MINING PRACTICES AND SAFETY AT THE LAVA CAP GOLD MINING CORPORATION MINES NEVADA CITY-GRASS VALLEY DISTRICT, CALIFORNIA

By
S. H. ASH

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MINING PRACTICES AND SAFETY AT THE LAVA CAP GOLD
MINING CORPORATION MINES, NEVADA CITY-GRASS
VALLEY DISTRICT, CALIFORNIA

By S. H. Ash

INTRODUCTION

Increase in number of operations and activity in lode-gold mining at hundreds of small mines has emphasized the importance of safety work in recent years. Mine operators and the public will realize the importance of the safety phase of gold mining when they are confronted with the fact that accident rates and costs have been consistently higher at the dry- and siliceous-ore lode-gold mines in the United States than in any other branch of the mineral industry, including anthracite mines. Relatively little has been published in the United States on safety in lode-gold mining, but the reasons for such undesirable conditions can be deducted from publications dealing with factors that have an important bearing on safety in the gold-mining industry of the Western States.

Many of the largest gold mines of the United States are in California. Because they are near gold-mining districts in Arizona and Nevada, operations and mining practices in these three States are similar, as shown strikingly by a review of the causes of fatal accidents; this reveals that the ranking cause in the mines of the three States is the same—misuse of explosives.

The purpose of this paper is not to present an outstanding safety record but to show that gold mining can be pursued with the same degree of safety and improvement as any other industry, if and when the management recognizes that it can and must be done. To indicate how this goal may be reached, the safety practices and accident experiences and costs at the mines of the Lava Cap Gold Mining Corporation are discussed.

ACKNOWLEDGMENTS

Acknowledgment for assistance in the preparation of this paper is made to Otto E. Schiffler, vice president and general manager, John W. Chandler, general superintendent, and John C. Franz, safety engineer, of the Lava Cap Gold Mining Corporation.

1 Work on manuscript completed November 1939.
2 District engineer, Bureau of Mines Safety Station, San Francisco, Calif.
GENERAL INFORMATION

The property of the Lava Cap Gold Mining Corporation is in the Nevada City-Grass Valley gold-mining district about 6 miles southeast of Nevada City, Calif. It covers 2,465.32 acres of mining claims and mineral rights (fig. 2).

The property is operated through the Banner and Central mines (figs. 5 and 6). These two gold mines were famous in the seventies and are mentioned by Lindgren.4

The present company began operations in 1933 when the Central shaft, which had been closed in 1915 (figs. 1 and 3), was dewatered. The property has been mentioned in various publications.5

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FIGURE 2.—Holdings of the Lava Cap Gold Mining Corporation, Nevada County, Calif. (Map of E. C. Uren, 1936; revised by J. F. Singfried, January 1940.)
Both mines are opened by inclined shafts and connected by an adit 6,000 feet long. The main underground operations are in the Central mine. The Central shaft dips 51° and is 2,000 feet long.

The ore is classed as dry and siliceous and is recovered from quartz veins in argillite walls. The metallurgical report of the mill for 1937 follows:

**Metallurgical report of Central mill**

<table>
<thead>
<tr>
<th></th>
<th>Gold</th>
<th>Silver</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry tons of ore milled</td>
<td>104,020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average value of heads</td>
<td>$11.34</td>
<td>$2.06</td>
<td>$13.40</td>
</tr>
<tr>
<td>Average value of tails</td>
<td>.53</td>
<td>.16</td>
<td>.69</td>
</tr>
<tr>
<td>Average value of concentrates</td>
<td>178.64</td>
<td>32.72</td>
<td>211.36</td>
</tr>
<tr>
<td>Average extraction including bullion, percent</td>
<td>95.62</td>
<td>92.62</td>
<td>95.15</td>
</tr>
<tr>
<td>Gross value of production</td>
<td></td>
<td>$1,324,915.87</td>
<td></td>
</tr>
<tr>
<td>Percent of time operated</td>
<td></td>
<td>97.70</td>
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*Figure 3.—View of Central shaft surface works.*

The average number of employees is 270 to 220 underground, 32 on the surface, 13 at the mill, and 5 in the office.

The average daily production is 300 tons. In 1938 the Lava Cap Gold Mining Corporation ranked fourteenth in order of output among the 25 largest producers of gold in the United States (excluding the Philippine Islands). It ranked sixth in the United States and third in the State of California in gold production among the lode mines of dry and siliceous ore, as well as being the second largest silver producer in the State.

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6 Bureau of Mines Minerals Yearbook, 1939, pp. 73 and 234.
SAFETY PRACTICES AND CONDITIONS

SURFACE PLANT CONDITIONS AND EQUIPMENT

The mill is constructed of wood and corrugated metal. Fire protection comprises water hydrant, hose, and chemical extinguishers. All electrical wiring is in conduit and cable. Precautions are taken against dust hazards by a suction-fan system with trapping units in

![Figure 4.—Banner hoist, underground installation.](image)

the coarse-grinding section. Workmen such as crushermen are provided with dust respirators when stationed in unavoidably dusty places. Stairways are guarded, and machinery and belt guards are inspected daily.

Tailings are discharged into gravity ditches and impounded in a "tailings pond" about 1 mile from the mill.

Concentrates exceeding 50 tons are not stored but are trucked about 20 miles to Colfax, Calif., for shipment by rail to the American Smelting & Refining smelter at Selby, Calif.
A steel head frame 90 feet high is installed at the Central shaft (figs. 1 and 3). The sheave wheels are 7 feet in diameter and are provided with a railed platform with railed stairway approach. The sheaves are inspected and oiled daily and are not operated during this procedure. The oilman advises the engineer in person when he has completed his job in order to avoid the accidents that not infrequently occur through misunderstood signals. The inspection is recorded weekly.

HOISTING EQUIPMENT

Electric hoists equipped with Simplex overwinding devices are used at both mines. The Central shaft hoist is a 300-hp., a. c., double-drum Nordberg type and operates at a speed of 1,000 feet per minute; it is equipped with Nordberg safety control for overspeed, oil brakes, and clutch. A safety control switch is placed in the head frame, electric eyes are installed at the shaft collar, and automatically operated controls at the hoist protect against overwind and overspeed. The hoist is housed in a steel and corrugated-metal building.

The Banner mine hoist, a 150-hp., a. c., double-drum type, is installed underground (fig. 4) in fireproof housing on the adit level; it is Simplex-controlled, operates at a speed of 600 feet per minute, and is equipped with mechanical brakes and clutch.

Fire protection at hoist rooms comprises hose and hydrant, chemical extinguishers, and sand and pails.

The hoisting engines and engineers' quarters are far enough apart that the noise of the machinery will not prevent the engineer from hearing signals.

The hoisting engineers must pass physical examinations at 6-month intervals and be physically fit at all times to comply with State standards.

The hoisting equipment is inspected weekly by the master mechanic, and the hoisting-ropes hitchings are inspected daily.

The skips used for handling ore have a capacity of 2.15 tons. When workmen are lowered or hoisted a man-car is chained to the bottom of the skip by a large safety hook and two safety chains; this car also is used for handling tools and steel, but at no time are tools or other material transported in man-cars or man-trips carrying men.

The man-car track guides and shaft lining are inspected weekly. Chain and wooden gates (fig. 7) are provided at all landings, and a cager is in charge when men are hoisted. Not more than six men are allowed to ride the skip at one time, and not more than four are allowed in the man-car. Signals are operated electrically through a bell-cord system and can be given either at the landings or from the skip while in motion. An independent system is used for calling the skip. The bell cords are made of \( \frac{1}{16} \)-inch stainless steel protected at the stations by enclosure in a 1-inch pipe. The rope speed for hoisting men is 500 feet per minute.

ELECTRIC POWER

Electric energy is purchased and alternating current delivered to the mine at 11,000 volts. The surface substation at the Central mine is well-constructed and is surrounded by a fence; the current voltage is stepped down from 11,000 to 2,300 for surface use and to
440 for mine use. At the Banner mine 11,000 volts of alternating current is taken underground through a vertical drill hole 2.75 inches in diameter and 500 feet deep; this is stepped down to 440 volts at well-installed fireproof underground transformer stations. A General Electric lead-covered, armored, 11,000-volt suspension cable is used for this purpose.

No trolley locomotives are used; direct current is provided by two motor-generator sets for field excitation for two synchronous motors and charging service for storage-battery locomotives and electric cap lamps.

Heating for all services is by electric and oil stoves instead of steam.

