# Ore Hoisting in the Butte District

## Part I

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In MANY mining districts future developments are uncertain. A mine or district may show either long life or prove to be a fizzle. Exceptional confidence, however, is evident in the future of the Butte district; this attitude is substantially shown in the fact that one conservative corporation has installed complete new hoisting plants designed for a depth of 5,100 ft., which is the generally accepted maximum depth of single-stage hoisting for economical operation. This trend toward deeper mining is significant, as the deepest shaft in the district at present is 4,000 ft.

New structures designed for future deep-hoisting conditions must provide for new requirements and possible changes in transportation, hoisting, and preparation of run-of-mine ore. For example, preparatory treatment plants with a gravity feed or conveyor belt system to the skip bins of the headframe may be installed in the near future. These may not only prove necessary but highly profitable. Forecasting developments in mining is at best an uncertain and difficult task that requires an intimate knowledge of existing and past conditions. Its importance in the design of steel headframes cannot be stressed too much, and can be fully realized only by men who have followed mining and witnessed the rapid growth and radical changes in some of the important mining districts. The general dimensions of a headframe can usually be determined if the method of hoisting is known; but if hoisting conditions are to be changed within the life of the structure, future developments and changes must be considered.

Three generally accepted methods of handling ore and waste through shafts are employed in the Butte district; namely, cars to cages; cars to skips; skip pockets to skips. With the exception of a few properties where buckets are employed, the cars to cages method is used almost exclusively in the smaller mines. The Anselmo, Lexington, Goldsmith, and the Orphan Girl are so equipped. Where caging is used exclusively, trips of two, three, and four decks or cages are employed, depending on the vertical clearance of the headframe. This practice is a factor influencing the height of headframes. Automatic skip dump hoisting has superseded cage hoisting at the larger properties.

Many of the mines, however, resort to the cage method to transport waste to the surface when stope filling is temporarily suspended. In the method of stope filling commonly used, waste transfer chutes open into the stopes to be filled, and a regular system of waste transfer from level to level is employed, except where enough barren development is under way to furnish the waste required for the stopes in the block below. As the amount of waste available varies and seldom is equal to the amount required in any one block, filling which is obtained from barren raises, drifts, crosscuts, shaft sinking, and underground sorting is transported from level to level within the mine to wherever it is needed. An auxiliary to the main hoists, known as the "chippy" lift or hoist and equipped with cages to handle waste, men, and supplies, provides interlevel service for these operations. Where the amount of barren rock exceeds filling requirements, the surplus is transported to the surface either in cars run onto the cages or in skips to the skip bins. Underground, waste rock is generally dumped directly into the skips from the cars. Before any waste is dumped into the skip bins, they are emptied of ore, as the waste goes directly to the dump.

In some of the mines vein mineralization may be erratic or low-grade. The expense of cutting large stations and skip pockets under such circumstances is inadvisable. In other instances, the

