the maximum turning moment is 1.112. The engine naturally must be able to start the hoist with the cranks in any position, so that the minimum turning moment must be at least sufficient to overcome the static load and friction. An electric motor, on the contrary, has a very large overload capacity in proportion to the mean power which it will give, and, consequently, the motor for winding engines is usually selected with reference to the equivalent continuous load, and it is very rarely indeed that the starting moment or acceleration peak needs to be considered.

The first type of drum to be employed for winding engines was the cylindrical drum, but later the conical drum was introduced. In some cases the latter gives easier starting conditions and is beneficial to the steam engine, because the rope supporting the cage at the bank top is wound off the greatest diameter, while the rope attached to the loaded cage at the pit bottom is wound on to the least diameter, so that the empty cage partially balances the rope and the loaded cage at the start of the wind.

The Koepe pulley winder is used to a considerable extent in Europe, particularly in Germany. It differs from any other type, as the rope is not wound on to and off drums but is carried over the pulley and makes contact with it for less than a single turn. Thus the rope from the ascending cage comes up the shaft over the driving pulley by the winder, and then down to the descending cage, being suitably guided by head sheaves.

It will thus be seen that the winding rope is driven by friction alone, and, consequently, there must be a very definite limit between the pull in the ascending rope and the pull of the descending rope, otherwise the rope will slip on the pulley, and, to keep the difference in pull of the two sides of the rope as small as possible, a balance rope is always necessary.

It should be noted that such a winder cannot work with a very high acceleration, otherwise slipping of the rope will take place. As the rope is bound to creep on the pulley to a certain extent, the depth indicator must frequently be reset to ensure its accuracy.

As with a Koepe pulley winder the axial length of the pulley is very short indeed compared with that of a drum on which the rope has to be wound, and as the weight of the winding drum is not increased by the rope which it is carrying, the moment of inertia of the revolving parts of a Koepe pulley winder is small, and this, together with the use of the balance rope, keeps the maximum acceleration peak comparatively small compared with that of other types of winder.

Generally speaking, the Koepe pulley winder shows to the greatest advantage with deep shafts as it avoids the use of excessively long drums, and, from the electrical point of view, where the winding speed is not very high and where the acceleration period is short compared with the total time of winding. It has the disadvantage that if the rope breaks, both cages are detached from the winder.

Table Showing the Influence of the Different Types of Drums on the Electrically Driven Winding Engine.

	Depth —1,600 feet. Output—270 tons per hour.			
	Cylindrical Drum	Conical Drum	Scroll Drum	Koepe Pulley
Power of motor	1,090	965	780	935
Speed of motor	84	66	62.7	97
H.P. per revolution ..	13	14.6	12.4	9.6
Maximum peak with Ward Leonard system	1,865	1,690	1,390	1,276
Average loss of power with three-phase system	325 H.P.	260 H.P.	170 H.P.	341 H.P.

Generally speaking, the authors are of opinion that the Ward-Leonard or Ilgner system of electric winding is the most suitable for vertical shafts, and for all cases where large outputs are required and short and frequent winds are made. The three-phase winder always has the disadvantage that it cannot be so completely protected against careless handling as either the Ward-Leonard or the Ilgner, but it may prove more economical for long slopes where the full speed run is a long one and the periods of acceleration are comparatively infrequent.

Regarding the choice of drums for the winding engine, the authors are of opinion that in many cases where electrical drive is adopted, the cylindrical drum winder will prove the most suitable, but that in cases of deep shafts where the winding speed is high the scroll drum winder may prove better than the cylindrical drum winder, but that the field of application of the conical drum winder to electric winding is very small.

The authors have purposely avoided any comparison between the running costs of a steam and an electrically driven hoist or rolling mill, because each case should be considered on its own merits and comparisons made for one case will not be valid for another where conditions are different. No general comparison has any practical value, sometimes the steam engine is the more economical, and sometimes the electrical plant, according to conditions, and in deciding which is the more advantageous there are other factors besides running costs to be considered.

The authors are of opinion that direct current is much better adapted for driving mills and machinery in a steel works than three-phase current. Where large reversing rolling mills are driven electrically, and the motor driving the motor generator set is supplied from a direct current system, it is found that the power supplied to the rolling mill plant can be maintained at a much steadier value than if it is supplied from a three-phase system, and with the direct current motor about a ten per cent. saving in power can be effected, as there is no loss of power in slip resistances.

With a direct current system the flywheel of the motor generator set can be utilized to a great extent for neutralizing sudden peaks of short duration in the power demand on other parts of the system, for, during such a peak, the motor generator set would not only cease to take power from the supply, but the motor can be actually reversed, and give its full output as a generator returning the energy of the flywheel as electrical energy to the supply system.

With a three-phase system, peaks in other parts of the system cannot be neutralized to anything like the same extent, for the motor can only be made to cease to take power from the supply system and cannot act as a generator returning power to the supply system.

The direct current compound wound motor is very well adapted to fulfil the conditions for driving three-high merchant and bar mills and that considerable complication and difficulties are involved in adapting the three-phase motor for this purpose.

Direct current motors are also particularly well adapted for driving slow speed sheet and tinplate mills, and it is very easy to provide a slow speed direct coupled motor and gain the advantage and economy of this drive, and, as there is no loss of power in slip resistances, the direct current motor will prove from twelve to fifteen per cent. more economical than the three-phase motor on this current alone.