. However, in some cases as in the case of fixed wheel gates moving on track provided on the face of the dam, skin plate is provided on the downstream side. In exceptional cases, skin plate is provided on both downstream side and upstream sides, if the down stream water is above sill. In such cases the gates maybe fully or partially buoyant. In case of fully buoyant gates, buoyancy shall be taken into account in determining the net balance of vertical forces and addition of ballast may be necessary to ensure lowering without difficulty. This problem is absent in the case of flooded gates but greater care against corrosion becomes necessary. The wheels are mounted on the end girders. The bottom of gate should be so shaped that satisfactory performance and freedom from harmful vibrations are attained under all conditions of operation apart from minimizing downpull. A typical arrangement of various components of gate is shown in Figure 24. Detailed design of this type of gates has been published by the Bureau of Indian Standards code IS: 4622-2003 "Recommendations for structural design of fixed wheel gates".

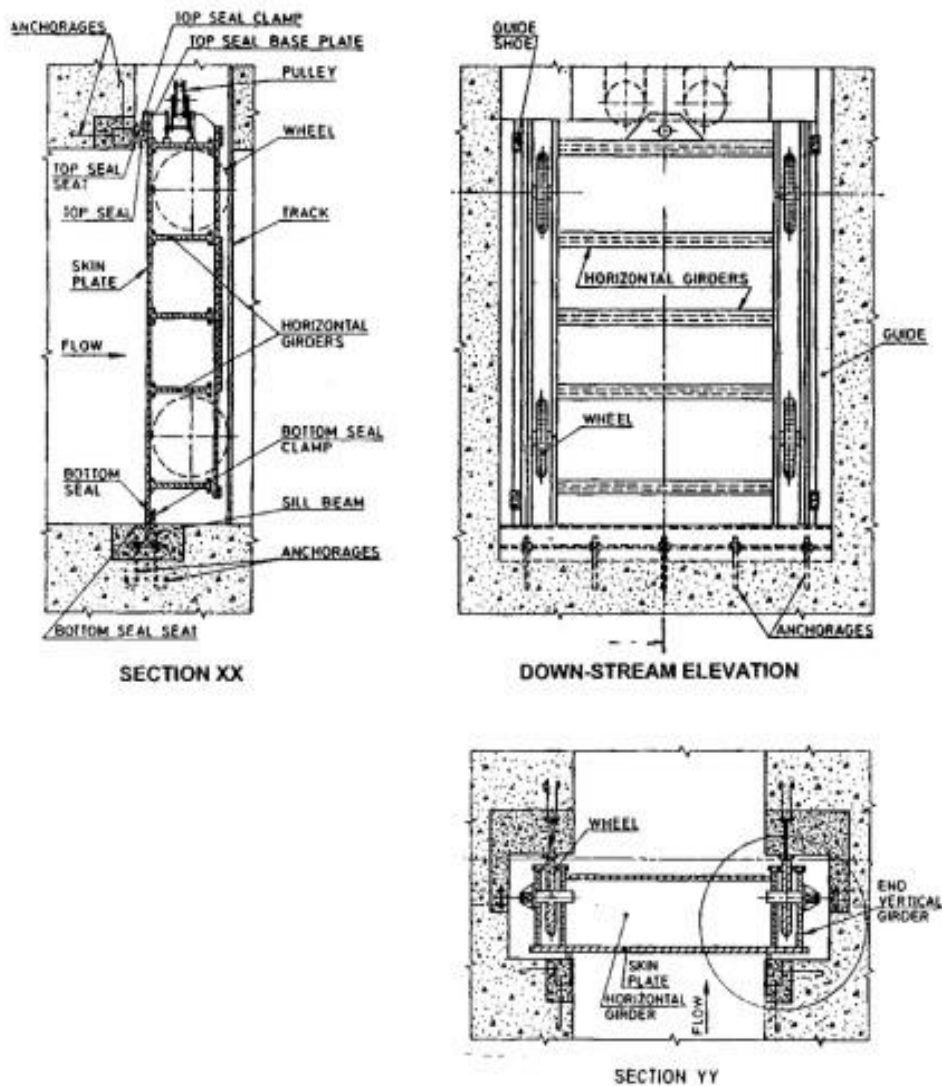


FIGURE 24. VERTICAL LIFT FIXED WHEEL GATE

Radial gates

Normally, the radial gate has an upstream skin plate bent to an arc with convex surface of the arc on the upstream side (Figure 25 and 26). The centre of the arc is at the centre of the trunnion pins, about which the gate rotates. The skin plate is supported by suitably spaced stiffeners either horizontal or vertical or both. If horizontal stiffeners are used, these are supported by suitably spaced vertical diaphragms which are connected together by horizontal girders transferring the load to the two end vertical diaphragms. The end beams are supported by radial arms, emanating from the trunnion hubs located at the axis of the skin plate cylinder. If vertical stiffeners are used, these are supported by suitably spaced horizontal girders which are supported by radial arms. The arms

transmit the water load to the trunnion/yoke girder. Suitable seals are provided along the curved ends of the gate and along the bottom. If used as a regulating gate in tunnels or conduits, a horizontal seal fixed to the civil structure, seals with the top horizontal edge of the gate, in the closed position. The upstream face of the gate rubs against the top seal as the gate is raised or lowered. Guide rollers are also provided to limit the sway of the gate during raising or lowering.

The trunnion anchorage comprises essentially of a trunnion yoke girder, held to the concrete of the spillway piers or the abutments by anchor rods or plate sections designed to resist the total water thrust on the gate. The trunnion or yoke girder is usually a built-up section to which the anchors are fixed.

The thrust may be distributed in the concrete either as bond stresses along the length of the anchors (Figure 27) or as a bearing stress through the medium of an embedded anchor girder at the up stream end of the anchors. In the latter case the anchors are insulated from the surrounding concrete.

Alternatively, anchorages of radial gates could also comprise pre-stressed anchorage arrangement. This system is especially advantageous in the case of large sized gates where very high loads are required to be transferred to the piers and the system of anchorages mentioned above is cumbersome and tedious. In this case pre-stressed anchorages post tensioned steel cables or rods are used which when subjected to water thrust will release pressure from concrete due to higher tensile stresses carried by anchorages.

The Bureau of Indian Standards code IS: 4623-2003 “Recommendations for structural design of radial gates” may be referred to for further details on radial gates design.

