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PROGRESS ON THE COMSTOCK LODE

Difficulties Which Caused the Shutting Down—Engineering and Other Advances That Have Aided the Reopening

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Item 93

Written for "Mines and Minerals," by R. L. Herrick

Nevada has been engaged in "boosting" such a multitude of new camps in the last few years that the old camps of the Comstock Lode have been elbowed to the background. Seldom have they been mentioned, except, perhaps, in the gorgeous prospectus of a promoter boosting his "greater than the Comstock, which produced $650,000,000." If mentioned at all in the daily press, the writer was usually content to make a fling at questionable methods of the Comstock stock manipulations, speak disparagingly of the great mines and their future prospects, and roast the management of the mines and the Sutro tunnel which drains them.

Up to the time of his recent visit, the writer, like many others, had grown to class the former greatness of Virginia City with the splendors of Babylon, and believe the chances of one as good as the other's for again assuming a position of much importance in the mining world. Before proceeding to a description of these recent engineering developments, whose inspection caused the writer to alter his opinion, it will be necessary to explain to the reader some of the Comstock complications which have long delayed the return of Virginia City to the ranks of important producers.

Historical.—It will be recalled that the famous old mines of Virginia City, and its suburb, Gold Hill, occupy adjoining positions along the north to south extent of the great Comstock Lode. The position of these mines is shown in the north to south section, Fig. 1, which shows merely the location of the principal shafts with their present water levels, the Sutro tunnel and only such stopes as have been excavated since the year 1890. The hundreds of miles of drifts, etc., and huge stopes worked out previous to this date can best be made apparent to the reader by his consulting the maps in the Government Report on the Comstock Lode (Becker's Atlas).

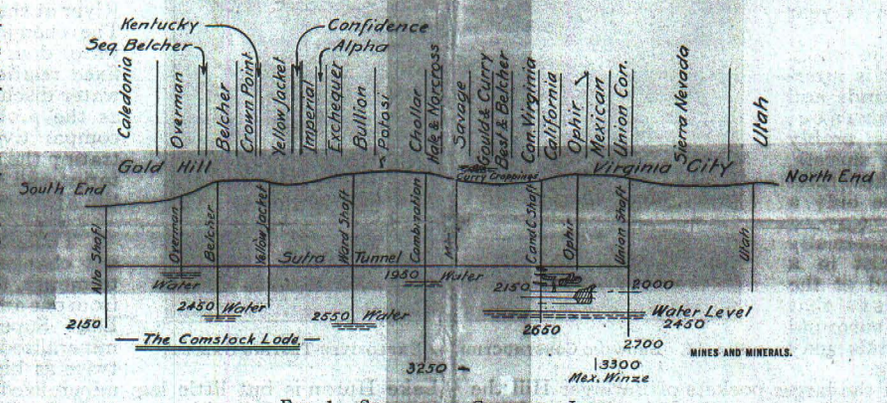

FIG. 1. SECTION ON COMSTOCK LODE

Up to the year 1883, the drainage of the mines of the lode was accomplished by several large pumping plants, the principal among which were the Cornish systems at the Union shaft, Combination shaft, Yellow Jacket, and Alta; also a large hydraulic system at the Combination. Practically the entire drainage of the lode was at that time accomplished by these plants whose combined weights of moving parts alone are said to have been nearly 6,500,000 pounds. Their combined maximum capacity was less than 5,400 gallons per minute raised to an average height of 1,152 feet which amounts to about 1 gallon of capacity for every 2,230 pounds of the pump's entire weight. The cost of their installation is given as about $1,400,000 and the cost of operation alone, exclusive of repairs, amounted to $58,120 per month, or $697,440 annually. This expense was borne jointly by the surrounding mines until the spring of 1883, when operations came to a dramatic close as follows:

A good ore body had been encountered on the 2,810-foot level of the Exchequer Mine, which was being rapidly prospected, when suddenly the drift broke into a heavy flow of water estimated at about 1,320 gallons per minute. As the pumps were already working at nearly their full capacity, they were unable to control this flow. The water level rose rapidly, flooding the mines and was with difficulty held at the 2,300-foot level until March. Discouraged by the failure to drain the mines, the surrounding properties then withdrew their financial support, thus forcing the abandonment of the mines March 28, 1883. Although connected by a drift on the 2,150-foot level with the Yellow Jacket, the Ward shaft avoided immediate drowning but by the construction of a solid brick bulkhead in this drift, equipped with valves for draining.

