

the ruined city (especially in the direction east to west) is in perfect accordance with what is told us by the oldest explorers, Calderon, Bernasconi, and Dupaix. We disagree only with the narratives of modern travelers who, having visited the edifices situated very near the Palace of the Kings, without penetrating further into the inextricable forest, have doubted the abundance of the ruins.

A single one of our discoveries—but, at the same time, the most interesting one—will form the special object of this article. We desire to speak of a temple which has hitherto been entirely unknown, and which hides within its sanctuary a mysterious piece of sculpture with a cruciform figure, very worthy of being reflected upon by American archaeologists (Figs. 1 and 2). In order to give an idea of the incredible density of the virgin forests in these desert places, we will state that the new temple is found, not at a great distance from the center of the ruins, but, on the contrary, quite near the Temple of the Cross (long known) and the Temple of the Trophy; the latter being in the form of two spears with a shield in the center, and called "Sun" also, because of the round form of the shield, which other travelers have taken for an image of the sun. These three temples are situated at a slight distance from the Royal Palace, toward the south-east—that is, in the direction of Cerro Alto del Palenque—with their facades turned toward a little triangular plaza, whose three angles they occupy. They are built upon a plan which is almost identical, and which may be called the typical one of the Palenque temples. Each one of them arises from a pyramid, which, in the two temples that have been long known, is free on every side, but in the last one discovered is built against the slope of Cerro Alto. The distance between the temples (which is something difficult to estimate) does not appear to exceed four hundred and fifty feet, and that between the foundations of the pyramids not even one hundred and fifty feet. The astonishing exuberance of the vegetation, connected with the fact that the pyramidal basement of the *adoratoire* forms a part of the very mountain, explains how this monument has been able to escape the attention of our illustrious predecessors. From the top of the pyramid, which is perhaps 125 feet high, arises the temple, which, from its base to the crest of the stone roof, does not exceed 25 feet in height. It is built entirely of undressed calcareous stones covered with stucco. The facade, or external portion of the vestibule, which, as in the two neighboring temples, was originally formed of four pillars sustaining the stone roof, has unhappily already ceded to the destructive action of the vegetation; and this is the more to be regretted, because these pillars were generally ornamented with superb figures in stucco and richly painted. The lower end of the sanctuary, in the central room, is ornamented with the most curious sculptures to be found in Palenque. They are executed on three slabs of calcareous stone, measuring six feet in height by a total length of 9½ feet. The two pillars which sustain the vault of the sanctuary were, as in the other temples, originally decorated with figures sculptured on large slabs of limestone, but which have now disappeared. Some bits of the figures, representing richly clothed personages, were still lying on the threshold, but it was impossible for us to put them together to obtain the general appearance of the two slabs. As an offset to this, the sculpture at the extreme end of the sanctuary is still perfectly preserved and quite visible, in spite of its slight relief. In a single place are seen the traces of a sacrilegious hand, which, by the aid of a lever, has vainly endeavored to pry these precious slabs from the wall. Upon a kind of stand is raised a cross (Fig. 1), of a much more striking design than that of the one in the neighboring temple, and which is so universally known. This cross is surmounted by a strange head, wearing around its neck a collar and medallion, the usual ornament among all great personages of Palenque. Ought we to regard this curious head, seemingly decorated with two horns, as a vague souvenir of the North American bison, or ought we to see therein the last traces of an almost effaced Christianity, which, in remote times, may have found its way from the distant races of Atlantis? These are questions difficult to answer. Above the cross is perched a bird with a hieroglyphical head. On the right stands a man on a graceful foliage. This person is not clothed like the great lords of Palenque, and undoubtedly represents one of the common people, as does the woman opposite to him. The latter holds an offering in her hand. In the left hand of the man is seen a small object difficult of explanation, but having some resemblance to the symbol of life, otherwise called the "handed cross," and which so many of the Egyptian statues hold in the same way. Both the man and woman have their mouths open, as a sign that they are speaking to the gods. Four rows of "Katun" (or Maya signs of writing) to the right and left of the figures, undoubtedly contain the information as to the worship to which the temple was dedicated, and as to the time of its foundation. We must decline an attempt to decipher them, and we must frankly confess that so long as we shall have at our disposal nothing but the key furnished by the fanatical Bishop of Yucatan, Fray Diego de Sando (in his "*Relacion de las Cosas de Yucatan*"), we shall never undertake a like task. This unfortunate individual, who has taken such a sad share in the destruction of Maya manuscripts, has left nothing to posterity in exchange for these irreparable losses but a scrawl which is as absurd as it is useless.

#### LEXINGTON OIL BELT—SANTA CLARA COUNTY, CALIFORNIA.

A LATE number of the San José Mercury contains an account of the above oil belt, its developments, and history. It says: So many rumors of big things in oil have come to us from the Lexington oil region during the last fifteen years, which afterwards proved to be largely of a fabulous character, that the public had crystallized into a condition of chronic doubt concerning the possibility of a pay strike in that section. Although it has been well known that oil existed here, yet but few people, especially after the first experiments at well-boring had been made, had any faith in the ultimate value of the district for oil mining.

Many of our older residents will remember the oil spring in what is known as Moody's gulch. This gulch is about two miles above Lexington, crossing the Santa Cruz road. The spring was located a few hundred yards above the road. Other and numerous indications of oil existed along a belt of country stretching across the hills and gulches in a southerly direction for a distance of five or six miles.

It was in 1865, we believe, when the first well known as the McLeran well, was sunk in Moody's gulch, near where once stood Moody's sawmills. This well was bored to the depth of some 400 or 500 feet, and a flow of about a barrel of oil a day procured. The well-boring tools were of a primitive order, and many difficulties were encountered from

inexperience and imperfect machinery. Some of the principal tools were finally stuck in the well, where they remain to this day. A year later, over the summit, and about four miles from the McLeran well, the Fargo well was bored to the depth of about 400 feet, and about the same quantity of oil obtained as at the former. This was also abandoned as of no particular value. The same year Messrs. Pulsifer and Gould bored a well on the Griswold place, some two miles back of Lexington, to the depth, we believe, of about 500 feet. They found some oil and a considerable quantity of salt water. None of these wells were sunk deep enough. One or two other efforts were made at that time and then the work was abandoned for ten years, and until the organization of the Santa Clara Petroleum Co., when Col. Boyer took the matter in hand. With improved machinery and experienced assistants, the well, known as the Boyer well, was bored in the Moody gulch, to the depth of 940 feet.

At the depth of 700 feet a flow of from two to three barrels of oil was obtained, but no genuine oil rock was found, indicating that the well was at one side and near the true rock. For the past year this well has yielded and continues to yield about the quantity of oil named.

About a year ago the company became involved in new complications. Boyer was sold out by the sheriff and disappeared from the scene, and new men came to the front. Among these were Charlie Felton, a man of indomitable pluck and a solid substratum of coin; and also R. C. McPherson, an experienced oil man from the Pennsylvania oil district, who was subsequently foremost in developing the Los Angeles oil district. It is to the sound judgment and true grit of Mr. McPherson, more perhaps than to any other person, that the company has kept steadily to its work for the last year and a half. He brought with him from Los Angeles some of his most experienced helpers, and imported from the East the best well-boring machinery to be had, and has pressed the work steadily forward to the present time.

Commencing a new well about 150 feet above the Boyer well, at a depth of a little over 700 feet the drill, a few days ago, penetrated the true oil sand rock. The result was most astonishing. So powerful was the escaping gas that the oil was thrown to the height of 100 feet, drenching the derrick and buildings, and flowing down the cañon. It is estimated that at least 100 barrels of oil was wasted before the well could be secured. Since then she (oil men always speak of a well as of the feminine gender, and often apply pet names to her) has acted like a "Little Daisy." The flow has been fully 60 barrels per day of the finest green oil, of from 46 to 47 standard gravity, while the standard of the best Pennsylvania wells is only 45 grade. As the best evidence of the genuineness of this strike we may state that during the brief period it has been in operation the company has shipped some 300 barrels of oil by the narrow gauge railroad. The oil at present is piped down the gulch to the turnpike, and thence hauled to Alma station about a mile distant. It is the intention soon to pipe it through to the railroad, and eventually, probably, to San José.