COMPRESSED AIR

Six units furnish compressed air; three are installed on the surface at the Central mine and have a capacity of 2,200, 12,601, and 360 cubic feet of free air per minute, respectively. Two units with a capacity of 160 and 285 cubic feet, respectively, are installed on the
surface at the Banner mine, and a 1,150-cubic foot unit is installed underground at the hoist station. Three synchronous and three induction motors are used as driving units.

SHOP BUILDINGS

The surface shop buildings are separate from the other surface buildings and each other (fig. 3). The steel shop is fireproof, and the machine shop is of wood-frame and corrugated-iron construction. Fire protection comprises hydrant and hose and carbon tetrachloride extinguishers. All wiring is in conduit and armored cable, and machines and belts are guarded efficiently. Full-view-type goggles are worn by workmen. Good housekeeping is enforced, and as a result the buildings are kept clean and hand tools are always ready for use. The electrical equipment is maintained in an efficient condition, and daylight windows and 100-watt incandescent-light installations provide adequate light.

CHANGE HOUSE

A modern change house constructed of steel frame and corrugated iron is used by all employees. The workmen's clothes are the main fire hazard. Attendants keep the premises clean and hose the floors
daily. Toilet facilities are provided, and the illumination by incandescent lighting is excellent. Heat is provided by a hot-air furnace and circulation maintained. Clothes hang from hooks at the roof and are controlled by chain. The shower units have foot baths for the prevention of athlete’s foot and are installed in such positions as to require the workman to use them. They are furnished also with electric sun lamps to give underground workmen a sun bath daily to offset the time spent underground.

![Explosives car for transporting explosives (open)](image)

**SUPPLY HOUSE**

The supply house is made of wood, is provided with carbon tetrachloride fire extinguishers for fire protection, and is illuminated by incandescent lights; no heat is provided. An orderly method of storing is maintained.

**STORAGE OF EXPLOSIVES**

At the Lava Cap mines the main surface explosives-storage magazines are constructed of wood and earth and have steel doors and wood floors. The Central mine magazine can hold 35 tons of explosives and
the Banner mine magazine 16 tons. Trucks convey the explosives supplies from the railroad to the mine storage quarters, which are 300 feet from the nearest building and 500 feet from the nearest transformer. The adjacent hills form natural barricades, and properly placed danger signs identify the buildings. Screened ventilators and the type of construction prevent excessive temperature variations in the magazines. Illumination is by incandescent light. The magazines are kept clean, and padlocks and watchmen prevent unlawful entry.

![Container for transporting capped fuses.](image)

There are no surface distributing magazines except where explosives are stacked temporarily for daily underground supply (figs. 8 and 9). The underground distributing magazines are sections of blind crosscuts provided with doors. Two days' supply of explosives is kept in each magazine. The magazines are lighted indirectly by incandescent lights outside the magazine, and persons entering the magazine for any purpose wear permissible electric cap lamps. Wood hammers and wedges are used for opening boxes; these are opened outside the magazine on benches provided for this purpose.
Nothing is stored with explosives, but hot-wire spitters are stored with the detonator supplies. Detonators or capped fuses are not stored underground but are taken into the mine during each shift just before blasting time. Unused capped fuses are returned to the surface at the end of the shift.

Distributing magazines are kept locked, and the powderman has the key.

Explosives are transported underground in well-constructed insulated cars (figs. 8 and 9) on the haulage levels. No other haulage is permitted while explosives are being transported. All explosives are taken to the working faces in canvas powder sacks.

Capped fuses are made on the surface and sent into the mine in special containers (fig. 10). They are carried to the face by workmen who do not carry other blasting supplies.

The primers are made at the working face by the miners.

**LAMP HOUSE**

The mine lamp house (fig. 11) is constructed of wood and corrugated iron. It houses a motor, generator charger, and charging unit.
with 240 up-to-date permissible electric cap lamps. The Lava Cap was the first gold mine in California to adopt electric cap lamps for miners’ illumination. The illuminating and heating facilities are adequate and efficient.

FIRE PROTECTION

It is recognized that any mine surface installation presents a fire hazard in some form or other, particularly where some of the buildings are constructed in part of wood and where timber must be stored in mine yards. Roads, paths, and walks are kept free from obstructions; timbers, ties, rails, and scrap material are piled and stored properly. The mill buildings are within 100 feet of the Central shaft. A separate fireproof building is used for storing oil on the surface. Surface fire protection comprises fire hydrants and 100 feet of hose at each hydrant. A 2,000,000-gallon reservoir of water with a 500-foot head is available for use at any point where fires may occur. A fire-alarm system is provided.

Water supply, sanitation, and housing of employees comply with State and United States Public Health Service standards.

The underground workmen are checked into and out of the mine by the cap-lamp batteries carrying the check numbers of the workmen.

UNDERGROUND MINING METHODS, CONDITIONS, AND EQUIPMENT

MINING METHODS

The Central mine is opened by a three-compartment inclined shaft 2,000 feet long, which dips 51° (figs. 3 and 4). Cut-and-fill stopes are used throughout both mines. Walls and back are supported temporarily by stulls or square-sets.

The Banner mine (figs. 2, 5, and 6, pp. 2 and 4) is opened by an adit 6,000 feet long, which connects with the Central shaft. About 5,000 feet from the portal an underground shaft is sunk to the fourth level, a distance of 600 feet below the tunnel on the incline, from which the present mine is developed and operated. An inclined two-compartment shaft 800 feet deep on the incline connects the extreme north end of the Banner mine with the surface.

TIMBERING

All shafts are timbered with standard 8- by 8-inch wall and end plates, and timber is kept in good condition (fig. 12). The mine is developed by drifts in the veins, and the levels are connected by raises that also assist the ventilation system.

A timbering outline is posted, and the timbering rules must be enforced strictly to avoid severe injuries. The roof is tested by sounding and by the vibration method. All men have orders to use timber at all times according to outline and to place safety stulls when bad ground cannot be barred down. There is evidence that timbering rules are not followed diligently; close supervision, inspection, and discipline are required to keep underground workings properly protected by timber.
EXPLOSIVES AND BLASTING

The misuse of explosives has been the major cause of mine fatalities in California since 1931; for many years preceding 1932 it ranked second as the cause of mine fatalities in the State and is now second in the Nation. The last fatality at the Lava Cap mine—on March 22, 1937—was caused by explosives practice involving fuse and caps.

Figure 12.—Timber framing lay-out.

Explosives accidents have focused the attention of State officials and mine managements on this hazard, and California Safety Orders, as of July 1, 1938, contain some innovations in explosives practice that should, if followed, improve California's unfortunate explosives experience and the unenviable position explosives accidents are assuming in the metal-mining industry as a whole. It is believed that electric blasting methods will improve conditions materially.

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BLASTING PRACTICE

Forty-five-percent dynamite (fume class 1) complying with the California Safety Orders \(^9\) is used in all work.

The cartridges are 1\(\frac{1}{8}\) by 8 inches. No. 6 electric detonators with iron legs short-circuited are used for delay blasting and No. 6 caps for blasting. Firing is done electrically from power circuits and by fuse and caps, using hot-wire spitters.

Electric blasting is done in long crosscuts, long drifts, wet headings, shaft sinking, and long and wet raises. The power blasting circuits are equipped with two double-throw switches; these are locked in the open positions except at firing time, when they are operated by the men doing the blasting, who have and keep the keys. A plug and receptacle are placed on the blasting line between the blasting switch and explosives charge when blasting is to be done. These are stretched across the passageway so that the circuit must be opened before anyone can pass and when not in use provide a wide gap in the blasting circuit. The outside and face end of all blasting lines are kept short-circuited until the lines are to be energized.

The rounds consist of 6 to 30 holes 6 to 8 feet deep. Mixed charges of explosives are not used; the primer is placed next to the bottom stick in the hole, and the detonator points toward the bottom of the hole. The prescribed practice for making the hole in the cartridge for the detonator is to use a wood stick, although some miners use a sixpenny nail—by no means a good practice.

The holes are loaded by the miner, and cartridges are slit. Air spacing is avoided, and wood tamping sticks are used to insert the charge. Holes are cleaned out by a blowpipe and compressed air.

Stemming is required in all holes, one or two sticks or dummies to a hole. The dummies are made of clay and slime from mill tailings and are 1\(\frac{1}{8}\) inches in diameter and 8 inches long; they are wrapped in pink paper as a means of identification in handling the explosive, loading the holes, and protecting against unexploded dynamite following blasting.

