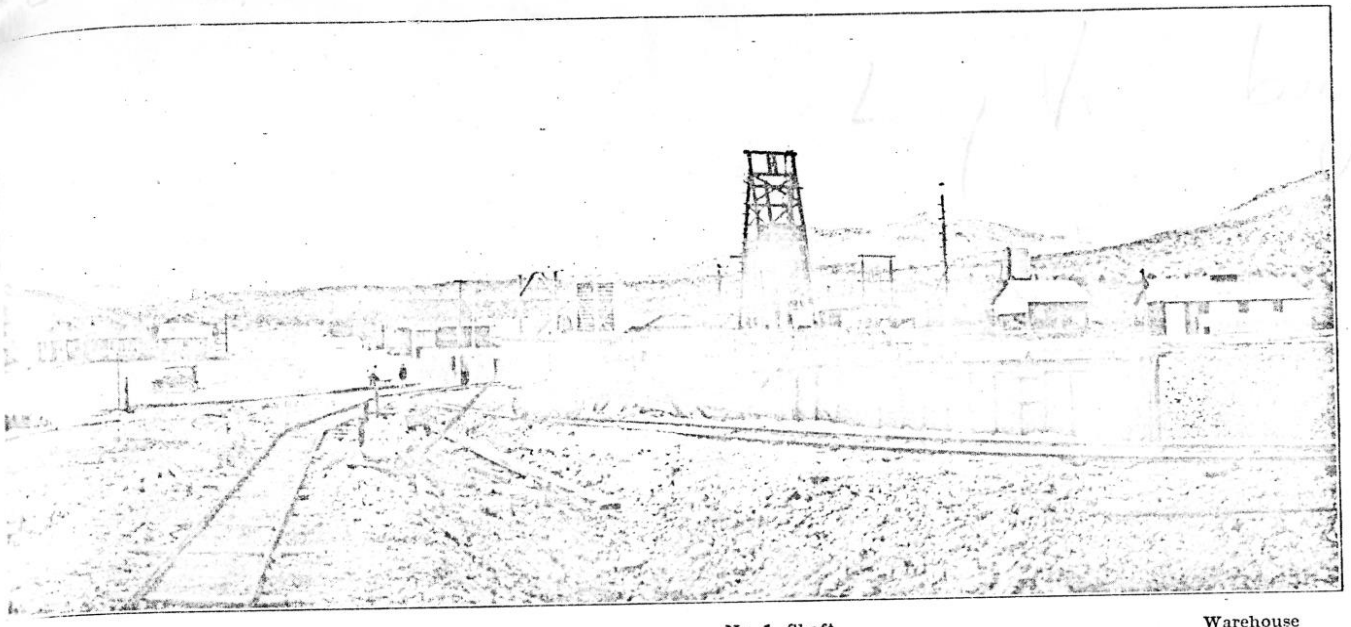


THE CALIFORNIA RAND SILVER MINE, LOOKING TOWARD RANDSBURG

The California Rand Silver Mine—I

The Story of the Enterprise

By Arthur B. Parsons

The story of the California Rand mine invites, and indeed deserves, less prosaic treatment than it necessarily must receive in this article. An interesting chapter on the subject might be entitled 'From grubstake to affluence in 90 days'; another might be 'Miss Edith Coons: a prospector at heart'; a philosopher would be tempted to discuss the 'Psychology of Prosperity' if he were to visit Randsburg today; and an excellent sermon for the present-day prospector might have as its text 'The California Rand mine; a bonanza that lay undeveloped for 25 years, within a hundred feet of a good road in the heart of a well-known mining district'. However, I shall endeavor to relate the story briefly, starting with the first discovery in the Randsburg district in 1893.

The accompanying map of California shows that the Randsburg district is situated almost on the dividing line between Kern and San Bernardino counties. Railroad communication is by way of Mojave, a station on both the Santa Fe and the Southern Pacific railroads; Bakersfield is the nearest city of importance, and all the large stockholders of the company owning the California Rand mine are residents either of Bakersfield or of Randsburg. Incidentally, I may remark that, up to September 1921, they had received almost exactly $1,000,000 in dividends, the first distribution having been made on September 10, 1919, just five months from the day the original discoverers chanced to pick up on the hillside a piece of loose rock that one of them recognized as being hornsilver. In a little more than two years there has been shipped 22,000 tons of ore that netted, after payment of high freight and smelter charges, $1,729,170.80. The gross value of the silver and gold in the ore averaged more than $100 per ton.