Forced by its finances to close down just as it would appear that the shaft was about to break into a paying zone, the Ward was abandoned in the early summer of 1883. Having drowned out all the mines on the southerly portion of the lode, the water now encroached on those of the northern end and quickly forced them to close down.

With the mines of both the northern and southern portions of the lode drowned out, those of the middle portion soon felt the great increase of water since the cessation of pumping. Among these was the Combination shaft, whose depth of 3,250 feet makes it the deepest gold and silver mine shaft in the world. The abandonment of the property in 1886 dealt the death blow to deep mining on the Comstock.

In the absence of authentic data we must assume that the flooding of these last groups of mines took place at a time when the majority of them had practically worked out their high-grade ore reserves. In the light of the production of two of these (the Con. Virginia and the Ophir) since their recent drainage, it is apparent that they, at least, lacked development rather than ore. The increasing flows of water, however, necessitated either the installation of new pumping plants or immediate abandonment. With no ore reserves, the great expense of such a plant could be borne only by assessing the stockholders. The majority of these, however, had probably purchased their holdings at the fancy figures of the mad boom, and the dividends in most cases failing to approximate their first investment, they viewed the closing of the mines with indifference. The broaching of a drainage scheme to such stockholders, if it was attempted, naturally ended in failure. The intrepid miner naturally yearned to continue prospecting for more pockets like the single one whose production is recorded at more than $134,000,000, but in the absence of working funds the rising waters were allowed to close over these, the world's greatest gold and silver mines, up to the level of the Sutro tunnel. At the time of the abandonment of the mines, the superintendents of all of them made a joint report concerning the prospects of finding more ores. An abstract of this detailed report has been recently made public in a report to the Pumping Association by Leon M. Hall, of San Francisco, Cal., consulting engineer. Suffice it here to state, however, that this report held out such alluring prospects that it has been made the basis of all subsequent endeavors to recover the flooded treasure lodes.

The first of these endeavors was initiated in 1890 by the Gold Hill Pumping Association, comprised of thirteen companies. Air-driven Dow pumps were installed on the Crown Point incline and the water pumped to the Sutro-tunnel level. After the expenditure, recorded at $640,000, in lowering the water but 200 feet, the attempt was abandoned in disgust.

Common Stock Manipulations.—With the exception of this above-recorded attempt the period of abandonment of the mines stretches unbroken from the year 1883 to 1898. During these 14 years, although the mines themselves were idle, the stocks were by no means so. The period may aptly be referred to as that in which the mines filled up with water while the "water" (unwarranted values) was squeezed out of their stocks. The devious ways by which this was accomplished is too generally understood to need explanation here. It suffices to explain that in the year of 1898 it seems probable that the majority of active stockholders in twenty-four of the principal mining companies belonged to that hopeful class hard to dismay by dismal forebodings and hard to freeze out by the usual simple process of levying assessments. They had bought in at fair prices with the understanding that the mines were to be reopened and were not to be discouraged by ordinary means. A fact not generally understood, however, is that during this period of abandonment the control of the mines came into the hands of a coterie consisting mainly of brokers, located for the most part, on Pine Street, San Francisco. This power was theirs, not by virtue of ownership of the majority of stock, however, but through their manipulation of proxies to elect themselves and their friends to the executive offices of the mining companies. The significance of this particular concentration of power will become apparent from the description given below of the Comstock Pumping Association.