Blasting by fuse is done by the miner and his helper. The shots are blasted at the end of the shift when the men are ready to leave the mine. No tests for noxious gases and no fire runs are made after blasting. Ample verbal warning appears to be given before the shots are fired; warning is particularly necessary for protection of workers when two places are coming together. In such instances the shift boss usually takes charge.

MISFIRES

Probably no single factor would contribute more to reduction of explosives accidents than the prevention of misfires. Explosives accidents are so common in California mines that they are no longer news, and as long as coroners’ inquests held in mining communities after explosives accidents return verdicts using the stock terms “premature,” “unexpected,” and “unavoidable” public opinion will not be aroused to needless sacrifice of life from this cause.

Misfires at the Lava Cap are reshot by the miners. As all shots are blasted at the end of the shift, the 5-hour period between shifts is

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\(^9\) See footnote 8.
the interval following misfires if they occur. The explosives are not removed but are reshot after stemming is washed out. Misfires following fuse blasting have killed two men at the Lava Cap mines since 1933 when the mine was reopened; such accidents lead in number of fatalities from blasting in California and are responsible in large part for California's bad record for blasting accidents in mining work.

Electric blasting offers the safest method for controlling shooting. As all workmen wear permissible electric cap lamps, there is no occasion for the use of open lights near explosives.

![Figure 13.—Underground main-fan installation.](image)

**VENTILATION**

**FANS**

Mechanical ventilation is provided at the Central mine and natural ventilation at the Banner mine. The main ventilating fan is installed in fireproof quarters underground in the Banner adit about 750 feet from the adit portal (fig. 13). The fan, a No. 90 reversible Sturtevant, is electrically driven and is operated exhausting; it delivers about 23,000 cubic feet of air per minute at 1 inch water gage. The
return air is saturated; on June 17, 1938, it had a wet- and dry-bulb
temperature of 57° F. The fan is so connected as to assist the natural
ventilation system of the Banner mine and by means of doors can
control it entirely if the occasion requires. The main fan is provided
with reserve electric power. The fan controls are operated manually,
and there is no automatic signal device to show when the fan slows
or stops. The fan and fan-house casing are of incombustible material
and are inspected daily by the safety engineer. The fan is operated
continuously from an independent electric circuit.

No explosive or natural noxious gases have been detected in the
mine workings. The only source of noxious gases and unhealthful
atmospheres would be the products from blasting and oxygen deficiency
resulting from oxidation of timber and rock or ore formations.

Air courses are provided through stopes and raises, forming a con-
tinuous ventilating system controlled by doors and strategically
placed concrete stoppings; steel doors in concrete frames are placed
in the levels between the main shaft and pitch workings.

The circulating system provides about 200 cubic feet of air per min-
ute for each man employed underground. Mules are not used under-
ground. The main air current is carried down the main shaft to the
bottom level. More than 17,000 cubic feet of air per minute
reached the bottom level on June 17, 1938. By means of the concrete
stoppings and regulators virtually 100 percent of the main air current
can be cored to the lower shaft level before it starts back through
the mine openings.

Some old workings are sealed in part, while others are ventilated,
depending on their utility for ventilation purposes or the hazards they
may present if left open. Permanent seals near landings and main
airways are of concrete, while others have wood walls of 2-inch lumber
with an 8-inch space between, filled and tamped with clay. Provision
is made for sampling air behind seals by inserting 1/2-inch pipes through
them; the atmospheres are known to be low in oxygen. Air from old
workings does not pass through the active parts of the mine. A good
ventilation map is maintained and used.

No large-capacity booster fans are employed underground, but
three electrically driven auxiliary blowers of the "Buffalo" type are
used with 8- and 6-inch metal pipe for ventilation in development
work; these are kept in good condition, and the fan intakes are placed
in fresh air.

SToppings and Doors

Stoppings are made of wood, except between main-shaft connections.

Nine wood doors hung singly are placed in the haulageways of the
levels; they are kept in tight condition, have heavy weights, and are
provided with latches in the active levels to insure that they remain
closed. If these doors were left open the effect, if any, would be to
short-circuit the air. Trappers are not employed. Doors should be
hung in pairs, and all main doors connecting with main hoisting shaft
or ventilating passageway should be of steel or other fire-resistant
construction and hung in fireproof concrete frames. Such precau-
tions may be, as they have been in the past, the means of saving prop-
erty or life if a mine fire occurs.

1939, pp. 20-25, 53.
SAFETY LAMPS AND SMOKING

Flame safety lamps are not used at the mine. Such lamps are available at the Central Mine Rescue Cooperative Station, of which the Lava Cap Gold Mining Corporation is a member.

Smoking is permitted underground on the man-trip used in the Banner adit, on shaft stations, and in the skips in the main shaft.

AIR SAMPLING

The company does not sample and analyze the mine air regularly. At the request of the company samples are taken by engineers of the Safety Division, Federal Bureau of Mines, and analyzed at the Central Experiment Station, Pittsburgh, Pa. The mine air was sampled in June 1938; in addition to vacuum tubes, supersensitive carbon monoxide indicators were used in sampling all parts of the mine. This study revealed that the carbon monoxide indicator is a valuable instrument for testing the quality of mine air, as the main source of carbon monoxide is the blasting of explosives; at no point was the carbon monoxide concentration excessive. The study indicated improvements that could be made in ventilation. The highest temperatures found in the mine workings were 60° wet- and 60° dry-bulb—ideal mine-air temperatures. During June 1938 the relative humidity ranged from 95 to 100 percent and temperatures from 54° to 60° F.

DUST

No discernibly bad dusty conditions prevail in these mines for the following reasons: An efficient, controlled ventilation system removes the finely divided dust particles thrown into the air by blasting; dust is minimized at the face during drilling by strict adherence to wet drilling; and muck piles are wet down before and during mucking operations, a practice that virtually eliminates the hazards from oxides of nitrogen and may tend to entrain any carbon monoxide present in the muck pile so that it will be liberated more slowly during mucking operations. Blasting is not done during the working shift; the mine works two shifts, and an interval of 4 hours elapses between blasting (when all men leave the mine) and the time the next shift resumes operations; during this interval the finely divided dust and powder gases are removed efficiently. The mines are naturally wet. The humidity of the air in the mine workings is above 95 percent, and generally the air is saturated. The velocity of the air current is above the critical velocity 11 necessary to remove smoke and finely divided dust particles; approved respirators are provided if local conditions warrant, but their use is limited because it is believed to be better to provide efficient ventilation and remove or reduce the dust rather than force the use of respirators.

UNDERGROUND HAULAGE

Main haulage underground is by storage-battery locomotives other than the skip haulage in the main shafts; all other haulage is by hand tramming.

The dip and alignment of the track in the main shafts are kept uniform and in excellent condition. The grades in the haulage levels

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are good; the tracks are well-ballasted, and alinement is good considering the numerous curves. Level haulage is slow to prevent derailments on the excessive number of curves. The roadbed ballast material is muck, which is kept wet, and the roadbeds are kept clean.

The track gage is 18 inches. The main-line rails weigh 35 and 20 pounds per yard and the hand-tram rails 12 pounds. Ties are made of 4- by 6-inch pine spaced at 18-inch intervals.

![Figure 14.—Special underground loading chute for waste.]

Switches are of the point type and are kept in good condition. The clearance of throws and cut switches is 4 inches, and blocking is efficient. The switch bars are sunk to avoid stumbling hazards. Illumination is furnished only at main-line switches, and guard rails and efficient blocking are provided at all frogs.

The clearance on haulage levels is limited, and walkers must find wide places to avoid hazards of passing trips; as there are no shelter holes, they must depend on the slow travel of the moving cars or trips and the signal lights and bells provided on them. Chute spouts are constructed substantially (fig. 14) and are protected.
Compressed-air tugger hoists operating in the manways are used for hoisting material on the pitch.

The main-shaft haulage rope, 1-inch plough steel, is inspected and oiled weekly. Rope clamps are resocketed or replaced immediately if inspection indicates that this is necessary. A written record of rope inspections is kept. Shaft rollers are maintained in good condition.

The California Code of Signals is posted and used.

Six storage-battery locomotives of the Jeffrey and Mancha types are used underground; these weigh 1 and 2½ tons. All locomotives are equipped with gongs and efficient lights.

Steel mine cars including both side-dump and end-dump types are used on the levels only, as the shaft haulage is by skip. They are tight, have a capacity of 1 ton, and are not provided with brakes; the couplings are the pin-and-link and chain type.