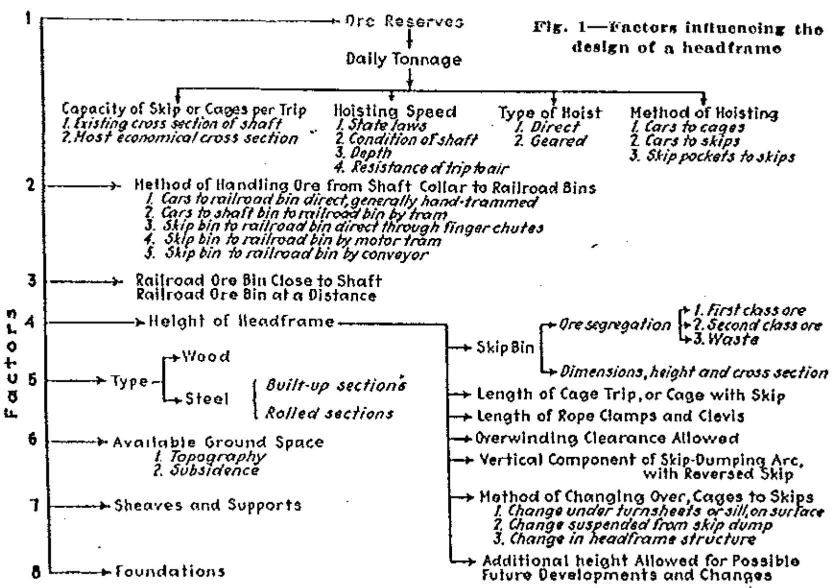



**Fig. 1—Factors influencing the design of a headframe**

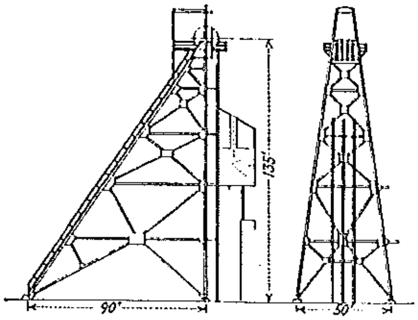


Fig. 14—The Black Rock No. 3 headframe

of the old Kimberly type. A flat hoisting rope is employed.

Fig. 14 shows the design of the Black Rock headframe erected in 1915 at No. 3 shaft. The structure is built of *H* sections, and is 135 ft. high. Sheaves are 12 ft. in diameter. The simplicity of its details is apparent.

A general drawing of the structure at the No. 4 shaft of the Pittsmont mine is shown in Fig. 15. The headframe is of the *A* type and unusually massive for its height of 50 ft. The foundation for the structure was built up with the slag from the Pittsmont smelter. Headroom beyond a low limit was not needed, as the method of hoisting employed at that time was "cars to cages." With the introduction later of automatic skip-dumping arrangements, additional headroom became necessary. Several mines avoided erecting new structures by constructing a 40-ft. level (see Fig. 17) or adit to the shaft and by putting in steel "sunken" skip bins around the shaft. Electric motor lorries, operating over a short trestle, tram the ore from the skip bins on the 40-ft. level to the loading bins.

During 1927, three of the important mines, the Mountain Consolidated, Belmont, and Badger State, were equipped with new surface plants designed for hoisting from a depth of 5,100 ft., the accepted maximum depth of single-stage hoisting. General details of these headframes are shown in Fig. 16. They are 125 ft. high from shaft collar to sheave center, and are designed for automatic skip dumping in two compartments. Their construction is of the rolled-section type, and convenience of erection was an important factor in their design. Sheaves over the main hoisting compartments are 12 ft. in diameter, and over the chippy compartment, 10 ft. in diameter. All sheaves are placed at the top of the frame. At the Badger State and Belmont, three hoisting compartments are employed, two for balanced skip hoisting, and one compartment for the chippy cage. A

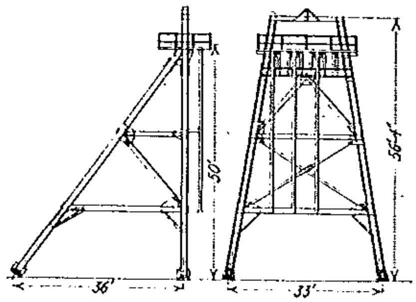


Fig. 15—Headframe at No. 4 shaft of the Pittsmont mine

fourth compartment is used for pipes and cables. At the Mountain Consolidated, five compartments are to be used: two for balanced skip hoisting, one compartment for the chippy, one for pipes and cables, and one for ventilation. Ore at these three installations is hoisted by 1⅝-in. steel ropes in automatic self-dumping skips of 7-ton capacity. The skips are suspended beneath a bonneted single-deck cage. Four-deck cages are used for man trips. Main posts or front columns are 14-in. *H* columns; and guide columns are 10-in. *H* sections. The back legs are also 14-in. *H* sections. Main struts and diagonals are rolled *H* sections.