The Comstock Pumping Association.—The concentration of the majority of the mines' executive offices into the hands of the Pine Street brokers had at least one advantage. Working

feet in lateral extent, F. L. Hess, of the United States Geological Survey, in a report just published, gives a list of about two dozen minerals found in this small area, among them a number of radioactive materials and others of great and increasing practical importance. Among the rare-earth minerals at Baringer Hill are fergusonite, gadolinite, polycrase, yttrialite, and cyrtolite.

The economic interest in these minerals is due to the incandescence of their oxides on being heated. This property makes them available for use as glowers in gas and electric lamps. Thoria, beryllia, yttria, and zirconia are the most useful minerals employed for this purpose. Until the discovery of the deposits at Baringer Hill it was practically impossible to get sufficient yttria-bearing minerals to manufacture mantles for electric glow lamps; but fergusonite and gadolinite, with lesser amounts of cyrtolite and other minerals containing yttria, occur here in quantities large enough to meet the demand. The Nernst Lamp Co. owns this valuable deposit, but its needs require only the occasional working of the mine. After enough yttria minerals are obtained to supply its wants for several months the mine is closed. Only a few hundred pounds a year are extracted.

The geologic island in which Baringer Hill is located is interspersed with other mounds and dikes of similar appearance, which have been considerably prospected, but without success. Mr. Hess states that as these rare-earth minerals constitute only a small fraction of 1 per cent. of the total mass, commercially large amounts may exist in a dike and not be exposed at the outcrop; but suggests that cracks that generally surround the nuclei of the minerals may be utilized in prospecting.

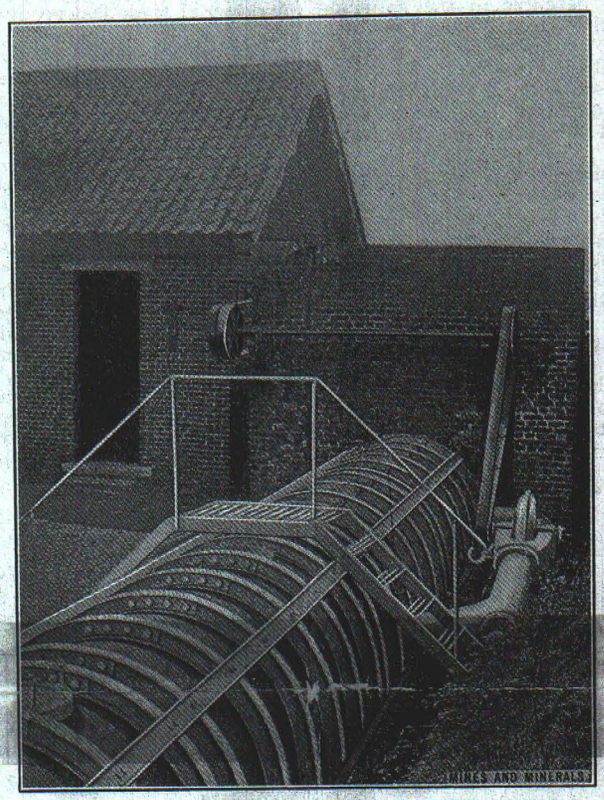

FIG. 11. SHOWING CONSTRUCTION OF EXPLOSIVES-TESTING GALLERY

In mining the ore of the larger pockets of Baringer Hill the hands and faces of the miners have been affected as if by sunburn, due, possibly, to the radioactivity of the minerals.

The Waters of the Great Lakes

More than four million people, living in a hundred cities, obtain water for domestic and industrial uses from the great inland seas on the northern boundary of the United States; and boiler water for the enormous land and water traffic that joins these cities to one another and to the rest of the world is derived from the same source. The chemical composition of these waters is therefore a matter of great interest to both sanitarian and chemical engineers, and a study of their composition is also valuable because the comparatively equable condition of the lake waters allows them to serve as a standard for comparison with other waters in the northern region.

About two years ago the United States Geological Survey began a study of the waters of the Great Lakes in connection with an extensive investigation of the economic value of surface waters in the United States For a year a 1-gallon sample was collected each month from each lake at a point where the water would probably represent the normal quality of the discharge. The waters were shipped in special containers to the water-testing laboratories of the Survey at Washington, D. C., and were analyzed from one to three months after collection.

