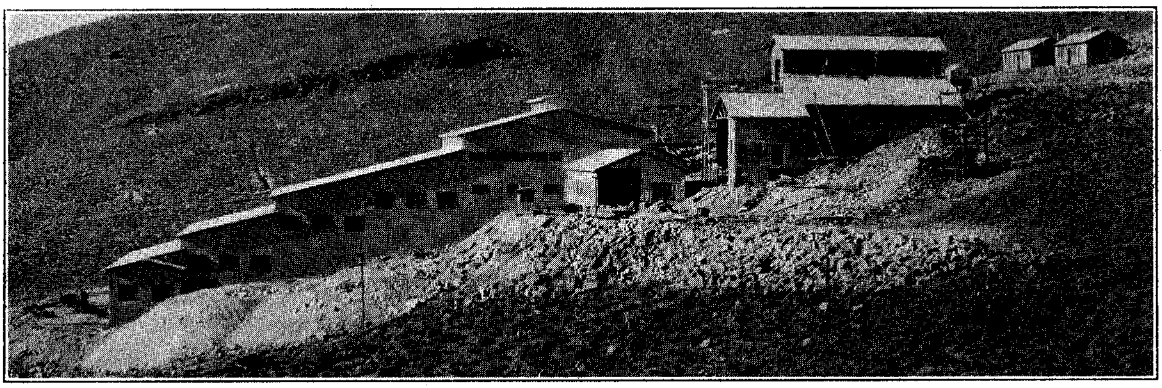


THE ROCHESTER COMBINED MILL, ROCHESTER, NEVADA

# Ball and Tube-Mill Drives at the Rochester Combined Mill

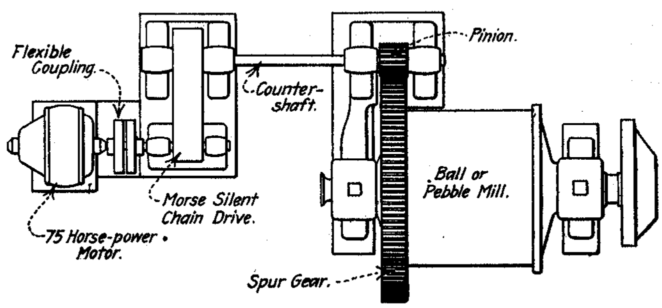
By K. FREITAG

The grinding elements in the Rochester Combined Mines Co.'s mill at Rochester, Nevada, are arranged in two units, each composed of one 6 ft. by 4 ft. 6 in. ball-mill and one 7 by 12-ft. tube-mill.

The ball-mills are fed from two cylindrical bins by apron-feeders that discharge into the centre-fed scoop-feeders mounted on the feed-trunnions. The size of the ore particles fed to the ball-mills is 1½ in. All the mills are of the overflow type employing no screens in the discharge end, but the trunnions are equipped with reverse-spiral liners. The ball-mills use forged-steel balls as a grinding medium, and the new balls fed through the central feed-opening are 5 in. The pebble-mills use flint, which is fed through the centre opening in the scoop in the same way as the balls. The ball-mill discharges its product to a duplex Dorr classifier operating in closed circuit with the pebble-mill, the pulp being ground so that 80% will pass a 200-mesh screen.

The feature of the equipment is the main-drive arrangement. Many designs of ball and tube mill-drives have been put into operation, and every known method of transmission has been employed, but nearly all have developed serious faults after a few months of continuous operation. From the early application of the long-belt drives to the later short-centre or Lenix drives, many variations of belt-drives have been applied. Of all belt-drives the long-centre straight drive has proved the best, but it requires considerable floor-space and is an obstruction where closed-circuit grinding is employed. All belt-drives involving a friction-clutch to reduce the starting torque introduce an accessory that is weak mechanically, as the strain on the clutch is extremely heavy when starting the mill from rest, even if rocking the mill is attempted.

With the introduction of closed-circuit grinding it was necessary to develop a short-centre drive. The first tried was a double-gear reduction, using a friction-clutch and constant-speed motor. Later, a chain-belt was used in place of the first-gear reduction, and finally, a single-gear reduction by means of herringbone gears. All these drives were objectionable either in the methods of application or under-rating the excessive strain on them; but the main trouble was that due consideration was not given to the end-surge which occurs in all ball and tube-mills, no matter how well they may be balanced. The bearings cannot be set close to the trunnion-collars, as clearance must be allowed for contraction and expansion




PLAN OF BALL-MILL DRIVE

of the mill-barrels. This is particularly the case with the longer tube-mills, in which the grinding temperature varies. In shorter mills, where it is possible to set a new mill with only slight clearance, the wear and tear of daily use will soon be noticeable.

It can be seen readily that this end-surge will seriously affect direct or single reduction gearing. The speed of the driving-shaft prevents it from following the jerky surge of the mill, and therefore causes excessive side wear on the driving-sprockets. In order to overcome the objectionable features embodied in the drives mentioned it was decided to eliminate them in order as they occurred. That this was accomplished has been demonstrated by the continued successful operation of the mills during the past year.