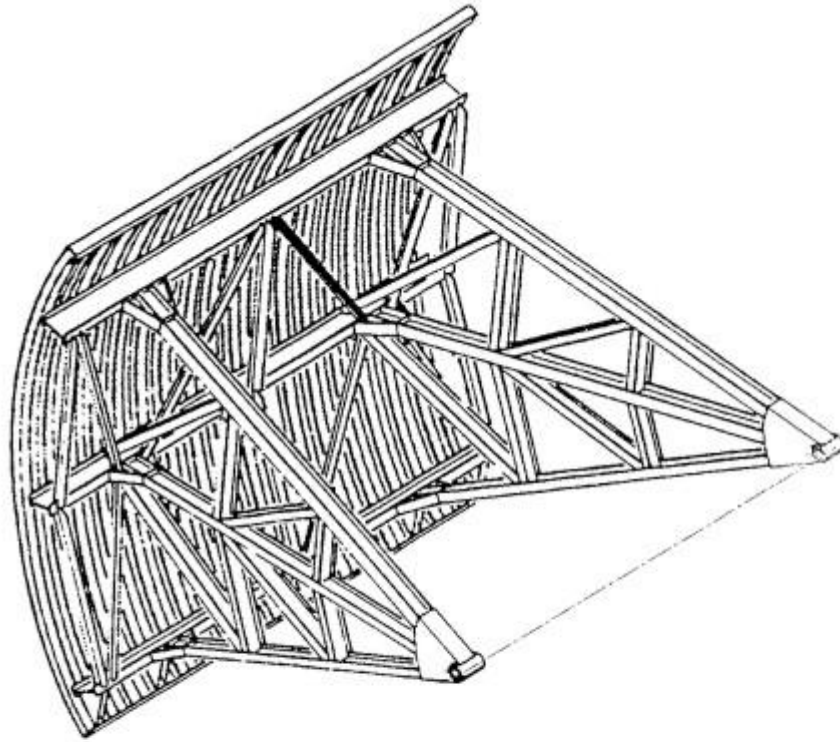


FIGURE 25. DOWNSTREAM VIEW OF A TYPICAL TAITER GATE

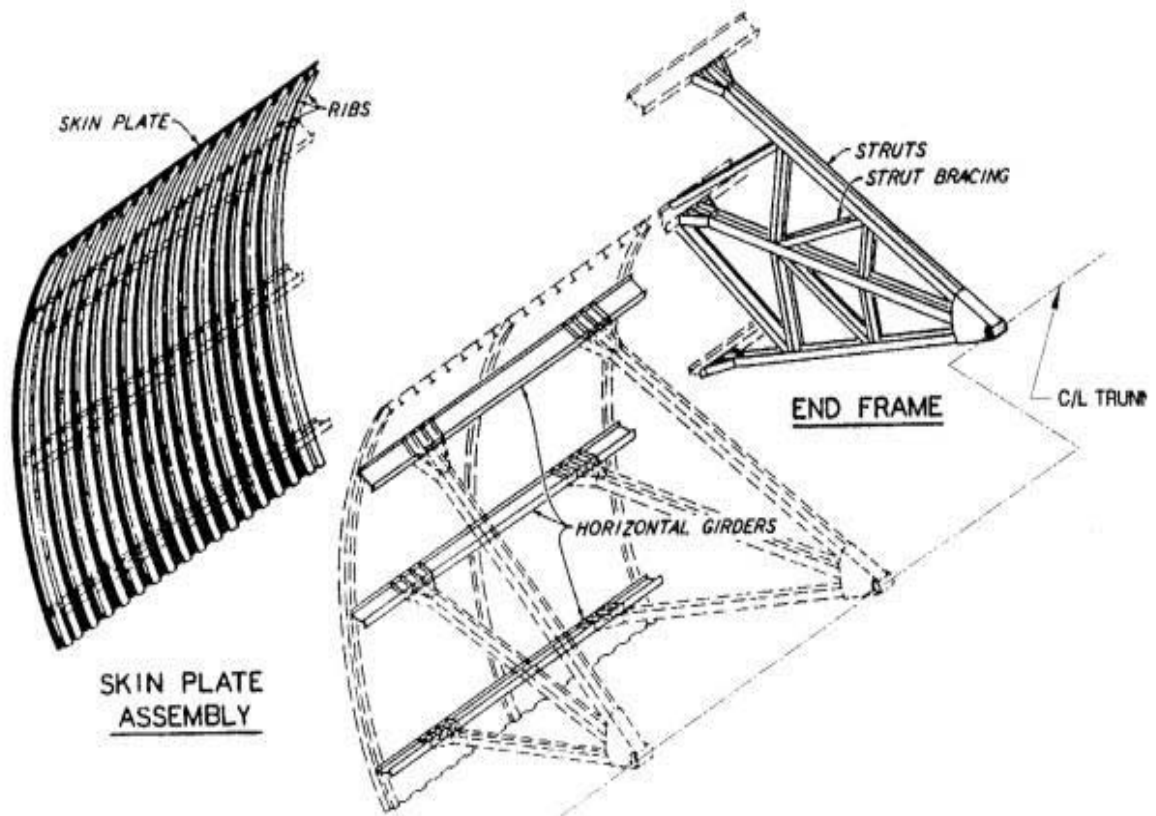


FIGURE 26. PRIMARY Tainter GATE COMPONENTS

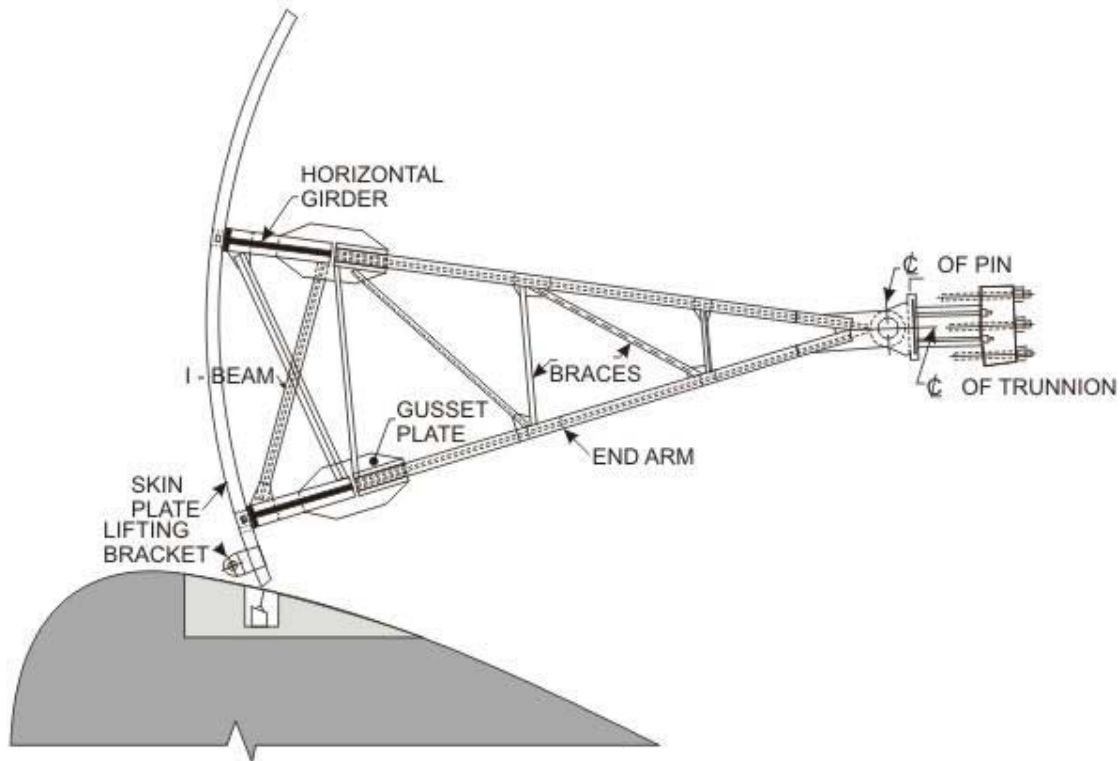


FIGURE 27. SIDE VIEW OF A RADIAL GATE

Sliding gates

Slide gates, as the name implies, are the gates in which the operating member (that is, gate leaf) slides on the sealing surfaces provided on the frame. In most cases, the sealing surfaces are also the load-bearing surface. Slide gates may be with or without top seal depending whether these are used in a close conduit or as crest gate. A typical installation of a slide gate is shown in Figure 14. These consist of a gate leaf and embedded parts. These embedded parts serve the following purposes:

- a) Transmit water load on the gate leaf to the supporting concrete (structure),
- b) Guide the gate leaf during operation, and
- c) Provide sealing surface.

The following Bureau of Indian Standards codes may be referred to while designing slide gates:

IS: 5620-1985 "Recommendations for structural design criteria for low head slide gates".

IS: 9349-1986 "Recommendations for structural design of medium and high head slide gates".

4.10.5 Commonly used hoists for gate operation

The mechanical arrangements used for operating the gates are called Hoists, which are classified as follows:

- **Mechanical hoist:**

1. Rope-drum type like winches, chain-pulley block, monorail crane, gantry crane, etc.
2. Screw operated type
3. Chain and sprocket type

- **Hydraulics hoist**

The Bureau of Indian Standards code IS 6938 – 1989 “Design of rope drum and chain hoists for hydraulic gates – code of practice” lays down the guiding principles for design of rope drum and chain hoists. The general principle of a rope drum and chain hoist for vertical lift gates is shown in Figure 28. The rope drum arrangement for radial gate is shown in Figure 29.

The Bureau of Indian Standards code IS 10210 – 1993 “Criteria for design of hydraulics hoists for gates” provides guidelines for typical hydraulic hoists for gates. A typical arrangement for hydraulic hoist for radial gates is shown in Figure 30 showing the position of the hoist and the gate in open and closed positions.

