Drilling Rig Systems, Components and their Functions (1)

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Previous Lecture

- Companies
- Contracts
- Personnel
- Work shifts

Lecture Learning Outcomes

By the end of this lecture, you will be able to:

- List the main rig components and understand their functions.
- Define the 5 main rig systems and their role within the drilling process with Listing their individual components.
- Comprehend the composition of drilling string, Define its components and Differentiate between their roles.

Content

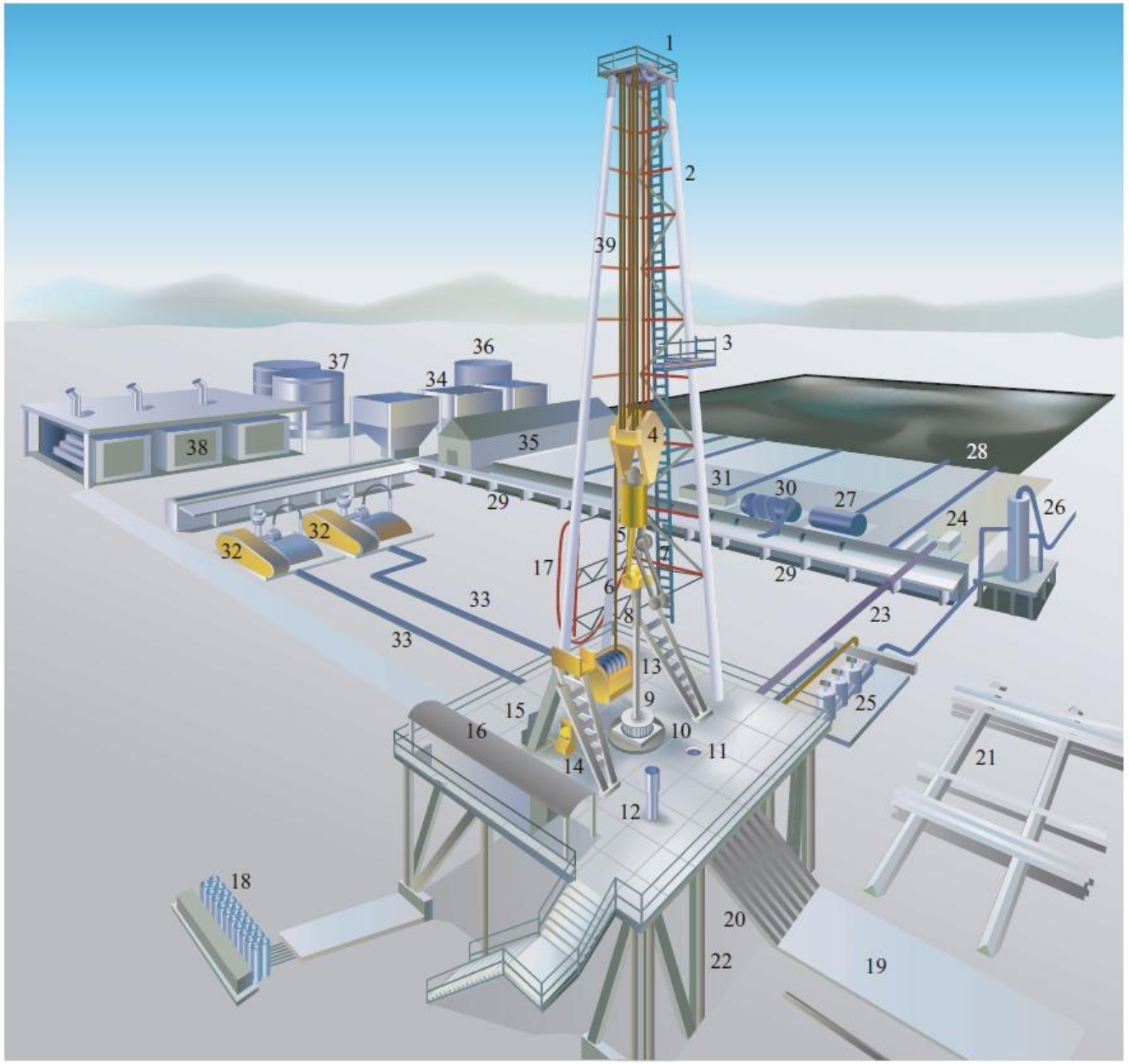
- Rotary Drilling Rig Systems.
  - Hoisting
  - Rotary System
- Rotary Drilling Rig Components.
- Functions of Rotary Rig Components.

Rig Components

- There are many individual pieces of equipment on a rotary drilling rig.
- The most important items of equipment are shown in figures in the next slides.
- Although the pieces of equipment associated with these systems will vary in design, these systems will be found on all drilling rigs.
- The equipment discussed in this chapter will be found on both land-based and offshore drilling rigs.

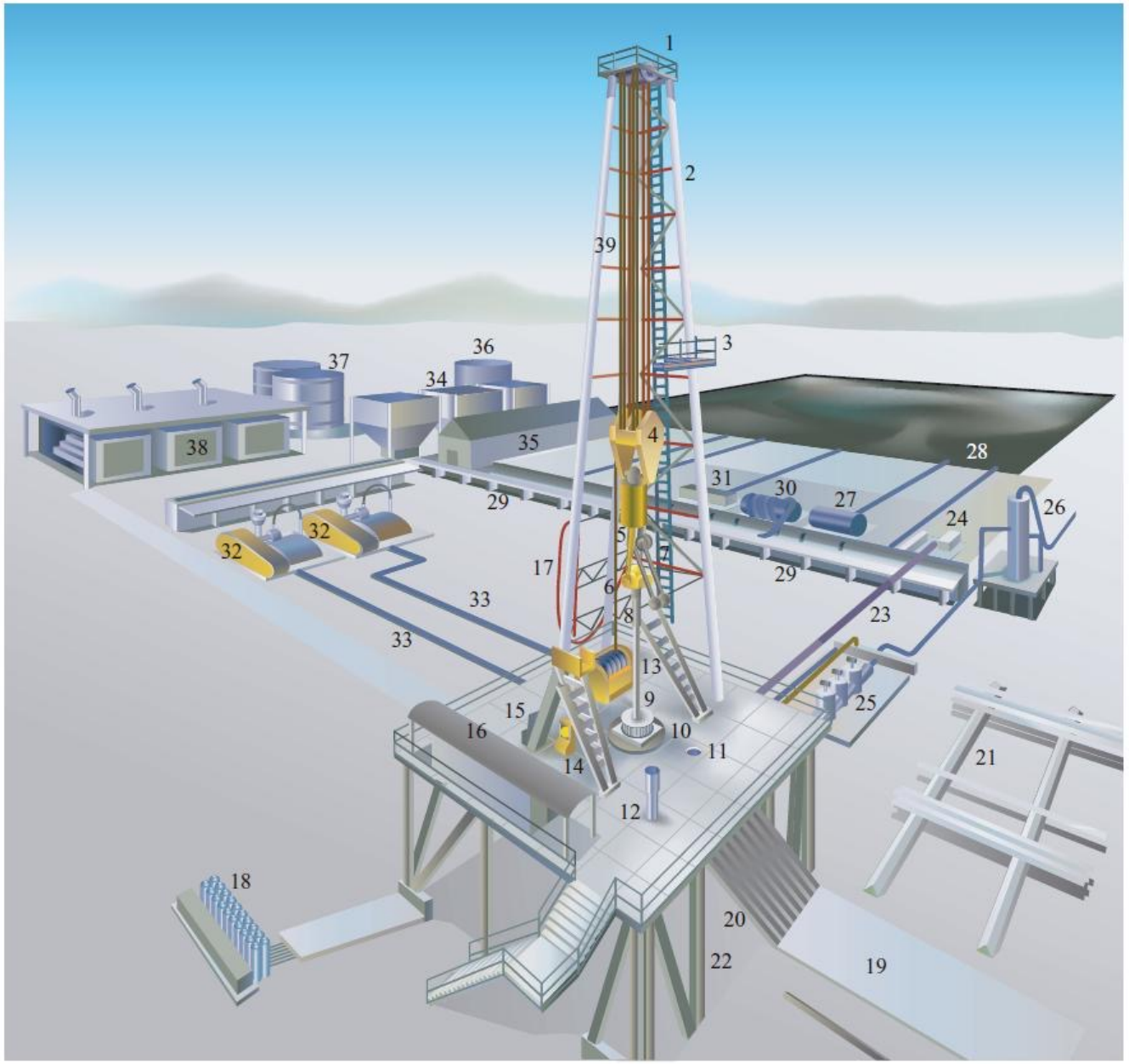
Rig Components

1.Crown Block
2.Mast
3.Monkey Board
4.Traveling Block
5.Hook
6.Swivel
7.Elevator
8.Kelly
9.Kelly Bushing
10. Master Bushing
11. Mouse Hole
12. Rat Hole
13. Drawworks
14. Weight Indicator