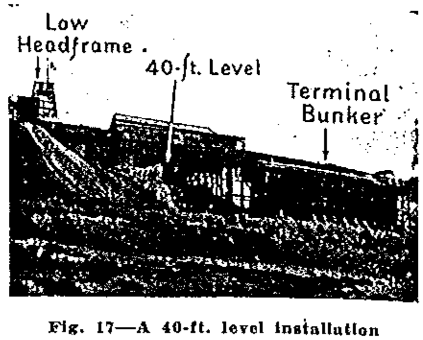



Fig. 17—A 40-ft. level installation

At the Mountain Consolidated mine (see Fig. 10), the hoist house was first placed closer to the collar of the shaft than it now is. Subsequent examination showed the first site to be unstable as a result of stoping operations. The new building was therefore erected on the brow of the hill, as shown in the figure. The position of the old hoist building is indicated by the dotted outline. In the foreground is the old engine room. Idler towers, provided with sliding idlers and a vertical adjustment, are installed in all three headframes to carry the ropes.

The year 1897 marked the first use of steel in the design of headframes in the Butte district, when the first steel structures were erected at the West Colusa shaft and the St. Lawrence mine. Since then many other steel headframes have been erected, and they are now common in the district.

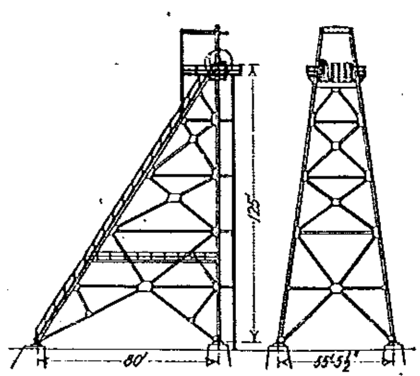


Fig. 16—General design of headframes at the Mountain Consolidated, Belmont, and Badger State shafts

The chart shown in Fig. 1 indicates most of the points considered by the designer or mine manager in planning the type of structure that will most efficiently meet operating conditions. At present nearly all of the large producing mines are equipped with steel headframes. Underground conditions that influence the design of head structures can be approximated from an article by C. M. Harrer that appeared in the July 30, 1927, issue of *Engineering and Mining Journal*.

At those properties where motor trams or lorries are used, the skip bin serves as a storage hopper. Capacity of the hopper is determined by the