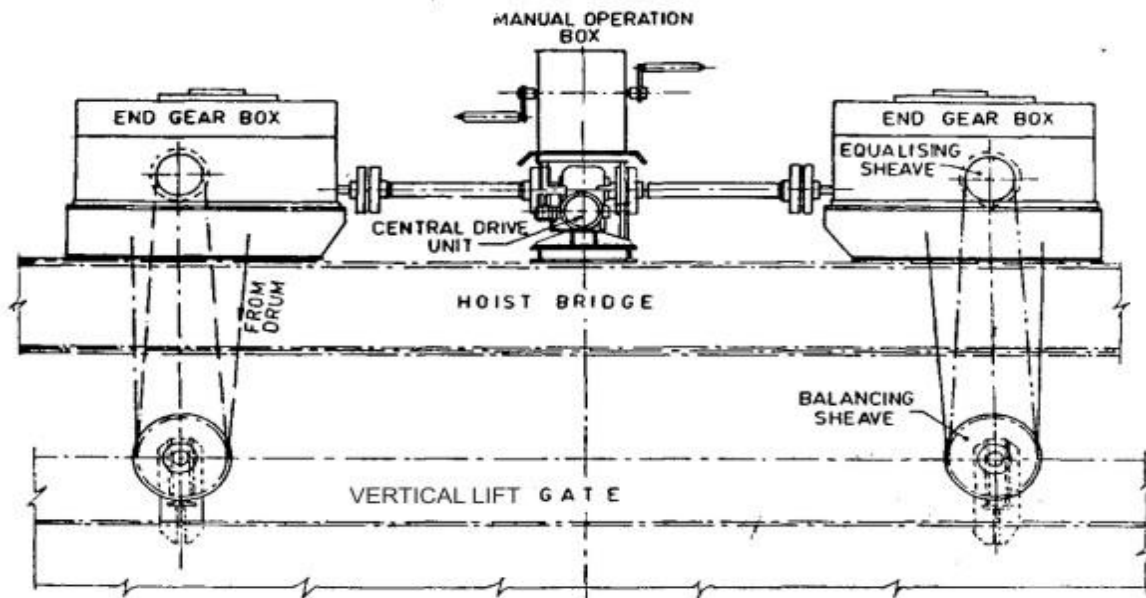


FIGURE 28. ROPE DRUM HOIST ARRANGEMENT FOR VERTICAL LIFT GATE

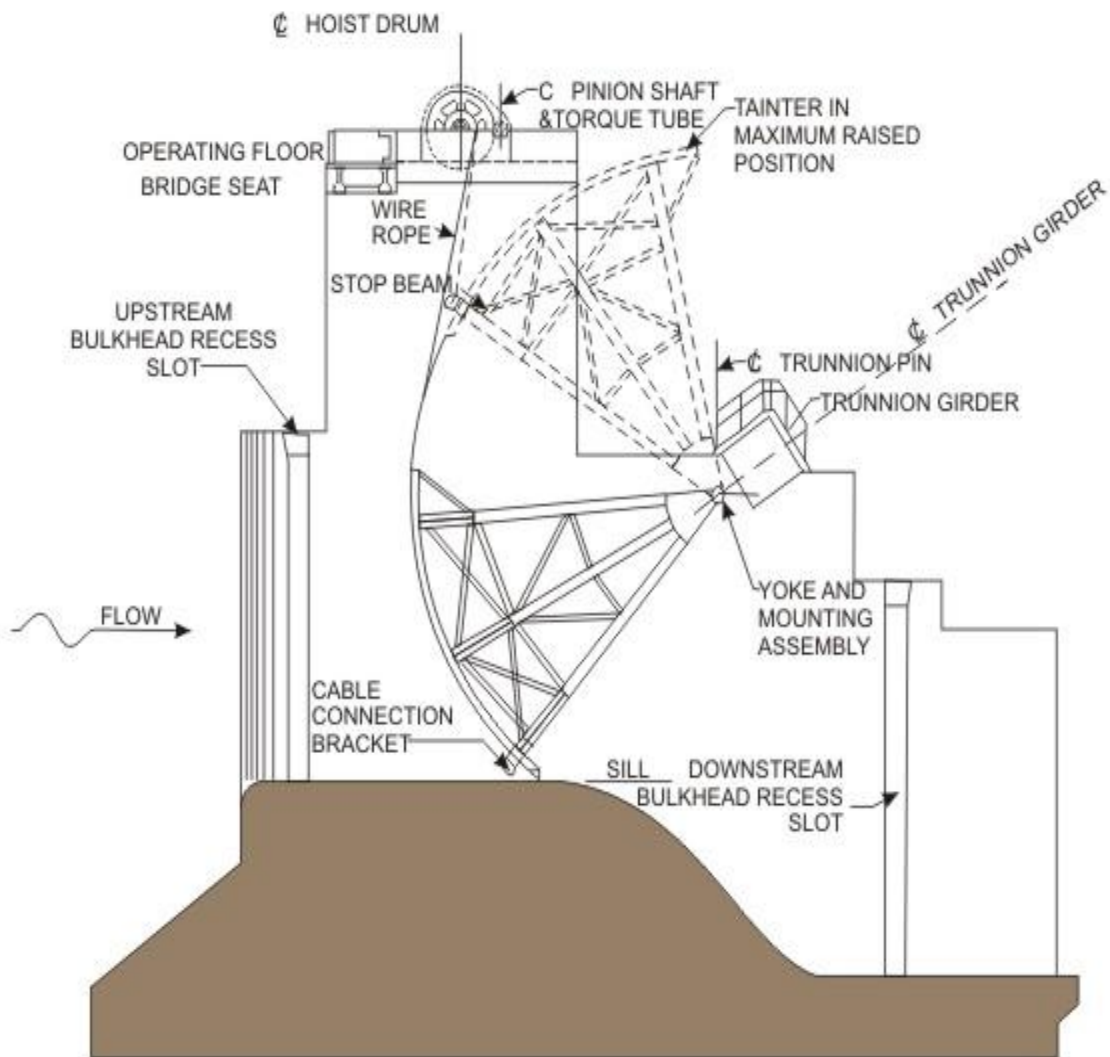


FIGURE 29. WIRE ROPE HOIST SYSTEM FOR RADIAL GATE

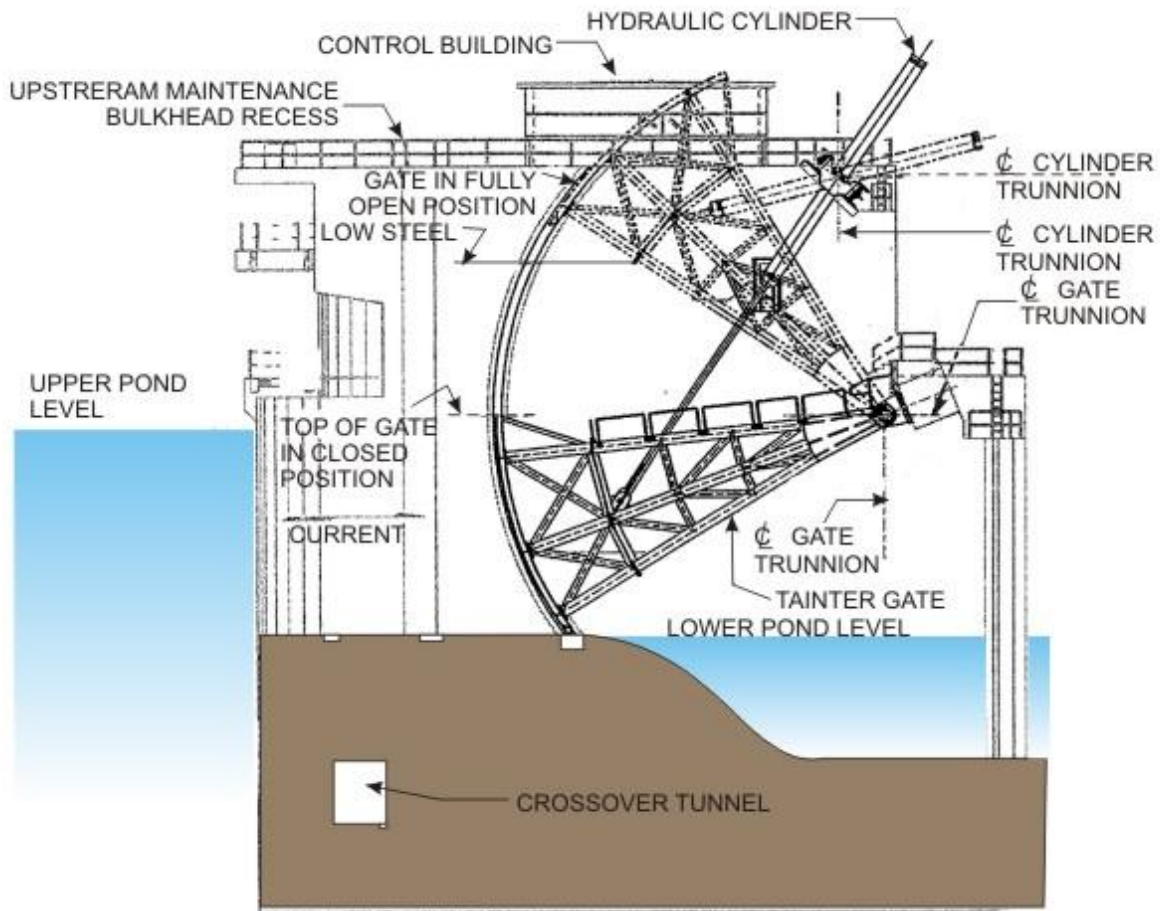


FIGURE 30. HYDRAULIC HOIST OPERATED TANTER GATE

4.10.6 Valves for flow control

Valves are different from gates by their way of operation as they remain in the water passage both in the closed and open positions. This is unlike a gate which, when not controlling the flow, remains in an external position and in most cases out of water. Different types of valves used in water resources engineering are mostly used to control flow in the high pressure conduits like penstocks conveying water to turbines for generation of hydroelectricity. The Bureau of Indian Standards code IS: 4410 (Part 16, Section 2) – 1981 mentions a list of valves in use for various purposes. The valves that are commonly used for water resources projects are mentioned below:

1. Butterfly valve

A valve in which the disk is turned about 90 degrees from the close to the open position, about a spindle supported on the body of the valve on an axis transverse to that of the valve (Figure 31).