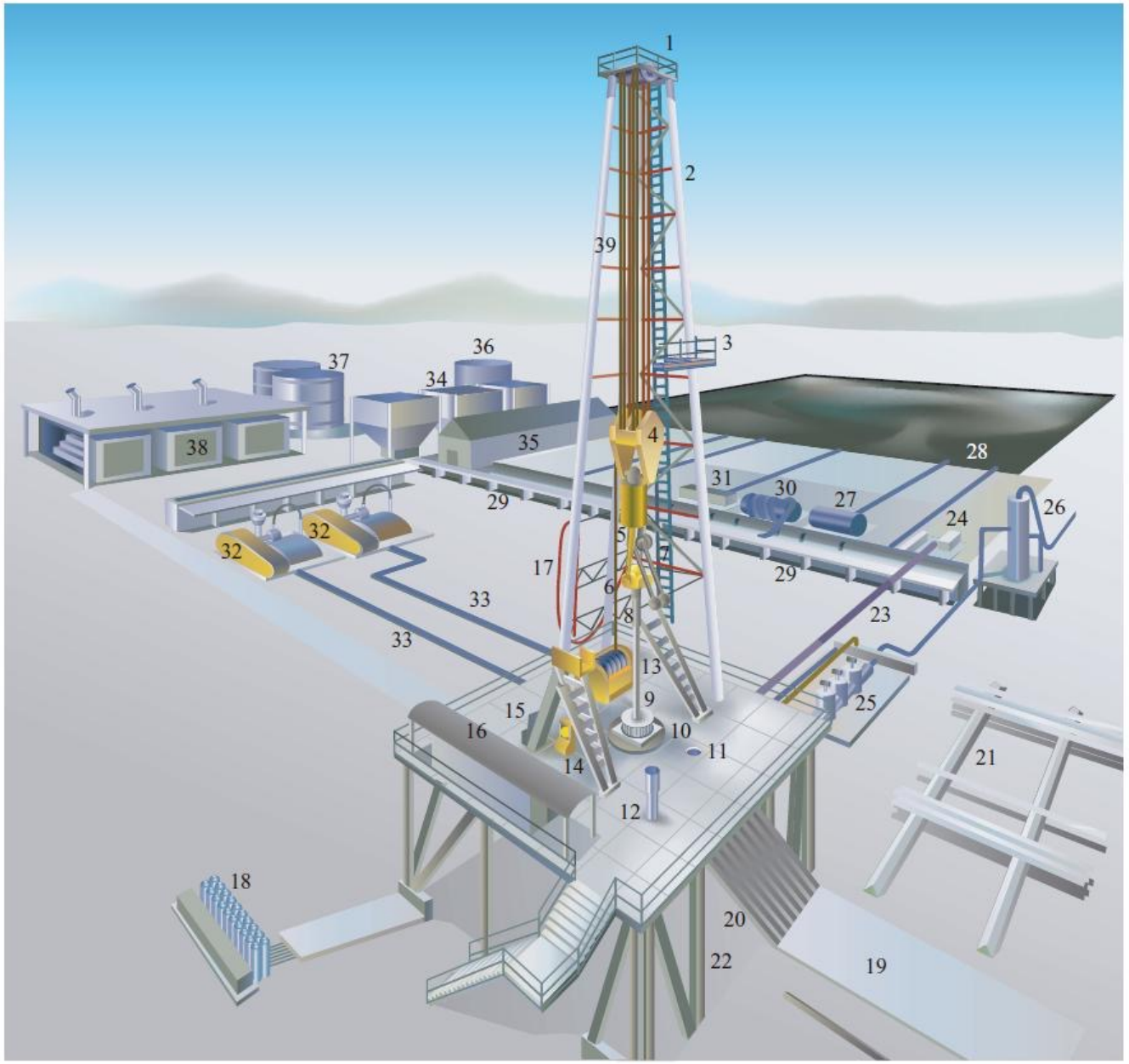
Rig Components

15. Driller's Console
16. Dog House
17. Rotary Hose
18. Accumulator Unit
19. Catwalk
20. Pipe Ramp
21. Pipe Rack
22. Substructure
23. Mud Return Line
24. Shale Shaker
25. Choke manifold
26. Mud Gas Separator
27. Degasser
28. Reserve Pit



Rig Components

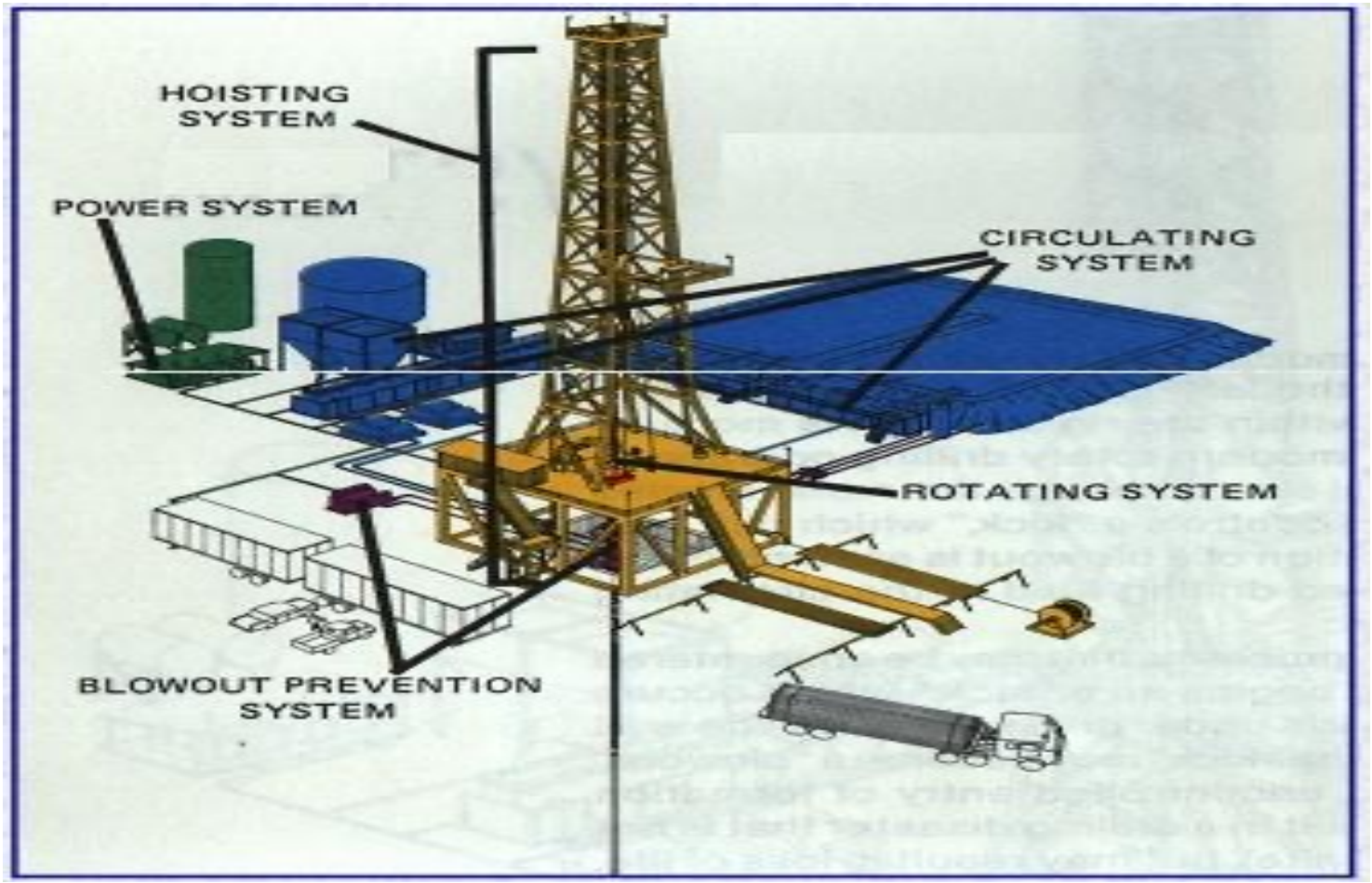
29. Mud Pit
30. Desander
31. De-Silter
32. Mud Pump
33. Mud Discharge line
34. Bulk Mud Component Storage
35. Mud House
36. Water Tanks
37. Fuel Storage
38. Engines & Generators
39. Drilling Lines



Ris Systems

- These individual pieces of equipment can however be grouped together into five subsystems.
- These systems are:

1. The hoisting system,
2. The circulation system,
3. The rotary system,
4. The power system
5. and the blowout prevention system.