### Statistics Pertaining to Headframes in the Butte District

| Shaft | Weight in Pounds Cage | Weight in Pounds Skip | Ore Capacity of Skip, Tons | Depth of Shaft, Feet | Ore Hoisting Speed, Feet per Minute | Height of Headframe, Feet | Weight of Headframe, Pounds | Diameter of Sheaves, Feet | Size and Type of Hoisting Rope |
|---|---|---|---|---|---|---|---|---|---|
| Anaconda | 4,000 | 8,500 | 5 | 2,800 | 2,200 | 58.82 | 74,700 | 10 | 7½" x ⅝", flat |
| Badger State | 4,000 | 10,500 | 7 | 3,500(a) | 2,800 | 129.5 | 256,000 | 12 | 1⅝" diam., rd. |
| Belmont | 4,000 | 10,500 | 7 | 3,400(a) | 2,600 | 129.5 | 256,000 | 12 | 1⅝" diam., rd. |
| Belmont (old) | 3,800 | 8,900 | 5 | 3,400 | 2,250 | 114 | Timber | 10 | 7½" x ⅝", flat |
| Berkely | 3,900 | 8,500 | 5 | 3,200 | 2,600 | 80 | Timber | 10 | 1½" diam., rd. |
| Black Rock No. 1 | 3,800 | 10,000 | 10 | 2,800 | 2,600 | 152 | 250,000 | 10 | 1½" diam., rd. |
| Black Rock No. 3 | 3,800 | 10,000 | 10 | 2,800 | 2,600 | 152 | 250,000 | 10 | 1½" diam., rd. |
| Diamond | 3,850 | 8,960 | 5 | 3,400 | 2,800 | 100 | 318,000 | 10 | 6" x ⅝", flat |
| Elm Orlu | 4,000 | 10,000 | 7 | 3,300 | 2,600 | 94 | 65,000 | 10 | 6" x ⅝", flat |
| High Ore | 3,850 | 8,960 | 5 | 3,400 | 2,600 | 100 | 292,000 | 10 | 6" x ⅝", flat |
| Leonard | 3,800 | 8,500 | 5 | 2,800 | 3,000 | 141 | 346,425 | 12 | 1⅝" diam., rd |
| Mountain Con. | 4,000 | 10,500 | 7 | 3,600(a) | 2,800 | 129 5 | 256,000 | 12 | 1⅝" diam., rd. |
| Mountain Con. (old) | 3,850 | 8,900 | 5 | 3,500 | 1,000 | 100 | Timber | 10 | 1½" diam., rd. |
| Mountain View | 4,000 | 11,000 | 5 | 2,600 | 2,200 | 80 | 183,000 | 7½ | 7" x ⅝", flat |
| Never Sweat | 3,200 | 5,700 | 3½ | 2,800 | 2,600 | 100 | 315,000 | 10 | 1½" diam., rd. |
| Original | 3,900 | 7,800 | 4 | 3,800 | 2,600 | 112 | 318,000 | 10 | 1½" diam., rd. |
| Orphan Girl | 3,050 | No skips | .. | 1,000 | 1,500 | 70 | 79,000 | 7 | 1" diam., rd. |
| Pennsylvania | 3,500 | 8,500 | 5 | 3,400 | 2,800 | 100 | 315,000 | 12 | 1½" diam., rd. |
| Pittsmont | 1,250 | 3,875 | 5 | 1,600 | 2,600 | 58.5 | 41,500 | 8 | 6" x ½", flat |
| St. Lawrence | 3,900 | 7,000 | 7 | 2,100 | 1,000 | 97 | 117,000 | 10 | 7" x ½", flat |
| Speculator | 2,100 | 11,000 | 5 | 2,800 | 2,200 | 50 | 42,200 | 10 | 1½" diam., rd. |
| Stewart | 3,800 | 8,500 | 5 | 3,800 | 2,800 | 100 | 292,000 | 10 | 1½" diam., rd. |
| Tramway | 3,850 | 8,500 | 5 | 2,800 | 2,800 | 100 | 315,000 | 12 | 1½" diam., rd |
| West Colusa | 3,500 / 2,200 | No skips | .. | 2,200 | 2,800 | 50 | 43,000 | 10 | 4" x ½", flat |

(a) Hoisting installation designed for depth of 5,100 ft.

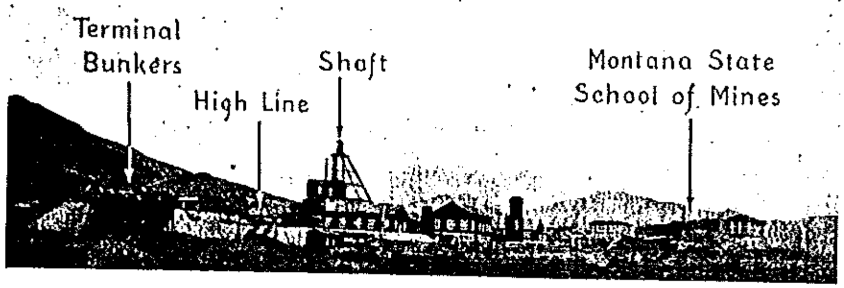
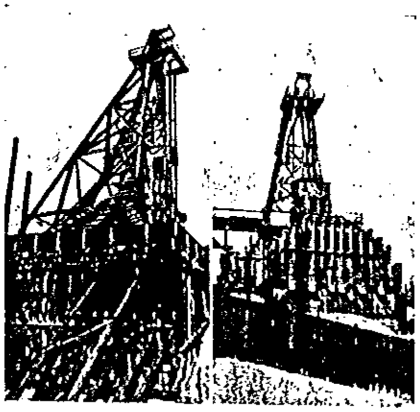



**Fig. 2—The Orphan Girl mine**

ground may be heavy and difficult to support over large excavations. The method of hoisting ore under such conditions will therefore be the cars-to-skips method. The contents of the loaded cars on the various levels are dumped directly into the skips, which are spotted about 6 in. above the level of the turnsheets. This does not necessarily imply that the whole mine is thus served. Only certain levels are operated in this manner, others being equipped with skip pockets. Where ore reserves can be fairly closely estimated, and where they indicate the advisability of a skip pocket, the ground permitting, large stations with skip pockets under the station sills are driven off the shaft when opening new levels.

