With the operation of two cages in one shaft came the necessity for the addition of guides to prevent the cages swaying about at the end of the ropes and clashing together as they passed each other.

These guides are of two general types. (1) The timber, or rail guide, which is fastened to cross pieces, called "buntons," let into the wall of the shaft at intervals to suit. These are not supported by the headgear, and, therefore, do not concern us.

(2) The other type is the guide-rope. Generally a set of these for each cage consists of four ropes, but for the larger cages six or more may be used. These are suspended directly from the headgear frame at a point just below the pulley platform. To the lower end of these ropes are attached cast iron weights in order to keep them taut and hanging vertically. Sometimes as much as ten or twelve tons will be suspended at the end of each rope, and, with the weight of the rope itself, these guides form quite a formidable load to design for. The guide-ropes, like the winding ropes, are all made of steel, and the diameter will be anything from one inch to an inch and a half.

With all winding or hoisting engines there is an increase in stress on the hoisting rope, due to the acceleration of the load, and this may amount to half the dead load suspended from the rope.

It has also been demonstrated that quite a large increase in stress is due to the vibration of the cage, caused by the pulsation of the engines, and this is very similar in effect to a piece of elastic held in the hand with a weight suspended at the free end, when a slight movement of the hand will cause the weight to jump about for a considerable period after the cause is removed. These pulsations are much more noticeable with engines of an inferior type, and also with the sudden application of the brakes or checking the speed by shutting the steam valve quickly. With an increase in load the vibrations appear to become less.

The increased stress on the rope due to acceleration may be found by the following method:—

Where P = effective pull in pounds causing motion.
T = Tension on the rope in pounds.
A = Acceleration of load in feet per second in a second.
W = Weight of cargo, load, and rope in pounds.
G = 32.

$$\text{Now } P = T - W,$$

$$\text{and also } P = \frac{WA}{G};$$

$$\text{therefore } T - W = \frac{WA}{32},$$

$$\text{or } T = W\left(1 + \frac{A}{32}\right)$$

It will be seen from this formula that if we take unit weight, then when the acceleration reaches, say, 32 feet per second, the tension in the rope will be twice that for load at rest.

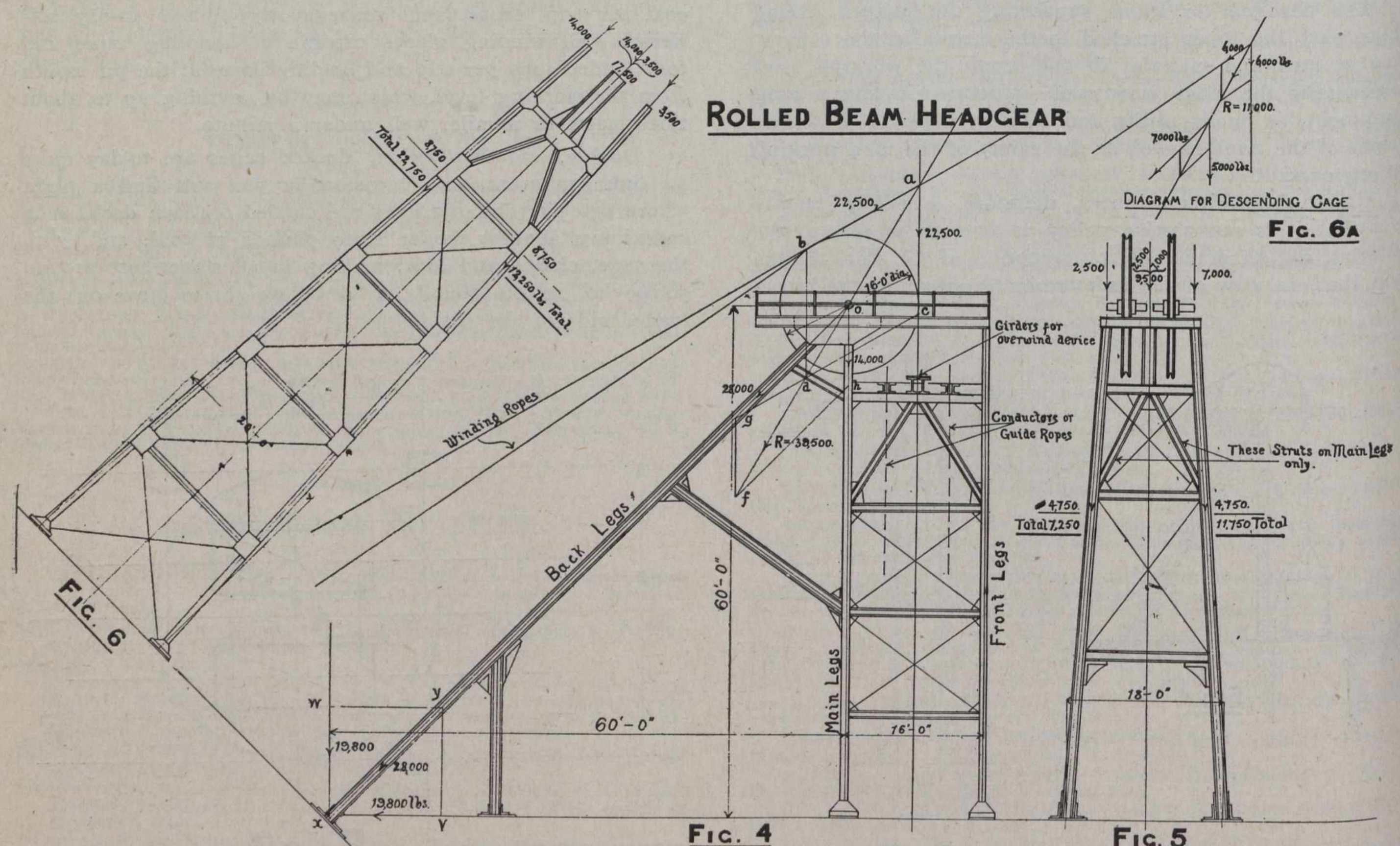

Fig. 6 Fig. 4 Fig. 5 Fig. 6A

Therefore, knowing the acceleration of the cage and load, and also the total weight to be lifted, the tension in the rope will always be W plus some fraction of W represented by $\frac{A}{32}$. For usual practice this is generally in the neighborhood of one and a half times the load, or the acceleration is approximately sixteen feet per second in a second.

Other loads of an important character are those caused by over-winding, when a safety catch is provided for supporting the cage after the rope has been automatically released, and also the adoption of a safety catch if the rope breaks.

To the tyro it looks a most difficult operation to bring a heavy engine and its load to rest at exactly the right place every time, year in and year out, but with the appliances and safety gear used to-day it really resolves itself into a purely mechanical operation. However, mistakes are