THE HEAD FRAMES Of SHAFTS AT CRIPPLE CREEK.

BY ALEXANDER FORSYTH.

In the Cripple Creek District one is impressed with the variation in design, and evidently in cost, of the so-called "gallows frames." This difference is clearly not proportionate to the hoisting requirements.

The problem before the engineer is to construct (i) a firm and strong support for the sheaves carrying the cables from the buckets or cages to the hoisting engine, (2) to provide for the convenient discharge and loading of buckets or cages, (3) to provide for their guidance while in motion, (4) to support separate sheaves for lowering or hoisting in the manway compartment, (5) to fit the design to special surrounding conditions, (6) to make the structure durable, (7) to reduce the cost as much as is consistent with satisfying the other requirements. The discussion is limited to frames for vertical shafts, as the writer is not aware of any important inclined shafts in the Cripple Creek District.

i. In order to produce a firm and strong support for the sheaves, the frame must resist the pressure due to the weight of the load as distributed along the inclined and vertical portions of the cable, and it must resist tendencies to twist, rack and spring, occurring either while the load is in motion or when it is at rest.

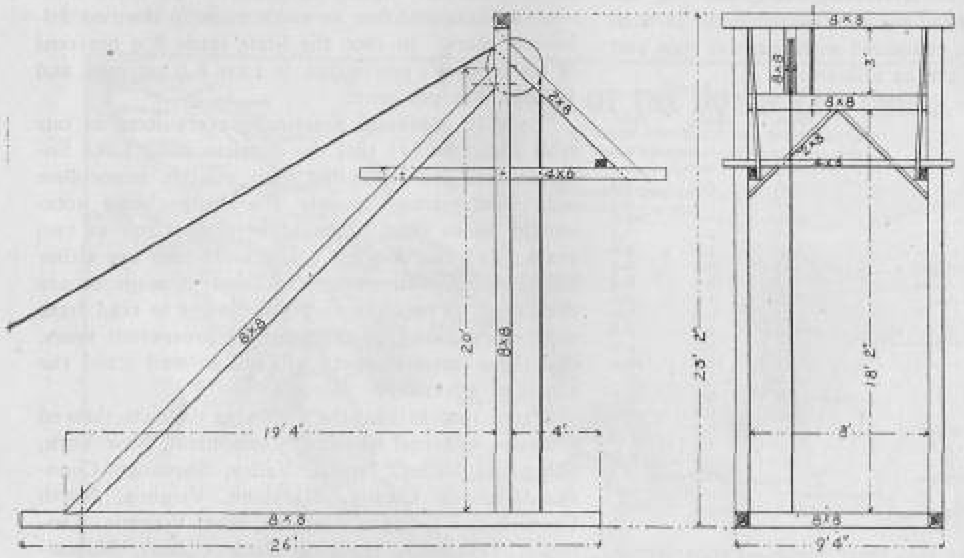


FIG. 2.—SMALL TWO-POST FRAME.

The resultant of the weight of the load into the vertical and inclined portions of the cable obviously tends to tip the frame *toward* the engine. This tendency is met by placing braces, characteristic of all the frames here described, from near the top of the frame to a point somewhere between the shaft and the engine. The question at once arises, What is the proper position for these braces with reference to the angle between the inclined and vertical portions of the cable?

In the Cripple Creek region the braces may be observed to occupy all positions between that of a bisector of the angle and that of a line parallel to the inclined side. The resultant force due to the load plainly bisects this angle. Now, if the brace bisects the same angle, it takes the whole of this resultant. If the resultant comes between the brace and the vertical portions of the frame, part of the resultant is borne by the brace and part by the vertical portion. This the writer regards as the proper design. And the brace should come well back toward a position parallel to the inclined part of the. cable. The weight of the sheaves and upper part of the frame and the lean of the braces all produce strain upon the rear posts, but not enough to relieve them from bearing a proper share of the load-resultant. In some frames, as, for example, in those of the four-post-derrick type, Figs. 9 and 10, the rear posts, as well as the braces, are set at a batter toward the engine. In this way the load-resultant is distributed properly between the brace and the post with the use of a shorter brace and sill, though with a longer post than would be necessary in the case of a vertical rear post.

To illustrate the above, let A B C, Fig. i, be the given cable angle; B O, the load-resultant; D E, the position of brace parallel to cable A B; F E, a vertical rear post; H E, an inclined rear post, and K E, the position of the brace to suit the use of an inclined rear post. Frequently, as in the diagram and Figs. 2, 3, 8, 9 and 10, the point E, which is the point of junction of rear post and brace, does not come into the line of the load-resultant on account of the position of the sheave. In this case there is a turning tendency which may be regarded as occurring about the point E. This turning tendency is met in four post frames, Figs. 9 and 10, by the forward posts: in the diagram, R S for a vertical post, and R T for an inclined post and also by the stiffness of the frame; in the two-post frames it is opposed by the stiffness of the frame alone. Thus, in designing a frame, braces and sheaves must be so placed as to give to braces and posts each its share of the load-resultant. Sheaves should be placed so as to equalize twisting tendencies as far as possible and to give each side of the frame an equal strain.

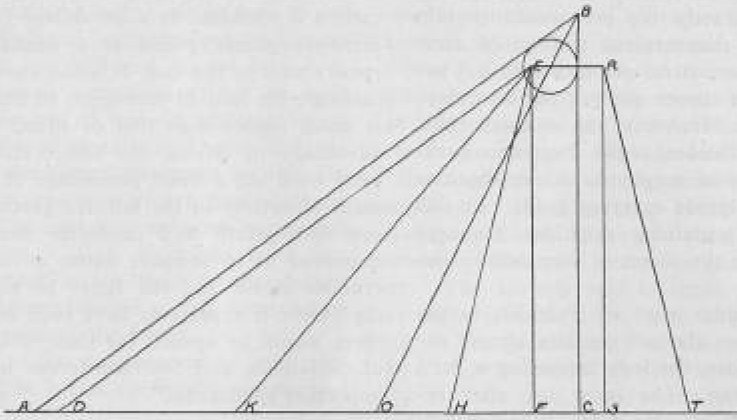


FIG. 1.—DIAGRAM OF LOAD DISTRIBUTION.