In the illustration it will be noted that the general design is identical for both ball and tube-mills. In order to secure interchangeability of parts, it was decided to build both mills as nearly alike as was possible, although the diameters were different. All trunnions and trunnion-bearings were made 24 in. diam. by 24 in. long, giving an extra large bearing-area and also providing large trunnion-openings. The trunnion-liners were made interchangeable as well as the feeders and discharge-spouts. This idea of interchangeability of parts was carried through to the motors and the entire drive arrangement. The motors were built on the same frame, thereby making all bearing-shells interchangeable. The switchboard and control apparatus were made identical with the exception, of course, of the grid-resistance.

The selection of motors to take full advantage of the desirable features of the drive was carefully investigated and it was determined finally to use motors of the Westinghouse CW type. These are phase-wound motors designed especially for good starting characteristics and high running efficiency with windings carefully braced to resist the vibrations incident to tube and ball mill-drive. A further advantage was that the Westinghouse company could supply motors of 75 and 100 hp. for the ball and tube mill-drives, respectively, built on the same frame so that all mechanical parts would be interchangeable. The ball-mills are driven by 75 hp. 585 r.p.m. 440 volt, three-phase, 60-cycle type CW motors and the tube-mills by 100 hp. motors of the same characteristics. Each motor is provided with a control panel of the Westinghouse type RF, style No. 245,374, equipped with suitable starting resistance. These RF panels are supplied with an ammeter, a primary circuit-breaker with overload trip and under-voltage release, as well as a drum-controller behind the board with a hand-wheel mounted on the face of the panel. The ammeters enable the operator to know at all times just what his mills are doing, and he is accordingly able to adjust his ball charge to get the best results. The RF control-panel has a special feature in that the operating mechanism of the motor starting-controller is interlocked mechanically with the primary circuit-breaker so that if the circuit-breaker has once tripped it cannot be closed again until the controller has been returned to the 'off' position.

On each motor-shaft is mounted a 24-in. Nordberg flexible coupling connecting the motor to a short shaft that carries the driving-sprocket for the chain-drive. This shaft is of the same diameter as the motor-shaft and is mounted in two rigid pedestal bearings supplied with ring-oiling removable bearing-sleeves interchangeable with the motor-bearings. These pedestals were furnished by the Westinghouse company. A heavy cast-iron sole-plate forms the base for the above bearings as well as for the main counter-shaft bearings, and as all bearings are provided with means for lateral adjustment, it forms a rigid base on which it is possible to maintain perfect alignment for the chain-belts.

The driving sprockets and chains for the ball-mills are as follows:

75 hp., 48-in. centres, reduction 585 to 160 r.p.m.

Driver-sprocket 21 tooth, 9¼ in. face, 10.02 in. diam., hardened steel.

Driven sprocket 77 tooth, 9¼ face, 37.03 in. diameter.

Chain, Morse type, 14.5 ft. long and 9 in. wide, 1.5 in. pitch.

The driving-sprockets and chains for the tube-mills are as follows:

100 hp., 50 in. centres, reduction 585 to 138.5 r.p.m.

Driver-sprocket 21 tooth, 12¼ in. face, 10.02 in. diam., hardened steel.

Driven-sprocket 89 tooth, 12¼ in. face, 42.75 in. diameter.

Chain, Morse type, 15.75 ft. long and 12 in. wide, 1.5 in. pitch.

Both of the above drives are enclosed in a galvanized iron case provided with hand-hole and oil-drip rings.

The main countershafts for the ball and tube-mills are $5\frac{1}{16}$ in. diam. mounted in heavy mill-type ring-oiling bearings. The two bearings next to the main pinion are mounted on a heavy cast-iron sole-plate which is tied to the main trunnion-bearing at the discharge end of the mills, ensuring perfect alignment of the main drive. The other end of the shaft, on which is mounted the driven sprocket, is carried in heavy ring-oiling bearings, similar to those on main-drive end, and mounted on the sole-plate, which also supports the bearings carrying the motor-shaft extension.

The main drives for the ball-mills are as follows:

Driving pinion cut cast-steel, 15 teeth, 3½ in. pitch, 14 in. face.

Driven gear close-grained cut semi-steel, 100 teeth, 4 in. pitch, 14 in. face.

Main drives for tube-mills are as follows:

Driving pinion cut cast-steel, 16 teeth, 4 in. pitch, 14 in. face.

Driven gear close-grained cut semi-steel, 100 teeth, 4 in. pitch, 14 in. face.

Both main-driving gears are made in halves and bolted to the end flanges of the mills in such a way that they can be easily removed or turned around, so that both faces of the teeth can be used. The speed of the 6-ft. ball-mills is 24 r.p.m. and of the 7-ft. tube-mills, 22 r.p.m.

This drive arrangement with all bearings mounted on interconnected sole-plates ensures perfect alignment of all the shafts. The employment of cut spur-gears, chain-drives, flexible couplings, and slip-ring motors is considered by the designers to be superior to any other drive arrangement for ball and tube-mills. The chains are relieved of all excessive strains and run perfectly, without the customary jerk so familiar in the old type of drives. Any undue strain or surge of the mills that is not absorbed by the cut main spur-gears and is transmitted to the chain-sprockets, due to slightly worn collars on the main shaft, does not affect the running of the chains; as this motion is not counter-acted by the motor, but is absorbed by the flexible Nordberg coupling connecting the motor with the floating motor-extension shaft.