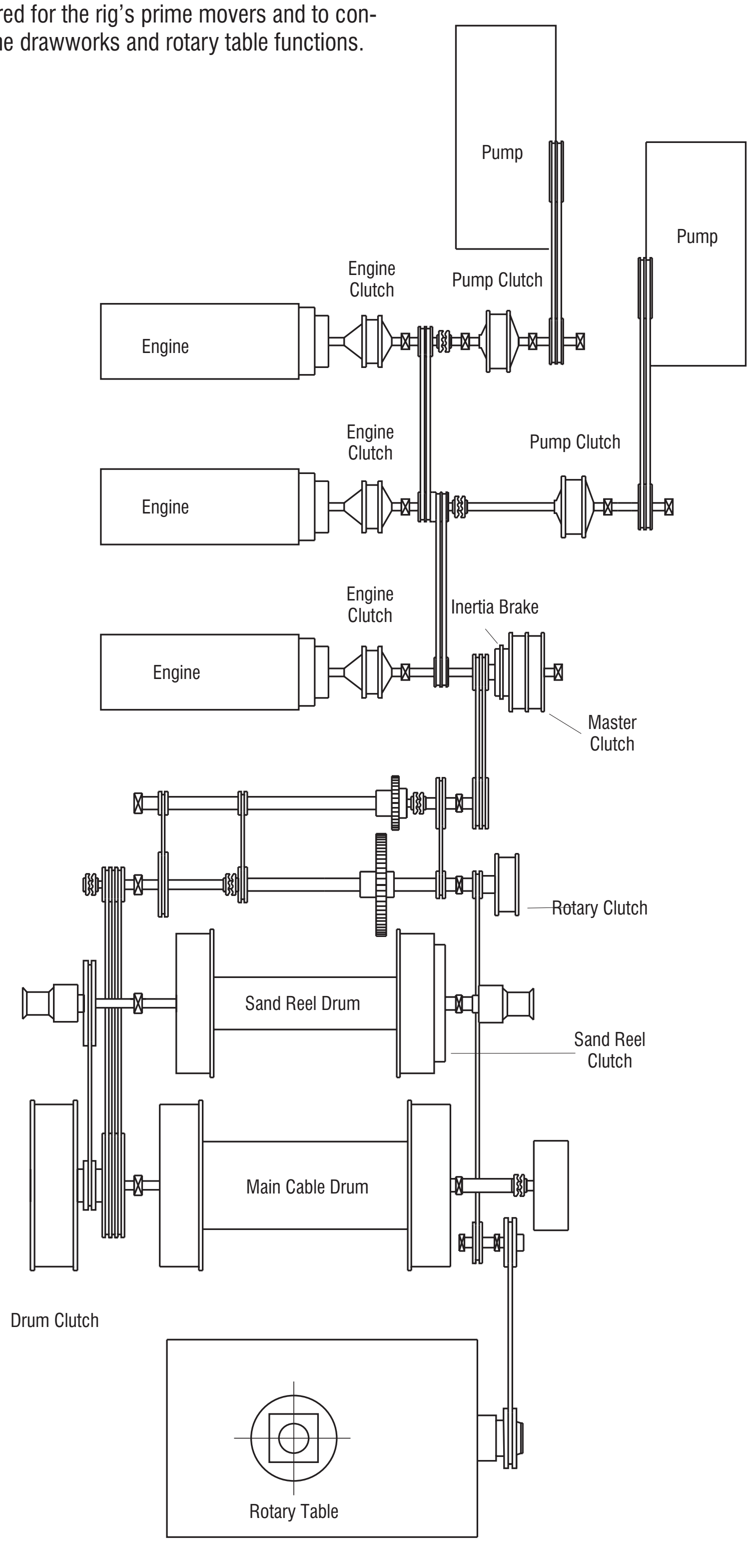
General

A rotary well drilling rig is a piece of equipment designed to bore a hole into the earth. For oil exploration, the hole can be anywhere from 4.5 to 20 inches (114 to 508 mm) in diameter and 30000 feet (9140 meters) in depth. Clutches are required for the rig's prime movers and to control the drawworks and rotary table functions.



Engine Clutches

On the majority of rigs, three or more diesel engines supply power to run all the machinery necessary to bore the hole. The engines are arranged so that they may be put in operation as the need arises. For instance, at the start of drilling, one engine may provide all the power necessary. As the hole becomes deeper, the second and then the third engine can be brought on-line. This arrangement is called a compound and CB clutches are used to engage and disengage the engines.

During the drilling operation, pumps are used to circulate a mud slurry to clean the bottom of the hole, to cool and lubricate the tools and to maintain the walls of the well. Hereto, CB elements are used to connect and disconnect the pumps as required.

A selection procedure for engine clutches is given in Section X. Use the procedure for clutch sizing.