Almost without exception in the smaller Cripple Creek frames (Figs. 2 and 3), and in many of the larger ones (Figs. 4, 5, 7 and 10), the sheaves are placed nearer one side than the other, thus all the members of one side are subjected to more strain than those of the other, and the whole frame suffers more torsion than if the sheaves were placed symmetrically with reference to the sides. The writer has observed only two or three frames of the type represented by Figs. 2 and 3, with sheaves mounted in the centers. The purpose in mounting sheaves on the side seems to be to fit the small frames conveniently over the two-compartment shafts. In these small shafts a sheave is rarely used for hoisting in the ladder compartment. In larger frames (Figs. 4, 5, 7 and 10) the main hoisting sheaves are placed on one side to allow space for a pipe compartment sheave.

Besides strains, due to the load-resultant, a frame is subject to complex racking and springing from the moving load and must be proof against such accidents as catching of the cage in the shaft. There are swaying tendencies, lengthways and sideways, which are resisted by the main braces and batter of the posts, while special braces are sometimes employed to resist side swaying as in the Elkton design, Fig. 6.

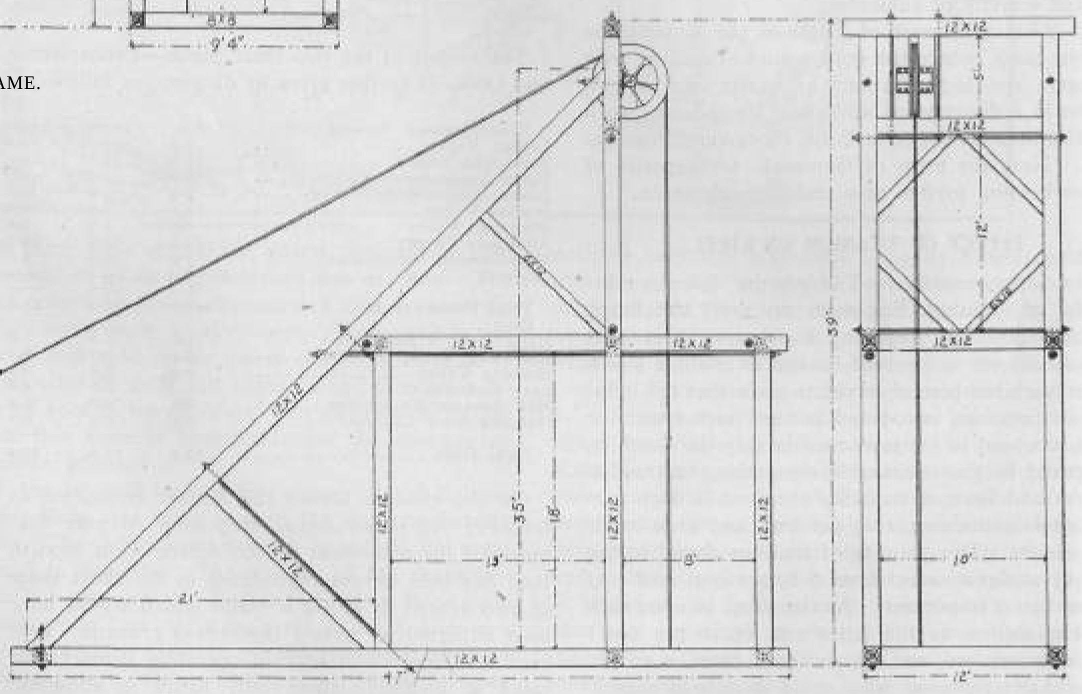


FIG. 3.—MINT FRAME.

The stiffening of the main braces and posts, and of the frame as a whole, should be most effective with the least expenditure of material and labor.