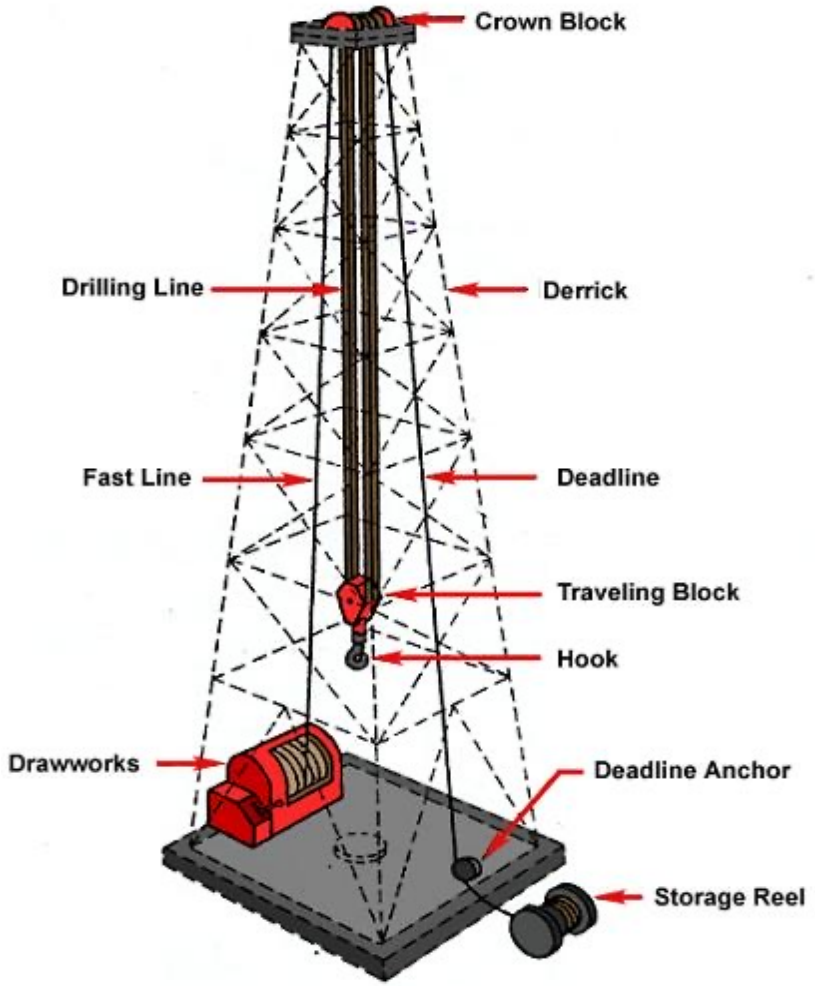


Hoisting System

- The hoisting system is a large pulley system which is used to lower and raise equipment into and out of the well.

- The main components of hoisting system are:

➢Derrick or mast
➢Drawworks
➢Crown block
➢Traveling block
➢Hook
➢Drilling lines
➢Fast line
➢Deadline
➢Deadline anchor
➢Storage reel
➢Drum
➢Drum brake



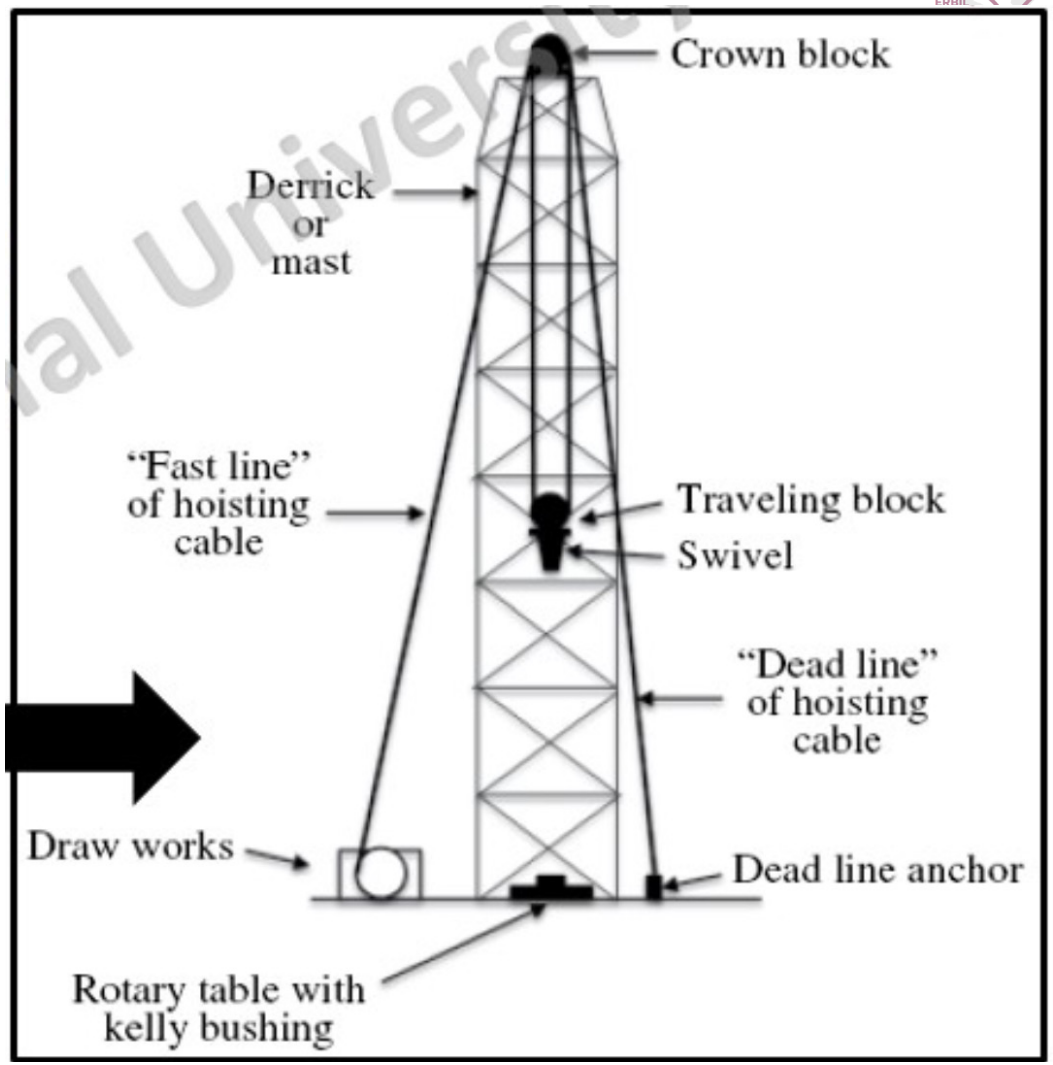
Hoisting System

1. Derrick or Mast

- Derrick is a large load-bearing structure, usually of bolted construction.
- The function of a derrick is to provide the vertical clearance necessary for raising and lowering the drill string into and out of the hole during drilling operations. It must be of sufficient height and strength to perform these duties in a safe and expedient manner.
- In drilling, the standard derrick has four legs standing at the corners of the substructure and reaching to the crown block.
- The substructure is an assembly of heavy beams used to elevate the derrick and provide space to install blowout preventers, casing heads, and so forth.
- Mast is a portable derrick that is capable of being raised as a unit, as distinguished from a standard derrick, which cannot be raised to a working position as a unit.
- For transporting by land, the mast can be divided into two or more sections to avoid excessive length extending from truck beds on the highway.

Hoisting System

- The derrick and its substructure support the weight of the drillstem at all times, whenever it is suspended from the crown block or resting in the rotary table.
- The height of the derrick does not affect its load bearing capacity, but it is a factor in the length of the sections of drillpipe that can be handled.
- The taller the derrick, the longer the section of pipe that can be handled when going in or pulling out of the hole.
- This can allow for the adding of two or three joints of pipe at the same time (called doubles and triples), which reduces down-time during the drilling process.