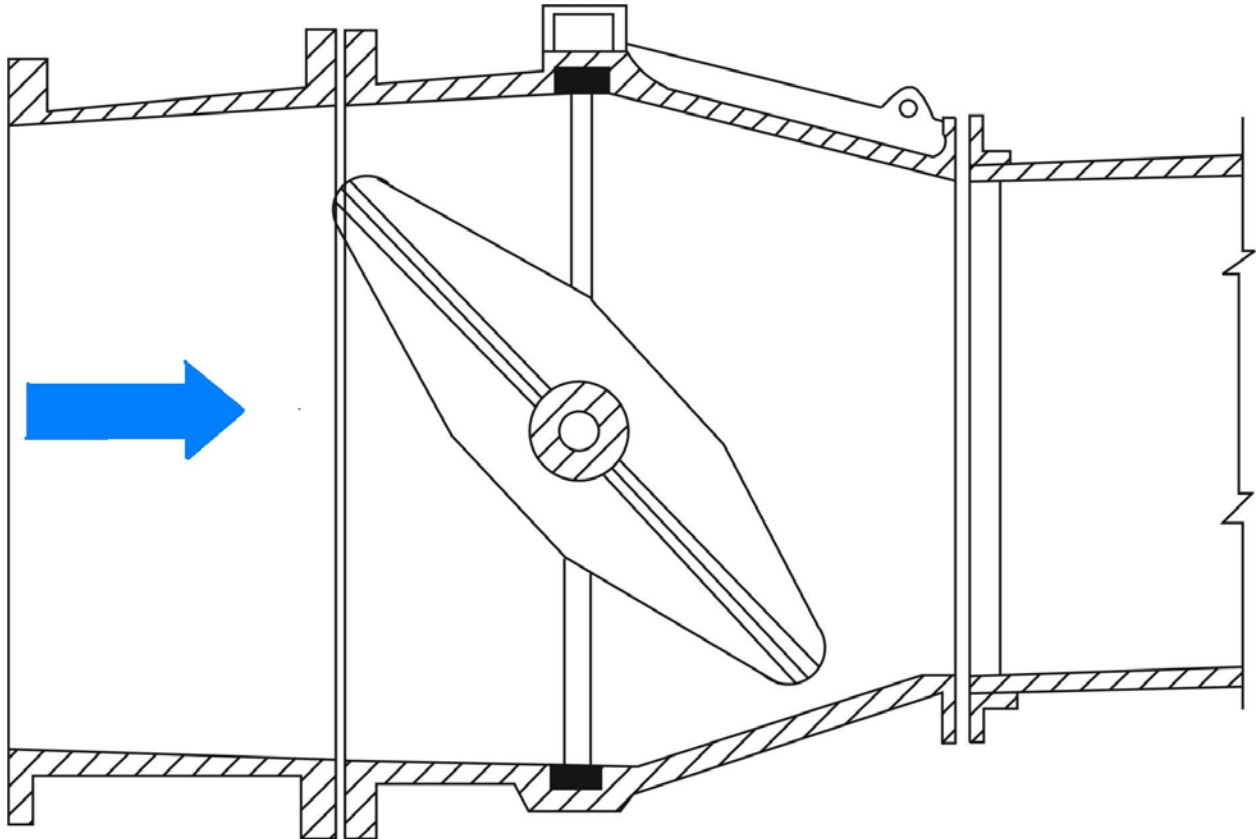


FIGURE 31. BUTTERFLY VALVE

2. Hollow jet valve

A high pressure valve wherein a needle, which, when moved downstream to open the valve, releases water in the form of a hollow jet (Figure 32).

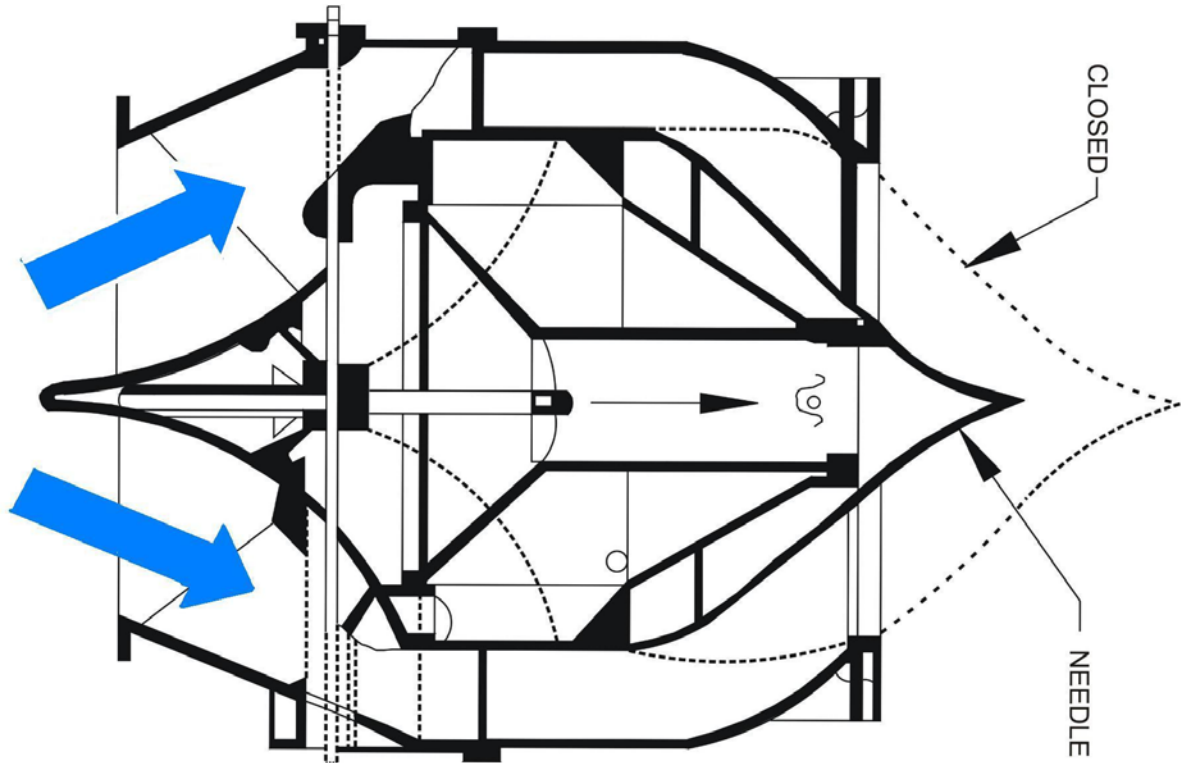


FIGURE32. HOLLOW JET VALVE

3. Howell-Bunger (Cylindrical) valve

A valve having two telescopic cylinders with a streamline dispersing cone secured to the inner cylinder by radial ribs. The outer cylinder closes the sideways opening between the cone and the inner cylinder when it is slid in position. In its open position, the water is discharged on the sides of the cylinder in the form of a highly diverging hollow inside in the shape of a cone (Figure 33).