2. The writer's second division of the problem refers to the discharge and loading of buckets and

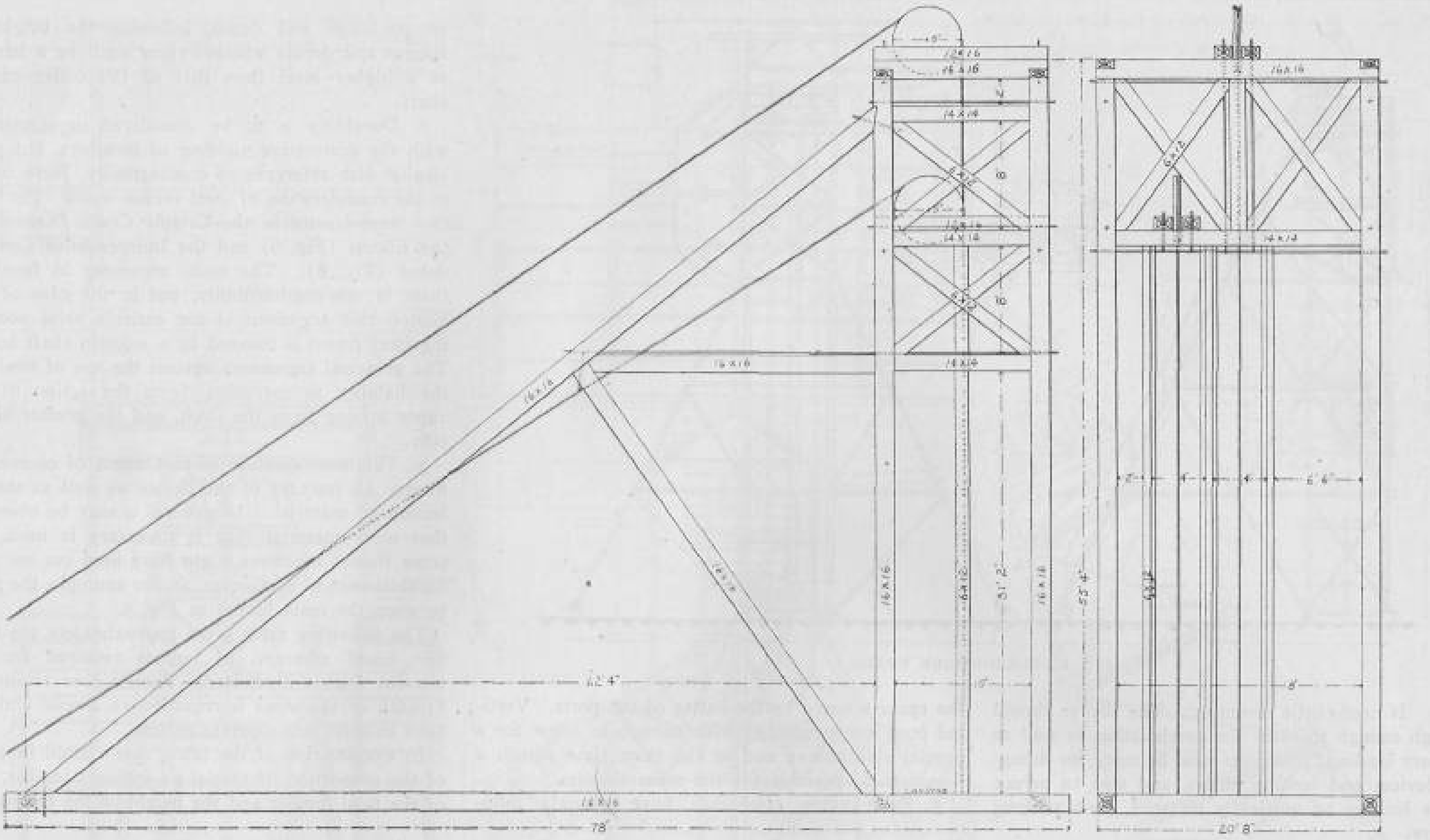


FIG. 4.—ANCHORIA-LELAND FRAME.

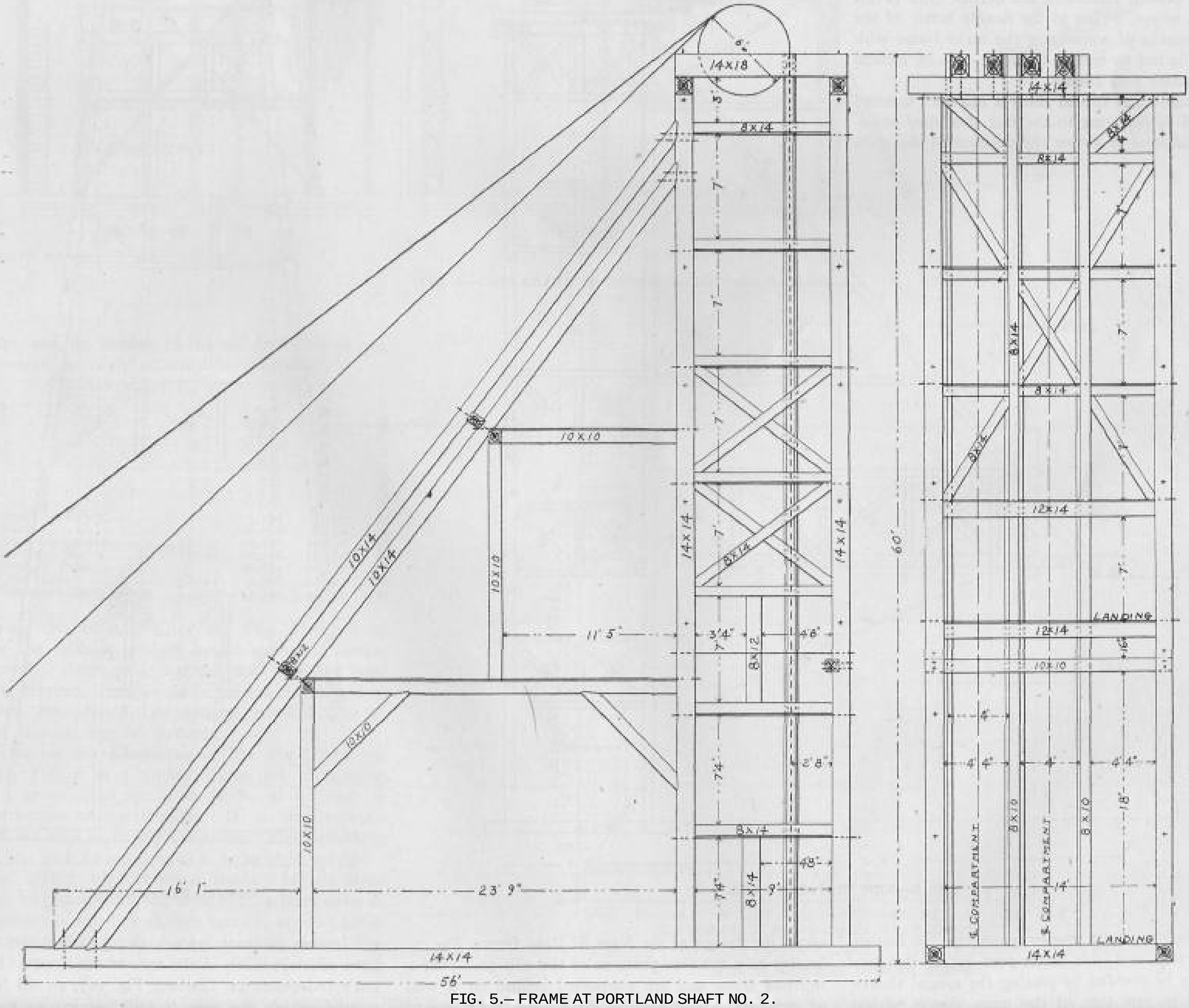


FIG. 5.— FRAME AT PORTLAND SHAFT NO. 2.