Mr. R. B. Dole, under whose direction the analyses were made, states that the most noticeable feature in a cursory examination of the analytical data is the slight variation in the concentration of the waters from month to month, the total variation, as shown by the dissolved solids figures, being only 18 parts per million, or 15 per cent. As rivers of ordinary size may vary 200 to 300 per cent. and even large rivers, like the Mississippi, may change 50 per cent. in their mineral content during the year, this annual fluctuation of 15 per cent. is very small. The average monthly fluctuation in the discharge of the Great Lakes is considerably more than 15 per cent., ranging from 40 per cent. in St. Marys River to 27 per cent. in St. Lawrence River at the foot of Lake Ontario. The chemical composition of the water does not, therefore, bear a fixed relation to the quantity of water discharged. Mr. Dole gives as the probable reasons for this comparative steadiness in concentration the absence of large tributaries and the low ratio between the areas of the drainage basins and the lake surfaces.

Though the lake waters do not change greatly from month to month, they differ a great deal from one another in concentration. Lake Superior is least strongly mineralized; Lake Michigan is twice as high in total solids, and Lake Huron is but little less mineralized than Lake Michigan. Lakes Erie and Ontario are practically alike in mineral content, holding about 2½ times as much solids in solution as Lake Superior. Reason for the striking difference in the lake waters is found in the character of the geologic formations in the drainage basins tributary to them.

Comparison of the analyses of the lake waters with those of tributaries to the system shows, according to Mr. Dole, that the lakes are almost invariably softer than their affluents. The reason for this difference is apparent: As the lake surfaces are large in proportion to their corresponding land drainages, a great part of the rain falls directly into the lake waters and dilutes them; on the other hand, rain falling upon the land becomes more or less impregnated with mineral salts before it reaches the lakes in the normal run-off. This fact has an important relation to the industrial consumption of the waters, and shows the importance of locating intakes outside of the influence of tributary streams.

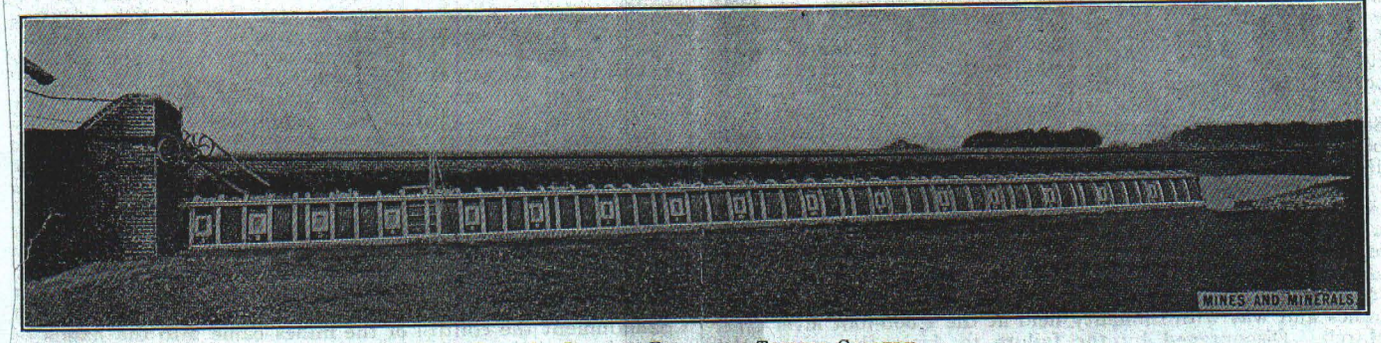

FIG. 10. BELGIAN EXPLOSIVES-TESTING GALLERY

Although the last contract with the Tunnel Company guaranteed an expenditure of but $125,000, up to the time of the writer's visit the Association had expended the sum of $262,772.73, thus nearly completely repairing the great work whose first cost of construction was more than $5,000,000.