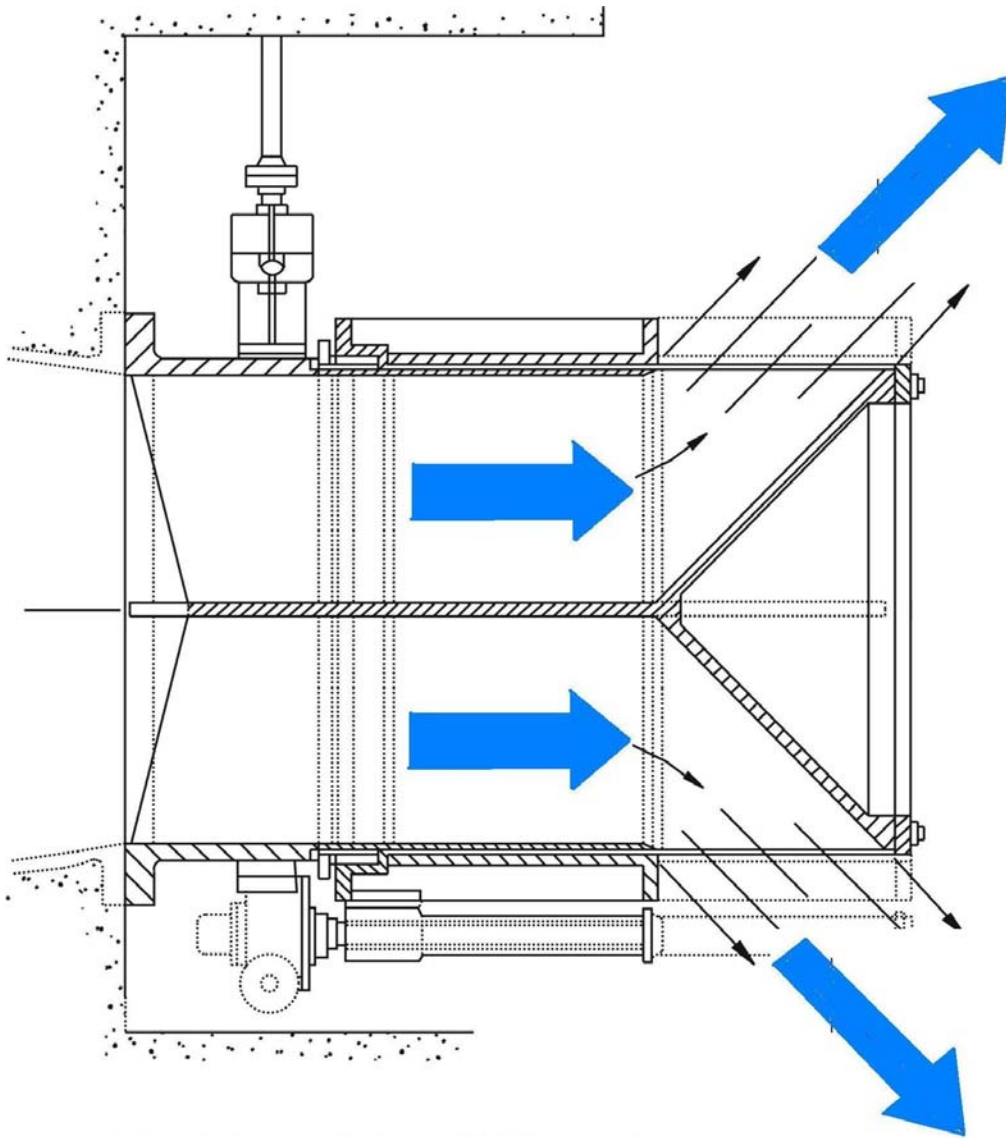


FIGURE33. HOWELL-BUNGER (CYLINDRICAL) VALVE

4. Needle valve

A valve with a circular outlet through which the flow is controlled by means of a tapered needle which extends through the outlet, reducing the area of the outlet as it extrudes, and enlarging the area as it retreats.

Balanced Needle Valve -A needle valve of improved design in which the needle is moved by water pressure from the outlet conduit, which acts on interior chambers in the valve. The movement is controlled by a hand wheel installed above the valve, with the motion transmitted through shafting and gearing to a poke positioning device located inside the valve (see Figure 34).

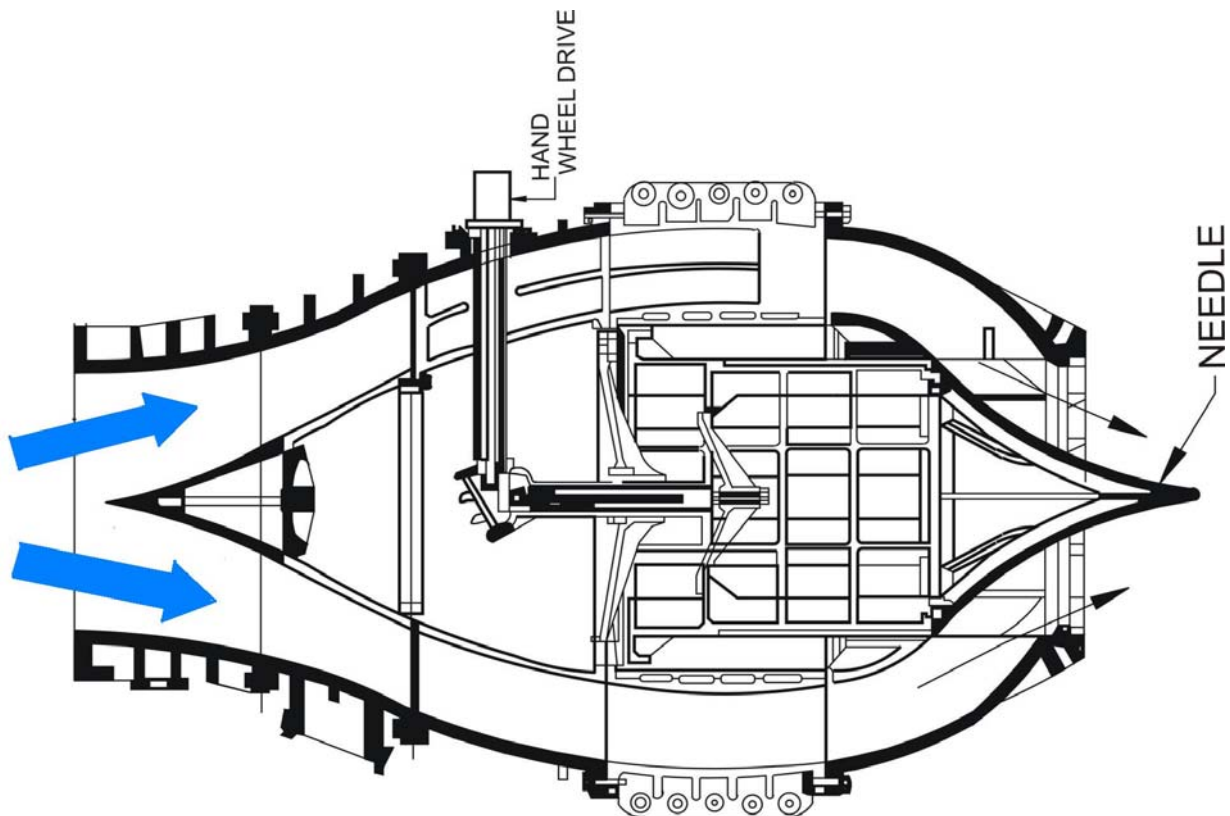


FIGURE34. BALANCED NEEDLE VALVE

Interior Differential Needle Valve- A differential needle valve with a needle that telescopes over a member fixed to the valve body instead of moving within the valve body as in the case of an internal differential needle valve (see Figure 35).