About 200 feet up the gulch from the main well work is progressing for another well, and will be pushed forward speedily to completion. The company is also preparing to bore a well over the range on the Taylor place. Near the latter place work is progressing rapidly on what is known as the Whiteside well, under the same company. The altitude here is about 300 feet above that of Moody gulch. The well is now down nearly 800 feet, and is in most encouraging rock. It is near here that the O. L. Crandell and Ily Morrill claim is located, one of the largest and most promising prospects in the oil belt. (And here we take pleasure in adding parenthetically that Mr. Crandell has stood in from the first in the oil business, and never lost faith in the ultimate results. The prospect is now luminous that a rich reward will gladden the remainder of his days, which we hope may be many.)

A number of new rigs will be prepared as soon as practicable, and in a short time from six to eight wells will be going down at once. In fact, the certain success already attained will so stimulate enterprise in this direction, that we may reasonably expect the time is near at hand when our oil regions will swarm with busy laborers, and millions be added to the wealth of our county and State.

#### THE SUTRO TUNNEL.

An Address before the Bullion Club, New York, by ADOLPH SUTRO.

##### DISCOVERY OF THE FIRST SILVER MINE.

GENTLEMEN: It is just twenty years since the Comstock lode was discovered in what was then a portion of the Territory of Utah. It was, as far as I am informed, the first discovery of a real silver mine within the borders of the United States, and, strange to say, it has proved to be not only one of the most valuable that has been found in the United States, but, in all probability, it will prove the most productive deposit of the precious metals of any known in the world. The yield thus far amounts to about four hundred millions of dollars in bullion; and at least an equal amount in low grade ores has actually been developed; but which ores, as I shall hereafter explain, have thus far not been extracted.

Strange as it appears, that the first silver lode discovered in the great West should have proved to be the most productive, it is equally strange that the first ore extracted from it should have been the richest. The first forty tons of ore taken from the Ophir mine on the Comstock lode were packed on mules and sent across the Sierra Nevada to San Francisco, and yielded \$160,000, or an average of \$4,000 per ton; and no body of ore approaching this in value per ton has since been found. You may readily imagine that the discovery of a mine containing ore yielding \$4,000 per ton created an intense excitement among the enterprising men of California.

##### EXTENT OF THE MINING REGIONS.

This discovery marks a new era in the tide of Western immigration, when men whose westward progress had been stopped by the Pacific Ocean commenced to retrace their steps eastwardly, overspreading the vast area of country lying between the eastern base of the Rocky Mountains and the western base of the Sierra Nevada. Here was a field well suited to the restless, adventurous spirit of the Western prospector; and so this immense stretch of country, embracing almost a million square miles, has within the last twenty years been traversed and prospected in every direction; and almost numberless mining camps have been established where not a mine was worked or even known at the time of the discovery of the Comstock lode, although several hundred thousand people, prior to that time, when on their way

to California, had, to some extent, prospected this identical territory. Gold, silver, and also the useful metals seem to occur almost everywhere in these regions, although not always in paying quantities.

These explorations have disclosed what may be considered an unexplained fact, that the summit of the Sierra Nevada Mountains forms the dividing line of what may be termed the pure gold ores; that is to say, the pure gold ores are almost uniformly found west of the Sierra Nevada, while silver ore in all varieties, though occasionally associated with more or less gold, is found to the eastward.

##### BACKBONE OF AMERICA.

It appears that the backbone of the American continent, stretching from Cape Horn to the icy regions of the North, forms the great mineral store-house of the globe; and that portion lying within the boundaries of the United States constitutes one of the most important interests of this country. This interest should be fostered and developed; and permit me to say to you that your club, which has been properly styled the Bullion Club, will form an important factor in the development of this great source of wealth, by disseminating information, and by bringing together representative men from every section.

In this connection, I intended to have made some remarks upon the influence which the increased production of the precious metals and a bi-metallic currency have upon the prosperity of the commercial world; but I leave this subject to the abler hands of Judge Kelley, of Pennsylvania, who will, as I am informed, shortly address your club upon that subject. Permit me now, after these general remarks, to turn to the Comstock mines and the Sutro Tunnel.

##### THE COMSTOCK LODE.

The Comstock lode appears on the surface of a range of hills called the Washoe Mountains, lying to the east of the Sierra Nevada, and running parallel therewith. The Comstock lode occurs mainly at the contact of two kinds of rock, and is, therefore, in fact, to a large extent, a contact vein, though in other parts, as at the north and south ends, it is surrounded by the same kind of country rock. The central portion of this mountain range is formed by Mount Davidson—a mountain rising to the height of something like 7,800 feet—and which consists of syenite; this is probably the oldest formation in that neighborhood. Immediately east, and, in fact, also west of the syenite of Mount Davidson, we find greenstone or porphyry, of which great varieties exist, which for convenience are called by the family name of propylite. Still farther east, we find the trachytic mountain range. There have been various theories advanced as to the origin of that lode, but there can be hardly a doubt that it is a true fissure vein. All the evidence tends to show that such is the fact.

##### FORMATION OF THE FISSURE.

According to Baron von Richthofen (who is probably one of the ablest geologists now living, and who has made a careful examination of the Comstock section of country, spending nearly two years there), the syenite is the oldest formation, the propylite or greenstone coming next in order, while the trachyte is the outburst which appeared at the latest geological period. If we examine the locality, we find, as already indicated, that the Comstock lode occurs mainly between the syenite and the propylite. The probability is, that when the trachyte made its appearance, the upheaval was so great that it uplifted a large portion of the greenstone. The effect of this upheaval was, that a fissure was formed at the plane of least resistance—that is, at the point of contact between the two rocks; large masses of country rock from the hanging-wall falling into the fissure, forming what we now call "horses," were the cause of keeping the fissure open. Had it not been for the fact of these masses falling into the fissure, it would, in all probability, have closed up again. But in this manner there was left an open channel down to an indefinite depth, which gradually became filled, probably by means of thermal agencies, or possibly by volatilization, according to the different theories which scientific men accept. These masses or horses must necessarily have fallen into the fissure from above; and, as a proof, we have the fact that in the Comstock lode every "horse" consists of greenstone, that being the upper rock; the syenite being at the bottom, none of it could have fallen into the lode. The open spaces thus left in the fissure were gradually filled, and the horses became surrounded by quartz and minerals, mainly silver ores, carrying more or less gold, which are sometimes accompanied by the base metals. I listened with great attention to the lecture which Professor Newberry delivered in this room last Thursday, in which he expressed the opinion that the particular fissure which he was describing had been filled in with ore by the process of deposits from thermal waters. It seems to be hardly probable that the Comstock lode was entirely filled in that way. It is probable that different processes were at work at different periods; and it is very likely that a portion of the vein matter which now fills that lode entered it by the process of volatilization.

##### VOLATILIZATION.

It seems difficult to imagine silver or gold in a gaseous form; but if you consider for a moment, it does not appear so strange. We know that all the substances of the entire globe exist in one of three forms: solid, liquid, or gaseous; while some substances are familiar to us in all three forms.

Take water, for instance: we know it as a solid when it is ice; we know it as a liquid ordinarily; and we know it as a gas in the form of vapor. We know all of the metals in two of these forms, as solids, and as liquids when molten. We know some of the metals in all three of the forms. In fact, in our laboratories, we can convert many solids into liquids by melting, and even into gases by volatilization. Now if we imagine the great laboratory of nature down in the bowels of the earth, where all the agencies probably exist which are necessary for reducing these various minerals to a gaseous state, the filling of fissure-veins with metals does not appear so difficult of explanation. We must try to realize the fact that in that laboratory of nature there may exist a pressure of millions of millions of pounds to the square inch, and that the steam which is there generated may be heated to white heat; that is, hot enough to melt iron or any other substance. If we imagine such a heat as that, we can readily perceive how any substance might be volatilized; and if to these two forces certain chemical agents are added, the transformation will seem still more probable. I doubt that a vein of the size of the Comstock lode would ever have entirely been filled by deposits from water.

