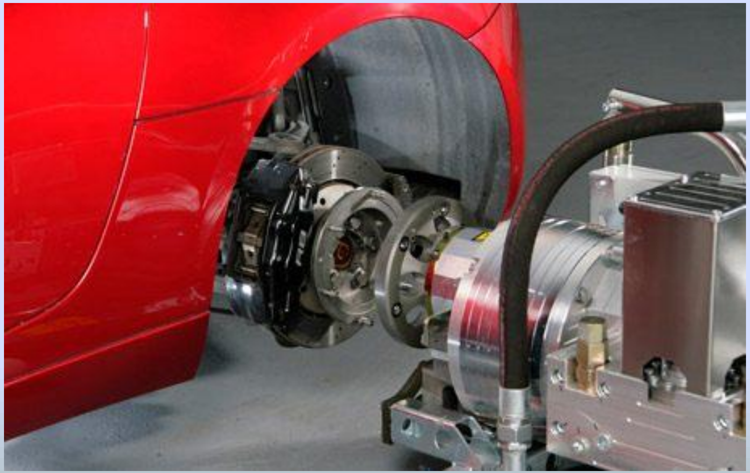
Friction Devices: Dynamometer



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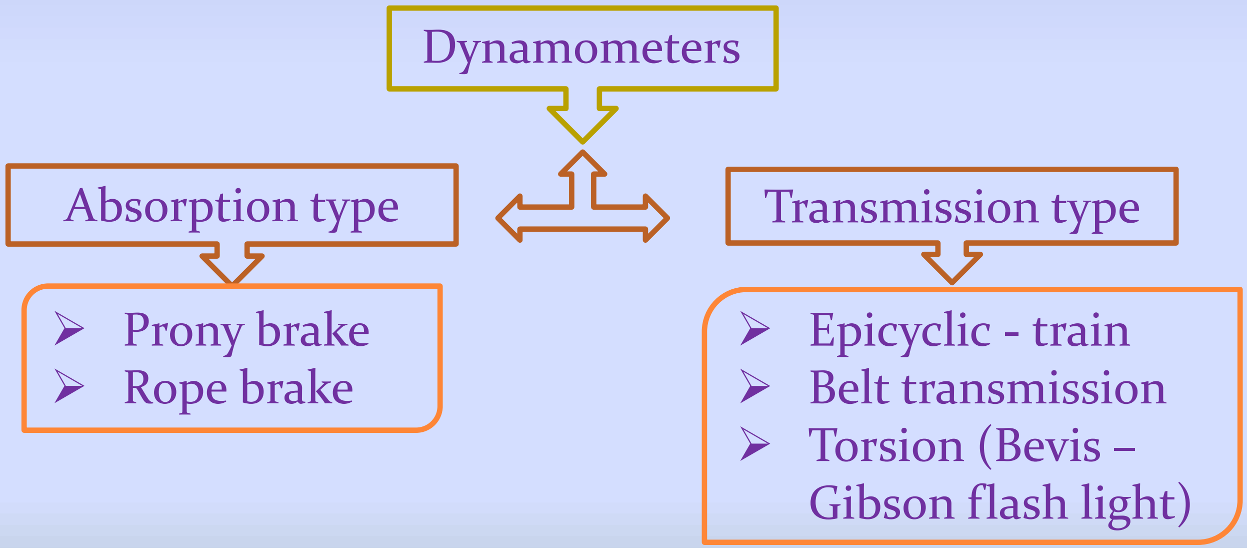
DYNAMOMETER

- A dynamometer is a brake but in addition it has a device to measure the frictional resistance. Knowing the frictional resistance, we may obtain the torque transmitted and hence the power of the engine.

❖ Types of Dynamometers



❖ PRONY BRAKE DYNAMOMETER

- A simplest form of an absorption type dynamometer is a prony brake dynamometer as shown in Figure 1.
- It consists of two wooden blocks placed around a pulley fixed to the shaft of an engine whose power is required to be measured.