Caving Along the Lode.—Although negotiations with the Tunnel Company extended over a long period before being brought to a mutually satisfactory conclusion, the work of unwatering the lode was being steadily pushed all the time. During the period of abandonment, the great stopes once so splendidly timbered were crushed in along the length of the lode from end to end. A great scar, which may be plainly seen from any point of vantage, extends along the surface parallel to the lode, showing that an extensive movement has taken place along and down the foot-wall. While the exact amount of this movement is not known, measurements taken on the 1,500-foot level of the old Con. Virginia shaft showed that the distance moved is at least 16 feet. Not only the stopes, but hundreds of miles of workings excavated in the bonanza days are thus known to have collapsed. In unwatering the old mines, therefore, it will be understood that danger was ever present due to the menace of great subterranean reservoirs of water held back only by the caved portions of the drifts connecting with the shaft.

The C. & C. Pumping Plant.—Owing to its excellent condition and favorable location for draining its neighbors, the C. & C. shaft was selected by the Pumping Association for the installation of its pumping plant, the water level at the start of operations standing about 25 feet below that of the Sutro tunnel

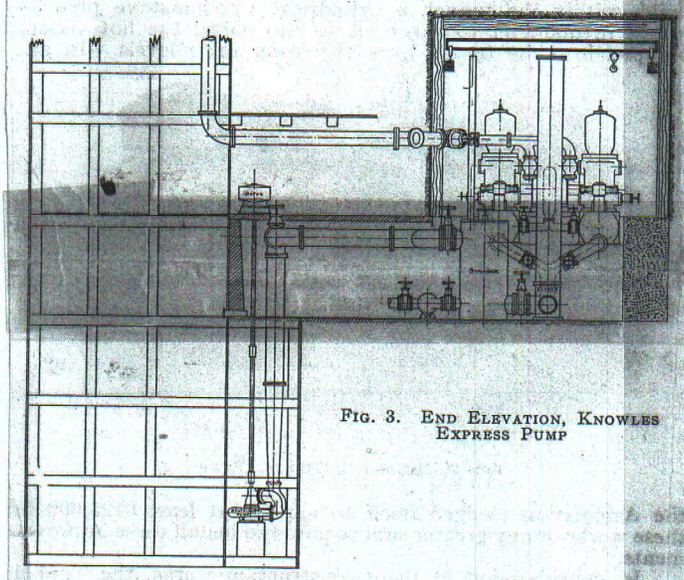

FIG. 3. END ELEVATION, KNOWLES EXPRESS PUMP

connection (1,650 feet). It will of course be understood that below the water level the shaft was in good condition, but the stations were caved, as were many of the drifts, and contained an immense amount of debris which had to be removed. All of this work we pass over, and from here on devote our description strictly to the pumping operations.

The water was lowered 500 feet, from the 1,650-level of the Sutro tunnel to a depth of 2,150 feet, by the use of hydraulic elevators acting on the injector principle. The main column pipe extending to the surface supplied a maximum of 200 miners' inches under a pressure of about 900 pounds per square inch at the 2,150-foot level, the velocity of the stream at the injector, shown in Fig. 6, sufficing to raise itself and the water drawn from the shaft, to the tunnel level. On the 2,150-foot level was then excavated a great pump chamber, 20 feet wide by 119 feet long and 20 feet high in the clear, supported by 14″ × 14″ timbers spaced on 4-foot centers and lagged. Here was installed the pumping plant shown in Fig. 7, consisting of $3\frac{11}{16}$″ × 24″ double-acting Riedler pumps, each with a pumping capacity of 1,500 gallons of water per minute from the sump on the level to the Sutro tunnel, each operated by a 200-horsepower Westinghouse induction motor.

Although equipped at the start of operations in 1899 with a fund of $100,000 for the work, the year 1902 found the north mines drained only to the 2,150-foot level, the funds of the Association exhausted and no more immediately forthcoming. Had not a fortunate and noteworthy event taken place, after the lowering of the water level but a little over 100 feet, the work might have been delayed some time. The saving event was the striking of the large ore body, shown in Fig. 1, on the 1,750-foot level of the Consolidated Virginia. This proved to extend into the Ophir ground so that both of these companies were quickly benefited by the joint work of the Association.