Drawworks Clutches

Sections of pipe are used to connect the drilling bit to the rotary table. After the bit has bored a pipe length depth, the operation is stopped and a new pipe section added. The drilling bits wear and must be replaced several times when drilling a well. This means the drill string (the bit and all the pipe sections) must be withdrawn from the hole, the bit replaced and the drill string re-assembled. Raising and lowering of the string is the function of the drawworks.

A drawworks is basically a hoist which raises or lowers heavy loads by means of wire rope (line) wound on a drum. The drawwork's transmission allows a number of drum speeds. The deeper drilling rigs have a low and high speed drum clutch which further increases the number of possible drum speeds. The drill string weight (hook load) determines which clutch is used.

Low speed clutch

The low speed drum clutch torque requirement $\mathbf{M_L}$ is determined by the single line pull **F** and the working drum radius **r**. Usually, the maximum hook load **H** is given instead of single line pull. Single line pull is calculated from:

$$F = \frac{H}{N \cdot E}$$

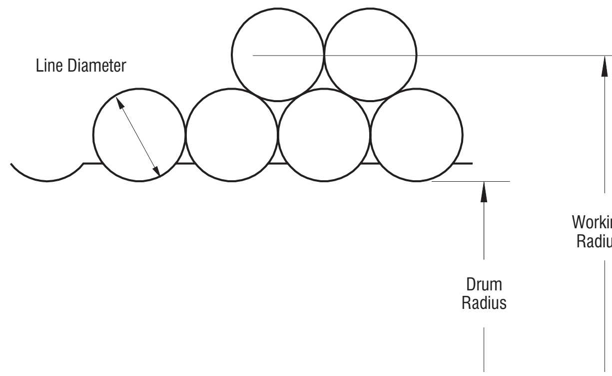
N: number of lines strung

E: Tackle efficiency

Good design practice limits the line pull to one-half of the line breaking strength.

N Number of lines strung	E Tackle Efficiency
4	0.908
6	0.874
8	0.842
10	0.811
12	0.782
14	0.755
16	0.728
18	0.703

The following figure illustrates the working drum radius. Usually, the drawworks is rated on the second line wrap on the drum. The working radius can be calculated from:

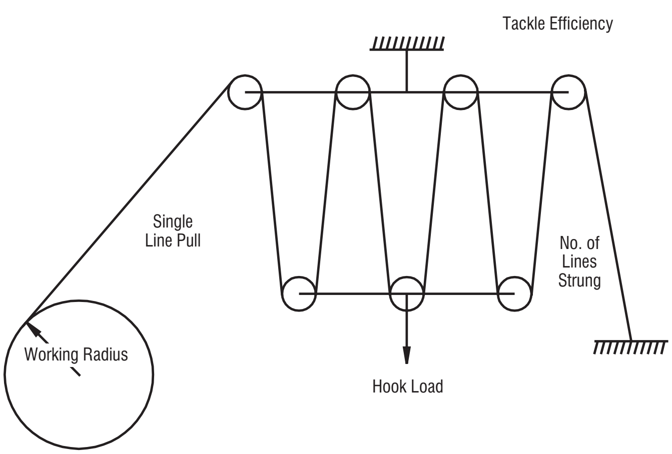


$$r = 0.5\,D + 0.866 \cdot d \cdot w - 0.366 \cdot d$$

D: drum diameter

d: line or wire rope diameter

w: number of wraps



Low speed clutch torque can then be calculated from:

$$M_L = F \cdot r$$

No service factor is used because this is the maximum torque required and only occurs at the maximum hole depth. Applying a service factor results in too large a clutch torque for the range of speeds and a overstressed line.

Using the calculated low drum torque and the lowest drum rpm $\mathbf{N_L}$, the power required for hoisting $\mathbf{P_h}$ is calculated from:

$$P_h = \frac{M_L \cdot n_L}{63025} \text{ (HP)}$$

$$P_h = \frac{M_L \cdot n_L}{9550} \text{ (kW)}$$

High speed clutch

High speed clutch torque $\mathbf{M_H}$ is calculated from the hoist power and the lowest high speed drum rpm $\mathbf{N_H}$. A service factor is applied because of abuse from higher engagement speeds and shock loading due to breaking the drill string free of the rotary table slips.

$$M_H = \frac{P_h \cdot 63025}{n_H} \cdot 1.5 \text{ (lb·in)}$$

$$M_H = \frac{P_h \cdot 9550}{n_H} \cdot 1{,}5 \text{ (N·m)}$$

In many cases, the same size clutch is used for both the high and low speed clutches to keep the number of clutch sizes on a rig to a minimum. Because of the large torque requirement, VC elements are used. Follow the selection procedure given in Section B.

Inertia Brake

This brake is used to stop the rotating transmission components of the drawworks. Its selection is based upon the rotating inertia, the brake shaft speed and the desired stopping time.

Other Drawworks Clutches

All other clutch selections with the exception of the sand reel are based upon the maximum power which the clutch must transmit, the clutch shaft speed and the appropriate service factor from the following table. The sand reel clutch torque depends upon its line pull and drum working radius.