##### DOWNWARD CONTINUANCE.

These theories may be correct or not, but we do absolutely

know that we here have a vein which lies between Mount Davidson, the syenitic mountain, and the propylite adjoining it, extending for a distance of four miles, and reaching downward as far as the miners have gone, and in all probability farther than mechanical means will ever permit man to go. There are obstacles in the way which will prevent an exploration to an indefinite depth. As far as the lode itself is concerned, we find that it retains its general characteristics at various depths; that it varies in width from fifty to one hundred and fifty feet; that it consists of solid quartz, interspersed with particles of ore; but that in many portions it is not sufficiently rich in ore to pay largely for extracting. It seems that the ore in the Comstock lode often occurs in the form of pockets, or channels, or chimneys, or, as we call them when we find a great body, "bonanzas." It is strange that, in the vein itself, a bonanza hardly ever occurs.

#### BONANZAS.

The lode descends on an incline eastwardly, following the dip of Mount Davidson; in places the pitch is greater than at others, but the average is about 45 degrees. The ore-bodies seem to occur outside and to the east of the vein; they are generally of a lenticular form. It frequently happens that, in sinking a shaft or in running a drift, no ore at all is found; a drift may run right over or under it; while the very next drift may show an ore body of great width. This accounts for the great fluctuations which have taken place in the stocks of the mining companies on the Comstock lode. People who are not familiar with the situation do not understand the reason for such fluctuations; but what I have stated will explain one of the causes. These ore bodies are not confined to any particular spot. The country to the east of the Comstock lode may contain ore-bodies to an almost indefinite extent. If we imagine, which I firmly believe, that the Comstock lode continues downward for miles, then it is possible that these ore-bodies may make their appearance at comparatively lesser depths, several thousand feet to the eastward of the present workings. The disposition of these ore-bodies is not governed by any rule. It seems to be entirely arbitrary. We do not know where they are until we stumble upon them. The only way to look for them is to run drifts all through the country, and then to cross cut from these every one hundred or two hundred feet. Some men say that the Comstock lode is working out. That is nonsense. Several deposits have been found which were of such immense value as to astonish everybody; but these bonanzas were limited in number—probably not over a dozen altogether; and they were always found in the manner I have described.

#### SINKING SHAFTS.

They first commenced the working of these mines by endeavoring to sink a shaft, on an incline, down into the lode itself. It was soon found that this was a poor way of mining. It was considered necessary to start shafts farther to the east. Accordingly, shafts were started which would cut the lode at a depth of seven or eight hundred feet; but they found that these shafts at that depth struck the rock of Mount Davidson, and, owing to the meager facilities which they then had for boring, they were obliged to give that up. They found it more profitable to start still other shafts farther east; and when these reached Mount Davidson rock, they were continued by inclines; lately, still other shafts were started so far east that they will not reach the lode until they have gone down to a depth of 3,000 feet; one of these shafts has lately been started on a gigantic scale, and so far east that it will not strike the west wall until it gets down to a depth of 4,000 feet. People look upon that as being rather an extreme undertaking, because the shaft will be so far away from the lode that they will have to drift, after it reaches a depth of 3,000 feet, still over 1,000 feet to get to the lode. So you see that it is not always advantageous to start a shaft so far away from the point designed to be reached.

#### STRENGTH OF CABLES.

During the past twenty years enormous sums have been spent on these mines. Probably, in no mines of the world that have been worked, has there been such a lavish expenditure for machinery, in order to secure every facility for the successful working of the mines. Such an expenditure was necessary. The work could not have been performed otherwise. The result has been that the mines have been more rapidly developed than any other mines ever worked. Of course, the difficulties in mining increase as we go down. In the first place, after you get down below 2,000 feet, the steel cables have to be made of such a size (in order to sustain their own weight), that it becomes a very serious question whether they can be used in one length to much greater depth. This is a subject which has been discussed very fully in England and in Belgium; and the engineers there have come to the conclusion that it is not practicable to hoist with them after you get down over 2,500 feet; but the people on the Comstock lode say that they can go down over 3,000 feet and still use them. It is a question simply of the strength of material. These cables are made of fine steel wires, woven together. There certainly must be a limit to their capacity, even if they are made tapering. If the cable is long enough, it will certainly break of its own weight, and without the attachment to it of any additional weight. On the Comstock lode I do not think that this will cause any very great practical difficulty for several years to come; and before that difficulty does arise a new basis for hoisting work will have been utilized at the level of Sutro Tunnel, where they can start afresh.

#### WATER AND TEMPERATURE.

Another difficulty, and one of the greatest obstacles encountered in the working of these mines, is the presence of water, which is found in great quantities—and hot water at that. Gentlemen have different ideas about this water, and how it gets so hot. I have, from my own observations, formed my own ideas about it. I do not think, as is contended by many, that this water is heated by chemical decomposition. My theory is, that the water from rains and the melting snow upon the Sierra Nevada Mountains rapidly descends through the fissures of the crystalline rocks (and as they generally incline at a sharp angle, the water descends very rapidly), until it reaches a depth of several miles. We know (although by some it has been disputed) that the increase in heat is about one degree of Fahrenheit to every sixty feet of descent. I think that this has been demonstrated all over the world. Of course, there are instances where this is not the case; but those are the exceptions. On the Comstock lode this rule does not strictly apply, because the heat increases much faster as you descend. There, at the depth of 1,400 or 1,500 feet, the mercury rises to 110°; and at 2,500 feet, the temperature of the rock is as high as 130°; and at 2,800 or 3,000 feet, it is as high as 150°. I have observed this matter for many years, and have looked

into it pretty closely, and my idea is, that this water descends from the Sierra Nevada Mountains to a depth of 10,000 to 15,000 feet; that it is there converted into steam, and finally into superheated steam. Of course, there is then exercised an upward pressure which does not permit any more water to descend, because the pressure of the descending water is counterbalanced by the pressure of the superheated steam. I recollect that I had, a few years ago, a controversy with Professor Sterry Hunt (probably the best-informed man on this subject in the United States) and some other gentlemen; and his idea was, that if there was so great a pressure down there, the steam would thereby be again converted into a liquid. But I do not think that bears upon my theory at all; because if the steam is reconverted into a liquid by the immense pressure, it would become steam again upon lessening or removing the pressure. If, therefore, the water descends until it becomes heated to a boiling point, it may then ascend, either because of capillary attraction or of pressure; and as it finds its way upward through the crevices of the rocks, it necessarily heats the rocks by the contact. And here it is where mistaken ideas come in; the rock does not heat the water at these higher points, but the water heats the rock. It seems to me quite evident that, as the water permeates all the cracks and fissures of the rock, the rock itself thus becomes heated. Of course the water loses some of its heat in its ascent. If we could go down 3,000 feet deeper than we now are, we should find boiling water. It is now 165° in some places.

At Steamboat, and in that immediate neighborhood, we find springs that are emitting great quantities of boiling water. On a direct line, these boiling springs are not over six or seven miles from the Comstock lode, and it is quite possible that these may be connected directly with that lode. The only difference between the hot water at the Comstock lode and that at the boiling springs is, that the water at Steamboat is somewhat sulphurous. Otherwise they are very much alike. That difference might be caused by the water passing over rocks containing sulphur.