Trip lights are used on the rear of all trips as well as on the front of all pushed trips of three cars or more; they are not used on the hoisting skip, which is the only rope trip in use.

**SUPERVISION**

Supervision is the sole means of controlling haulage other than the automatic overspeed and overwind control for the main skip, which has been described.

The man-trips in the main shafts have been described. Special all-steel man-cars are provided (fig. 15) for hauling the workmen in the Banner adit; these haul 16 men each and are pulled by a storage-battery locomotive at a maximum speed of 4 miles an hour. Trips come to full stop before men are loaded or unloaded. The greatest danger to the men is in traveling the haulageways.

Flying switches are not allowed, nor are men permitted to run ahead of moving trips to throw switches or open doors. Trips are pushed; this practice is hazardous, but the danger is limited in this mine because of hand operation of trips. Cars are relaid by lifting and rail frogs. Loose clothing presents some hazard in connection with haulage as well as other operations.

**ELECTRICITY UNDERGROUND**

Transmission lines enter the mine by way of drill holes and the main shafts, the latter presenting a fire hazard in the event of serious derailment of skips. They are placed in intake air. Power wires that carry more than 220 volts are in armored cables that are grounded. All wiring is installed on insulators, and 110- or 220-volt lines are BX in dry places and BXL and tellurium rubber-covered cables in wet places. Power wires are guarded where men must pass under them and insulated where they pass through doors. As sectional switches are provided, there are few if any contact or arcing hazards. Oil-type switches are used at all power installations.

The storage-battery locomotives are not permissible types; batteries are charged at the main shaft stations where good ventilation is provided.

An efficient underground telephone system connects various points underground and at the surface. There are 12 main telephone stations underground at such points as the shaft stations, hoist room,
and fan station. These, all of permissible type, are kept in good operating condition and are insulated from the power wires.

Seven electrically driven pumps are installed underground, some in fireproof and some in partly timbered quarters; fires have been known to originate in mines in electrically operated installations through failure of electrical equipment. All pumps in the Lava Cap mines are equipped with automatic starting and stopping controls—electrical for starting and overload and pressure to prevent operation if prime is lost. Thermostatic control, connected with the bearings and housings, stops the pumps if equipment is overheated owing to pump, motor-bearing, or electrical failures or fire in a pump room. An electrically operated horn on the surface connects with each pump to give warning of starting failures.

**FIRE PROTECTION UNDERGROUND**

The Lava Cap shafts are not strictly fireproof; the maximum insurance against underground fires is recognition that they can and do happen in any mine for reasons often beyond human control.
Metal-mining men generally are difficult to convince that fires can happen, that the first line of defense is to provide controlled ventilation,\textsuperscript{12} and that the main fan should be placed on the surface or at a point near and accessible at all times from the surface if a fire occurs.

Fireproofing all main shafts probably is not feasible, but all main shafts certainly should be separable from adjacent workings by fireproof seals or doors. The management has analyzed lessons from previous mine fires and made efforts to meet the requirements of this mine.

Essentials in the underground fire-protection scheme at the Lava Cap mines are: Ventilation is controlled; controls and fire protection are provided at electrical installations; electrical quarters are fireproof or practically so; transformer stations are isolated, and transformers are filled with fireproof oil; telephones and fire signals are efficient; water for fire protection is piped throughout the mine from a large reservoir; connections are arranged for turning water into the air lines in the event of fire; fire plugs and hose are installed and inspected regularly at shaft landings; underground stations are fitted with 100-gallon water barrels and two fire buckets; sand and pails are provided at electrical installations; welders are required to carry and use fire pumps to wet the ground and inflammable material near the job before beginning and after finishing work; the main hoisting shaft is on intake air; manways are marked and provided with excellent ladders; electrical and stench methods of fire-signal warnings are provided; all shafts are separated effectively from adjacent connections by fireproof stoppings and doors; the mine can be sectionalized in the event of fire; workmen are trained and educated in fire protection; a safety engineer is employed to keep in mind the fire hazard and to protect against it; all workmen wear permissible electric cap lamps; oil is stored in fireproof containers and quarters; workmen are not permitted to smoke while traveling or while in the shafts or at shaft stations; shavings and discarded combustible material are removed from the mine; and, of most importance, the operating officials recognize that fire hazards exist.

No mine fires have occurred at the Lava Cap mines.

\textbf{GENERAL SAFETY CONDITIONS}

\textbf{PROTECTIVE CLOTHING}

Most of the injuries at Lava Cap result from rock falls; the management recognizes that too many such accidents occur, in spite of the fact that it has expended much effort in trying to eliminate or at least to reduce them to a minimum. All workmen wear hard hats and hard-toed safety shoes of rubber and leather. They are also supplied goggles of the full-view type but do not wear them continuously; this lapse is reflected in the many eye injuries incurred by the workers. A campaign is being conducted to emphasize the importance of wearing goggles at all times and also gloves to reduce hand injuries. Unquestionably injury experience has improved since the adoption of protective clothing.

\textsuperscript{12} Ash. S. H., work cited in footnote 10.
Experienced and technically trained men are employed as supervisors. Each shift boss supervises 30 to 40 workmen and visits all working places twice daily. Insistence on obeying orders and dismissal for serious infractions are aids to discipline. Shift bosses report on use of explosives supplies, tool requirements, timber supplies, and other safety conditions, as well as instruct workers in safety and efficiency as they make contacts with the workers on their inspection rounds.

SAFETY ORGANIZATION

The safety organization comprises four sectional safety committees of three men each—elected by the workmen—the shift boss, mine foreman, mine superintendent, and the safety engineer. The whole safety committee makes a general inspection trip every 60 days, and each sectional committee inspects its section of the plant monthly and reports its findings at the monthly safety meetings, which are open to all employees, including officials.

At the safety meetings consideration is given to reports and recommendations for mine safety improvements made by the management, safety inspector, members of the committee, and mine employees. Minutes are kept, and minutes of preceding meetings are read at the current meeting.

Unsafe conditions observed during an inspection are corrected immediately. Nonuse of protective clothing, misuse of explosives, and other safety matters are reported by the committees with a statement of the corrective action taken.

The minutes of the meetings also include a report on investigations of any accidents that have occurred since the previous meeting and recommendations to prevent recurrence. They also show the total number of safety recommendations by the safety committees and others and the number that actually have been carried out.

The following are typical 60-day inspection reports and minutes of safety meetings:

60-day inspection trip

March 31, 1938, a. m.:
Chandler.
Procter.
Miller.
Leehy.
Franz.

Fuse house:
1. Fire extinguisher is gone.

Oil house:
1. In good condition.

Compressor house:
1. Metal containers should be supplied to take care of oily rags.

Change room:
1. Put shield around smoke pipe from water heater to prevent clothes from coming in contact with it and starting a fire.

Hoist room:
1. Chain or railing should be across the south door of the hoist room. Some kind of a strap should be placed at this door because it is used by a great number of men.
2. Metal containers should be supplied for oily rags.
3. Provision should be made for a drinking fountain in the hoist room.
4. A door should be placed at the switchboard panel.
Steel shop:
1. There should be a guard in the hammer belt.

Carpenter shop:
1. A new stove should be built for the shop, with only a firing door in the top, to prevent the emission of sparks.
2. The present stovepipe should pass through the roof and be screened to prevent the emission of sparks.
3. Clean up around present stove.

Garage:
1. Quite a few rags were found lying around the garage.
2. There should be a fire extinguisher in the bus repair shop.
3. There should be a fire extinguisher at oil house and gas pump.

Mill:

CRUSHING PLANT
1. The back entrance should be cleaned up where old scrap was thrown off the jaw crusher.
2. A footbridge should be built over conveyor belt to prevent workmen from stepping over belt.
3. The lower part of the driving belt for the rolls needs a guard.

BALL-MILL FLOOR
1. Guard off ball-mill motor coupling.
2. Fire hose should be kept in place at the hydrants.

ASSAY CRUSHING DEPARTMENT
1. The belt on flywheels of both crushers should be guarded.
2. Guard should be placed at belt of pulverizer.

Minutes of safety meeting, March 7, 1938 (JWC)

The meeting was called to order by the chairman. The minutes of the previous meeting were read and approved.
The report of the Central Safety Committee was read by Frank Campbell and the Banner report read by Chas. Farrar. All of the safety suggestions had been carried out.

There was a discussion of the Banner men climbing off the man-car across the scrap-iron pile into the main path. It was suggested that the man-car be taken farther down the track, that the men use the present stairway at the shop, and that the pathway be repaired around the shop.