The year 1893 was particularly dry, so that farming in the valley above Mojave languished, a circumstance that stimulated prospecting for placer gold in the hills, where a number of productive claims were worked. These included the Goler, Summit, Red Rock, El Paso, Last Chance, and Black Mountain, all of which proved profitable to their owners. One of the partnerships that was created for the purpose of mining gold consisted of Frederick M. Moores, formerly of the 'Brooklyn Eagle'; Charles A. Burcham, a teamster; and John Singleton, a hard-rock miner; they traced the alluvial gold to its source on Olympus mountain, where they staked 11 lode claims and organized the Rand Mining Co., the name being changed a little later to the Yellow Aster. The total production from the Yellow Aster has been $9,000,000 in gold, and in late years it has paid dividends to the amount of $1,250,000. Following the discovery made by Moores and his partners, hundreds of claims were staked and the town of Randsburg grew at the foot of Olympus mountain. There seemed to be plenty of gold near the surface, and the town prospered. In 1894 the Garlock stamp and amalgamation mill was

built at a point 12 miles below Randsburg; later a mill was built at Barstow on the main line of the Santa Fe railroad. Both these plants received high-grade gold ore from the Yellow Aster and from other mines; much of the ore returned $600 to $1000 per ton by straight amalgamation.

Tradition has it that outside capital was not welcomed; the reason for this attitude of exclusion is explained by the following incident, the accuracy of which is readily vouched for by 'old-timers' at Randsburg. It seems that George Kinyon and his two sons, Will and John, owned the Good Hope group of claims, from which they were mining rich ore as rapidly as they needed money. A group of capitalists at Los Angeles was desirous of doing some speculating in gold mining, and, without any extensive preliminaries, began negotiation for the Good Hope claim. But Messrs. Kinyon declined to show any particular interest. Someone suggested privately to the representatives of the capitalists that the Kinyons distrusted banks and paper money, whereupon a wire was sent from Los Angeles saying: "Am placing $150,000 gold coin in Wells Fargo office subject your order for Good Hope mine". In behalf of his sons and himself, the elder Kinyon, although he had full confidence in the Wells Fargo Express company, declined the offer on the ground that after the education of the children and the comfort of the womenfolk had been provided for, there would be only about $30,000 apiece for the father and two sons. "This", he said, "is so little that if we should accept it there would be a foot-race to see who could go broke first so as to borrow from the others." When one visits Randsburg he will probably be told this story by way of explanation of the lack of deeper development of the mines.

In 1895 the Yellow Aster company erected a 30-stamp mill, and in 1900, when the railroad was extended to Johannesburg, two miles distant, a 100-stamp mill was built. To supply this plant the mine was opened as a huge glory-hole and a large volume of low-grade ore was milled. The rising cost of labor and supplies, however, caused the suspension of operations in 1916, although I am told that part of the mill has been in regular operation on ore mined by sundry lessees since my visit to Randsburg last August. It is interesting to note that Dr. Rose L. Burcham, the widow of Charles A. Burcham, is now secretary for, and a prominent stockholder in, the Yellow Aster company. This fact tends to support the statement regarding the inhospitality to outside capital.

When beginning this story, I suggested a discussion of the psychology of prosperity. Prosperity is contagious; it breeds optimism. Most of the inhabitants of Randsburg are either miners who are earning excellent wages in the California Rand Silver mine and at neighboring prospects or they are owners of old mines or leases in either the gold or silver 'zones' of the district. Those in the first class are prosperous; those in the second are optimistic. The rich silver ore that is being mined from an orebody two miles distant can have little significant geological relation to the gold-bearing veins, but it has had the effect of renewing the confidence of these faithful old adherents to a 'camp' that has been almost dead, so far as gold mining is concerned, for several years. They point to the millions produced from shallow workings in the past; they point to the fact that, except for the Yellow Aster company, nearly every man did his own mining, spent his money as fast as he got it, and accordingly didn't have the capital to follow the lode when it faulted or when the grade of the ore diminished. They point rhetorically to Butte, to Virginia City, to Leadville, and they declare that Randsburg's only need is outside capital to develop 'at depth' the mines that are already opened. Then, they say, will follow a resurrection that will make the present prosperity seem like the