Hoisting System

2. Drawworks

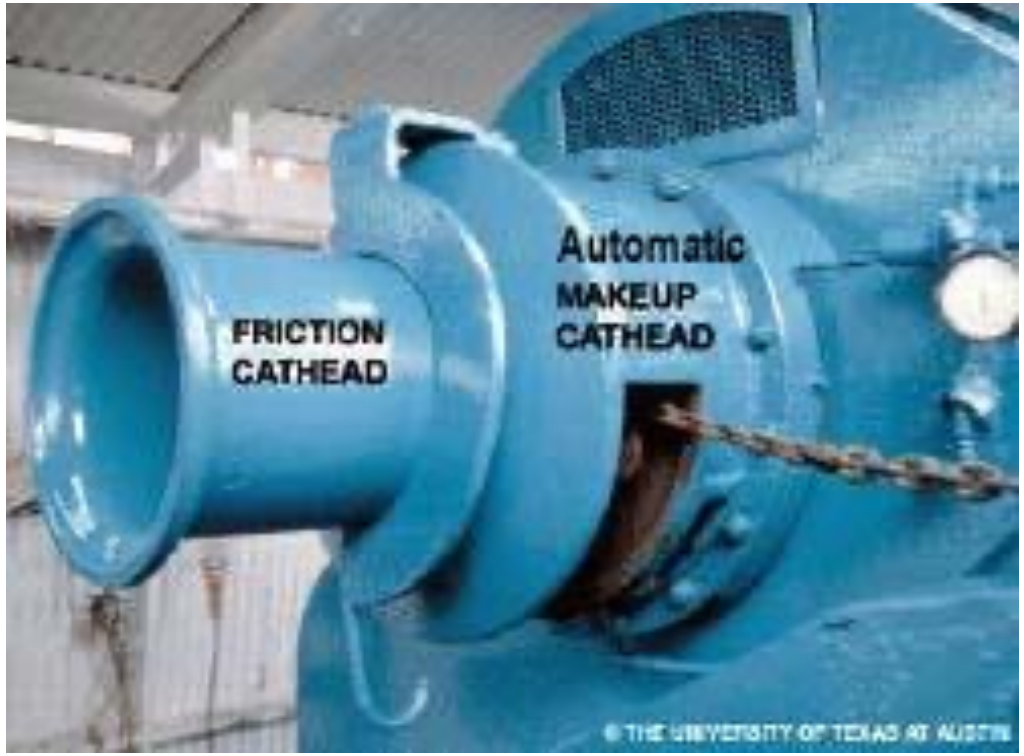
- This is an assembly of a rotating drum, a series of shafts, clutches, chains and gears for changing speed and for reversing.
- The main purpose of the drawworks is to reel out and reel in the drilling line.

Hoisting System

- One outstanding feature of the drawworks is the brake system, which enables the driller to easily control a load of thousands of pounds of drillpipe or casing.
- On most rigs, there are at least two brake systems.
- One brake is a mechanical friction device and can bring the load to a complete stop.
- The other brake is hydraulic or electric; it can control the speed of the descent of a loaded traveling block, but is not capable of bringing it to a complete stop.
- An integral part of the drawworks is the gear system. This gives the driller a wide choice of speeds for hoisting the drillstring.

Hoisting System

- Another feature of the drawworks are the two catheads.
- The make-up cathead, on the drillers side, is used to spin up and tighten the drillpipe joints.
- The other, located opposite the driller's position on the drawworks is the breakout cathead. It is used to loosen the drillpipe when the drillpipe is withdrawn from the borehole.



Hoisting System

3. Crown block

- A block located at the top of the derrick. It contains a number of sheaves on which the drilling line is wound.
- The crown block provides a means of taking the drilling line from the hoisting drum to the travelling block.

Hoisting System

4. Traveling block

- A block containing a number of sheaves which is always less than those in the crown block.
- The drilling line is wound continuously on the crown and travelling blocks, with the two outside ends being wound on the hoisting drum and attached to the deadline anchor respectively.

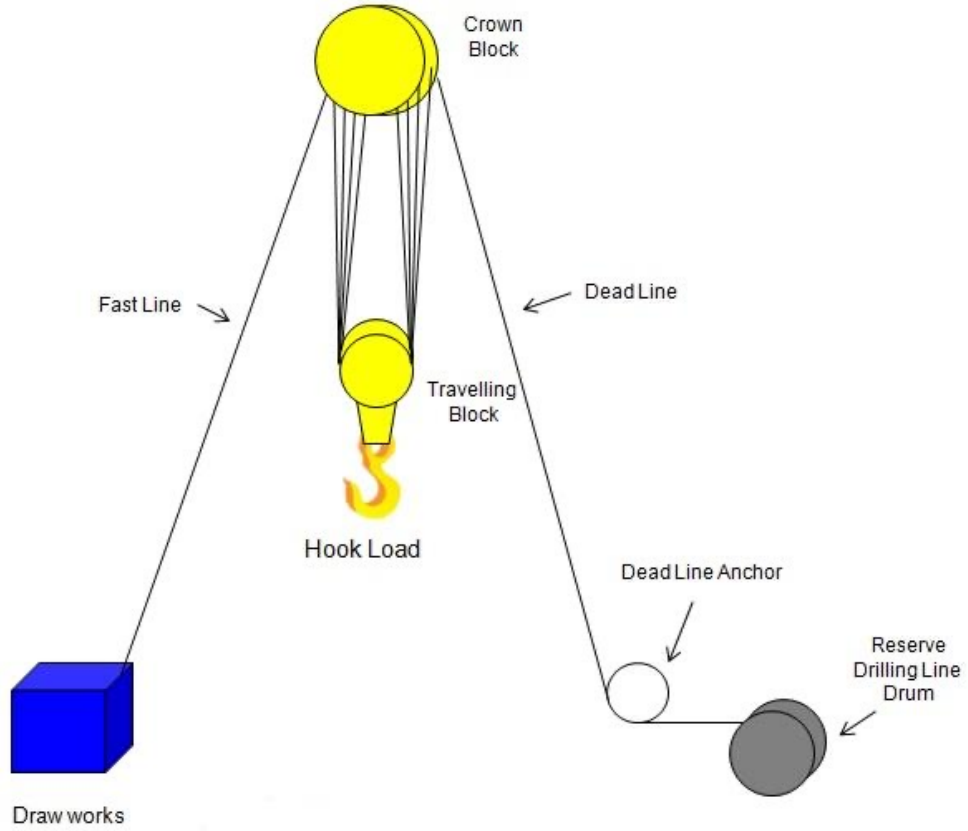
5. Hook

- The high-capacity J-shaped equipment used to hang various other equipment, particularly the swivel and Kelly.
- The hook is attached to the bottom of the traveling block and provides a way to pick up heavy loads

Hoisting System

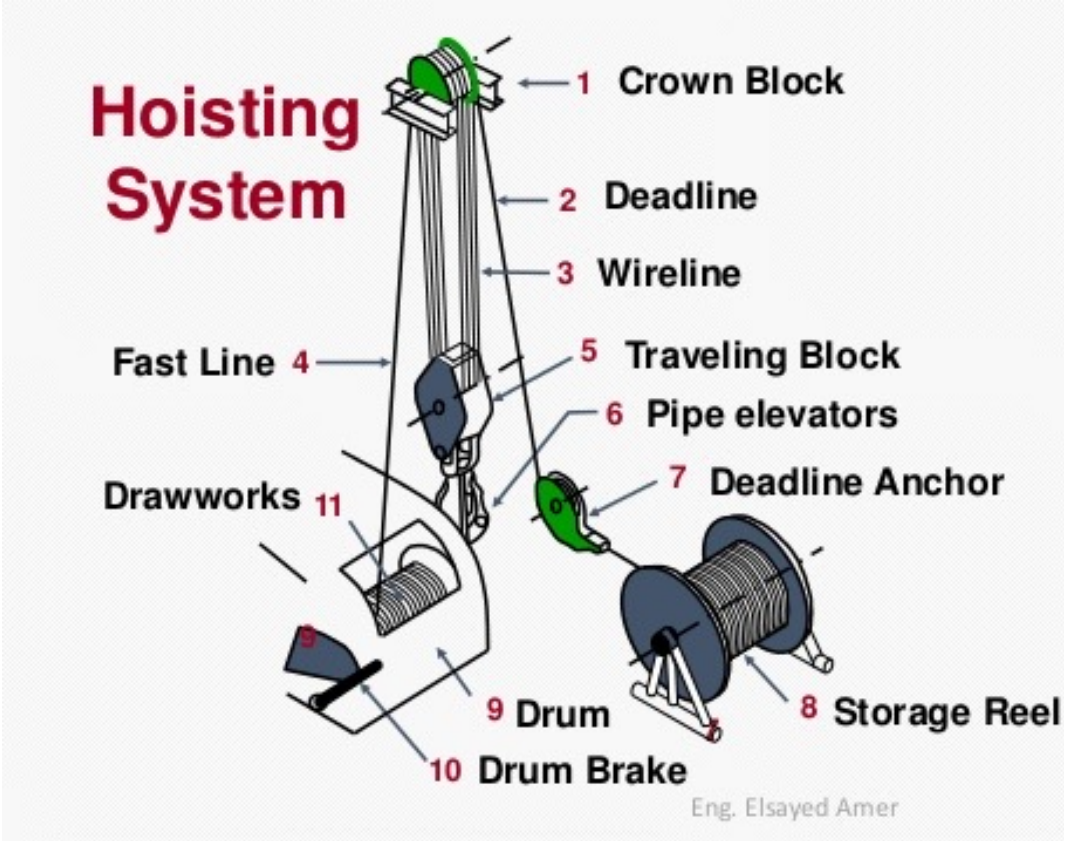
6. Drilling lines

- Drilling line is a very strong wire rope runs from 1⁄2 to 2 inches in diameter and is made out of steel wires.
- It looks very much like what the rest of the world calls "cable" but is designed especially for the heavy loads encountered on the rig.
- The line comes off a large reel (a supply reel).
- From the supply reel, it goes to a strong clamp called the "deadline anchor".
- From the deadline anchor, the drilling line runs up to the crown block.