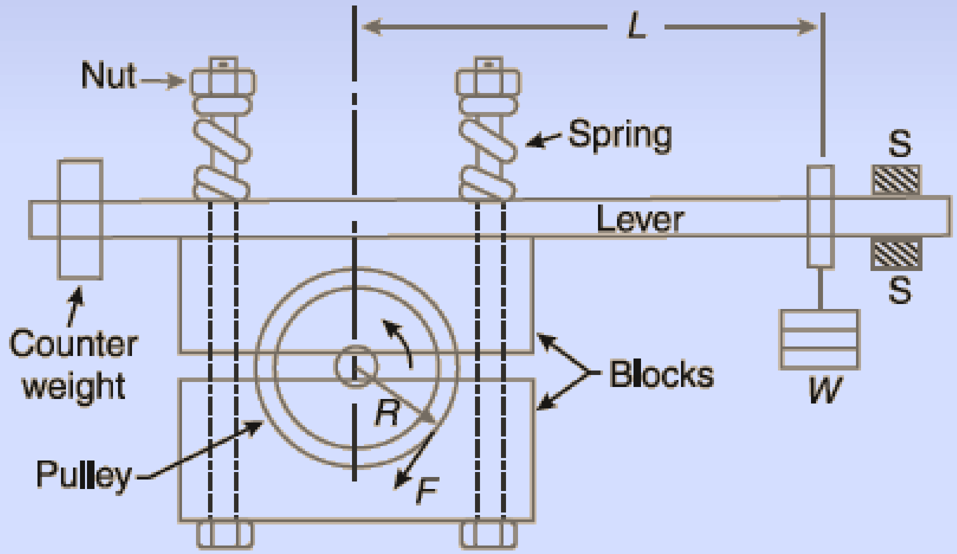


Figure 1. Prony brake dynamometer

- The blocks are clamped by means of two bolts and nuts, as shown in Figure 1. A helical spring is provided between the nut and the upper block to adjust the pressure on the pulley to control its speed.
- The upper block has a long lever attached to it and carries a weight *W* at its outer end.
- A counter weight is placed at the other end of the lever which balances the brake when unloaded. Two stops S, S are provided to limit the motion of the lever.
- When the brake is to be put in operation, the long end of the lever is loaded with suitable weights *W* and the nuts are tightened until the engine shaft runs at a constant speed and the lever is in horizontal position.
- Under these conditions, the moment due to the weight *W* must balance the moment of the frictional resistance between the blocks and the pulley.

❖ ROPE BRAKE DYNAMOMETER

- It is another form of absorption type dynamometer which is most commonly used for measuring the brake power of the engine as shown in Figure 2.