#### LIMIT TO MINING.

Accordingly, the limit of mining on the Comstock lode will be reached when the mines get to a depth where it is so hot that human beings can not exist any longer. Some think that said point will be reached very soon, considering the rapidity with which the mines are worked. The fact is, that now, already, where the men are working in the lower levels, it seems almost impossible for a human being to exist. The men could not work in such a heat but for the fact that in the particular locality where they are swinging their picks a stream of compressed air, or cool air from a blower, is directed upon them; but as they go to and from that particular locality, they have to pass through places which are intensely heated, and in which they could not exist for any length of time. By means of such appliances, using very large blowers and powerful compressing machinery, I have no doubt that the men could work these mines even where they contain boiling hot water. If you show the people a big bonanza, they will devise some way of getting out the ore. The only trouble is, that at this great depth it takes so much longer to explore the mines that people get impatient. Where it formerly took only three months to explore a new level, it now takes six, nine, or twelve months. I believe that the Comstock lode can be successfully worked for thirty, forty, or fifty years to come below its present depth; and there is work enough above it to last for a hundred years to come.

#### MINING TUNNELS.

After these general remarks about the Comstock lode, I will now proceed to say a few words about the Sutro Tunnel. The idea of running a tunnel into a mountain for mining purposes is nothing new. It has been done ever since mining commenced. In Germany, where mining has been carried on largely, and also in Spain, and even in England, they have used tunnels quite extensively in connection with mining operations. In the Hartz Mountains, a great number of tunnels have been thus constructed. The topography of the country there is such that tunnels can be run to considerable depth, and they have been constructing tunnels for the last eight hundred years. At the end of the last century they constructed a tunnel 6½ miles in length; then, starting at a lower level, they constructed another tunnel, and so on, until finally a tunnel was completed, some twenty years ago, which had a length of 14 miles, and which reached three hundred feet below the level of the next deepest tunnel. In other parts of Germany and in Hungary we find the same thing.

#### THE SUTRO TUNNEL.

Fourteen or fifteen years ago, I proposed to run a tunnel into the Comstock lode, a distance of four miles. The people thought that it was an immense undertaking. Those who are interested in the mines would never have consented to contribute to such a work, for their interest is only of a temporary character; they calculate their profits from day to day, in the attempt to make a stock speculation. All such people care for is to make a "turn" in the stock, to sell at a high rate, and then they back the stock at a lower rate. In other words, the men owning shares in the mines were unwilling to give any portion of their earnings for the construction of a work which would not benefit them immediately; it troubled them but little what would become of the mines after some years. Their method of mining was a regular "grab" game. They looked for big bonanzas; they left the poor ore untouched and seemed unwilling to make any provision for the future which would enable them to work the lower grade of ore profitably. I did not, at that time, know much about these tunnels in Europe, but I saw that the construction of a tunnel to the Comstock lode was a common-sense proposition. I saw that it would be an immense benefit to run a tunnel reaching the mines at a depth of 1,700 feet. Many other people began to think so, too; they were finally convinced that it would be a good thing; but, instead of lending their aid and influence, and spending their money in the construction of the tunnel, they spent their money in fighting it. They spent more money in fighting the tunnel than we spent in constructing it; and they were beaten in the end. It was a question of millions. The opposition to it was persistent and powerful. The object was to get possession of the work for themselves. They were determined to oust us. Finally, they found that they could not continue the opposition any longer, and that it would be impossible to work the mines without the assistance of a tunnel; and so at last we came to an understanding all around. We commenced, last spring, to negotiate the terms of a new agreement. They were pretty stiff-necked about it, and so were we. We thought, as they had held back so long, and as they had to have the aid of our tunnel finally, that we were entitled

to make fair and equitable terms. And thus it took about three months to negotiate an arrangement. At last we came to an understanding, which is looked upon as being a fair arrangement for all parties concerned. Under that the agreement which we had originally entered into with the mining companies was modified. Under the original agreement we had contracted not only to run a tunnel to the Comstock lode, a distance of four miles, but we were also to construct a tunnel along the Comstock tunnel for three or four miles more. A part of the settlement is, that we agreed to reduce our royalty on all ores yielding under forty dollars per ton, from two dollars to one dollar per ton, while all ores yielding above forty dollars still pay two dollars. They, on their part, agree to pay for these lateral tunnels in the form of a loan; but it is really no loan at all, for we pay no interest upon it, and it is not repayable except by deducting half the royalties that we earn. So, if a mine finds no ore, we are never to repay it. It is, therefore, not in the form of a debt. We are now engaged in constructing these lateral branches, and the mining companies pay us from \$20,000 to \$40,000 on the fifth day of every month, which fully pays for the work. We have, also, already commenced earning some royalty, though not a great deal as yet. We probably receive from \$7,000 to \$8,000 per month from that source; and as soon as the lateral tunnels are extended past each mine it commences to pay, and our royalties, therefore, will increase gradually. The production of the Comstock lode, at the present time, is very limited. The fact is, that during these pending difficulties they could not prospect their mines, and for three years they have hardly been doing anything. Since we have constructed the tunnel, and commenced carrying off the water which obstructed them, they have again begun to prepare for prospecting the mines. These preparations have occupied many months; they are now just about ready for a start; and I think that by the end of the year they will be able to prospect a number of the mines, and especially those that they call the water mines, such as the Savage and Hale & Norcross. From that time they will go right on prospecting and opening up the mines.

#### DIFFICULTIES IN TUNNELING.

In the construction of this tunnel we had a severe struggle to get along. On the one hand, we had these people opposing us, and on the other hand we encountered the difficulty of raising money sufficient to carry on the work, and that was about the "toughest job" of all. But still we succeeded. There were some gentlemen who took broad views of the matter, and partly through their influence and aid the money was forthcoming, and since then we got along reasonably well.

In one way and another we encountered many difficulties in doing the work. We had to work our way inch by inch through solid rock. In these tunneling operations, we have first to drill a dozen or twenty holes, charge them with giant powder, explode the blast, then wait for the smoke of the powder to disappear before we can commence loading the *carrioles* on the cars for removal. Under the circumstances, one can not get ahead very fast; but altogether we made quite as rapid progress as has ever been made in any similar undertaking. In fact, our progress was more rapid than was the construction of the Hoosac, the Mont Cenis, the St. Gothard, or any other tunnel.

#### A CHAPTER ON MULES.

Up to the present time all the transportation has been done by means of mules. We found it more convenient to use mules than to use steam, because, under ground, steam is fatal to life. We are now preparing to use compressed air motors, built on the same plan as those in use on the Second avenue in this city. We have now two motors building in England. We have been using mules for years, and have found that they are tolerably good animals; but there is a prejudice against mules, though they are very intelligent. I think that I could write a chapter on their traits, as I have had a very extensive experience with them. It has been said that they have a strong propensity for kicking, but I have never seen them kick when in the tunnel. They become very tame under ground; in fact, they become the miners' pets. The men become quite attached to them; and as the shift-mules pass along by the men at lunch, they will often receive from one a piece of pie, and from another a cup of coffee, etc. When a signal is given to fire a blast, the mules understand the signal, and will try to get out of the way of it just as the men do. Of course, under ground is very dark, and the mules become so accustomed to the darkness that even when they go out into the sunlight they can not see very well, and when they go back from the sunlight into the mine, they cannot see at all. So we are in the habit of covering one eye with a piece of cloth whenever they go out, and keep the covering over the eye until they go into the tunnel again; we then remove the cloth, so they have one good eye to see with. We had to adopt this plan for preserving their sight, because the mule is so stubborn that he will not pull unless he can see his way ahead. We have found out another thing about mules. We tried horses at first, but we found that whenever anything touched the ears of a horse, he would throw up his head and break his skull against the overhanging rock; but if you touch a mule's ears, he drops his head. For that reason we could not use horses; we employed mules, and they have answered very well.