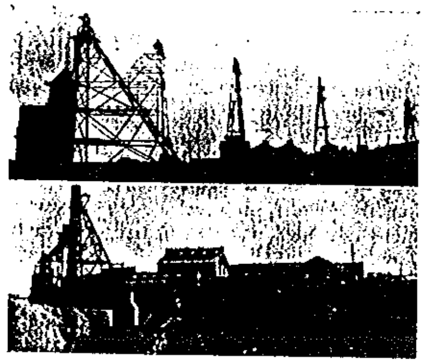
Hoisting details are therefore dependent upon underground conditions and operations, such as the extent and continuity of the orebody, the method of opening up levels, the mining method, and the transportation of ore to the shaft stations. The grades and size of orebodies are considered in relation to market conditions in determining the daily tonnage rating of the mine and the planning of operations.

Methods of transporting the ore from the collar of the shaft to the loading bins are listed in the chart, shown in Fig. 1. Hand tramming car directly to terminal bins presupposes a sharp relief in topography, such that the top of the loading bin will be approximately on a level with the collar of the shaft.



**Figs. 3 and 4—The Never Sweat and Original headframes. The latter is to the right.**

This method is used at only a few small mines, leases, and prospects, but was extensively employed in the early days when low headframes were in vogue and tonnages were comparatively small. A variation of the method that is used at several properties consists of a headframe of medium height and a "high-line" or trestle that connects the headframe with the loading bins or railroad cars. At the Anselmo mine no terminal bunkers are used, the contents of the loaded cars being dumped directly into railroad cars from a tipple arrangement on the "high-line." All of the early wooden headframes, with the exception



**Figs. 5 and 6—The Granite Mountain headframe is seen above. Below is the surface plant at the Speculator shaft.**

of the old timber structure at the Belmont mine, were built to conform to surface hand-tramming methods. Many were subsequently partly or entirely reconstructed to adapt them to automatic skip dumping.

Where the distance from the hoisting plant to the loading bins is excessively long, an intermediate bin or hopper is built at the hoisting plant. Ascending (loaded) trips of cars (in cages) are emptied into the bin or hopper by hand. Special trammers load from this bin and tram to the loading bin. At present electric motor lorries are usually employed in this work. This method is exemplified at the Orphan Girl mine, west of the Montana State School of Mines, at Butte. A general view of this property, showing terminal bunkers and "high-line," is presented in Fig. 2.

The older proven properties of the large operating companies have standardized their equipment to provide ore discharge from the skip bin to the loading bin through chutes or by a motor tram from skip bin to railroad loading bin, the general topography determining the choice of either arrangement. The increase of daily tonnages to their present proportions necessitated the installation of automatic skip-dump hoisting arrangements, which have been developed almost to the exclusion of other methods. Transfer from skip bin to railroad bin by chutes is exemplified at the Never Sweat, Original, Speculator, and Granite Mountain properties, which are shown in Figs. 3, 4, 5, and 6. Only two dis-

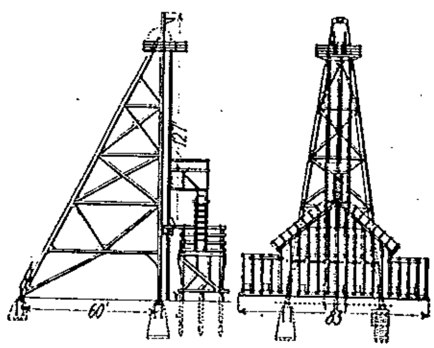


**Fig. 7—General design of the Original headframe**

tributing chutes are used in the Speculator and Original installations, which are so nearly alike that a description of one will suffice for both.