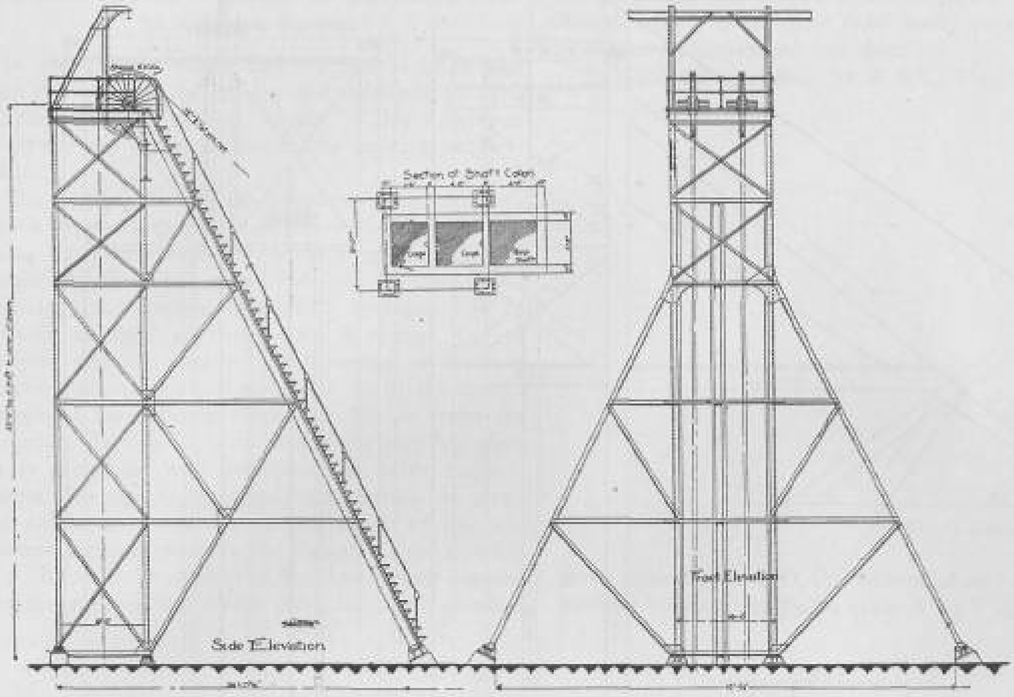


FIG. 6.—ELKTON IRON FRAME.

cages. It needs little comment. The sheave should be high enough to allow for overhoisting as well as ordinary landing; provision must be made for dumping devices and landing chairs, and also to permit of the loading of unwieldy material, such as long timbers.

3. The attachments of guides needs special attention in the case of frames of the derrick type (Figs. 9 and 10), where, owing to the double batter of the posts, the means of connecting the main frame with the guides is not so simple as in the case of vertical or single batter post frames.

4. The subject of special sheaves has been touched upon above in referring to the fact that they sometimes are allowed to throw the position of the main hoisting sheaves out of proper symmetry. In frames of the derrick and side-batter-post types, this objection may be avoided by placing the special sheave below and to one side of the main sheave within the space allowed by the batter of the posts. Vertical post frames are not wide enough to allow for a special side sheave and at the same time permit a symmetrical position for the main sheaves.

5. Surrounding conditions have strongly influenced the design of the New El Paso frame, Fig. 7. In this case the rear portions of the sills pass over a railroad track and are supported behind on a wall of masonry. Surrounding conditions, with regard to ore-house and dump, influence the height of frames and decide whether there shall be a landing at a higher level than that of the collar of the shaft.

6. Durability is to be considered in connection with the destructive yielding of members, but principally with reference to combustibilty. Here comes in the consideration of steel versus wood. The only two steel frames in the Cripple Creek District are the Elkton (Fig. 6) and the Independence Consolidated (Fig. 8). The main argument in favor of them is non-combustibility, but in the case of the Elkton this argument is not entirely valid because the steel frame is covered by a wooden shaft house. The principal arguments against the use of steel are the liability to corrosion, from the action of the vapor arising from the shaft, and the greater initial cost.

7. This consideration of cost must, of course, influence all features of the design as well as the selection of material. In general it may be observed that more material than is necessary is used. In some frames members might have been cut out with no detriment to usefulness, as, for example, the girth between the main braces in Fig. 5.

The following table gives approximately the total feet, board measure, of lumber required for the wooden frames illustrated. Timber over 12 ins. in breadth or thickness is regarded as *special* and has been entered in a separate column.

In examination of the table, note should be taken of the proportion of *special* to *ordinary* lumber, also of the total lumber and the height of the frame. In the lumber estimate, guides and guide-timbers have been omitted, since, in the case of one frame (Stratton's Independence, Limited, Fig. 10), an old frame, around which the new is built, serves to support