#### OBSTACLES TO PROGRESS.

In carrying on a work of this kind, we meet all sorts of difficulties. Now and then we would get indications of water. The men would put in a blast, and the water would pour out in a perfect torrent, and the men would have, at times, to quit temporarily to escape it, and wait until the water had subsided sufficiently, so that they could go to drilling again. Every now and then we would come to a clay, that would swell and cave so as to reduce our progress of 150 feet (and afterward with improved machinery of 300 feet) per month to less than 50 feet per month. Sometimes we could not keep the roof up. As soon as we would get started a little way in our work of excavation, the rock would yield, and hundreds of feet would come pressing down on the timbers with such force that it was almost impossible to resist it. The worst ground that we came to was the swelling ground. This is sometimes clay, and sometimes it is rock. The moment you dig into it, it swells out; and no matter what size of timbers you use, it will snap them off as if they were but matches. Nothing will resist it. You must let it swell. In one place the swelling was so great that the track swelled up a foot or two seven different times, and each time we had to cut it down. The timbers used are a post and a cap. The pressure on this cap would be so great that the post would be pressed through the cap in twenty-four hours—just as though the



cap were a piece of cheese. The only way to keep the timbers from breaking, in such ground, was to employ men to ease up the ground behind the timbers. That is to say, they would take away the rock or clay from behind the posts from time to time, until, after a year or so, the ground settles down to its natural state and does not swell any longer. We have very little trouble of that sort now; but I suppose that we shall encounter it every now and then as we go on with the lateral tunnels.

#### BAD AIR.

The greatest obstacle encountered by us was the heat and the poor air. Our last opening to the surface was at shaft No. 2, about 9,000 feet from the tunnel entrance. From there we had to go to the Comstock lode, a distance of 11,000 feet, without any natural air connection. After we got in to a distance of 17,000 feet from the mouth of the tunnel, the heat became so intense and the air so bad that it was almost impossible to keep the air sufficiently cool and pure to sustain life. There was not oxygen enough in the air to make our candles burn. Although we blew in air by means of blowers and air-compressors, still at times there was not sufficient air to enable the men to work. In the place where the men were at work we could generally manage to keep the air sufficiently pure; but at some distance back from the face of the tunnel the air was so bad that one could hardly exist. In fact, in going through these portions of the tunnel, the men would often give out; and as for the mules, we could not get them there at all. A mule would make straight for the air-pipe, and you could not get him away. We had one mule that would not go away from the air-pipe at all. They beat him, but it was of no use. He had to be carried out, and that mule escaped. He never went into the tunnel again. A shift mule would always want to go to where the stream of air was rushing in, and he would monopolize it all to himself. He would never leave it, but would stand there, and as he bobbed his head up and down past the pipe, you would hear the air whistling by him.

#### ACCIDENTS.

We had some sad accidents happen. These air pipes are made of galvanized iron, and the leakage is prevented by wrapping the joints with canvas which is covered with tar or with white-lead. I recollect that one day after a blast had been fired, one Garnett, the man whose duty it was to keep these joints wrapped, went forward (he was nearly fainting) to the end of the air-pipe near the face of the tunnel; but before he got there, he fell down in a swoon. When the blaster went forward to examine the blast which had just been made, he found that two of the holes had not gone off, and so he re-connected them and fired the blast while this poor man was lying on the ground. It did not kill him, although he was riddled with rocks. He had about a hundred large and small pieces of rock in him, one being in the back of his head. I thought that he could not live for ten minutes; but he is alive now and as well as ever. The most curious part of it is that for a long time previous this man had been in ill-health, and that application of rocks cured him. He has told me often, since, "That confounded thing cured me." It was rather a severe cure, but it was effectual.

As we approached shaft No. 2, 9,000 feet from the tunnel entrance, which had been abandoned some time previous because it had filled by a great influx of water to the depth of about 900 feet, we bored a diamond drill hole into it, and the pressure of that column of water, 900 feet high, was so great that it threw out the drill-rod and cast it a distance of several hundred feet, although the rod weighed several hundred pounds.

#### CAVES.

Not long ago some timbers broke down, and the report came to me that a man had been killed. We found, however, that he was not injured, but that he had been caved on and could not get out. I started in with the doctor to see how he was getting on. We found that all the work had stopped, and that the man, who had been working in the ditch which we were then constructing in the floor of the tunnel for the purpose of carrying off the hot water, had been caved on and become surrounded by a lot of loose, fine gravel, up to his chest, and that the water running in around this gravel had packed it so tightly that the man could not move. We had to get him out in some way, and so three or four men (which were as many as could get into the confined space) got down alongside of him and tried to dig him out; but, as fast as they would dig, the gravel would cave in again. When I reached the place the man had been fast for three or four hours. The miners had built dams above in the tunnel to stop the water from flowing down; for, if the water had been permitted to come down, it would soon have risen to his mouth, and would have drowned him. He was so fast that he could only move the upper part of his body a little. I urged the men to work away with all their might at the dam to keep the water back; but after a while they reported that it was of no use, that the water was rising above the dam. We did not want to see the man killed, and used every effort to rescue him. I told the men to pass a rope under his legs and try to pull him out. We thought we had better pull him out, even if it should injure him somewhat, rather than let him drown; but as soon as we began to pull, he commenced to cry out, so that we had to give that plan up. Then the men dug again for a while, until the foreman came and said that if we did not get him out within ten minutes, the water would be down in such volume as to drown him. Then the men worked again with the rope for dear life; at last they got one leg out, then they gave another jerk, and brought the man out.

#### HOSPITAL.

As I have remarked, we employ a surgeon. There were many accidents, although we had less than there were in other works. In the Hoosac Tunnel, 185 men were killed in the construction of the work. In our tunnel, but 12 men were killed, and I do not think that of the 12 more than three or four were killed by anything actually happening in the tunnel itself. I told our men several years ago, that every man employed by the company must pay three dollars per month toward a hospital fund; that the company could not afford to give the men all the attention that they ought to receive in case of accidents. The men remonstrated a good deal against this; they did not wish to spend their money in that way; each one thought that no accidents would happen to himself; but I made this payment compulsory, and after a while the men became reconciled to it.

We employed a physician and opened a drug store. If a man was injured he received every attention. He had the care of nurses, physicians, and medicine. But these miners are all members of an association, the Miners' Union, which

does not permit any man to work a shift of eight hours under four dollars per day. All the mine managers have agreed to yield to their wishes, and I think a man working in these hot places well earns his four dollars. But sometimes the union will interfere with us where they should not. They sent a deputation to me not long ago, to say that we were not paying our men four dollars per day. I said that we were. They said that we deducted three dollars per month for the hospital, and that therefore the men only received one hundred and twenty-seven dollars per month, which was not four dollars per day. I replied that that was for the benefit of the men themselves; that it was a work of benevolence; that I had inaugurated it solely for the benefit of the men. They insisted that the men should not be compelled to pay anything to that fund; and as we had to complete a certain amount of work at a given time, and could not afford to get into any trouble with the men, we had to yield in this matter.

#### STARTING A GRAVEYARD.

One labors under all sorts of difficulties in dealing with the men. It seems ridiculous; but the most difficult thing we had to do was to start a graveyard. It took some three years to start it. Whenever a man got killed or died, the men would get up a big funeral, and go off to Virginia City or some other place to bury the man. All work had to be stopped for one or two shifts. They would each lose their \$4.00 for wages; would pay \$300 or \$400 more for teams; and some would drink so freely as to be unfit for work the following day. I was determined to put a stop to that. So said I to the men: "Why can we not have a graveyard of our own and bury our men here? I had a grave dug for the next man that died. The dead man's friends came and said they would not have the man buried there. I asked them why? They said that 'it would be too lonely for the poor fellow.'" That seems ridiculous, but it is a fact. I did not wish to have any trouble over the matter; and so I let them bury the man where they chose. Every time a man died, we had just the same trouble again. At last two miners got killed who had not paid their fees to the Miners' Union, and had been discarded. They had no friends there to object, and so we buried them there, and thus were able at last to start our own graveyard.

#### ADVANTAGES OF THE SUTRO TUNNEL.

But, gentlemen, I fear that I am detaining you too long with these outside matters, and will now proceed to speak about the advantages of the Sutro Tunnel itself. The first great advantage of the Sutro Tunnel is, that it creates a new base of operations. We open a new surface for mining operations—a surface which is in fact a better surface than the original one. We are down 1,700 feet from the surface, and can introduce water through the shafts, and thus get a fall of 1,700 feet; or we can take the water which exists at some point between the surface and the tunnel and let it flow down to run the machinery which is placed at the tunnel level. We thus could get an abundant water-power. A very small stream of water with a pressure of 1,700 feet will give an immense power. The time will come in the working of these mines when they will economize all of the water. In fact, the water which is brought in pipes from the Sierra Nevada Mountains can be most profitably used for that purpose; and the time will come when it will be so used extensively. You can readily perceive that a new surface at that point adds just so much to the working possibility of the Comstock lode.