General details of the headframe structure at the Original property are shown in Fig. 7. The steel headframe, which was erected in 1902, is of the built-up section type and designed for automatic skip dumping. From the skip, the ore passes down the "throat" through two chutes or fingers, and thence into two loading bins, each having a storage capacity of 100 tons. Chutes are lined with heavy plates. The headframe is 127 ft. high from the collar to the sheave center, and is a distinct variation from the sill type of structure. The present depth of the mine is 4,000 ft., the deepest in the camp. Weight of a cage is 3,900 lb.—four cages to the trip. The skip is suspended

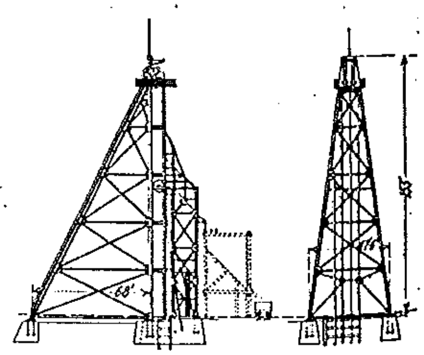
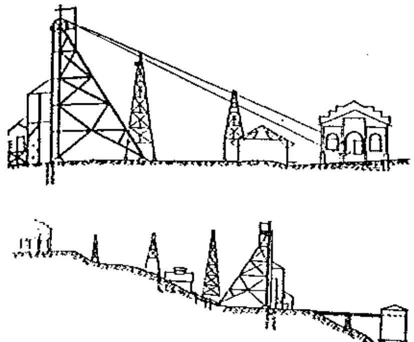


**Fig. 8—Headframe at the Leonard No. 1 shaft**



Figs. 9 and 10—Sketch of the new Belmont installation is seen above. Below is a profile of the new Mountain Consolidated surface plant.

under a bonneted cage. The weight of the skip empty is 7,800 lb. Ten-foot sheaves are used over the main hoisting compartments, with 1½-in. ropes. Skips are hoisted in balance. The Speculator headframe is situated uphill above the loading bins, which difference of elevation permits a correspondingly smaller structure, 50 ft. in height. Seven-foot sheaves are used, with flat cable. Only one loading bin is available, and the chutes empty into either end of it. Deflectors are sometimes introduced to spread the ore uniformly.

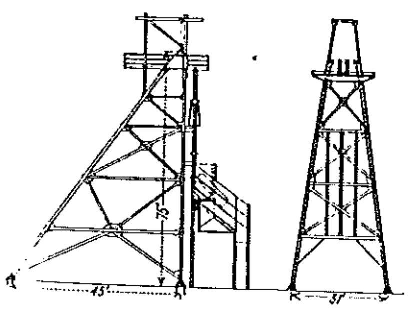



Fig. 11—Details of the Elm Orlu surface plant

The headframe at the Leonard No. 1 shaft, at Meaderville, is of special interest in that the collar of the shaft and the sill of the loading bin are on the same level. This necessitated an unusually high structure to provide gravity flow from the skip dump through chutes and by distributing lorry to the loading bin. Fig. 8 shows the design of this structure, which is the highest erected in the district, being 141 ft. from shaft collar to center of sheaves and 152 ft. over all. The frame was built by the American Bridge Company in the heyday of the Boston & Montana Company in 1905. The mine is served through a four-compartment shaft, two compartments of which are used for balanced skip hoisting, one compartment of which is used for chippy cages, and the fourth for heavy pump-column pipes, power cables, and compressed-air lines.

Operations at the mine have reached a depth of 2,800 ft. Ore is hoisted in 5-ton skips of the Kimberly type, suspended beneath a cage. The weight of the skips is about 8,500 lb.; ore load varies between 10,000 and 10,700 lb. Four-deck cages are used for hoisting men, eight men being hoisted on each deck. A 1½-in. round hoisting rope is used in the skip compartments. Present rate of hoisting is about 3,000 ft. per minute. Twelve-foot sheaves set 5 ft. 10 in. on centers are used over the main hoisting compartments. The chippy sheave, which is 6 ft. 9 in. in diameter, is set 75 ft. above the collar of the shaft on tie girders to the skip bin. The two skip bins have a capacity of 75 tons each. From the skip bins, the ore passes through chutes to the railroad loading bin, which has a capacity of 1,500 tons and is fireproofed on the exterior with gunite. The headframe is made of built-up sections. Many engineers, however, now prefer the use of rolled members in headframe construction.