Hoisting System

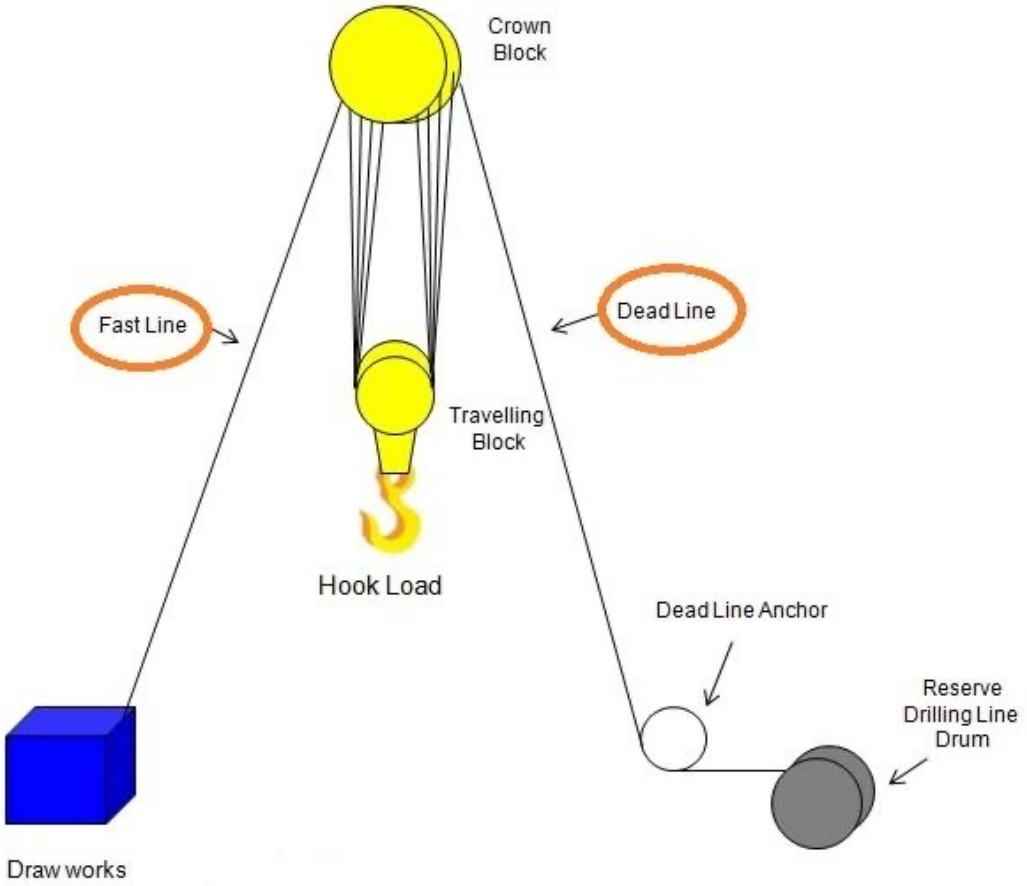
- The drilling line is threaded several times between the crown block and traveling block.
- The heavier the anticipated loads on the traveling block, the more times the line is threaded between the crown and traveling block.
- For example, only eight might be used for lighter loads. For heavier loads, twelve or more could be strung.
- Once the last line has been strung over the crown block sheaves, the end of the line goes down to the drawworks drum, where it is firmly clamped.
- The driller then takes several wraps of line around the drum.



Hoisting System

- The part of the drilling line running from the drawworks to the crown block is called fast line because it moves as the driller raises or lowers the traveling block greater velocity than any other portion of the line.

- The end of the line that runs from the crown block to the deadline anchor is called deadline because it does not move.



Hoisting System

7. Deadline Anchor
- A device to which the deadline is attached, securely fastened to the mast or derrick substructure.

8. Storage (Supply) Reel
- A device to which the deadline is attached, securely fastened to the mast or derrick substructure.

Hoisting System

Static Derrick Loading

Static derrick loading = Fast line load + Hook load + Deadline load

$$SDL = F_f + F_h + F_d$$

- Assume that the system consists of four line supporting the hook load . Then under static conditions:

$$F_f = \frac{F_h}{4} \qquad F_d = \frac{F_h}{4}$$

$$\therefore SDL = \frac{F_h}{4} + F_h + \frac{F_h}{4} = \frac{3}{2} F_h$$

- For N lines, the static derrick load is given by:

$$SDL = \frac{N+2}{N} F_h$$

Hoisting System

Example:

The total weight of 9,000 ft of 9 5/8-inch casing for a deep well is determined to be 400,000 lbs. Since this will be the heaviest casing string run, the maximum mast load must be calculated. Assuming that 10 lines run between the crown and the traveling blocks and neglecting buoyancy effects, calculate the maximum load (at static conditions).

Solution:

$$SDL = \frac{N+2}{N} F_h$$

$$SDL = \frac{10+2}{10} 400000 = 480000\ Ibs$$

Notes:

- The marginal decrease in mast load decreases with additional lines.
- The total derrick load is always greater than the load being lifted.

Rotary System

Rotating System

- The rotary system is used to rotate the drillstring, and therefore the drill bit, on the bottom of the borehole.

Generally, rigs can rotate the bit in one of three ways:

A. The traditional way, the method that still dominates drilling, especially on land sites, uses a rotary table and Kelly.
B. A second way uses a top drive system, which drilling contractors began to employ widely in the 1980s.
C. A third way uses a downhole motor, which contractors use in special cases.

Rotary System

A. Traditional Components

- Today, many contractors, especially those offshore, employ top drives on their rigs.
- However, many rigs still use the rotary table system to rotate the drill string and bit.
- The main components of rotary table system are:

➢Rotary table with turntable

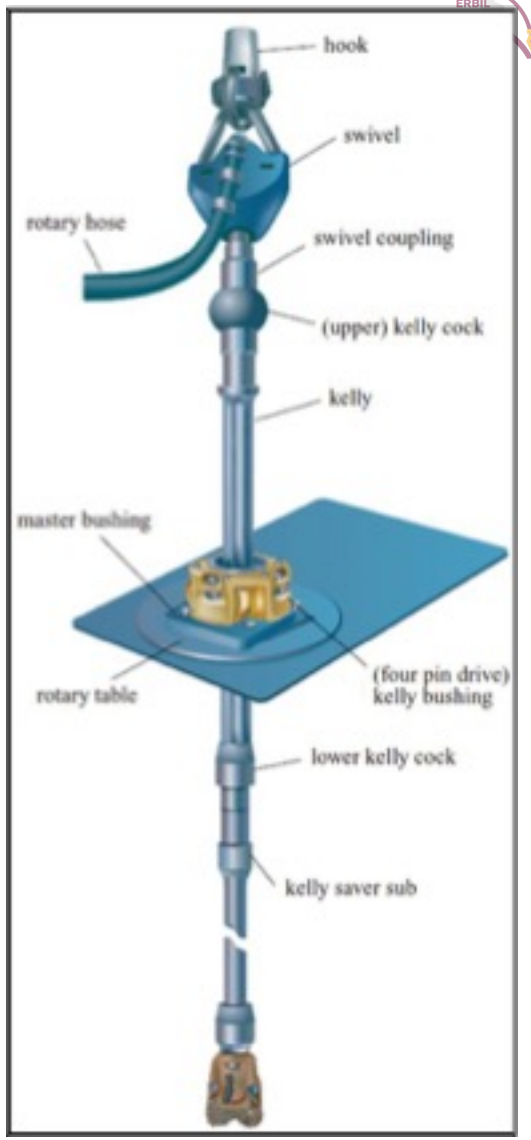
➢Master bushing

➢Kelly drive bushing

➢Kelly saver sub

➢Kelly

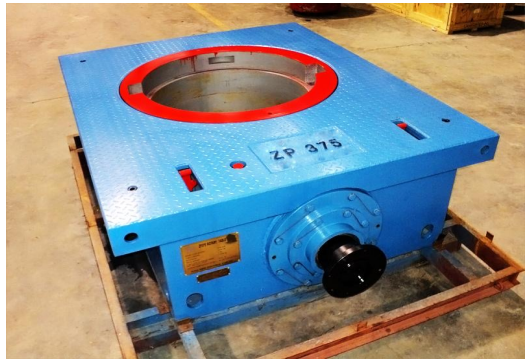
➢Swivel

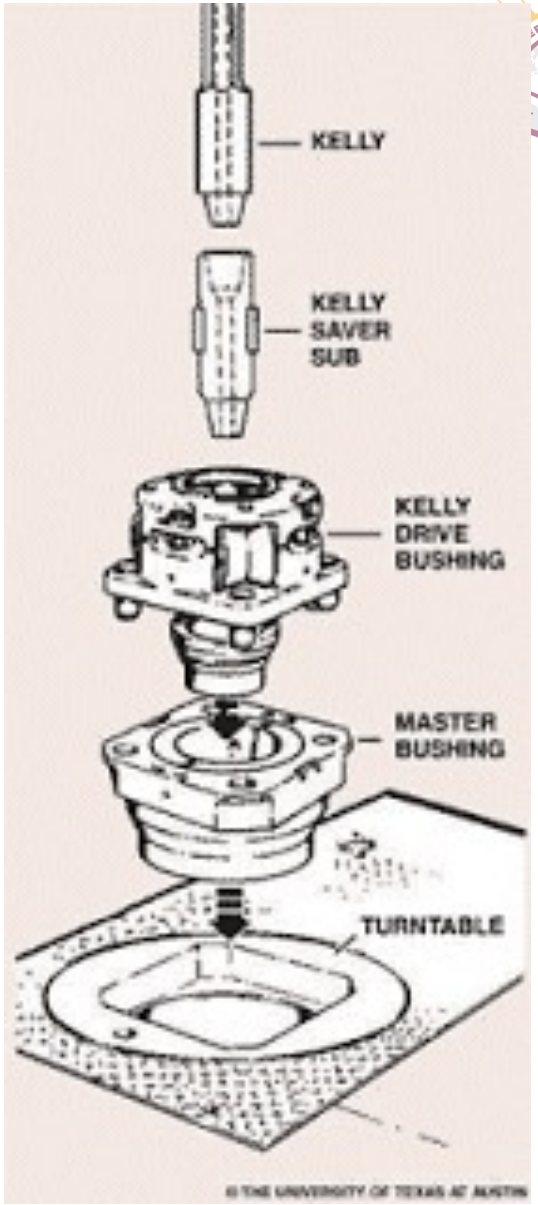


Rotary System

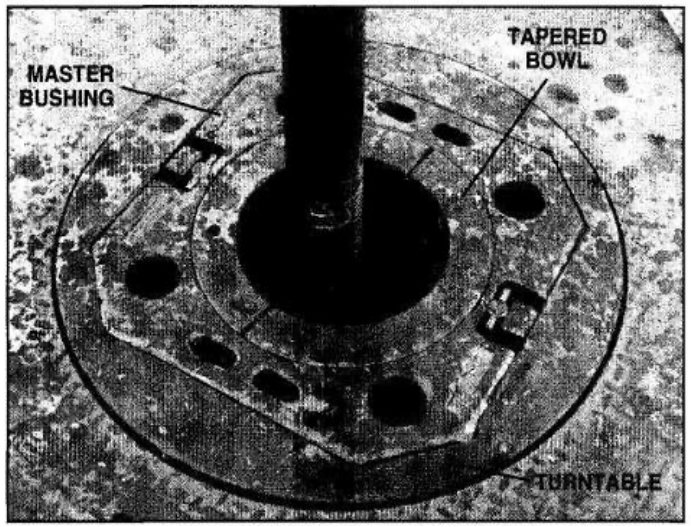
1. Turntable

- A stationary heavy-duty rectangular steel case houses the rotating turntable.
- The turntable is round in shape and is near the middle of the case.
- The turntable produces a turning motion that machinery transfers to the pipe and bit.
- An electric motor or gears and chains from the rig drawworks power the turntable.
- Additional equipment transfers the turntable's turning motion to the drill pipe and attached bit.





Rotary System



2. Master Bushing

- A bushing is a fitting that goes inside an opening in a machine.
- A rotary table master bushing fits inside the turntable.
- The turntable rotates the master bushing.
- The master bushing transmit torque and rotation from the rotary table to the Kelly bushing.
- The master bushing has an opening through which crew members run pipe into the wellbore.

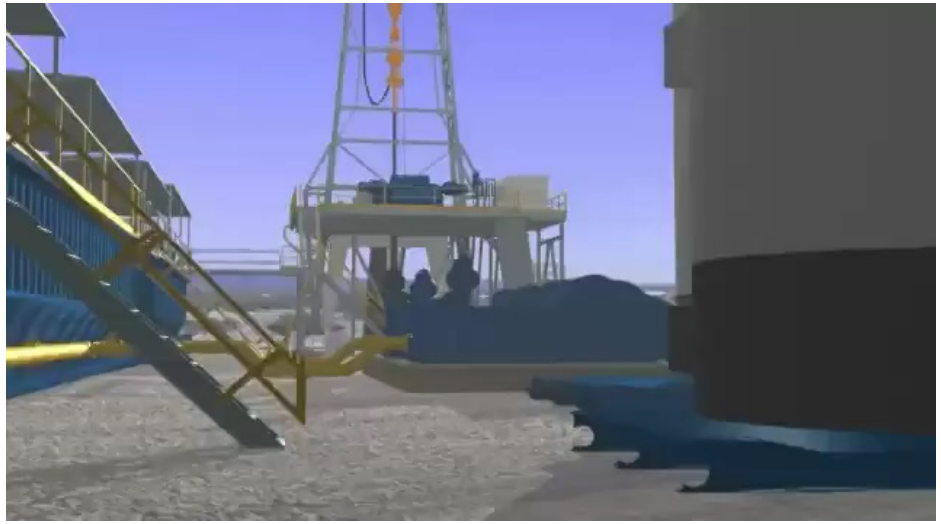
Rotary System

- A tapered bowl fits inside the master bushing.
- This bowl serves a vital function when the pipe and bit are not rotating.
- When the driller stops the rotary table and uses the rig's hoisting system to lift the pipe and bit off the bottom of the hole, it is often necessary for crew members to suspend the pipe off bottom.
- To do so, they place a set of segmented pipe gripping elements called "slips" around the pipe and into the master bushing's tapered bowl.
- A master casing bushing is used to handle casings.

Rotary System

3. Slips
   - ➢Drill Pipe Slips
   - ➢Drill Collar Slips
   - ➢Casing Slips

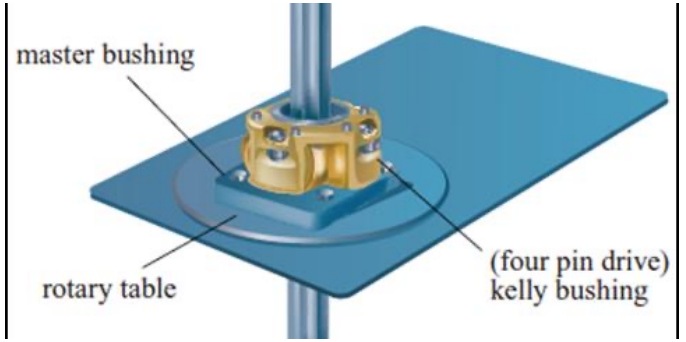
- Because of the slick shape of most drill collars, a safety clamp is always used above the drill collar slips.
- If the drill collars slides in the slips, the safety clamp works as a stop to force the slips to grip the drill collar.



Rotary System

4. Kelly Drive Bushing

- A kelly drive bushing transfers the master bushing's rotation to a special length of pipe called the "kelly".
- The kelly drive bushing fits into the master bushing.
- Two types of master and kelly drive bushing are available.
- One master bushing has four drive holes. Strong steel pins on the bottom of a kelly drive bushing made for this type of master bushing fit into the holes.
- When the master bushing rotates, the pins engaged in the drive holes rotate the kelly drive bushing.



Rotary System

- Another type of master bushing has a square opening and no drive holes.
- The opening corresponds to a squares shape on the bottom of a kelly drive bushing made for this kind of master bushing.
- The square bottom of the Kelly drive bushing fits into the corresponding square opening in the master bushing.
- With the square drive bushing in place, the rotating master bushing turns it.