The lode extends down indefinitely, and the ore bodies recur at different places; we cannot tell exactly how or where, because their distribution seems not to be governed by any known law. The tunnel adds to the working possibility of that lode certainly 1,640 feet, which is the level at the point where the Savage shaft is intercepted by our tunnel, and that shaft is away down the hill. That is, of course, an incalculable advantage; for those 1,640 feet are surely added to the working possibility of the Comstock lode, and ought to be worth to it a great many millions of dollars, perhaps hundreds of millions. The Comstock lode has already yielded something like \$400,000,000, and there is in it an enormous quantity of low-grade ore which has not been taken out.

#### DRAINAGE.

The next important advantage secured by the tunnel is that we carry off the water. Instead of pumping this immense body of water to the surface, it is pumped into our tunnel, which saves 1,640 feet of pumping. When I last left the work there were running out about 12,000 tons of water every twenty-four hours. To lift this water to the surface, estimating it at a very low rate—indeed, at much less than it actually costs, say at 25 cents per ton, it would cost \$3,000 per day to pump it out to the surface. In order to carry off this volume of water (and we agreed to take the water within ninety days from the time we made the settlement with the mining companies), we had to provide the means. Some of this water has a temperature of 165°; some has a lower temperature: where it is all mixed together it is about 130° or 135°. If we were to let this water flow through the open tunnel, a distance of four miles, the heat would be so great that we could use the tunnel for no other purpose; the steam would suffocate the men. We were therefore compelled to construct a drain, and to place a wooden box in this drain. We had quite a controversy over the way this drainage should be effected. Every man had his own ideas as to the best way; each engineer thought that he knew all about it. I contended that if we were to construct a wooden flume, perfectly tight, of 3-inch yellow pine, we should be able to carry off the water and not radiate much heat from it. Others disputed it. I had machinery built for planing, tonguing, and grooving this yellow pine, and which cut it off, all in the same operation, so that the construction of this box was done at a very reasonable cost. We placed these boxes and joined them together with slips of iron  $\frac{1}{4}$  by  $1\frac{1}{2}$  inch, which were driven into the ends of the boxes, and it made a continuous box so perfectly tight that when the covers (which were also tongued and grooved) were nailed on, and the water was turned in, there was not a leak from one end of the tunnel to the other; and, to the utter astonishment of everybody, the temperature of the tunnel has not been increased materially by the passage of the hot water through it; and the water, which was at 130° on entering the box, after flowing the four miles still has a temperature of 123°, having lost only 7° of heat in the passage. After it gets to the mouth of the tunnel the water is conducted down a shaft in the machine shop, where we have a water wheel placed at the bottom of the shaft 60 feet in depth. From thence the water is carried off by a tunnel, 1,100 feet in length, which serves as a tail race. From this small tunnel the water flows about a mile and a half to the Carson River. This water can now be used for many pur-

poses. The first who utilized it were the boys, who made small ponds to swim in at the lower end of the town. It can be turned to account in heating hot houses. We have a rich soil there, which, if covered over by glass, will produce early vegetables and fruit at very little cost. We use this water first for power and then for irrigation.

#### FARMING.

We have quite a farm belonging to the company, which will become very profitable indeed. The company owns over five thousand acres of land. The soil is very fertile, and all that is needed to make it highly productive is water. The water from the Comstock lode is particularly well adapted for irrigation, because it contains in solution sulphate of lime or gypsum, which is of itself a valuable addition to the soil, although that land is now so rich that it does not need any fertilization whatever.

#### VENTILATION.

The tunnel will also be of great advantage for the purpose of ventilation, not so much, however, by the air going four miles directly through the tunnel; for we find that does not answer so well as to use the air in the lateral tunnels by connecting every shaft with the other shafts. By that means we get a draught of air from shaft to shaft that is wonderful. Not long ago we were laboring under a great difficulty in the south header of the tunnel which was not ventilated. In fact, for three months we could not do anything. The men in these heated places are taken with "cramps," as they call it. We really did not know what the difficulty was, until one day a mule died while in there, and I had the surgeon hold a post-mortem examination on it. He found every organ perfectly sound, until he came to his lungs, which were found to be congested with blood. We can carry ventilation down the shafts as deep as they may go; and this fact will make it possible to work the mines at much greater depths than they have yet been worked. The great volume of air going through a shaft causes an evaporation of moisture which covers the sides of the shaft, and in that way lessens the temperature. Up to lately it was so hot in the north header that the men could not do a full day's work; but about two weeks ago we made the connection by a drift with a shaft, and now the air there is delightful, and our men are doing double the work that they did before. This shows how much depends upon a proper system of ventilation. It is worth millions to the mines. When the temperature is so high and the air so impure as it usually is in the mines, the men cannot do much work; in the hottest places it takes six or eight men to do a day's work; a man can only work five minutes at a time, and then he must retire to a cooling station; but if you give the men good cool air, they can do a day's work.

#### LOW-GRADE ORE.

Another very important thing in connection with our tunnel is the fact that it will make possible the extraction of the enormous body of low-grade ore in the Comstock lode. As I have already said, \$400,000,000 have been extracted from the different bonanzas. People speculate in mining shares to make a fortune, and they want to make it overnight; and in searching for these bonanzas they have passed by the low-grade ores, because they thought they would not pay, or would pay so little as to amount to nothing worth the effort required. By means of our tunnel we can transport the ore to the mouth for one cent per ton per mile, which is as cheaply as the best-regulated surface railroad can do a similar work. We can afford to take these ores out and reduce them at the mouth of the tunnel. We have not yet commenced doing this; it has taken so much money for other purposes that we have not been able to do anything yet with the low-grade ores; but the time is coming when we shall be able to utilize them. Suppose that we are able to work 1,000 tons per day, which would not be considered very heavy work on the Comstock lode; that would give at least \$2 or \$3 per ton profit. They are willing to sell the ore to us at \$1 per ton. We have established a scale of prices by which we are to pay \$1 per ton for ore which yields under \$15 per ton. But rock that yields \$15 to the ton will assay a good deal more. Everything that we can get out of it is so much clear gain to the world; for under the old system they can never utilize these low-grade ores. I think there are \$300,000,000 or \$400,000,000 to be extracted from these ores now in sight in the 200 miles of drifts on the lode—enough to last for a hundred years' steady work.

#### CHEAP FIREWOOD.

There are other sources of revenue that the Sutro Tunnel Company will have. The Carson River, which flows within a mile and a half of the tunnel entrance, has its rise in the Sierra Nevada Mountains. There is wood enough there to last for many years, which can be floated down for less than \$5.50 per cord. We can, by contracting therefor, a season in advance, get our wood there for less than \$5; it is worth in Virginia City \$10 per cord, and they often get \$12, and the consumption is 600 cords per day. It will not cost us over \$1.50 to deliver it at Virginia City. There is also a profit to be made from the sale of timber.

#### ICE.

There is another article which may be made remunerative, and that is ice, which is used in these mines to an extent which is really marvelous. The quantity of ice water that a man working in the mine will drink would astonish you. You know what you can do in that way when taking a Turkish bath; but they can discount that several times over. They drink it by the gallon. The men will rub ice all over their bodies, and it does not make them feel chilly. They get so heated that the ice feels comfortable to the body. When the surveying engineers go into the mines they have to take with them big sacks of ice to rub their heads and bodies, or else they could do no work. I cannot state the number of tons per day used at the mines; but there is more ice used there than there is in the whole city of San Francisco. It sells there for \$20 per ton. Certain parties largely monopolize the ice business there; but some of the mining companies are ready to take ice from us. We can make it for fifty cents per ton. It freezes from six to fifteen inches thick every winter. We shall have a tram road down to the river, propelled by water power, over which we can haul up wood, timber, and ice. That will be a great advantage in connection with the working of these mines.