The chairman took up a discussion of our recent accidents, including eye injuries. Most of the accidents were due to thoughtlessness. Also, reports on many accidents were late. It was found that out of 23 accidents there were 18 with regular reports with 5 days lost time, and there were 5 late reports with 11 days lost time.

The chairman spoke on the care of electric lamps; some had broken head-pieces, and the batteries were badly bent.

There was a complaint on No. 4 bus that the bolts were sticking down from the roof above the rear seat and should be fixed so that men would not hit their heads.

There was an election for safety-committee members. Obie Winn was elected to the Central Committee, and Cecil McGraw was elected for the Banner Committee.

Adjournment.

Minutes of safety meeting, March 14, 1938

The meeting was called to order by the chairman. The minutes of the previous meeting were read and approved.
The committee chairmen read their reports for the Banner and Central mines. All suggestions had been taken care of with the exception of the exit manway on north side of shaft through 402 stope; ladders should be matched up where they enter cribbing.

There were no safety suggestions from the floor.

There was a discussion about the men coming out of the tunnel portal. There was a great deal of scrap iron over which they had to climb and which was very slippery during rainy weather. Chuck Miller advised that this was being cleaned up and that a stairway would be built in a few days.
The chairman spoke on our accident record for the past 3 months. A great many of them were leg injuries. He also spoke on the late-reporting accidents being the cause of a great many lost-time accidents. Gloves have helped to cut down hand accidents considerably. Eye accidents have dropped considerably since the use of goggles.

The chairman also spoke on the men taking better care of their lamps and batteries. Some of them have received quite a lot of abuse with broken head-pieces and bent batteries.

There was an election of safety-committee members. Olaf Shaffer of the Banner and H. T. Fitzgerald of the Central were elected.

Adjournment.

Minutes of safety meeting, April 11, 1938

The meeting was called to order by the chairman. The minutes of the previous meeting were read and approved.

The committee members read their reports, and all suggestions had been placed in effect with the exception of a fire extinguisher being installed on the 600 in the Banner.

There was one suggestion from the floor and that was that the inactive chutes should be bulkheaded.

The chairman spoke on our accident record for the complete mine, including the Banner, Central, and surface. A great many accidents consisted of back injuries. Hand injuries had dropped considerably with the use of gloves. Eye accidents had been cut with the use of goggles; and by this drop if all wore goggles at all times while working, eye accidents would be nil.

He also stated that the late reporting of accidents had dropped, although during the month of March there were five late reports.

Adjournment.

One of the most difficult problems in connection with safety meetings is to make them interesting and prevent stiffness and formality. Free discussion is customary at the Lava Cap meetings, and the workmen apparently realize that accident prevention is their problem as well as that of the management.

The California Mine Safety Orders are accepted as safety rules and standards; a major function of the safety meetings is to acquaint the employees with these rules.

Bulletin-board service including bulletin-board safety bulletins, posters, and reports of accidents are utilized in an endeavor to create "safety consciousness."

A safety bonus system was begun in July 1938. At present it applies to shift bosses, but the formulation of an effective system to include all workmen is being considered, as it is realized that prevention of accidents devolves mainly upon the workmen. The "shift boss" bonus system provides for the payment to shift bosses of safety bonuses on the basis of 1½ cents for each man-day supervised, less $5 for each injury causing a time loss of only 1 day and less $10 for each injury causing a time loss of more than 1 day. Injuries are classed as compensable when a workman’s time loss exceeds 7 days; no bonus is paid to a shift boss if one of his workmen has a compensable injury during the current month. Deductions for lost-time accidents do not carry over to the next month, and the shift boss’ record is cleared at the close of the month.

FIRST-AID AND MINE RESCUE TRAINING

For several years all employees have been trained each year in first aid by a Bureau of Mines instructor and company instructors under the cooperative plan.13 Fifteen employees are trained each year in

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mine rescue by a Bureau instructor; these workers are retrained each month by the Central Rescue Station instructor. This company is a member of the Grass Valley Central Mine Rescue Station.¹⁴

Up-to-date first-aid stations are maintained on the surface and underground. An up-to-date hospital is readily accessible and is used under contract by the employees.

**ACCIDENT EXPERIENCE**

All accidents are investigated by the safety engineer, and all serious ones are investigated also by the general superintendent and the safety committee. Accidents are analyzed monthly and recorded in detail; such phases as cause, nature, responsibility, and cost of injuries are listed. In addition, reports of accidents are made to the State Industrial Accident Commission.

Prevention of accidents requires knowledge of the exposure to which the workmen are subjected; number, frequency, and severity of injuries and time lost therefrom; nature of injuries; causes of accidents; and certain other factors.

**FREQUENCY AND SEVERITY OF ACCIDENTS**

Too often frequency alone is considered the prime factor in the analysis of accidents and is stressed unduly to make a record. Unquestionably it is the easiest to calculate and furnishes the prodding tool—no frequency, no severity. On the other hand, common accidents of low frequency often cause the greatest economic loss and human suffering. In numerous instances efforts to reduce frequency are ineffective in promoting safety because men as well as shift bosses hesitate to report injuries, where they feel that no time loss will result or the injury is noncompensable, for fear of caustic rebukes or possibly the infliction of unfair discipline. Every effort should be made to insure that all injuries are reported, and a manager who does not insist on such reports will find himself in difficulty sooner or later. Many operators have observed that although frequency rates are decreasing compensation and loss of time in many instances are increasing.

Severity of injuries should certainly be known, as this factor determines accident cost and human incapacity. Some companies prefer to use an injury index, a combination of the frequency and severity figures. Invariably, where safety work is advancing the frequency rate actually increases or remains stationary for a time, and the ratio of no lost-time to lost-time injuries actually increases. When workmen report all injuries and receive medical care, if necessary, the severity and cost of injuries almost certainly will show desirable results in time.

Bonus systems for all workmen that stress the reporting (with penalties for not reporting) of all injuries rather than the number of lost-time injuries only appear to assist materially in reducing accidents. Injuries from cuts, infections, bruises, and contusions will not develop nearly so often into disability injuries if all injuries are reported and suitable remedial action taken as promptly as possible.

The following tables compare the accident experience in the Lava Cap gold mines for 1934 to 1938, inclusive, with similar experience

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for available comparative years in the metal mines of California and the United States. The accident rates are based upon man-hours of exposure, and accident-frequency (number of accidents per million man-hours of exposure) and accident-severity (time lost in 8-hour days per thousand man-hours) rates are used. These tables include all lost-time injuries of 1 day or more, although for compensation-cost purposes California has a 7-day waiting period that is included in all lost-time data.

The Bureau of Mines schedule of time losses for injuries has been used in accordance with the scale of rates adopted by the Association of Industrial Accident Boards and Commissions for the metal mines of California and the United States. In determining the Lava Cap injury rates the same rating system is used for fatalities and permanent total disabilities, as well as for permanent partial disabilities in the sense that each injury is known and the time lost is assigned for the degree of disability or actual period of disability beyond the degree limitation, if such is the case. Temporary disabilities at the Lava Cap mines are assigned their actual time loss.

Table 1 gives the number of injuries and time lost for all lost-time injuries, by class of injury, at the Lava Cap gold mines for 1934 to 1938, inclusive; at all metal mines in California for 1923 to 1933 and 1934 to 1936; and at all metal mines in the United States for 1934 to 1936.

Table 2 gives the number of mines, man-hours, men employed, number of injuries, and frequency rates at the Lava Cap mines for 1934 to 1938, inclusive, and at all metal mines in California and in the United States for 1929 to 1933 and 1934 to 1936.

Table 3 lists the frequency and severity rates for all lost-time injuries at the Lava Cap mines from 1934 to 1938 and at all mines, except coal, in California and in the United States for 1929 to 1930 and 1934 to 1936.

Table 4 lists the frequency and severity rates for all lost-time injuries, by class of injury, at the Lava Cap mines for 1934 to 1938 and at all mines, except coal, in California and the United States for 1929 to 1933 and 1934 to 1936.