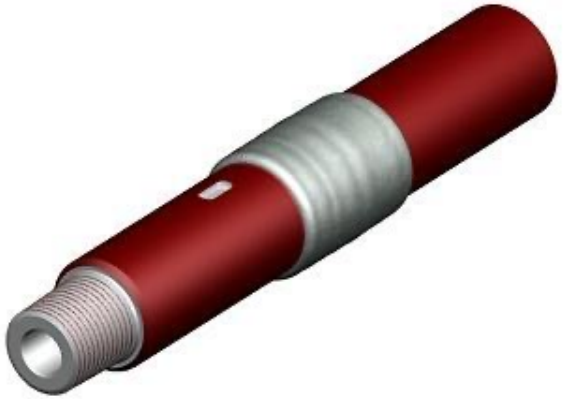
Rotary System

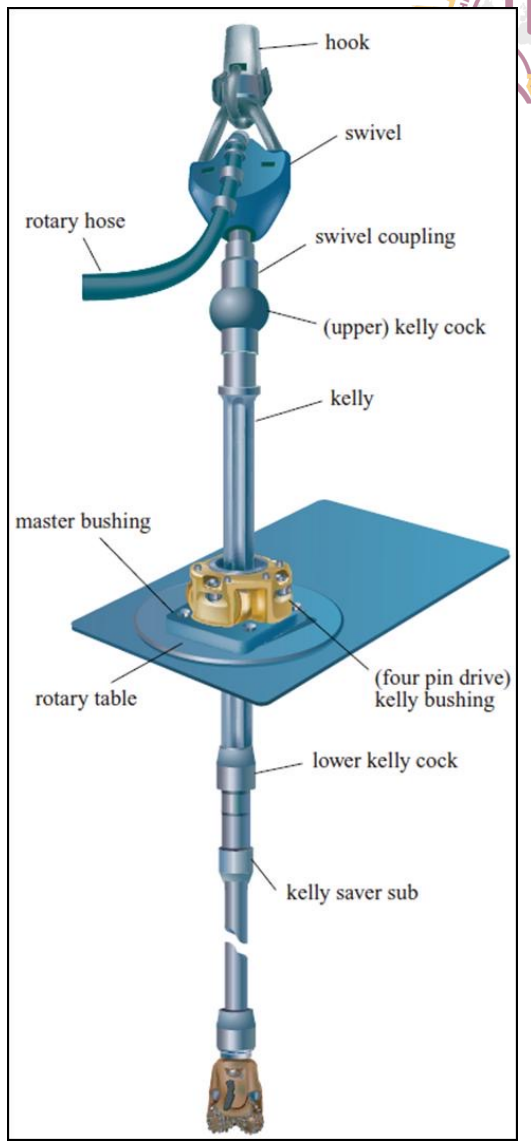
Types of Master and Kelly Drive Bushings

Rotary System

5. Kelly Saver Sub

- Kelly saver sub is used between the kelly and the first joint of drillpipe.
- The Kelly saver sub prevents excessive wear of the threads of the connection on the Kelly, due to continuous make-up and breakout of the Kelly whilst drilling.

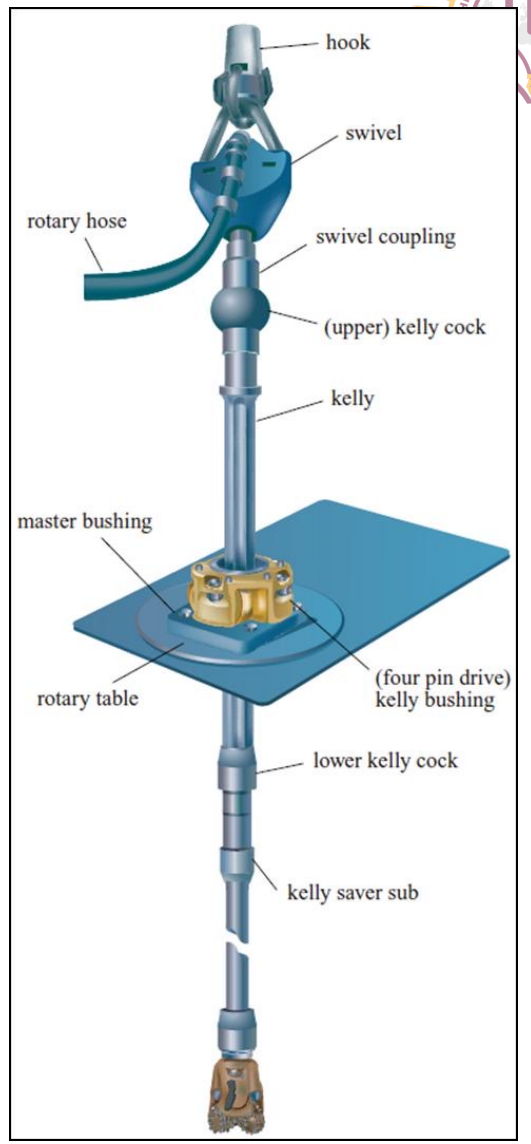




Rotary System

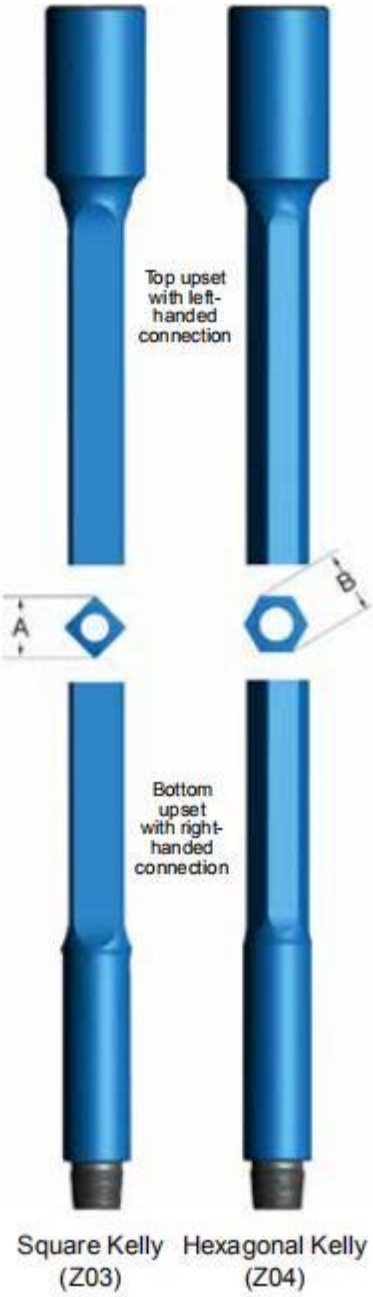
6. Kelly

- The Kelly is the rotating link between the rotary table and the drill string.
- Its main functions are:
  - Transmits rotation and weight-on-bit to the drill bit
  - Supports the weight of the drill string
  - Connects the swivel to the uppermost length of drill pipe; and
  - Conveys the drilling fluid from the swivel into the drill string.
- The Kelly comes in lengths ranging from 40 to 54 ft. with cross sections such as hexagonal (most common and stronger), or square.



Rotary System

- The kelly's flat sides mate with a corresponding square or hexagonal opening in the kelly drive bushing.
- The kelly slides easily into the drive bushing opening. It is therefore free to move up or down through the bushing opening, even as it rotates.
- The kelly's being able to move through the rotating bushing is important because it allows the kelly to follow the bit down as it drills deeper.
- In general, a hexagonal kelly is stronger than a square kelly. Consequently, contractors tend to use hexagonal kellys on large rigs to drill deep wells because of their extra strength.
- Small rigs often use square kellys because they are less expensive.

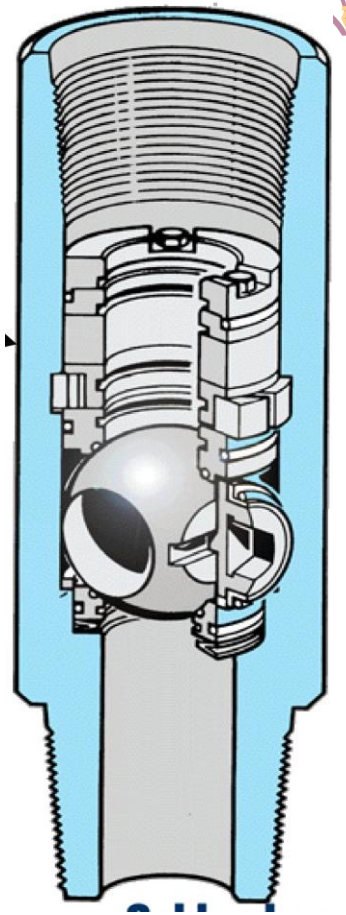


Rotary System

Kelly

Rotary System

- The Kelly is usually provided with two safety valves, one at the top and one at the bottom, called upper and lower Kelly cocks, respectively.
  - ➢The Upper Kelly Cock can be used to control Kick pressures by shutting off flow in the drill string at any time.
  - ➢The Lower Kelly Cock can stop mud loss when the kelly is disconnected from the drillstring.



Rotary System

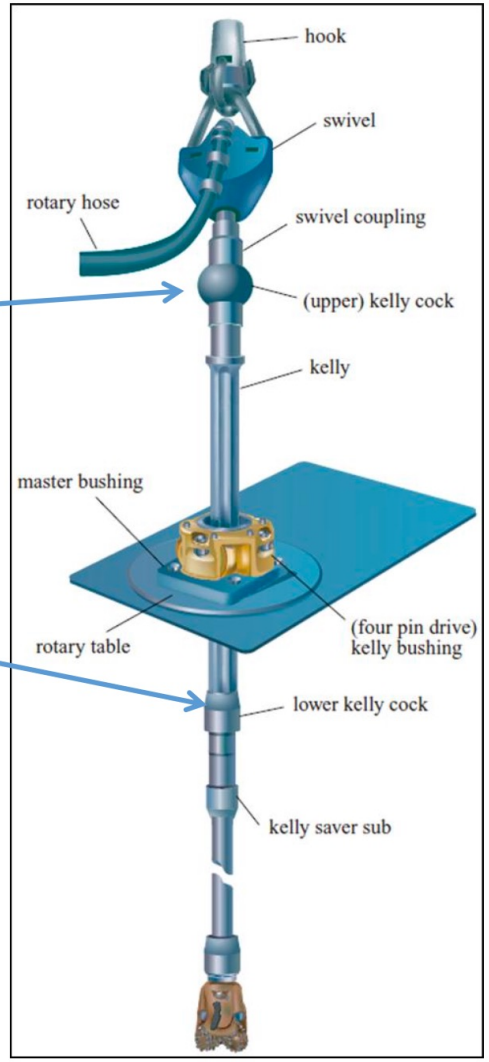
Kelly, cont.