#### ROYALTY.

I will refer, in conclusion, to the royalty to which we are entitled. Before the settlement made last spring we were entitled to a royalty of \$2 per ton for every ton of ore taken from the mines in all future time. Whether it was taken through the tunnel or not, they were to pay us \$2 per ton. We, however, partly yielded our rights, and agreed to take

\$1 per ton for all ore that yields under \$40 per ton, and for all ore that yields over \$40 the old rate of \$2 per ton was retained. As the lateral tunnels progress our revenue will increase. I think that the royalty alone will in the end amount to \$100,000 per month.

We have another source of revenue, from the transportation of men and ores. The royalty is received for draining the mines. We receive that without doing any further service. For the transportation of ore and men we will make additional charges. On ore or rock we are entitled to charge 25 cents per ton per mile. Negotiations are now pending for opening some of the mines east of the Comstock, and the people will want to go to work through the tunnel and to take their ore out through it.

#### MINERAL LAND GRANT.

I think that the most important possession of the Sutro Tunnel is its mineral grant. Under the Act of Congress of 1866, there was given to the Tunnel Company a strip of mineral land 2,000 feet in width on each side of the tunnel, forming the very heart of the Comstock country. The tunnel runs at right angles with the Comstock lode, which it reaches in a distance of four miles. After passing the Comstock lode we may go still three miles farther, through Mount Davidson, and beyond it. As far as this strip of land is concerned, we have discovered and opened several large ledges. We have cut one vein 120 feet thick, and we have just commenced to prospect it. We have run into it on one side—that is to say, we prospect the vein for a width of 4 feet, which is the size of the drift. That does not explore the vein. After we get in a certain distance we propose to cross-cut it at given intervals. We get assays of that ore varying from \$2 to \$43 per ton. There is no body of it that will assay at that rate; it is only in spots that it will do it. These veins are all of the same nature as the Comstock lode. We may here come across as big a bonanza as has ever been found on the Comstock lode. These veins were probably all formed at the same time, and they may all unite somewhere; but we can never get to that point, as it is probably two or three miles down. Under the Act of Congress, we are entitled to all the mineral deposits we find on that grant, which were not owned in 1866, and worked according to the mining laws. The Comstock lode is, by words, specifically excepted; so that, of course, we have no claim to any part of it; but the Comstock mines have to pay their contributions for benefits derived.

To the other veins I think we have a pretty clear title, with the possible exception of one or two mines, which the companies claim to have possessed and held before this act was passed.

So far as our grant of land beyond the Comstock lode is concerned, I think it will before long be prospected by continuing the tunnel beyond its present end. We have to cut through the syenitic mountain, which nobody else could ever pierce. People there think that there are no mineral veins in the syenite.

#### MOUNT DAVIDSON.

I have visited many of the mining districts of Europe, and I found that at Schemnitz, in Hungary, there is precisely the same formation as at the Comstock lode. I have mingled specimens of the country rock from the two places, and I have never found anybody in Nevada who could tell them apart. We have the syenite there, as well as the greenstone and the trachyte. We find at Schemnitz half a dozen veins in the syenite that have been worked for a long time. We know that there are outcrops on Mount Davidson which show well in metal. They have not gone into Mount Davidson, because they have been afraid of striking water. We do not care how much water we strike, for it will flow off through the tunnel. The water all comes from that side, from the Sierra Nevada Mountains. They have not gone into that mountain because they were afraid of being drowned out, and also because the rock is so hard that the men say they can never get through it. I think that in this respect they are mistaken. We have never yet seen any rock that we could not go through with a 5-inch percussion drill. With it we can strike a blow of 1,000 pounds, at the rate of 300 per minute, which will drive the drill through almost anything. But we are not yet prepared to go into Mount Davidson. It will take considerable money to do so, and we have a use for all the money we have at present. The time will come before long when we will go ahead with that.

The same formation existing east of the Comstock lode also occurs beyond Mount Davidson. We there find the same propylite, with specimens of gold, on the surface, although there is no well-defined ledge. But you cannot tell anything about these outcroppings until you get down to a considerable depth, for the surface is all covered over with debris. You may find ore there, and you may not. You may find a chimney there. It is a mistaken idea to suppose that, because you find a vein of ore, you may be able to dig out the whole vein. The ore occurs in all mineral veins, in zones, chimneys, and spots. There is always some uncertainty in working a mine. You may explore and find a good showing of ore, but you cannot tell how far the ore goes. Experience teaches us that this is uncertain. But the ore does occur in zones, and you may have to dig a long distance through the vein before you find another zone.

#### LONGEVITY OF MINING DISTRICTS.

But if you take a whole mineral district you will find that there is a most extraordinary permanency about the aggregate yield. History tells us that the mines of Cornwall have been worked for over three thousand years, and they are being worked to this day, and the yield still is very considerable. The same is true of the mineral deposits of the Hartz Mountains. The mines there have been yielding for over eight hundred years. The same is true of the district of Freiberg. That has also been worked for centuries, and it still furnishes a good yield.

If you take the district of Schemnitz, you find that it is the same. If you go into Mexico, you find that the mines of the Veta Madre, of Guanajuato, have yielded over \$800,000,000, and are yielding still. If they were to put up proper works there, they could continue to work those mines for centuries to come. There is a chance for an enterprising man to go and dig a tunnel into those mines. I do not, myself, want to dig any more tunnels; it takes too long a time. So, too, the mines of the Veta Grande, of Zacatecas, are yielding still four or five millions per year, though they have been worked almost since the discovery of America.

I consider that an enterprise like the Sutro Tunnel, based as it is upon the results obtained in a whole mining district, furnishes one of the most promising and surest investments in the world. It may take time to realize, but it is sure. These every-day ventures are gone into by everybody, and, as a result, there is only a little money to divide.

#### SECURITY OF TITLE.

Under the Act of Congress we are given certain rights. At that time the United States was the sole owner of these lands. At the time of the passage of the Sutro Tunnel Act the government owned in fee all the mineral lands in the West. Shortly after that time a general law was passed, giving a title to any man under certain conditions who wants to purchase mineral lands. Immediately succeeding the Sutro Tunnel Act, this general act was passed. But our act has the precedence over all others, and our title is better than the title of anybody else holding mineral lands; for ours is the first act and the first grant of mineral lands made by the Government of the United States since its organization.

The cost of the Sutro Tunnel thus far has been about \$3,800,000. That is according to the last balance sheet, and is exclusive of interest. Adding the interest, it would figure up about three millions more during ten years. So I estimate the total cost of the tunnel to be about \$7,000,000.

I have taken up your time much longer than I intended. I could go into other phases of the history of the tunnel, but it would take entirely too long.

The above address was delivered November 6, 1879. Mr. Sutro was listened to with close attention, and at the conclusion of his remarks the Club tendered him a vote of thanks.

#### SHAFTING, COUPLINGS, AND HANGERS.\*

*Shaft-bearing.* Fig. 1, A, clamp-block.  
B, pillow-block resting on cast iron wall plate, *a*, and provided with oil dish, *b*.  
C, the same inverted; used for carrying the head-shafts of long lines of shafting.  
D, the same built into a wall and protected by an arched wall box, *c*.

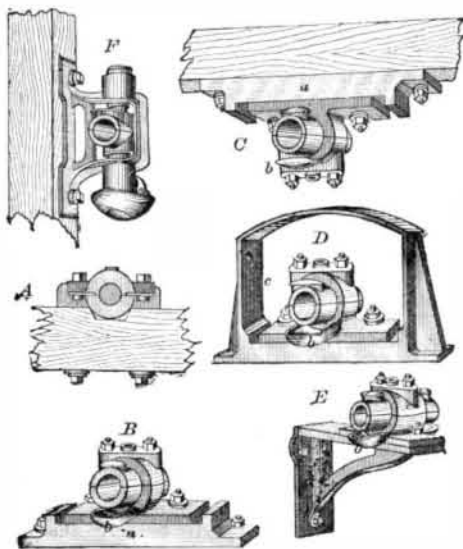


FIG. 1.—PILLOW-BLOCKS.