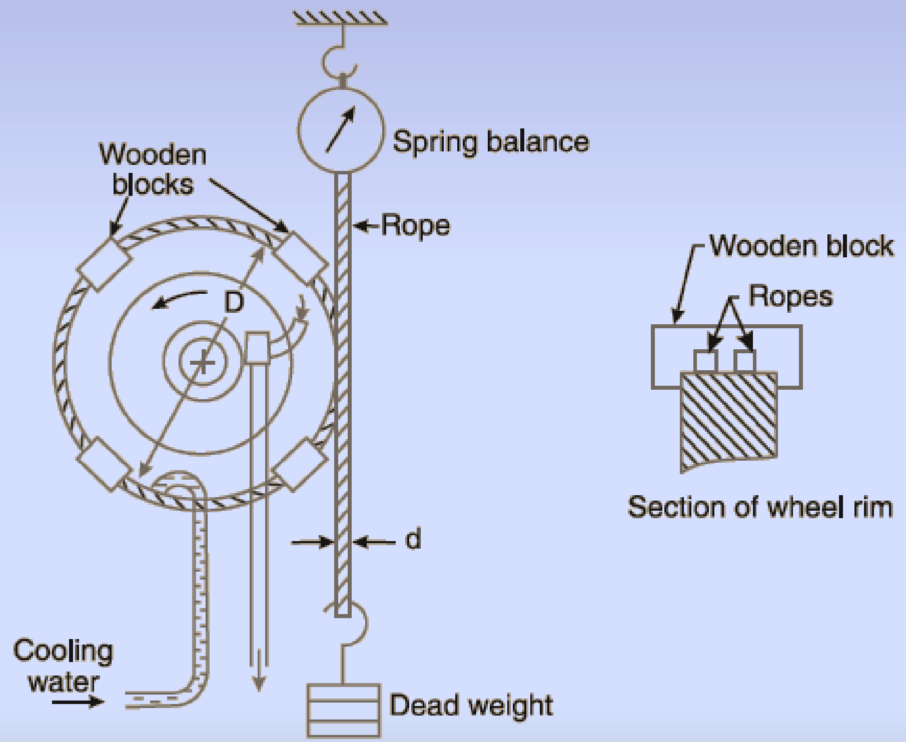


Figure 2. Rope brake dynamometer

- It consists of one, two or more ropes wound around the flywheel or rim of a pulley fixed rigidly to the shaft of an engine.
- The upper end of the ropes is attached to a spring balance while the lower end of the ropes is kept in position by applying a dead weight as shown in Figure 2.
- In order to prevent the slipping of the rope over the flywheel, wooden blocks are placed at intervals around the circumference of the flywheel.
- In the operation of the brake, the engine is made to run at a constant speed. The frictional torque, due to the rope, must be equal to the torque being transmitted by the engine.

❖ EPICYCLIC-TRAIN DYNAMOMETER

- An epicyclic-train dynamometer, as shown in Figure 3, consists of a simple epicyclic train of gears, *i.e.* a spur gear, an annular gear (a gear having internal teeth) and a pinion.

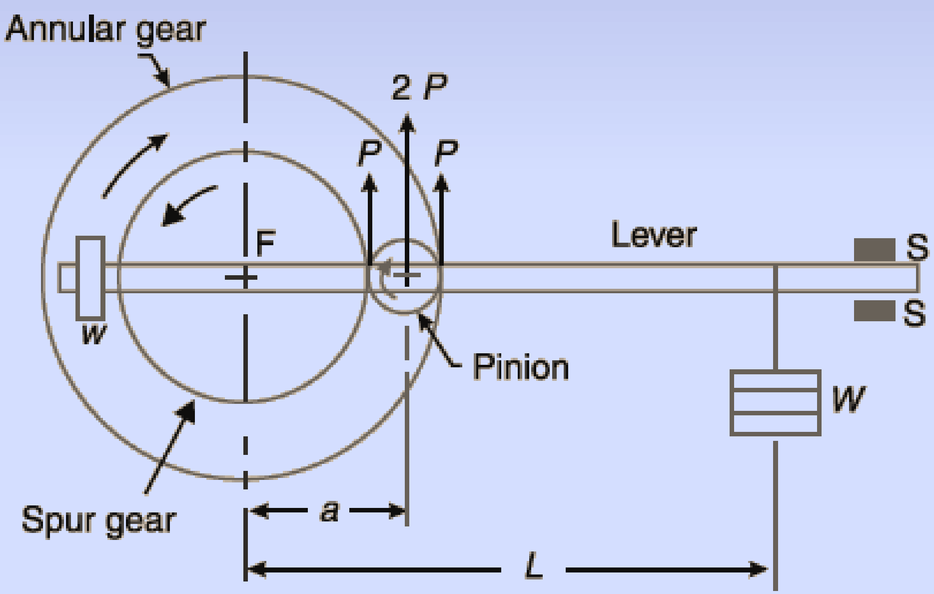


Figure 3. Epicyclic - train dynamometer

- The spur gear is keyed to the engine shaft (*i.e.* driving shaft) and rotates in anticlockwise direction.
- The annular gear is also keyed to the driving shaft and rotates in clockwise direction.
- The pinion or the intermediate gear meshes with both the spur and annular gears.
- The pinion revolves freely on a lever which is pivoted to the common axis of the driving and driven shafts.
- A weight w is placed at the smaller end of the lever in order to keep it in position.
- A little consideration will show that if the friction of the pin on which the pinion rotates is neglected, then the tangential effort P exerted by the spur gear on the pinion and the tangential reaction of the annular gear on the pinion are equal.
- Since these efforts act in the upward direction as shown, therefore total upward force on the lever acting through the axis of the pinion is $2P$.
- This force tends to rotate the lever about its fulcrum and it is balanced by a dead weight W at the end of the lever.
- The stops S, S are provided to control the movement of the lever.