Upper Kelly Valve

Lower Kelly Valve API connections

Upper kelly valve

Lower kelly valve



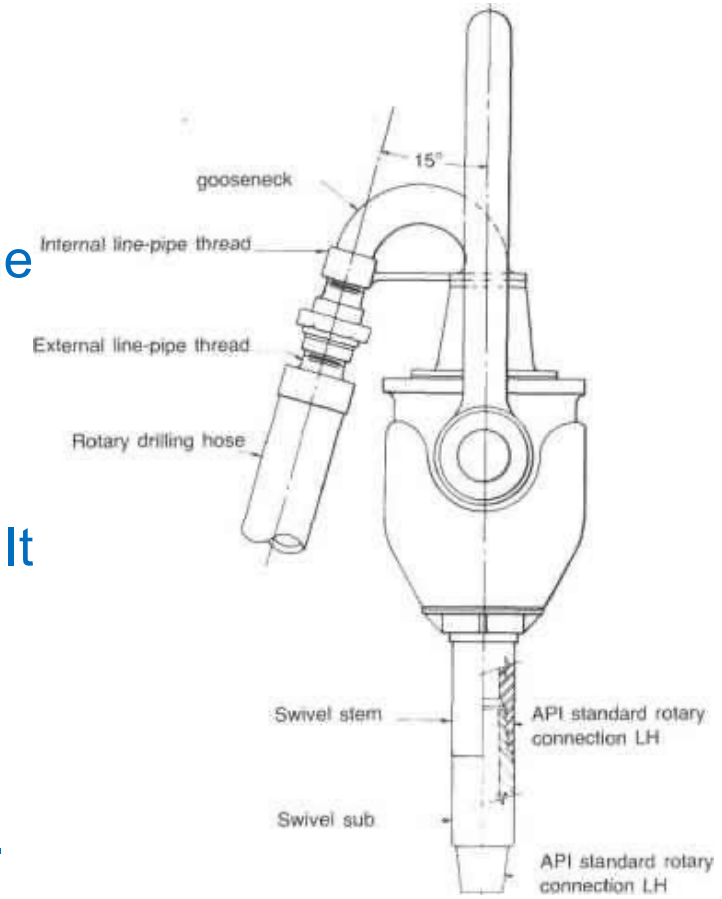
Rotary System

7. Swivel

- Another principal part of a rotary-table system is the swivel.
- The swivel interfaces the rotary system with the hoisting system.
- A heavy-duty bail, similar to the bail, or handle, on a water bucket but much larger, fits into a big hook on the bottom of the traveling block.
- The hook suspends the swivel and attached drill string.
- Crew members make up the top of the kelly to the swivel.
- The kelly screws onto a threaded fitting (the stem), that comes out of the swivel.

Rotary System

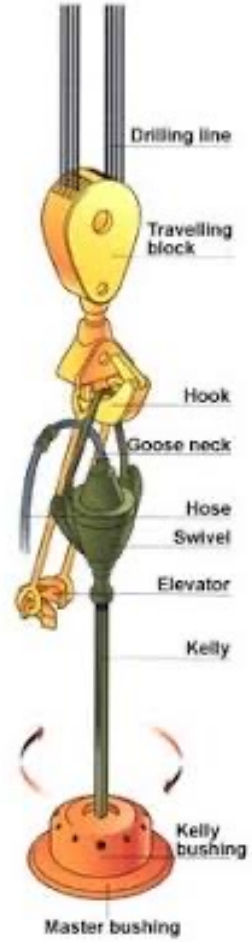
- This stem rotates with the kelly, the drill string, and the bit.
- At the same time, drilling mud flows through the stem and into the kelly and drillstring.
- Near the top and on one side of the swivel is a gooseneck.
- The gooseneck is a curved, erosion-resistant piece of pipe. It conducts drilling mud under high pressure into the swivel stem.
- A special hose, the rotary hose, attaches to the gooseneck.
- The rotary hose conducts drilling mud from the pump to the swivel.



Rotary System

Summary of kelly and rotary table system

1. The turntable in the rotary table rotates the master bushing.
2. The master bushing rotates the kelly drive bushing.
3. The kelly drive bushing rotates the Kelly.
4. The kelly rotates the attached pipe and bit.
5. The swivel suspends the pipe, allows it to rotate, and has a passage for drilling mud to enter the kelly and pipe.



Rotary System

B. Top Drive System

- The top drive is basically a combined rotary table and Kelly.
- This system does away with the kelly and thus the kelly drive bushing and a rotating master bushing.
- Instead, a top drive, rotates the drill string and bit.
- Like a regular swivel, a top drive hangs from the rig's large hook and it has a passageway for drilling mud to get into the drill pipe.
- However, a top drive comes equipped with a heavy-duty electric motor (some large top drives have two motors).
- Drillers operate the top drive from their control console on the rig floor.

Rotary System

- The motor turns a threaded drive shaft.
- The crew inserts the drive shaft into the top of the drillstring. When the driller starts the top drive's motor, it rotates the drill string and the bit.
- A top drive eliminates the need for a conventional swivel, a kelly, a rotating master bushing, and a kelly drive bushing.
- Rigs with a top drive, however, still need a rotary table with a master bushing and bowl to provide a place to suspend the pipe on slips when the bit is not drilling.
- Because the rotary table only serves as a place for crew members to place slips on rigs with top drives, manufacturers make special rotary support tables for top drive rigs that are lighter and smaller than regular rotary tables.

Rotary System

- The main advantage of a top drive over a kelly and rotary table system is that a top drive makes it safer and easier for crew members to handle the pipe.
- Because of the way in which a rig with a rotary table system operates, the crew can add only one joint of drill pipe at a time as the hole deepens.
- With a top drive system, on the other hand, because it operates differently from the conventional system, the crew can add pipe three joints at a time, if they choose to do so.

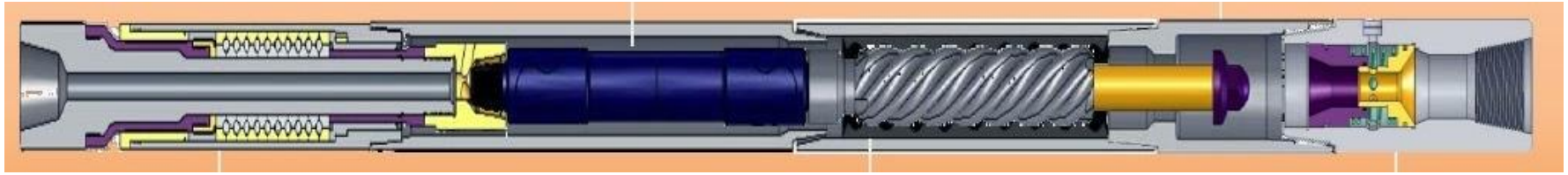
Rotary System

C. Downhole Motors (Mud Motors)

- In special situations, the rig may use a downhole motor to rotate the bit.
- Unlike a rotary table or a top drive system, a downhole motor does not rotate the drill string. Instead, it rotates only the bit.
- Drilling mud powers most downhole motors.
- Normally, crew members install the motor in the drill string just above the bit.
- To make a mud motor rotate the bit, the driller pumps drilling mud down the drill string as usual.

Rotary System

- When the mud enters the motor, however, it strikes a spiral shaft, which goes inside a tubular housing.
- The shaft and housing fit in such a way that mud pressure causes the shaft to turn.
- Because the bit is attached to the motor shaft, the shaft turns the bit. The mud exits out of the bit as usual.
- Rigs often use downhole motors to drill directional holes.
- Because it is easier to get the bit to drill in the desired direction if the drill string does not rotate, rigs employ downhole motors.



https://www.youtube.com/watch?v=Ba-arRTGDsI&t=55s

Next Lecture

In the next lecture on Sunday November 19th, 2023. At 11:00 in class 214 we will take the following topics:

- Rotary Drilling Rig Systems,
  - Circulation System
  - Well Control System
  - Power System
- Rotary Drilling Rig Components
- Functions of Rotary Rig Components
- Drill String Components.
- Types of Drill Bits.

End of Lecture