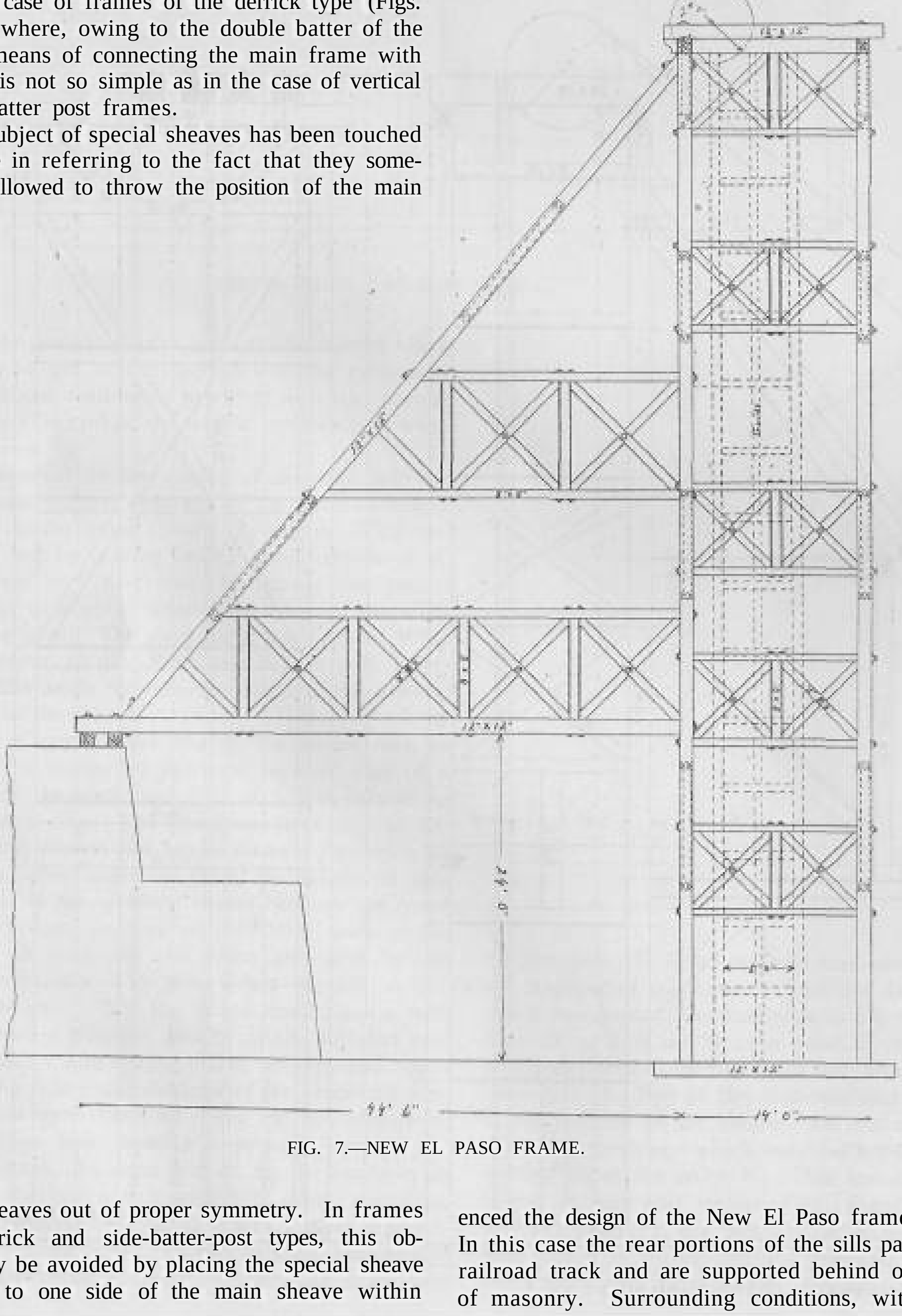
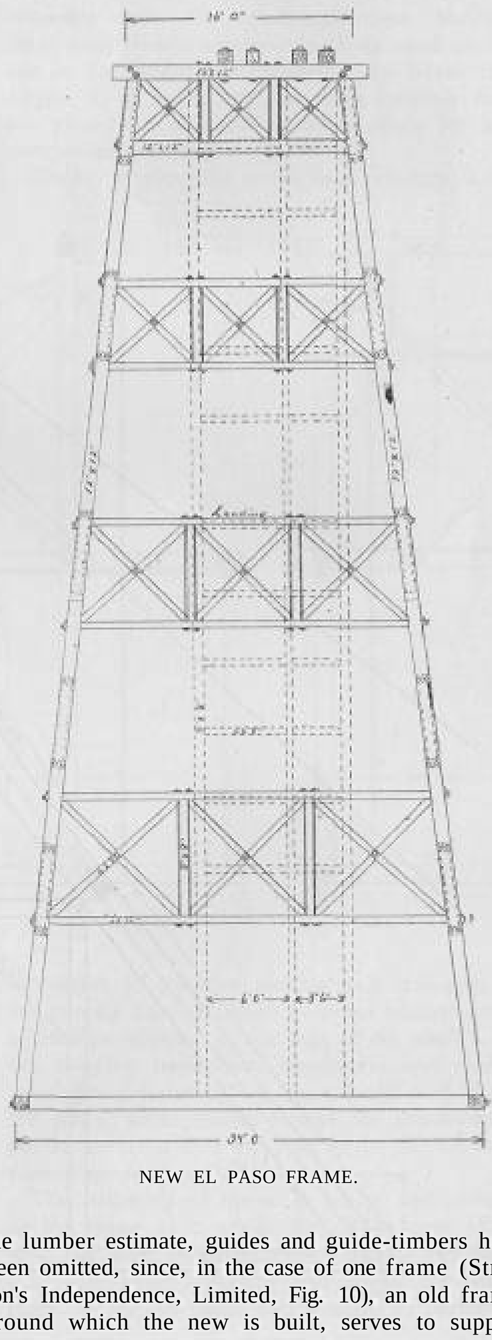


FIG. 7.—NEW EL PASO FRAME.