The following shows the production and dividends paid by these two companies since the strike in 1898.

	Bullion Production	*Dividends Paid*
Consolidated Virginia	$ 995,766.09	$ 64,800
Ophir	1,528,705.09	221,760
Total	$2,524,471.18	$286,560

It is now apparent why the Consolidated Virginia was enabled to step into the breach in the year 1902, and advance the Pumping Association $100,000 to pay for the installation of the great Riedler pumps, thus enabling the continuation of draining the mines below the 2,150-foot level. Below this level, the shaft water was lowered by again using hydraulic elevators as before, draining down to the 2,470-foot level. At this level today is installed a single elevator which raises 3,000 gallons per minute to the 30,000-gallon Riedler pump tank, requiring for its operation 1,400 gallons per minute fed from the surface down the column pipe under a pressure of about 1,100 pounds per square inch. That this one pumping plant has been instrumental in lowering the water over the entire lode is shown by the decreased levels in the shafts today, below what they were before pumping. In the workings of the C. & C., Union, Ophir, Mexican, Sierra Nevada, Best & Belcher, the water now stands at the 2,450-foot level; in the Combination shaft the level has sunk 200 feet, while even in the distant Overman shaft it decreased 60 feet before the starting of the pumps in the Ward. Greatly encouraged by this success, the management has purchased a 5-step centrifugal pump, with its motor, to be installed on the 2,450-foot level. This will relieve the hydraulic elevator so that it can be used to pump to the sump of the centrifugal as sinking progresses another 500 feet to the 2,650-foot level.

The Ward Shaft Association.—Foreseeing the success of the Comstock Pumping Association, the year 1903 was marked by the organization of the Ward Shaft Association, composed of nine of the original twenty-four companies which had organized the former. These companies ceased paying their pro rata to the first organization in order to devote their funds to the support of a plant entrusted with the draining of their mines quicker than could be accomplished from the C. & C. shaft. The Ward Shaft Association consisted of the following companies whose properties extend for nearly a mile along the middle and southern portion of the lode; namely, the Gould & Curry, Savage, Chollar, Potosi, Bullion, Alpha Consolidated, Exchequer, and Julia Consolidated.

The Ward shaft, like the C. & C., was selected for the pumping-plant installation for its apparent excellent condition and favorable location for draining neighboring properties. Had its true condition beneath the water level been foreseen, it is probable that a new shaft would have been sunk without attempting the repair of the Ward. At the time operations started, in October, 1903, the water level was about even with that of the Sutro tunnel. At the time of its abandonment, 20 years previously, it had been sunk to a total depth of 2,481 feet, but although the Sutro tunnel was only about 300 feet distant from its 1,600-foot level, no connection between the two had ever been driven. After retimbering down to this level, therefore, the connection was made, greatly improving ventilation and thus lowering the high temperature. In reopening the shaft below this level, the pumping of considerable flows of hot water necessitated the installation of an extensive temporary pumping plant. This consisted of the following three units:

1. At the bottom of the shaft, 2,435 feet below the collar and 835 feet below that of the Sutro tunnel, was placed a 9-inch Knowles sinking pump operated by compressed air from the plant located on the surface.
2. This lifted the water to the 2,330-foot level above, on which was located a centrifugal pump belted to a 50-horsepower Westinghouse induction motor.
3. This centrifugal pump lifted the water up its last stage of 230 feet to the 2,100-foot level on which was located a $6\frac{3}{4}$-inch Knowles vertical triplex pump geared to a 100-horsepower Westinghouse induction motor. This last pump made the final lift of 500 feet to the Sutro tunnel, pumping 300 gallons per minute.