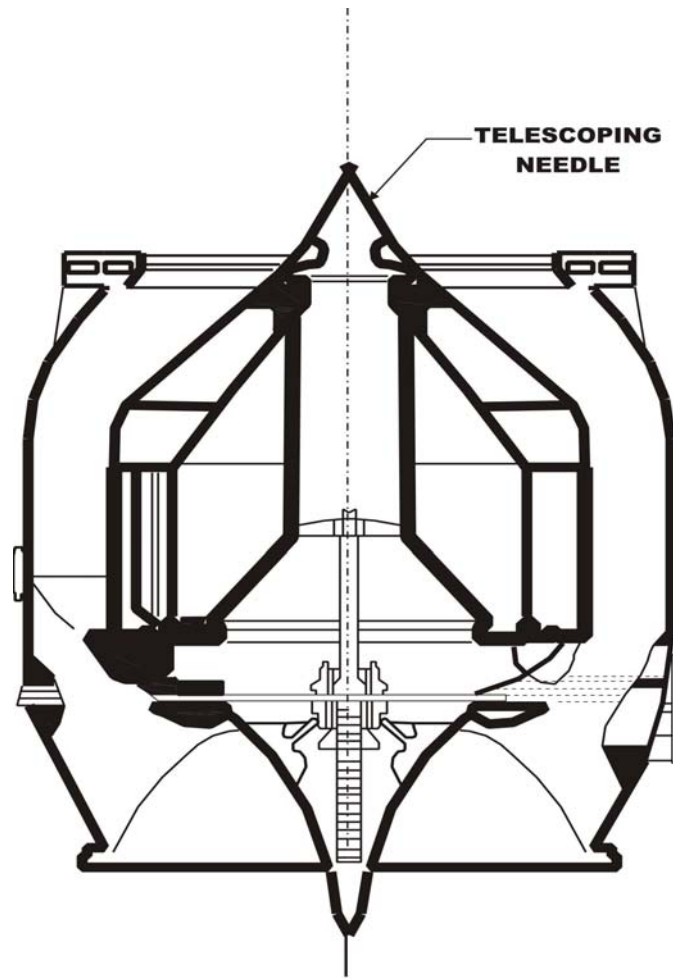


FIGURE 35. Interior differential needle valve

Internal Differential Needle Valve - This is an improved type of balanced needle valve with three chambers in the needle. The two end chambers are connected. The valve is operated by the differential thrust resulting from the changes in pressure in the end chambers with respect to that in the central chamber through a valve paradox (see Figure 36).

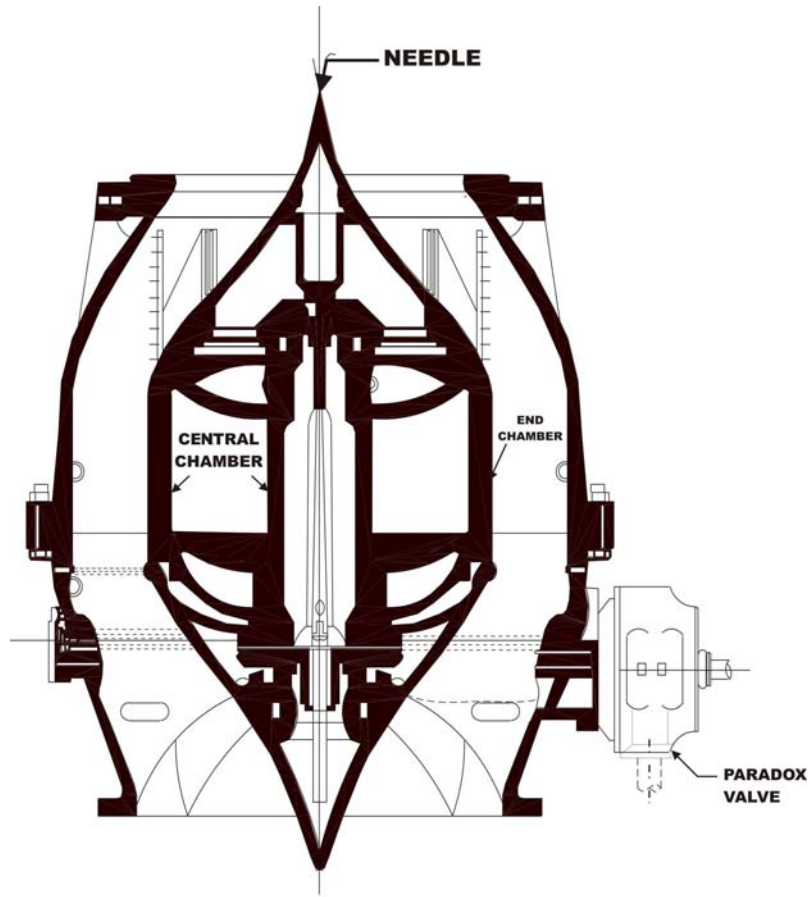


FIGURE 36 Internal differential needle valve

Motor-operated Needle Valve- This is a needle valve in which the position of the needle is controlled by a motor-operated rod (see Figure 37).

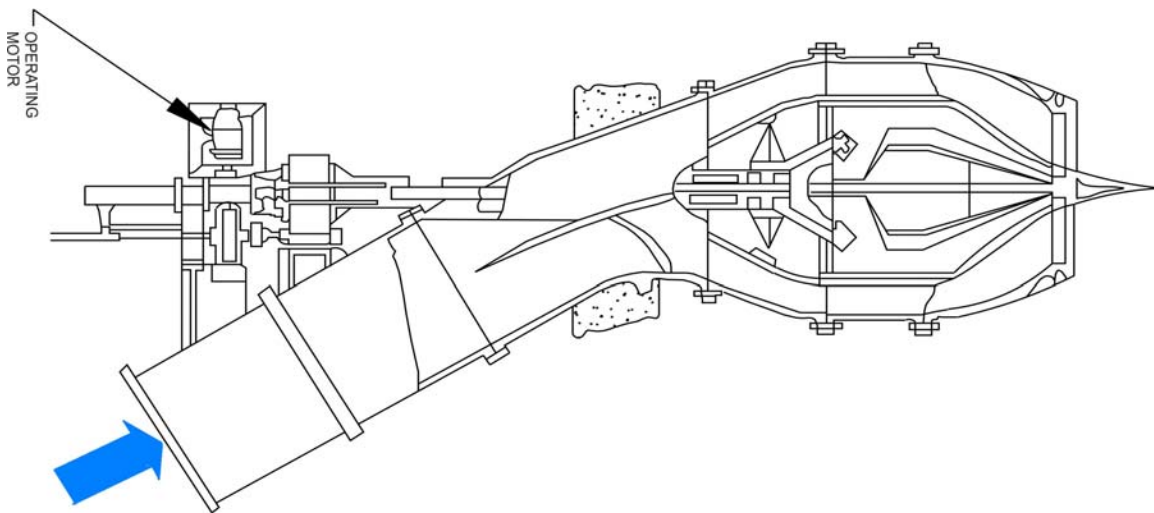


FIGURE 37. MOTOR-OPERATED NEEDLE VALVE

5. **Tube Valve** - An improvement over the needle valve. The water passages are similar to the internal differential valve, except that the downstream end of the needle is omitted. A tube or hollow cylinder similar to that of the cylinder gate, instead of a needle, comprises the moving part of the valve. This is actuated by a hydraulic cylinder and piston and a pressure pump or by a screw with an electric motor or by manual control (see Figure 38).