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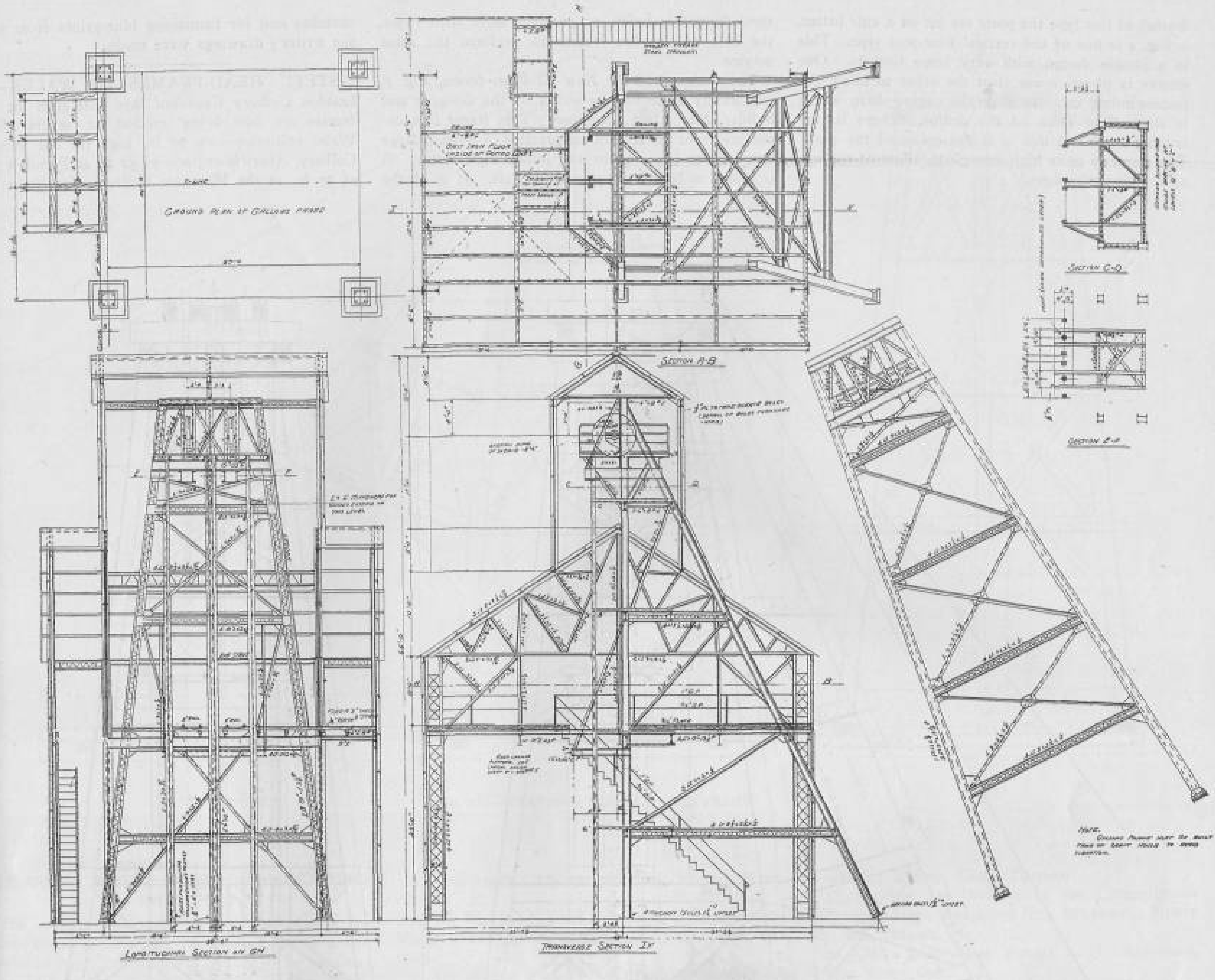

FIG. 8.—IRON FRAME OF INDEPENDENCE CONSOLIDATED.

guides, and the lumber of the old frame could not, of course, be fairly admitted in the table.

Figure.	Name.	Feet B. M. of sizes over 12 x12.	Feet B. M. of sizes under and including 12 x12.	Total feet B. M.	Height in feet.
2	Small Two-Post		1,190	1,190	23
3	Mint		6,752	6,752	39
4	Anchoria-Leland	19,294	1,248	20,542	55
5	Portland No. 2	15,796	1,786	17.582	60
7	New El Paso		20,857	20,857	76
9	Gold Coin	18,164	4,928	23,092	66
10	Stratton's Ind'p'nd'nce	14,221	7,702	21,923	53

From this table, Fig. II has been prepared, to show the relation between height and total lumber required. From this diagram not only the relations between lumber and height in individual frames, but also a fair general relation between these factors, may be deduced.

Notes on the Illustrations.—The small two-post frame, Fig. 2, is a typical frame for prospecting shafts up to about 300 ft. in depth. It is simple in construction, and serviceable. It is usually mortised, but may be simply toe-nailed. The writer has seen one with no mortises in it doing good service.

Fig. 3 is a large two-post frame. In one sense It may be regarded as four-post, but the front posts do not go to the top, though they serve to support firmly the cross timber for the bucket dumping chain. The main batter braces are well stiffened. In some

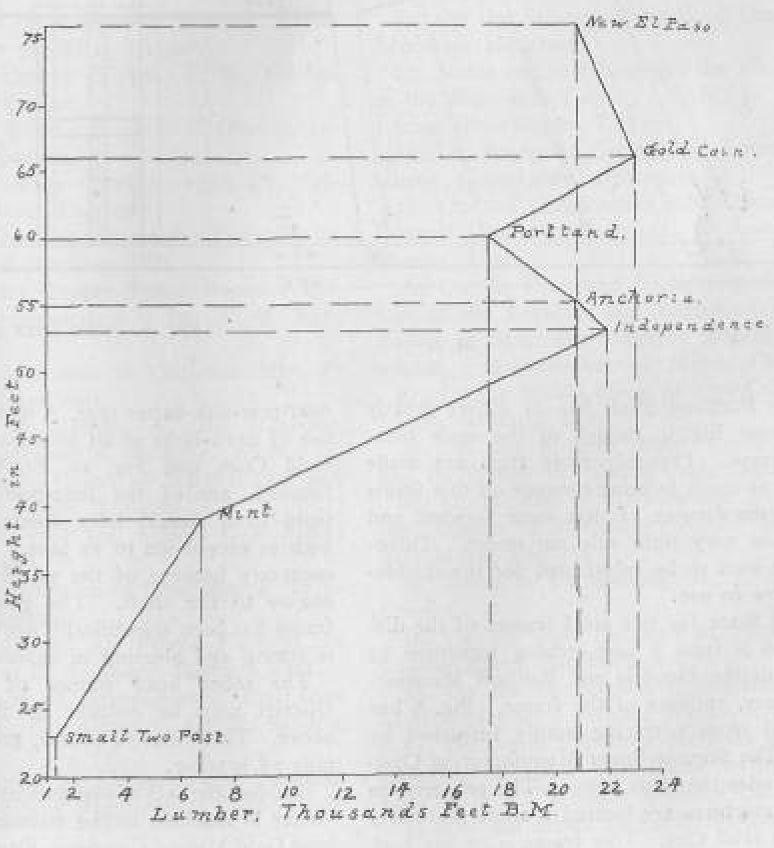

FIG. 11.—HEIGHT LUMBER CURVE.

frames of this type the posts are set on a side batter.