Clutch	SF
Master	1.5
Rotary	1.5
Pump	1.8
Sand Reel	1.25

Example

Determine the low and high speed drum clutch torques required for the following conditions:

Maximum hook load H: 500000 lb

Hoist drum dia. D: 20 in

Lines strung N: 8

Line dia. d: 1.125 in

Rated wrap W: 3

Low speed range: 34 to 77 rpm

High speed range: 108 to 254 rpm

$$F = \frac{H}{N \cdot E} = \frac{500000}{8 \cdot 0.842} = 74228 \text{ lb}$$

$$r = 0.5 \cdot D + 0.866 \cdot d \cdot w - 0.366 \cdot d$$

$$= (0.5 \cdot 20) + (0.866 \cdot 1.125 \cdot 3) - (0.366 \cdot 1.125)$$

$$= 12.51 \text{ in}$$

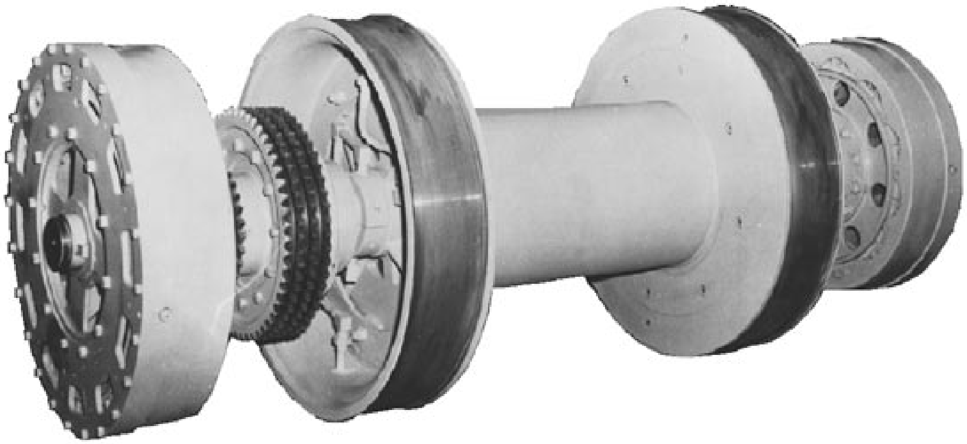
$$M_L = F \cdot r = 74228 \cdot 12.51$$

$$= 928593 \text{ lb·in}$$

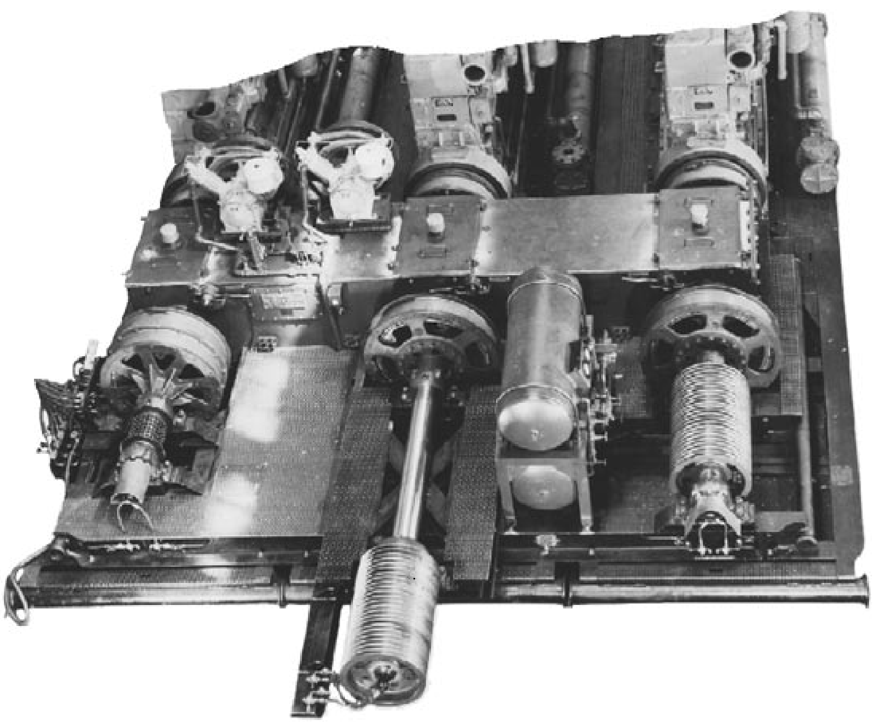
$$P_h = \frac{M_L \cdot n_L}{63025} = \frac{928593 \cdot 34}{63025} = 501 \text{ HP}$$

$$M_H = \frac{P_h \cdot 63025}{n_H} \cdot 1.5 = \frac{501 \cdot 63025}{108} \cdot 1.5$$

$$= 438550 \text{ lb·in}$$



High and low speed VC clutches on main drawworks cable drum.



Various CB clutch applications on an oil well drilling rig.