❖ BELT TRANSMISSION (FROUDE OR THRONEYCROFT) DYNAMOMETER

- When the belt is transmitting power from one pulley to another, the tangential effort on the driven pulley is equal to the difference between the tensions in the tight and slack sides of the belt as shown in Figure 4.

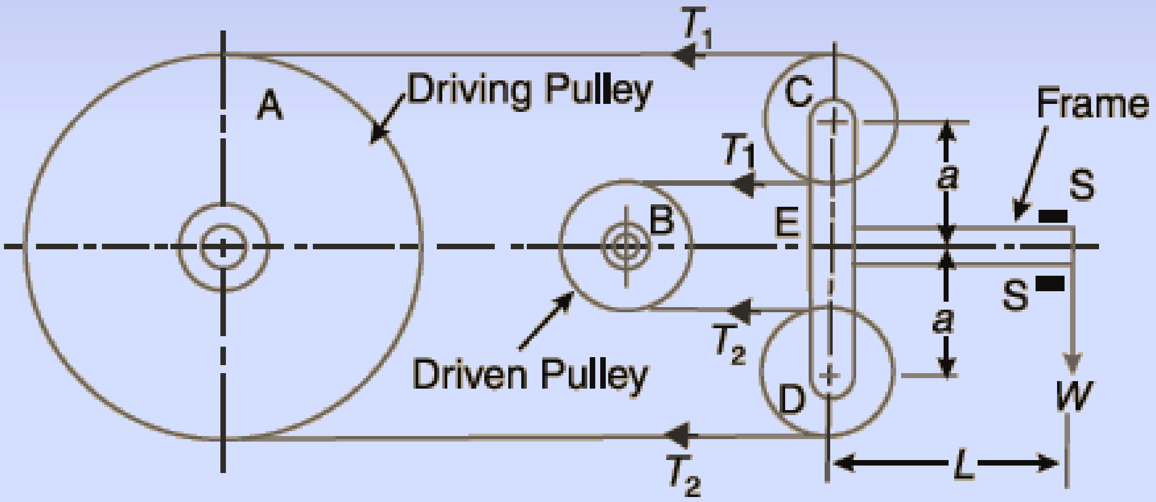


Figure 4. Froude or Throneycroft dynamometer

- A belt dynamometer is introduced to measure directly the difference between the tensions of the belt, while it is running.
- A belt transmission dynamometer, as shown in Figure 4, is called a Froude or Throneycroft transmission dynamometer.
- It consists of a pulley *A* (called driving pulley) which is rigidly fixed to the shaft of an engine whose power is required to be measured. There is another pulley *B* (called driven pulley) mounted on another shaft to which the power from pulley *A* is transmitted.
- The pulleys *A* and *B* are connected by means of a continuous belt passing round the two loose pulleys *C* and *D* which are mounted on a *T*-shaped frame.
- The frame is pivoted at *E* and its movement is controlled by two stops *S*,*S*. Since the tension in the tight side of the belt (T_1) is greater than the tension in the slack side of the belt (T_2), therefore the total force acting on the pulley *C* (*i.e.* $2T_1$) is greater than the total force acting on the pulley *D* (*i.e.* $2T_2$).
- It is thus obvious that the frame causes movement about *E* in the anticlockwise direction. In order to balance it, a weight *W* is applied at a distance *L* from *E* on the frame as shown in Figure 4.

❖ BEVIS GIBSON FLASH LIGHT DYNAMOMETER

- It depends upon the fact that the light travels in a straight line through air of uniform density and the velocity of light is infinite. It consists of two discs *A* and *B* fixed on a shaft at a convenient distance apart, as shown in Figure 5 (*a*).