Fig. 4 is one of the vertical four-post type. This is a simple design with very large timbers. One sheave is placed lower than the other to allow the underwinding cable to clear the engine-shaft, which is situated in front of the drums. There is one landing level and this is at the collar of the shaft. The frame is quite high enough to allow of the use of double-deck cages.

Fig. 5 (the Portland Shaft No. 2) differs greatly in bracing from Fig. 4, though of the same four-vertical-post type. Probably more trips are made per shift and as much hoisting tonnage on this frame as on any in the district. It has some forward and back sway, but very little side movement. Three-ton skips are soon to be substituted for the double-deck cages now in use.

Figs. 6 and 8 are the two steel frames of the district. Fig. 6 is from a zinc etching furnished by the courtesy of the Hendrie and Bolthoff Manufacturing Company, builders of the frame. Fig. 8 has been prepared from a tracing kindly furnished by the builders, The Stearns-Roger Manufacturing Company. It includes the shaft house. The property on which these structures are located is more familiarly known as the Hull City. This frame is of the high two-post type with side batter. The cost of these steel frames is twice, or possibly more than twice, the cost of wooden frames to perform the same service.

The drawing of the New El Paso frame, Fig. 7, was kindly made for the writer by the designer and builder, Mr. A. A. Rummel. This frame is a departure from the traditional practice of putting large size lumber (over 12 by 12) into a high frame. It is about to be put to a working test. It is of the four-post-side-batter type. A distinctive feature is the use of draw-bolts in all principal joints. Fig. 9, the Gold Coin, and Fig. 10, Stratton's Independence, Limited, are of the four-post-derrick type. The Gold Coin should have special mention as being high in proportion to its base. This proportion was necessary because of the proximity of the hoisting engine to the shaft. The general design of this frame has been scientifically worked out. The frame is strong and pleasing in appearance.

The other head frames of the Cripple Creek District may be reduced to the types illustrated above. There are, of course, great variations in details of bracing.

Besides the acknowledgments already given, the writer is indebted to the managements of the Portland Gold Mining Company, Stratton's Independence, Limited, and the Gold Coin for permission to make sketches and for furnishing blue-prints from which the writer's drawings were made.

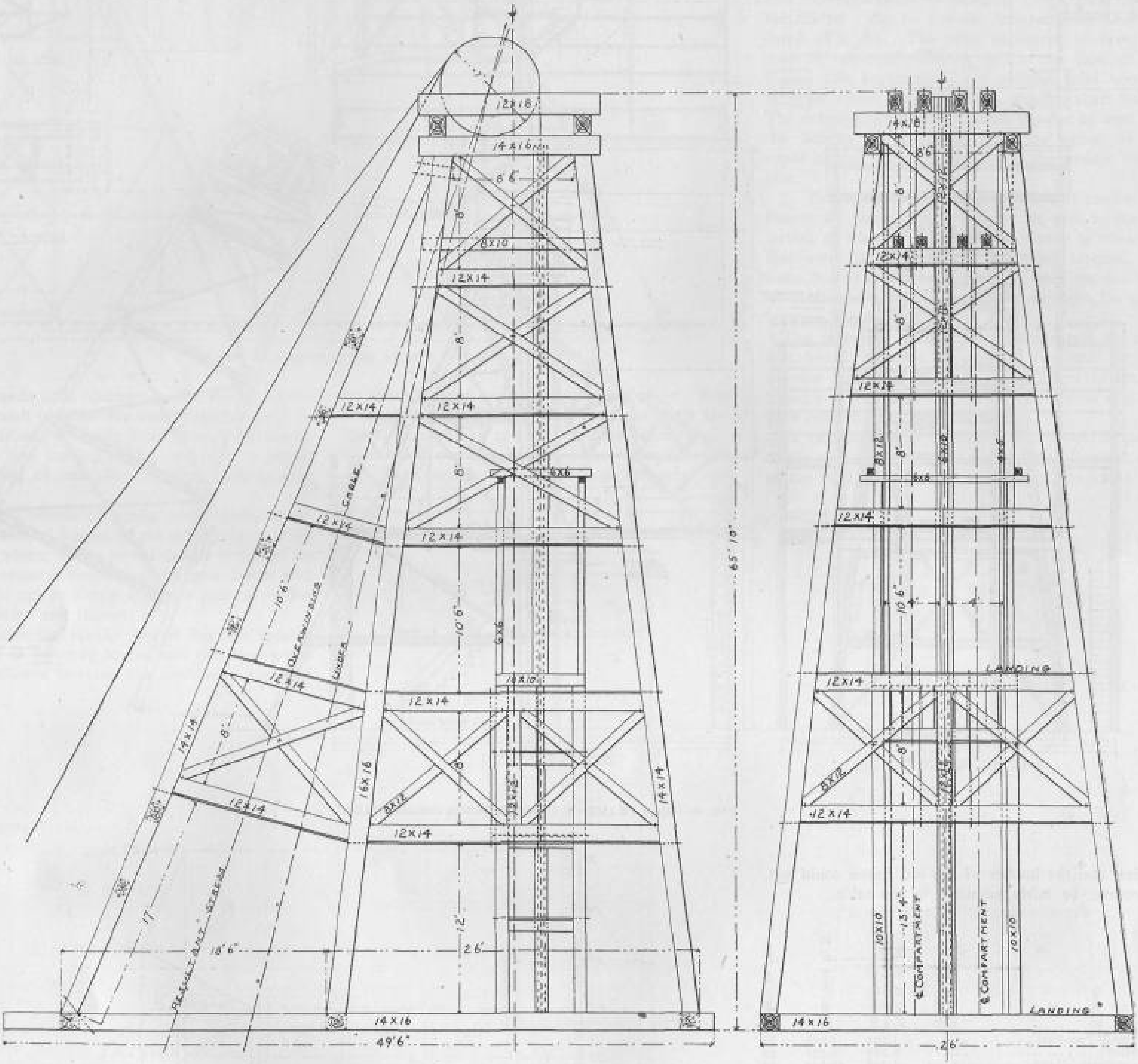

FIG. 9.—GOLD COIN FRAME.