Table 1.—Number of injuries and days lost for all lost-time injuries, by class of injury, at Lava Cap gold mines, 1934–38, inclusive, and similar data for available years at all metal mines in California and the United States

<table>
<thead>
<tr>
<th>Class of injury</th>
<th>1934</th>
<th>1935</th>
<th>1936</th>
<th>1937</th>
<th>1938</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
<td>12,000</td>
<td>1</td>
<td>6,000</td>
<td>1</td>
</tr>
<tr>
<td>Killed</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent total disability</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent partial disability</td>
<td>72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporary disability</td>
<td>68</td>
<td>56</td>
<td>87</td>
<td>957</td>
<td>78</td>
</tr>
<tr>
<td>All nonfatal</td>
<td>71</td>
<td>56</td>
<td>90</td>
<td>3,357</td>
<td>79</td>
</tr>
<tr>
<td>Grand total</td>
<td>72</td>
<td>58</td>
<td>90</td>
<td>3,357</td>
<td>80</td>
</tr>
</tbody>
</table>

1 Killed by fall of roof.  2 1 killed by fall of roof, 1 by explosives.  3 Killed by explosives

TABLE 1.—Number of injuries and days lost for all last-time injuries, by class of injury, at Lava Cap gold mines, 1934–38, inclusive, and similar data for available years at all metal mines in California and the United States—Continued

<table>
<thead>
<tr>
<th>Class of injury</th>
<th>Lava Cap, 1934–38</th>
<th>Metal mines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of injuries</td>
<td>Number of injuries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1929–33 4</td>
</tr>
<tr>
<td>Killed</td>
<td>4</td>
<td>109</td>
</tr>
<tr>
<td>Permanent total disability</td>
<td>6</td>
<td>3,735</td>
</tr>
<tr>
<td>Permanent partial disability</td>
<td>6</td>
<td>4,790</td>
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<tr>
<td>Temporary disability</td>
<td>8</td>
<td>7,335</td>
</tr>
<tr>
<td>All nonfatal</td>
<td>10</td>
<td>4,400</td>
</tr>
<tr>
<td>Grand total</td>
<td>39</td>
<td>12,044</td>
</tr>
</tbody>
</table>


* Compiled from Bureau of Mines reports on metal-mine accidents in the United States.
* 39 killed by fall of roof, 27 by explosives.
* 7479 killed by fall of roof, 62 by explosives.

TABLE 2.—Injury and frequency rates and man-hours of exposure at Lava Cap gold mines and in the metal mines of California and the United States for available comparable years, 1934–38, inclusive

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of mines</th>
<th>Men employed 1</th>
<th>Man-hours worked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lava Cap</td>
<td>California</td>
<td>United States</td>
</tr>
<tr>
<td>1934</td>
<td>2</td>
<td>1,227</td>
<td>3,598</td>
</tr>
<tr>
<td>1935</td>
<td>2</td>
<td>3,386</td>
<td>10,619</td>
</tr>
<tr>
<td>1936</td>
<td>2</td>
<td>(9)</td>
<td>(9)</td>
</tr>
<tr>
<td>1937</td>
<td>2</td>
<td>(9)</td>
<td>(9)</td>
</tr>
<tr>
<td>1938</td>
<td>2</td>
<td>(9)</td>
<td>(9)</td>
</tr>
<tr>
<td>1934–38</td>
<td>(9)</td>
<td>659</td>
<td>(9)</td>
</tr>
<tr>
<td>1934–36</td>
<td>2</td>
<td>(9)</td>
<td>(9)</td>
</tr>
<tr>
<td>1936–38</td>
<td>2</td>
<td>(9)</td>
<td>(9)</td>
</tr>
</tbody>
</table>

1 Average number of men.
2 Not available.
4 Not operating.
### Table 3.—Frequency and severity rates for all injuries at Lava Cap gold mines and in the metal mines of California and the United States for available comparable years, 1934–38, inclusive

<table>
<thead>
<tr>
<th>Year</th>
<th>Gold mines, Lava Cap</th>
<th>Accident-frequency rates</th>
<th>Accident-severity rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>California</td>
<td>United States</td>
<td>Gold mines, Lava Cap</td>
</tr>
<tr>
<td>1934</td>
<td>243.69</td>
<td>117.19</td>
<td>68.95</td>
</tr>
<tr>
<td>1935</td>
<td>139.99</td>
<td>108.13</td>
<td>64.29</td>
</tr>
<tr>
<td>1936</td>
<td>156.41</td>
<td>91.93</td>
<td>73.38</td>
</tr>
<tr>
<td>1937</td>
<td>140.20</td>
<td>(3)</td>
<td>(7)</td>
</tr>
<tr>
<td>1938</td>
<td>143.48</td>
<td>(7)</td>
<td>(7)</td>
</tr>
<tr>
<td>1939–38</td>
<td>171.22</td>
<td>108.38</td>
<td>71.33</td>
</tr>
<tr>
<td>1935–36</td>
<td>146.63</td>
<td>(7)</td>
<td>(7)</td>
</tr>
</tbody>
</table>

1 All mines other than coal.
2 Not available.
4 Not operating.

### Table 4.—Frequency and severity rates for all lost-time injuries, by class of injury, at Lava Cap gold mines, 1934–38, inclusive, and similar data for available period 1934–38 at all mines in California and the United States

<table>
<thead>
<tr>
<th>Class of injury</th>
<th>Lava Cap mines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
</tr>
<tr>
<td>Killed</td>
<td>3.39</td>
</tr>
<tr>
<td>Permanent total disability</td>
<td>10.16</td>
</tr>
<tr>
<td>Permanent partial disability</td>
<td>230.14</td>
</tr>
<tr>
<td>Temporary disability</td>
<td>240.30</td>
</tr>
<tr>
<td>All nonfatal</td>
<td>248.69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class of injury</th>
<th>1929–33</th>
<th>1934–38</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>California</td>
<td>United States</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>Severity</td>
</tr>
<tr>
<td>Killed</td>
<td>1.78</td>
<td>10.67</td>
</tr>
<tr>
<td>Permanent total disability</td>
<td>.01</td>
<td>.09</td>
</tr>
<tr>
<td>Permanent partial disability</td>
<td>1.78</td>
<td>1.42</td>
</tr>
<tr>
<td>Temporary disability</td>
<td>104.84</td>
<td>1.38</td>
</tr>
<tr>
<td>All nonfatal</td>
<td>106.60</td>
<td>2.90</td>
</tr>
<tr>
<td>Grand total</td>
<td>168.38</td>
<td>13.57</td>
</tr>
</tbody>
</table>

An analysis of the data in tables 1 and 4 by classes of injuries indicates that California since 1930 has materially and steadily improved its fatality record, and from 1934 to 1936 it is on a par with the average experience at all mines of the United States. In 1930 the frequency rate for fatalities in California mines compared with that in the Nation as a whole was more than 2½ times greater than for the average period 1934–36 and 3½ times greater than in 1936; in 1936 it was ¾ less than that in the country as a whole.

The achievement at Lava Cap lies in the fact that for the period 1934–36 the fatality rate was almost 2½ times greater than at the average metal mine in California and in the United States, whereas for the period 1936–38 it was 50 percent less than in the State and Nation.

To reduce the severity of injuries at Lava Cap to the average for the State and Nation, accidents causing permanent partial disability must be reduced.

The story of the success of the Lava Cap safety program is shown graphically in figure 16. During the period 1934–36 the severity rate was 2½ times that of the Nation as a whole and more than twice that at the average California mine, whereas for the period 1936–38 it dropped materially below that of the State and Nation. The trend at the Lava Cap is toward a decidedly better-than-average position. On the other hand, it has also reached a point where constant vigilance must be exercised and improvements in practices that
are hard to change must be made to remove potential hazards that the law of averages brings into play sooner or later. These relate to explosives practice, use of protective clothing, and exposure to falls of roof.

A review of data available at the Lava Cap mines for 1937–38 reveals that for every 10 injuries reported 3 have a time loss of 1 day or more. Compensable injuries constitute 30 percent of the lost-time injuries and 9 percent of all injuries reported. Over a 5-year period the average time loss per lost-time injury was 92 days, compared with an average of 101 days at 355 representative California metal mines.16

CAUSE AND NATURE OF INJURIES

The causes and means of prevention of accidents at metal mines in the various States are discussed in the annual mine-accident reports of the Federal Bureau of Mines. The prominence of explosives accidents, which now rank first as a cause of fatalities in the Pacific Coast metal-mining States, is striking. No single cause offers a more fertile field for reducing deaths at the average California mine than the use of explosives. There are several reasons 17 for this. The use of explosives is the major cause of fatalities, yet it is the least supervised of any important phase of mining practice. The transportation, handling, and preparation of explosives, as well as the loading and firing of the holes, are left universally to the individual miner. Moreover, inspection of the face and reporting and handling misfires are as a rule left entirely to the miner, as essentially are all methods of control.