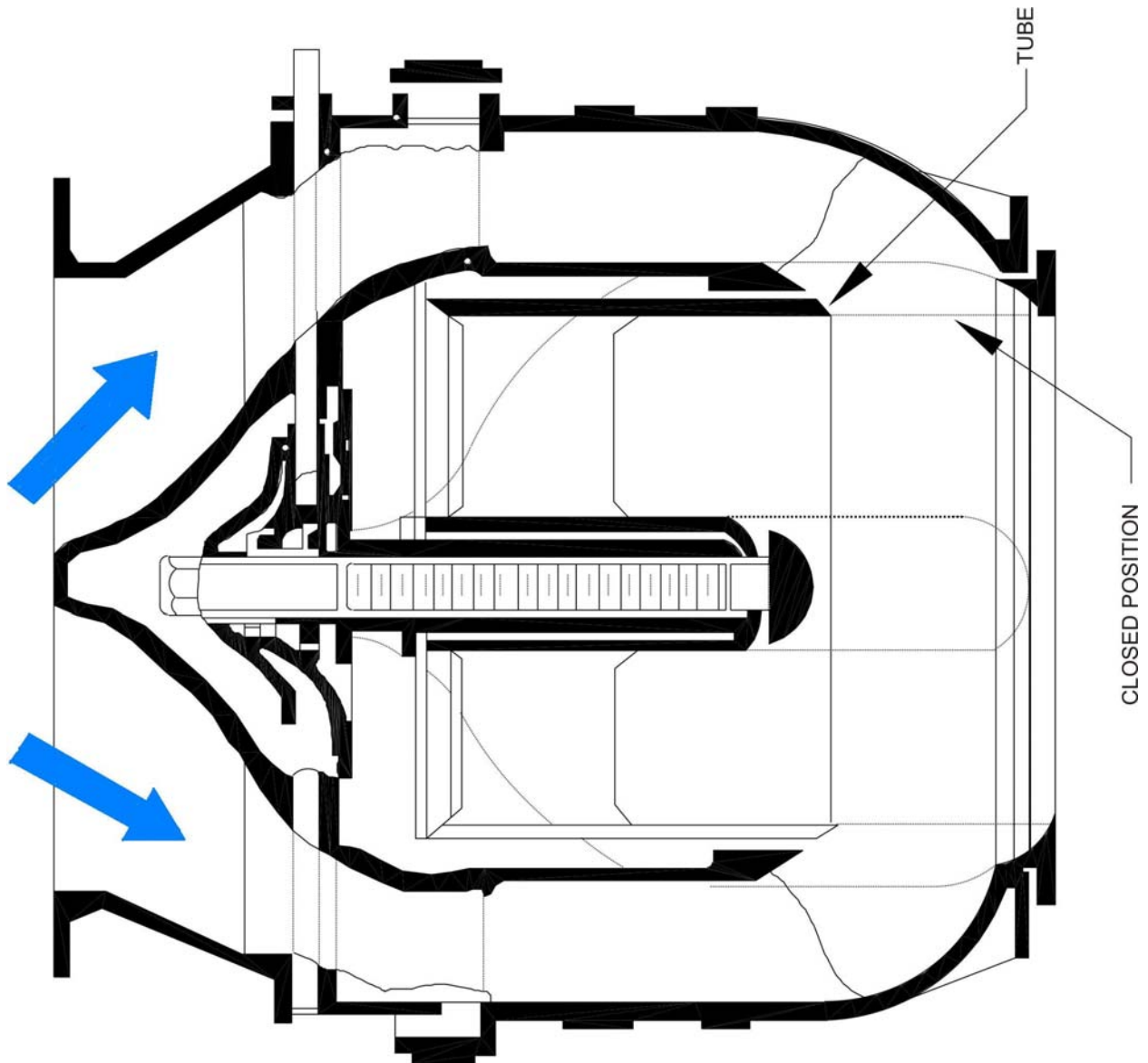


FIGURE 38. TUBE VALVE

6. **Spherical or Rotary Valve** - A valve consisting of a casing more or less spherical in shape, the gate turning on trunnions through 90 degrees when opening or closing, and having a cylindrical opening of the same diameter as that of the pipe it serves (see Figure 39).

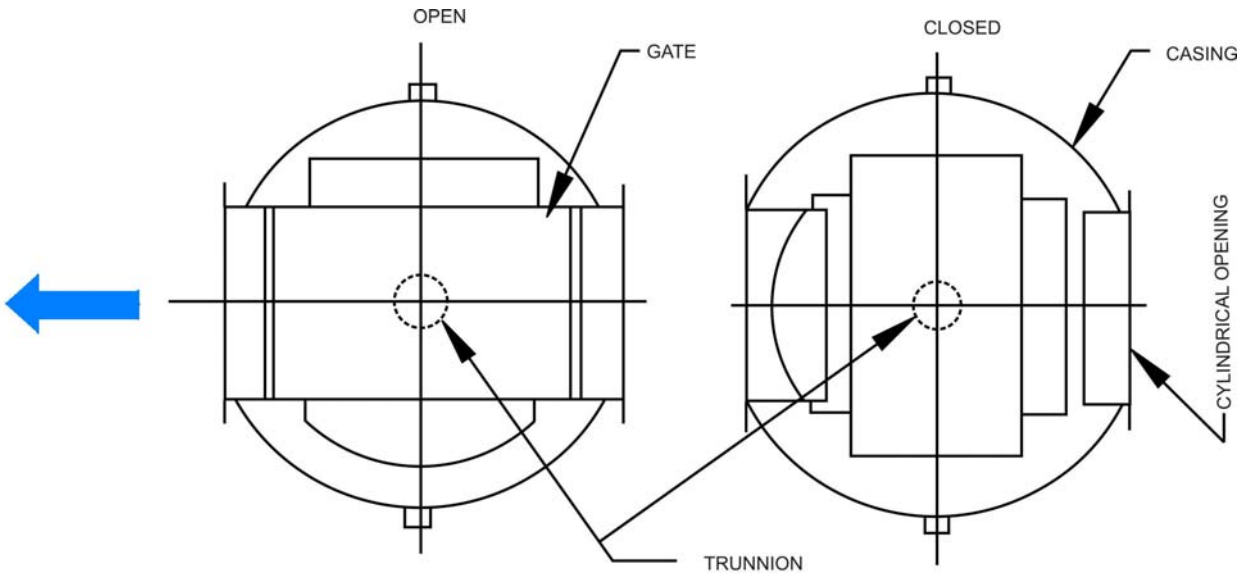


FIGURE 39. SPHERICAL (ROTARY) VALVE