The front posts are built up of two 12-in. channels, with 16-in. cover plates, 5/16 and ¼ in. thick, laced on the inner side. Construction of the two lower panels in the plane of the back legs consists of 12-in. channels, with a 16-in. cover plate ⅜ in. thick. The third section is made up of two 12-in. channels, with a 16x5/16-in. cover plate; the upper two sections are of 12-in. channels, laced on both sides. Main struts and diagonal braces are constructed of two channels with top and bottom battens, and guide columns are made of two 12-in. channels. Skip bins are supported on columns constructed of two 10-in. channels, laced on both sides. Total shipping weight of the headframe was 346,425 lb. All sway brace members in the first bent plane converge toward the center of the structure. This practice has been discontinued so that the lowering or hoisting of sheaves within the headframe may be facilitated. Formerly, sheaves were hoisted outside the structure. Another feature that has also been discarded is the "tied-in sill." The Leonard No. 1 headframe was designed for a depth of 3,500 ft., but at 2,800 ft., the present depth, it vibrates during hoisting operations.

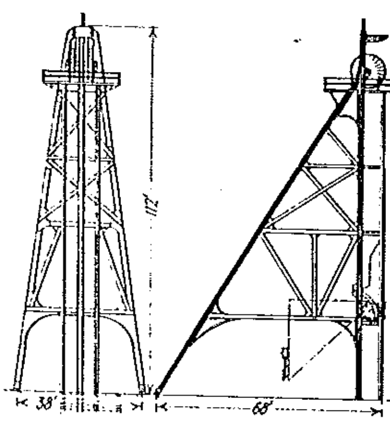



Fig. 12—Headframe structure at the High Ore shaft

An elevation drawing of the new Belmont installation is shown in Fig. 9, and the profile of the new Mountain Consolidated surface plant in Fig. 10. Both installations exemplify design based on motor transportation between skip pockets and loading bins. The Belmont has the longest lorry haul in the district. At the Mountain Consolidated a cylindrical steel loading bin has been installed. The general design of the Elm Orlu headframe, which was erected

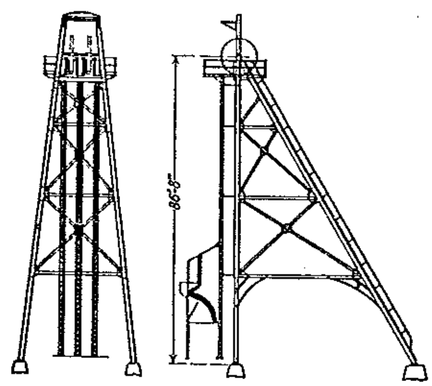



Fig. 13—General design of the Black Rock No. 1 headframe

in 1912, is shown in Fig. 11. In 1915, when the headframe was moved to a new position, two additional back legs were added to bring the resultant well within the 75-ft. structure. In Fig. 12 is shown the design of the headframes at the High Ore, Diamond, Never Sweat, and Tramway mines, all of which are identical. The structures are of heavy construction, and 100 ft. high from shaft collar to sheave center. They are of the built-up section type. In the Diamond and Tramway structures, skip dump and bins are in front of the forelegs, whereas at the Never Sweat and High Ore mines they are built within the head structure and the skips dump inward instead of outward. At the High Ore mine the ore is transported from the skip bins to the loading bin by motor lorry, and at the Never Sweat three-finger chutes extend from a common throat to the first ore bin; the other bins are filled by motor lorry.

The two steel structures of the Butte & Superior company were adapted to a variation from any other pre-existing method of transportation between collar of shaft and loading bins. The skip bins discharge into cylindrical steel bins, which in turn discharge onto a conveyor belt that passes through a picking plant and discharges into loading bins. In 1912, the first steel headframe, shown in Fig. 13, was erected at the Black Rock No. 1 shaft. It was designed for a skip dumping outward, leaving the space within the structure open, and is of the built-up section type, 86 ft. 8 in. from shaft collar to sheave center. Sheaves 9 ft. 10 in. in diameter are used over the main hoisting compartments. The skip dump is an adaption