Safety work, including supervision, inspection, compliance with orders, safe tools, and safety clothing, is recognized as essential, but the average mining man is inclined to attribute an explosives accident resulting from the use of fuse and caps to the material used rather than to the method of using it. Explosives manufacturers rightfully can boast of advances in safety as far as they are concerned in the use of explosives. Here the safety record ceases, and the metal miner finds himself in essentially the same hazardous position as he always has been; in other words, little or no progress has been made in the prevention of accidents from unsafe methods of using explosives in metal mines. Improvements in shot firing, as well as other factors connected with blasting in coal mines, have advanced the coal miner’s safety materially in the past quarter of a century. In thousands of coal-mining operations electric blasting is now the rule, as in tunneling and quarrying practice, with the result that the number of explosives accidents in these branches of the industry is being reduced gradually; in some mines millions of pounds of explosives have been used without a single accident.

The major potential cause of fatalities in California mines today is explosives, as unfortunately also at the Lava Cap mines, but changes in practice are being made to eliminate this cause. The significance of this statement is revealed in table 1 by the record of fatalities at the Lava Cap mines; during 1934–38, 1 man was killed by explosives and 1 by falls of roof, while in California 27 fatalities were attributed to

explosives and 39 to falls of roof and in the metal mines of the United States 62 to explosives and 160 to falls of roof.

Table 5 gives the number, time loss, and percentage of lost-time injuries, by cause of injury, at the Lava Cap mines for 1934–38, inclusive, and the percentage of nonfatal lost-time injuries in the metal mines of California for 1924–34.

Table 6 shows the rank and percentage frequency of injuries, according to part of body injured, at the Lava Cap mines and at all California metal mines for the latest available period.
<table>
<thead>
<tr>
<th>Cause</th>
<th>1934</th>
<th>1935</th>
<th>1936</th>
<th>1937</th>
<th>1938</th>
<th>Total lost-time injuries, 1934–38</th>
<th>Total time loss, 1934–38, days</th>
<th>Time loss, percent</th>
<th>Percentage of non-fatal injuries in California, 1924–34, by cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falls or slides of rock or ore from back or wall.</td>
<td>12</td>
<td>15</td>
<td>12</td>
<td>6</td>
<td>14</td>
<td>2,100</td>
<td>57</td>
<td>14.65</td>
<td>15,508.00</td>
</tr>
<tr>
<td>Timbering</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>62</td>
<td>27</td>
<td>6.94</td>
<td>488.00</td>
</tr>
<tr>
<td>Hand tools</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>25</td>
<td>2</td>
<td>0.65</td>
<td>58.00</td>
</tr>
<tr>
<td>Haulage</td>
<td>6</td>
<td>131</td>
<td>8</td>
<td>67</td>
<td>8</td>
<td>108</td>
<td>13</td>
<td>114</td>
<td>66.00</td>
</tr>
<tr>
<td>Handling materials</td>
<td>6</td>
<td>55</td>
<td>8</td>
<td>83</td>
<td>6</td>
<td>120</td>
<td>9</td>
<td>67</td>
<td>57.00</td>
</tr>
<tr>
<td>Mucking and sorting ore</td>
<td>10</td>
<td>92</td>
<td>11</td>
<td>98</td>
<td>15</td>
<td>120</td>
<td>12</td>
<td>35</td>
<td>47.00</td>
</tr>
<tr>
<td>Drilling</td>
<td>19</td>
<td>604</td>
<td>7</td>
<td>88</td>
<td>15</td>
<td>76</td>
<td>13</td>
<td>70</td>
<td>57.00</td>
</tr>
<tr>
<td>Machinery</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Falling down shaft, chute, winze, raise, or stop.</td>
<td>2</td>
<td>30</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>7.00</td>
</tr>
<tr>
<td>Skips, cages, or buckets</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>Explosives</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6,000</td>
<td>2</td>
<td>19</td>
<td>2.00</td>
</tr>
<tr>
<td>Sovereign from mine gases</td>
<td>2</td>
<td>19</td>
<td>2</td>
<td>19</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>5.00</td>
</tr>
<tr>
<td>Mine fires</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Total mine</td>
<td>55</td>
<td>9,805</td>
<td>53</td>
<td>13,000</td>
<td>81</td>
<td>1,703</td>
<td>69</td>
<td>6,777</td>
<td>77</td>
</tr>
<tr>
<td>Surface:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mill</td>
<td>2</td>
<td>28</td>
<td>2</td>
<td>14</td>
<td>4</td>
<td>821</td>
<td>3</td>
<td>37</td>
<td>15.00</td>
</tr>
<tr>
<td>Shops</td>
<td>2</td>
<td>38</td>
<td>3</td>
<td>93</td>
<td>5</td>
<td>833</td>
<td>3</td>
<td>18</td>
<td>17.00</td>
</tr>
<tr>
<td>Total surface</td>
<td>4</td>
<td>105</td>
<td>5</td>
<td>97</td>
<td>9</td>
<td>1,654</td>
<td>11</td>
<td>103</td>
<td>41.00</td>
</tr>
<tr>
<td>Mine and surface not segregated</td>
<td>13</td>
<td>56</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>1,117</td>
<td>9</td>
<td>2,723</td>
<td>389.00</td>
</tr>
<tr>
<td>Grand total</td>
<td>72</td>
<td>9,967</td>
<td>58</td>
<td>13,117</td>
<td>90</td>
<td>3,357</td>
<td>80</td>
<td>6,889</td>
<td>89</td>
</tr>
</tbody>
</table>

2 i killed.
3 1 eye injury, 1,800 days lost.
4 3 eye injuries.
5 Not segregated as to surface and underground.
Table 5 reveals that experience at Lava Cap from falls of roof and falling down shafts, chutes, etc., is above average, whereas it is below average for the other major causes of haulage—mucking and sorting ore, drilling, and falls of persons.

The causes assigned for injuries do not always indicate the remedy as clearly as does a review of the nature of injuries sustained.

As may be seen in Table 4, the rank of injuries according to nature is identical with that for the State. The use of gloves at Lava Cap is reducing hand injuries.

Head injuries cost less in both suffering and money at Lava Cap than at other mines in the State owing to the rigid requirements for head protection, but eye injuries are more severe at Lava Cap and also account for a large part of the accident cost. In the State as a whole 24 percent of the permanent-partial-disability injuries are eye injuries; these are not indicated in studies where causes of injuries alone are given. Eyes are injured in many ways, but there is only one sure way—rigid enforcement of the wearing of goggles—to prevent an injury once the injuring fragment is on its way.

Some of the most recent safety practices adopted to prevent injuries at Lava Cap are the use of duralumin machine column bars to prevent injuries from falls of roof and persons while drilling and the trial of Primacord in blasting cut holes by fuses to insure simultaneous firing. Another important feature in promoting safety is the fact that strains and sprains often are in large part a result of physical impairment, as revealed by physical examinations.

COST OF INJURIES

The management at Lava Cap has long recognized that the cost of injuries is a problem of management, and its cost experience reflects this viewpoint in accident costs. As exemplified at Lava Cap, self-insurance is more likely to lead to safer operation (fig. 14) than where the operator assumes a position that as long as an insurance carrier pays the accident cost he need not take unusual precautionary measures to prevent accidents.

Table 7 summarizes accident-cost experience at the Lava Cap mines for 1934–38, inclusive, and at California metal mines insured by private carriers, including the State fund, for 1933–36.

Industrial-insurance costs depend primarily on accident occurrence and the safety practices employed. They are influenced also by the insurance system and schedules of payments in effect in the State.  