E, pillow-block secured to a knee, *d*, attached to the face of a wall. *b*, oil dish.  
F, post-hanger fastened to an upright or pillar. See also STEP; SPINDLE.

*Shaft-coupling.* 1. A device for connecting together two or more lengths of a revolving shaft by shaping the ends into flat surfaces or bearings, which are held together by a strong iron bush or coupling box.

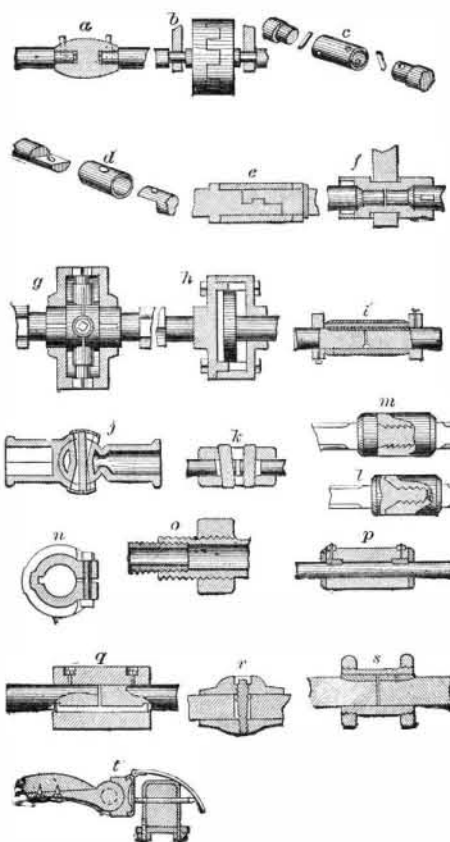


FIG. 2.—COUPLINGS.

A common but unyielding coupling, *a* (Fig. 2), is formed by fitting and fastening the square ends of the sections of coupling into sockets in an iron block.

Another mode, *b*, which admits of some yielding when the shafting is not perfectly in line, consists of serrated disks

\* From Knight's Mechanical Dictionary. H. O. Houghton & Co., publishers, New York and Boston.

on the adjacent ends of the sections of shafting. These have sufficient play to permit the joint to bend a little when the shafting is out of line.

A form of coupling, *c*, consists of a cylindrical box with pins at right angle engaging the ends of the sections of shafting. By allowing a little play to the parts, this partakes in a degree of the principle of the *gimbal*.

The lap-joint coupling, *d*, is formed by reducing the ends of the shafting to a semi-cylindrical form, so as unitedly to form a cylinder, which is inclosed by a coupling sleeve secured by a pin or key.

By scarfing the ends together, *e*, they are protected against longitudinal displacement, without depending on the strength of the pin.

Murray's coupling box, *f*, rests in the hanger, and has sockets at the ends for the reception of the ends of the shafting and the keys, which are at right angles to each other. A slight play is allowed in the fitting of the parts.

In another form of coupling, *g*, a cross is interposed between the boxes, which are at the end of each section of the shaft. Each arm of the cross has a screw at its end; two of these receive motion from two projections on one box, while the other two bear against two similar projections on the other box, causing the two shaft sections to turn together. This coupling performs to a limited extent the function of a universal joint, but requires a bearing at each end of every section.

One form of friction coupling, *h*, consists of a pair of boxes, inclosing disks on the ends of the adjacent sections of shafting. Between the disks is a planchet of leather, which is compressed to such an extent by screwing up the bolts, as to cause the motion of one shaft to be communicated to the other. If a violent strain occur beyond the coupling, greater than that for which the coupling is intended, one of the disks will slip on the leather.

Mattison's friction coupling has caoutchouc on the abutting faces of the wheels on the respective sections of shafting. The frictional contact of the India-rubber when the wheels are brought into contact, causes them to revolve together when motion is imparted to one of them.

*i*, Hawkins. T-headed keys occupy longitudinal slots in the abutting ends of the shafts, and are held in place by a sleeve.

*j*, Wheeler. A ball on one shaft enters a socket on the end of the other, and is held there by a key passing through a slot in the ball and retained in place by a cap, allowing a certain degree of rolling motion.

*k*, Fox. The ends of the shafts are made tapering, are inserted within the tubular coupling, and held by keys.

*l*, Lecky. The end of one shaft has a screw-threaded tenon of peculiar shape, which enters a correspondingly threaded cavity in the enlarged end of the other.

*m*, Lecky. Is similar in general to the foregoing, but the screw-threads are flat on the sides which have to resist a pulling force.

*n*, Briggs. This coupling has an opening on one side, permitting it to expand somewhat to readily receive the shafts, upon which it is compressed by bolts and nuts; a recess on the opposite side receives one half of a key, fitting counterpart slots in the ends of the two shafts to compel their simultaneous rotation.

*o*, Bolles. Is particularly designed for well or other tubular shafting. The ends of each tube are threaded both internally and externally; the former threading receives an internal thimble connecting the sections, and the latter an exterior nut which covers the joint.

*p*, Gray. Two or more pawls within a sleeve are, by means of binding screws, pressed into nicks in the shafts so as to prevent their independent rotation.

*q*, Baum. A coupling fin provided with studs enters slots in the two sections of the shaft, and is retained in place by a sleeve held to the sections by screws.

*r*, Ruggles. The coupling box is in two parts, which are drawn together by a bolt having differential screw-threads adapted to corresponding internal threads in each half of the box between which the shaft is clamped.

*s*, Light. The ends of the shaft sections are slotted to receive a key which is held by a split sleeve secured by a nut screwed on to each of its ends.

*Shafting.* (*Machinery.*) The principal means in a machine shop for the transmission of power. It serves to convey the force which is generated in the engine to the different working machines, for which purpose it is provided with drums and belts, or else cog-wheels firmly keyed on.

Horizontal shafts are known as *lying*; vertical, as *upright*. Their *stiffness* resists *flexure* and *torsion*; their *strength* resists *fracture*. The *stress* is the power tending to break them.

A, Fig. 3, represents a portion of a line of shafting attached to beams of a ceiling. The hangers, *a*, are secured to the beams by bolts, and are provided with swivel boxes, *b*, facilitating adjustment and keeping of the shafting in line. These are adjustable in height by bolts and nuts. *c* are oil-drip cups, *d* a pulley, and *e* the coupling which unites two lengths of the shaft. These are shown in contact, but disconnected at B. C C are inside and outside views of the coupling proper. D, one half of the coupling, with its appendages complete. E E are the *thimbles*, and F F the securing nuts. The cylindrical interior of the coupling is bored with a *slam* between the two sections, so as to allow something for compression or hug. These are placed over the butting ends of the shaft sections, and secured thereto by pins, if desirable; the thimbles or cone rings are slipped over them, and the nuts, F F, screwed on with a spanner, binding the whole together.

In Fig. 4, A shows another pattern of shafting, with hangers and appurtenances. The journal box, *a*, is held between two pintles or stems, *b c*, the ends of which are concave, those of the box bearing being convex, so as to form a species of ball and socket joint, and allow the box to adjust itself to the alignment of the shaft.

The box is self-lubricating; the oil, after being drawn up from a reservoir below by the rotation of the shaft, and performing its office, is again returned to the reservoir, the drip cup being dispensed with.

Fig. 5 is a cast-iron plummer block; it is lined with gun metal or Babbitt metal, and supported on a wall plate having snugs between which the block fits, and is adjusted in line with the shaft by cotters driven between its ends and the snugs.

Fig. 6 is a form of flexible shafting, avoiding the use of gearing.

It sometimes becomes necessary to take down a section of shafting, drive out keys and remove couplings, merely to slip on a pulley. To obviate this necessity, pulleys have been made in sections to be keyed together on the shafting.

Preferable to this is an arrangement by which a small section of hub and rim are made removable.