STEEL HEAD-FRAMES IN WALES.—The London *Colliery Guardian* says that steel pit head frames are now being erected at several South Wales collieries—one 70 ft. high for the Windsor Colliery, Abertridwr; one of 52 ft. at Ferndale; one of 50 ft. at the Mountain Colliery, Gorseinon; and one of 45 ft. at the Rhymney Iron Company's Pengam Colliery.

MINERAL IMPORTS AND EXPORTS OF SPAIN.—Imports of fuel into Spain for the year ending December 31 were 2,136,818 tons of coal and 171,878 tons of coke. Exports of minerals for the year are reported by the *Revista Minera* as follows, in metric tons:

	1901.	1902.	Changes.
Iron ore	6,893,863	7,546,512	I. 552,649
Copper ore	1,006,669	932,775	D. 73,894
Zinc ore	75,755	95,705	I. 19,950
Lead ore	3,105	2,685	D. 420
Pyrites	404,815	473,648	I. 68,833
Salt	303,410	278,046	D. 25,364

Exports of metals included 31,525 tons of pig iron, against 43,078 tons in 1901; 21,734 tons copper, against 28,118 tons; 1,788 tons spelter, against 2,101 tons; 170,987 tons lead, against 148,492 tons in 1901.

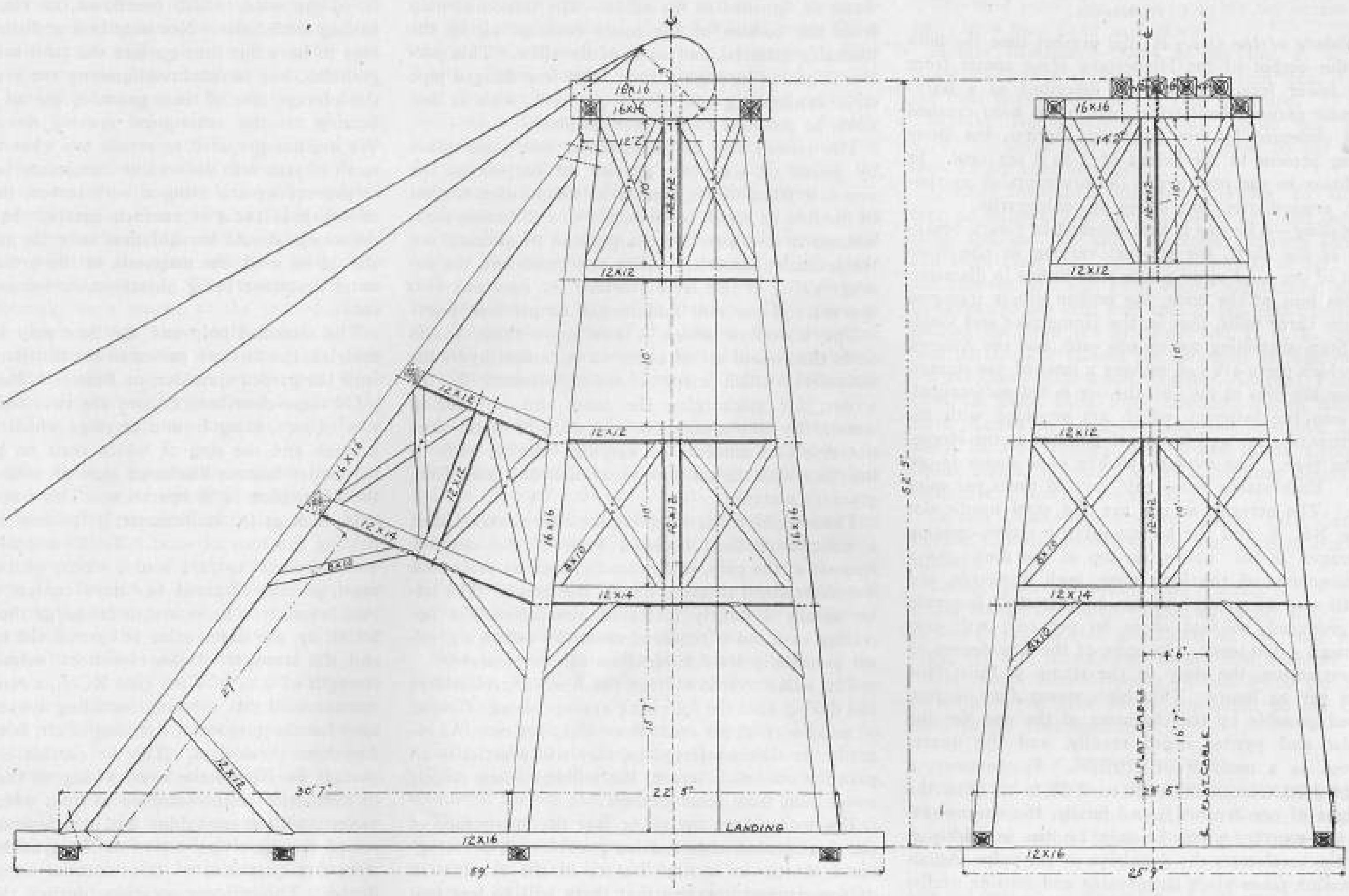

FIG. 10.—STRATTON'S INDEPENDENCE FRAME.