Having drained the shaft below the 2,400-foot level, this temporary plant was replaced by a 5-step centrifugal pump located on this level operated by a 200-horsepower motor speeding at 1,720 revolutions per minute that makes one lift of 800 feet to the Sutro tunnel, pumping 600 gallons per minute from its sump, which is kept full by the sinking pump.

together as they did, they were enabled to plan and adopt a method of joint work between the mines for the unwatering of the entire lode. This resulted in the organization of the Comstock Pumping Association in 1898, composed of the twenty-four principal mining companies owning the property extending from the Utah on the north, along the lode south to the Alta as shown in Fig. 1. The governing board of this association consisted of the presidents of the various mining companies under whose management a superintendent directed the actual mining work. Whether this form of organization was responsible for the many well-known abuses of power and of inside information to manipulate the stock market, we leave to our readers to decide. Now that a change has come over former conditions, however, and these abuses are practically at an end, it seems worth while to study the lesson that may be learned from the events transpiring during the "Stock-Market Regime."

It is, of course, understood that the proposal of the Association to unwater the lode at once created an active market for the mining stocks. The buyer thus became liable to such assessments as were allowed by law, namely a maximum frequency of once in 90 days. The funds thus raised were of course supposed to be devoted to the unwatering of the lode, each mining company of the association paying its pro rata cost of the common work. Had all of these funds been properly and economically expended, it is safe to say that the condition now only recently attained by the mines would have been reached several years ago. But with the managing board devoting most of its time to the Stock Exchange, it is not hard to understand the reason for many of the aggravating delays.

Now it may be stated as a maxim that whenever one finds the development policy of a mine dictated from a broker's office, the annual report of that particular company will read like the London *Punch* and constitute a joke book of unconscious humor to the mining engineer. For instance, the expenditures published by some of the mining companies sometimes showed that if it became necessary to economize, and either discharge some of the multitudinous heads of the office force or give the miners an extended lay off, it was the mine that was always shut down, while the salaries continued to dry up the dribble from stockholders' assessments. These are harsh statements, it is true, yet so often were they made to the writer at the time of his visit, and so common has become the knowledge, that he is assured it will prove no revelation to those most interested. Whenever it becomes easy and more profitable to work the stockholders for assessments, than to work the mines for precious metals, we may confidently expect the former. Engineers may conceive plans for development that shall restore great mines to the list of producers, yet let those plans be submitted to a broker's office, and the view point changes from the engineering to the market position.

It will now be understood that those engineers entrusted with the solution of the grave engineering problems incident to the unwatering of the lode have been handicapped in a way that few of the profession relish. They have at times been criticized for delays in completing their work, yet, possessed of the foregoing facts and having in mind the record of achievements to follow, their fellow engineers will be able to bestow both criticism and commendation where they belong.

The Sutro Tunnel.—As this tunnel in good condition constituted the key to the drainage situation and was so accepted by the Pumping Association, the first work of unwatering the lode was the improvement of the tunnel.

Completed in 1878, by Adolph Sutro, at a cost of about $5,000,000, this great adit with its laterals nearly 7½ miles in length connected most of the shafts, as shown in Fig. 1. Prior to the closing of the mines, the water had been pumped from their lower levels to the tunnel and been carried to its portal through its drainage box.

As the Sutro Tunnel Co.'s sole source of revenue during its years of usefulness before the shut-down had been derived from the bullion-producing mines, their closing spelled disaster to the tunnel. Failing to derive further revenues, the management of the tunnel devoted itself to making necessary repairs and replacement of timbers, and maintaining the airway and trackage facilities unimpaired. This was accomplished for years at small expense until the introduction of hot water in volume. On the resumption of pumping in 1898, the hot water flowing through it filled the air with steam and was instrumental in causing the rapid decay of the timbering, leading to cave-ins that threatened the total destruction of the tunnel. Friction then developed between the Tunnel Company and the Association, growing out of the inability of the former to pay for the needed repairs to its property until sufficient revenue had accrued from the royalty to be derived from ore production by the mines and transporation of ores over its tracks, and the inability of the mines of the Comstock Lode to pay revenues until pumping had first exposed the ores. We pass over several deadlocks between the two, extending over a period of 5 years, during which it was demonstrated that the Tunnel Company's property could not be forced to a sale by the Association, although any such intent is denied by officials of the latter.