---

Table 6—Rank and percentage frequency of injuries, according to part of body injured, at Lava Cap gold mines and mines of California for latest available period

<table>
<thead>
<tr>
<th>Part of body injured</th>
<th>Rank</th>
<th>Percentage of Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lava Cap gold mines</td>
<td>California metal mines¹</td>
</tr>
<tr>
<td>Arms</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fingers</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Hands</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Legs</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Toes</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

¹ All mines except coal mines. ² Includes remainder of parts of body.
<table>
<thead>
<tr>
<th>Item</th>
<th>Lava Cap mines</th>
<th>California metal mines,(^2) (1933-36)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1934</td>
<td>1935</td>
</tr>
<tr>
<td>Pay roll</td>
<td>$195,590</td>
<td>$263,266</td>
</tr>
<tr>
<td>Man-days (^4)</td>
<td>56,627</td>
<td>51,762</td>
</tr>
<tr>
<td>Earned premium</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>Compensation</td>
<td>$6,271</td>
<td>$5,317</td>
</tr>
<tr>
<td>Medical aid</td>
<td>$3,474</td>
<td>$3,605</td>
</tr>
<tr>
<td>Benefits (losses)</td>
<td>$284</td>
<td>$19,222</td>
</tr>
<tr>
<td>Administration (overhead)</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>Costs per $100 of pay roll:</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>Compensation</td>
<td>$3.19</td>
<td>$2.94</td>
</tr>
<tr>
<td>Medical aid</td>
<td>1.25</td>
<td>0.92</td>
</tr>
<tr>
<td>Total benefit costs (pure premium)</td>
<td>4.42</td>
<td>3.86</td>
</tr>
<tr>
<td>Administration (overhead)</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>Earned premium</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>Loss ratio (percent)</td>
<td>45.33</td>
<td>48.56</td>
</tr>
<tr>
<td>Number of lost-time injuries (^1)</td>
<td>172</td>
<td>158</td>
</tr>
<tr>
<td>Industrial-insurance cost (^1) per lost-time injury</td>
<td>$248</td>
<td>$242</td>
</tr>
<tr>
<td>Rate per $100 of pay roll (manual): (^{11})</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>No. 1122, mining, surface (no underground workings)</td>
<td>$9.15</td>
<td>$9.15</td>
</tr>
<tr>
<td>Silicosis surcharge</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>No. 1123, mining, underground (^2)</td>
<td>$11.00</td>
<td>$11.00</td>
</tr>
<tr>
<td>Silicosis surcharge</td>
<td>()</td>
<td>()</td>
</tr>
<tr>
<td>No. 1124, mining, surface employees N. F. D.</td>
<td>$9.15</td>
<td>$9.15</td>
</tr>
<tr>
<td>Silicosis surcharge</td>
<td>()</td>
<td>()</td>
</tr>
</tbody>
</table>

\(^1\) State data for policy years 1933-36, inclusive.

\(^2\) Self-insured after Mar. 15, 1936; overhead costs include reinsurance, legal and administrative, safety-engineer salary, and miscellaneous costs, under self-insurance; private insurance carrier administrative expense, $6,400 in 1936.

\(^3\) Risks carried by private insurance carriers, including State fund, policy years 1933 to 1936, inclusive; classifications 1122, 1123, 1124, 1164; includes dust disease.

\(^4\) 8-hour shifts.

\(^5\) Refunds, private insurance carrier, 1934, $2,283; 1935, $3,710.

\(^6\) Earned premium, private insurance carrier, $5,905; refund, $7,762.

\(^7\) Estimated outstanding liability Dec. 31, 1938, less than $1,000.

\(^8\) Does not include medical aid for policies for 1933; excluding medical-cost pay roll of $1,112,795, compensation was $5,017.

\(^9\) Period of 1 day and over.

\(^{11}\) Includes compensation, medical care, and overhead.

\(^{11}\) For State of California.

\(^{12}\) No change in silicosis surcharge for 1939. Other rates: Classification 1122, $4.27; classification 1123, $9.17; classification 1124, $3.92.
Industrial insurance at the Lava Cap mines was carried by private insurance companies during 1934, 1935, and until March 15, 1936, when the management decided to carry its own insurance. The laws of the State require self-insurers to carry a bond of $30,000 or more to insure benefits to injured workmen. In this instance the company has provided $30,000 in Government bonds, which are held in escrow by the State, and the interest from these bonds accrues to the company.

Medical care is provided under contract, and up-to-date medical attention and hospital service are readily available for injured workmen. Under the self-insurance plan the management pays a flat rate of $1.50 per man-month (number of days, exclusive of Sundays and holidays, in each calendar month) for this service.

**SUMMARY**

1. Accident rates and costs have been consistently higher at the dry- and siliceous-ore lode-gold mines in the United States than in any other branch of the mineral industry.
2. The ranking cause of fatal accidents in the mines of California, Arizona, and Nevada is the misuse of explosives.
3. The safety practices, accident experiences, and costs at the mines of the Lava Cap Gold Mining Corporation illustrate how gold mining can be pursued with the same degree of safety as any other industry.
4. The average number of employees at Lava Cap is 270, and the average daily production is 300 tons.
5. The hoisting equipment has a safety control switch in the head frame, electric eyes at the shaft collar, and automatically operated controls at the hoist to protect against overwind and overspeed. It is inspected weekly by the master mechanic, and the hoisting-rope hitchings are inspected daily.
6. Hoisting engineers must pass physical examinations at 6-month intervals and be physically fit at all times to comply with State standards.
7. A modern change house is provided for the use of all employees.
8. Explosives are stored on the surface in magazines 300 feet from the nearest building and 500 feet from the nearest transformer.
9. A 2-day supply of explosives is kept in each magazine underground.
10. Detonators or capped fuses are not stored underground but are taken underground during each shift just before blasting time.
11. A mine lamp house is provided with 240 up-to-date permissible electric cap lamps.
12. Water supply, sanitation, and housing of employees comply with State and United States Public Health Service standards.
13. All shafts are timbered with standard 8- by 8-inch wall and end plates, and timber is kept in good condition. There is evidence that timbering rules are not followed diligently; close supervision, inspection, and discipline are required to keep underground workings properly protected by timber.
14. Forty-five-percent dynamite is used in all work. Firing is done electrically from power circuits and by fuse and caps using hot-wire spitters.
15. Prevention of misfires would contribute more than any other single factor to the prevention of explosives accidents, which are so common in California mines.
16. Electric blasting is the safest method for controlling shooting.
17. All workmen wear permissible electric cap lamps.
18. The Central mine is ventilated mechanically and the Banner mine by natural means. The circulation system provides about 200 cubic feet of air per minute for each man employed underground.
19. Flame safety lamps are not used in the mine.
20. Smoking is permitted underground on the man-trip used in the Banner adit, in shaft stations, and in the skips in the main shaft.
21. During June 1938 the relative humidity ranged from 95 to 100 percent and temperatures from 54° to 60° F.
22. The clearance on haulage levels is limited, and walkers must find wide places to avoid hazards of passing trips; as there are no shelter holes, they must depend on the slow travel of the moving cars or trips and the signal lights and bells provided on them. Chute spouts are constructed substantially and are protected.
23. Special man-cars are provided for hauling the workmen in the Banner adit. Tools, explosives, and other supplies are not carried on man-trips.
24. Power wires are guarded where men must pass under them and are insulated where they pass through doors.
25. An efficient underground telephone system connects various points underground and at the surface.
26. The operating officials recognize that fire hazards exist. Workmen are trained in fire protection, and a safety engineer is constantly on the alert for fire hazards.
27. Most of the injuries at Lava Cap result from falls of rock. All workmen wear hard hats and goggles but not continuously. Accident experience has improved since the adoption of protective clothing.
28. Experienced and technically trained men are employed as supervisors. Each shift boss supervises 30 to 40 workmen and visits all working places twice daily.
29. The safety organization comprises four sectional safety committees of three men each—elected by the workmen—the shift boss, mine foreman, mine superintendent, and the safety engineer. The whole safety committee makes a general inspection trip every 60 days. Each sectional committee inspects its section of the plant monthly and reports conditions at the monthly safety meetings, which are open to all employees, including officials.
30. A shift-boss bonus system provides for payment of 1½ cents for each man-day supervised, less $5 for each injury causing a time loss of only 1 day and $10 for each injury causing a time loss of more than 1 day.
31. Employees are trained each year in first aid by a Bureau instructor and company instructors under the cooperative plan; 15 employees are trained each year in mine rescue.
32. First-aid stations are maintained on the surface and underground, and an up-to-date hospital is accessible to the employees.
33. All accidents are investigated by the safety engineer and all serious ones by the general superintendent and the safety committee as well.
34. The achievement at Lava Cap is the marked reduction in fatalities; for 1934–36 the danger of getting killed was almost 2½ times greater than that at the average metal mine in California and in the United States, whereas for 1936–38 it was 50 percent less than in the State and Nation.

CONCLUSIONS

The Lava Cap enterprise conducts its mining operations on a safer plane than the average lode-gold mine and because of its size among metal mines has a material influence on the industry as a whole. This paper describes many safety practices in gold mining which, if adopted, would make lode-gold mining a much safer branch of the mineral industry, save thousands of dollars of wasted dividends in the gold-mining industry, and prevent much human suffering.
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