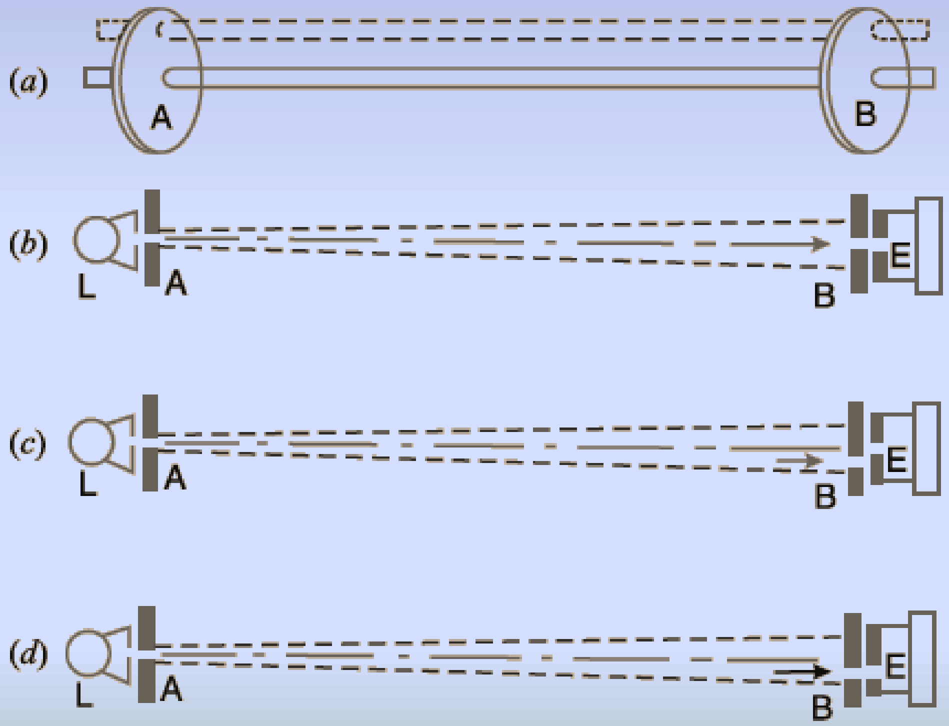


Figure 5. Bevis Gibson flash light dynamometer

- Each disc has a small radial slot and these two slots are in the same line when no power is transmitted and there is no torque on the shaft.
- A bright electric lamp *L*, behind the disc *A*, is fixed on the bearing of the shaft. This lamp is masked having a slot directly opposite to the slot of disc *A*.
- At every revolution of the shaft, a flash of light is projected through the slot in the disc *A* towards the disc *B* in a direction parallel to the shaft.
- An eye piece *E* is fitted behind the disc *B* on the shaft bearing and is capable of slight circumferential adjustment.
- When the shaft does not transmit any torque (*i.e.* at rest), a flash of light may be seen after every revolution of the shaft, as the positions of the slit do not change relative to one another as shown in Figure 5 (*b*).
- Now when the torque is transmitted, the shaft twists and the slot in the disc *B* changes its position, though the slots in *L*, *A* and *E* are still in line. Due to this, the light does not reach to the eye piece as shown in Figure 5 (*c*).
- If the eye piece is now moved round by an amount equal to the lag of disc *B*, then the slot in the eye piece will be opposite to the slot in disc *B* as shown in Figure 5 (*d*) and hence the eye piece receives flash of light.
- The eye piece is moved by operating a micrometer spindle and by means of scale and vernier, the angle of twist may be measured upto 1/100th of a degree.

- The torsion meter discussed above gives the angle of twist of the shaft, when the uniform torque is transmitted during each revolution as in case of turbine shaft.
- But when the torque varies during each revolution as in reciprocating engines, it is necessary to measure the angle of twist at several different angular positions.
- For this, the discs *A* and *B* are perforated with slots arranged in the form of spiral.
- The lamp and the eye piece must be moved radially so as to bring them into line with each corresponding pair of slots in the discs.

ANY QUERY?