Several events of this period tended to unite these jarring factions and, forced together by mutual interests, a joint meeting of the Tunnel Company and the Association in the summer of 1903 resulted in the appointment of an engineering staff to thoroughly examine the tunnel and report upon its condition to the Association.

In February, 1904, the Association entered into a preliminary contract with the Tunnel Company to repair and retimber certain specified points at an expense not to exceed $18,200. Financed by this sum, almost ridiculous when the magnitude of the needed repair work is considered, the Tunnel Company expended this money in new timbering, trackage, and repairs, as provided, and in maintaining an open airway.

In January, 1905, the engineering staff previously appointed reported that the tunnel with its tracks and sidings could be repaired and a 30-inch wooden-stave drainage pipe constructed through it as far as the Ward Shaft connection for the sum of $125,000 including $57,077 for the drain pipe.

The turning point was reached in April, 1905, when the Comstock Tunnel Co. then, as now, managed by the Leonards, negotiated a contract with the Pumping Association, the substance of which was as follows:

During the 5-year period from 1905 to 1910, the Pumping Association, at its own expense, should make all repairs required, install 1,500 sets of new timbers, thus nearly completely retimbering the tunnel during that period. It should also build, within the tunnel, a cylindrical wooden-stave pipe 30 inches in diameter to carry off to the portal the hot waters pumped into the tunnel from the lower mine levels. In all,

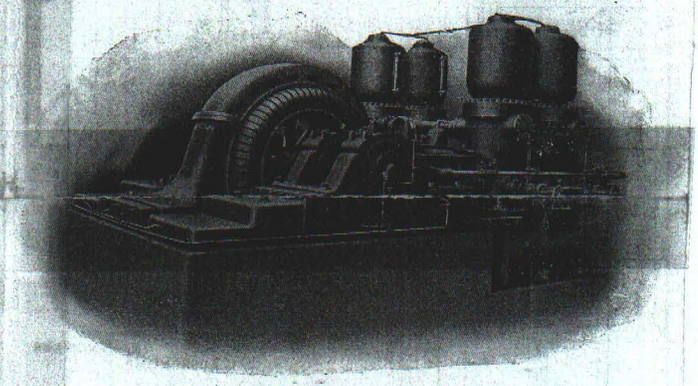

FIG. 2. KNOWLES EXPRESS PUMP

the Association pledged itself to expend at least $125,000 in these works or any greater sum required to install these improvements.

In consideration of these construction works, the Tunnel Company agreed to allow a 50-per-cent. rebate on the regular royalty income from the mines of the Pumping Association for a period of 5 years from April 15, 1905.

Retimbering.—At the time of the writer's visit, June, 1908, the retimbering of the tunnel was well on toward completion, leaving the way open for transportation to the portal, and the completion of the wooden-stave pipe to carry out the hot water. This water has a temperature of 160 degrees Fahrenheit in the deepest levels of the Ward shaft, although at the point where it is discharged into the tunnel it is considerably cooler. The steam from this water, however, is in a great part responsible for the hot, humid condition of the mine air which formerly limited the continuous working periods to from 15 to 20 minutes. The average dry heat of the mines is probably not much in excess of 105 degrees Fahrenheit where the ventilation is good, although in places where it is poor the mercury registers considerably higher. The addition of steam to these otherwise bearable temperatures of dry heat, results in almost unbearable conditions for the miners, greatly increasing the expense of operation by badly impairing their efficiency. Again, the deleterious effect of the steam upon the mine timbers can readily be imagined. The completion of the stave pipe to the tunnel portal will thus constitute a great step toward the economical rehabilitation of the mines, and make bearable the conditions surrounding those engaged in the transportation of their ores to the tunnel portal. It is planned to cover the stave pipe with concrete, in the near future, thus producing eventually a concrete pipe which can be easily repaired and made to last almost indefinitely.