MAP OF CALIFORNIA

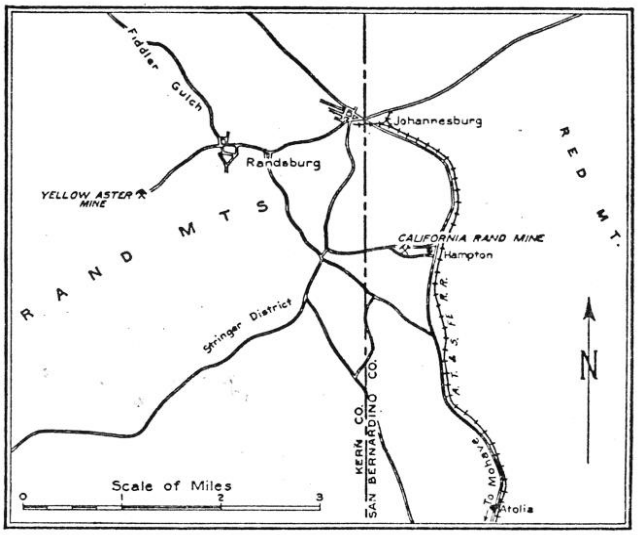
flurry before a storm! These old-timers are pleasant to talk with; their hope is the fond hope of every miner, and, as I say, their faith is bolstered by the prosperity of their neighbors who are mining silver. No one can help but wish that their dreams may be realized.

During 1916, 1917, and 1918 the Atolia mine, five miles to the south-east, was in active operation, and Randsburg enjoyed some of the fruits of a payroll that amounted to about $60,000 per month. The Atolia during this brief period produced nearly $10,000,000 worth of tungsten ore. However, in the spring of 1919, when the demand for tungsten ceased, the town was very quiet, the only activity was some desultory development work and prospecting for gold. Among those who persisted in digging were the owners of the K C N lode claim over which passed the highway from Randsburg to Atolia and thence to Mojave. To many, K C N suggests the cyanide process of extracting gold; but the locators

of this claim were more intent upon mining ore than on treating it. K stood for Kelly, C for Coons, and N for Nosser, which introduces three of the principal characters in the present story. John W. Kelly had mined at Randsburg years before, after which he had gone to Bakersfield, where he had served as Sheriff of Kern county for several terms. Miss Edith F. Coons was County Assessor for Kern county, having succeeded J. M. Jameson, for whom she previously had been deputy; and Jack Nosser was a typical miner who boasted no particular accomplishment other than the ability to sink a hole into hard rock under adverse circumstances. He was the type of miner that the 'movie' directors try to imitate—I say "was" because outwardly, at least, he no longer 'is'. The fourth partner was W. H. Williams, familiarly and generally known as 'Hamp'. His mother was a Piute Indian and his father was a prospector of considerable intelligence. From them probably he has inherited his instinct for living in the hills and searching for mineral. He had studied enough to know something of the character and the habits of ore-bearing rock. Some years before, he had discovered the Cowboy and the Gold Peak mines in the Amelia district near Bakersfield, but in 1919, like Nosser, he was financially 'broke'.

Accordingly, these two did the work on the K C N claim while Kelly and Miss Coons supplied the money to buy powder, tools, and 'grub'. In the course of a conversation with me during my recent visit to Randsburg, Hamp said a number of interesting things; among them was this: "Miss Coons was a good gambler all right". This, I believe, is as genuine a compliment as was ever given one prospector by another—for Miss Coons is truly a prospector, even though she did not share in the actual work of searching for ore. For a long time she sent Nosser and Williams $75 per month from her none too generous earnings, which she might have spent for more tangible things; that the 'investment' made her wealthy is to the credit of Dame Fortune, but to Miss Coons must be accorded the honor of having the nerve to play the game. Every one with whom I talked has a high opinion of Miss Coons.

The K C N shaft reached the depth of 100 ft. without revealing shipping ore, although some good stringers were cut. Williams and Nosser were feeling rather blue, when Kelly received a letter from Los Angeles inquiring about possible deposits of hematite suitable for making paint. He persuaded Hamp and Jack to go across the valley east of the K C N ground and stake some claims that he thought might contain hematite. This they did on the 12th day of April 1919. According to Hamp, Nosser started ahead of him on the return journey to the camp at the K C N. Williams, following, found Nosser sitting near a pile of loose rock on the side of the hill about half a mile from the K C N claim and only 30 ft. from a well-traveled road. The rock near where Nosser sat had apparently been blasted loose from the lode by some prospector; Jack was idly looking at a piece when Williams came up. "That's funny looking stuff, Hamp; I wonder if it's any good?" inquired Nosser as he handed it over. Nosser's mineralogical examination had concluded with a fruitless search with his lens for free gold; Hamp was more sophisticated—he knew hornsilver when he saw it! He wisely declines to express an opinion as to the exact phraseology of his pronouncement; even seasoned prospectors do not stumble on a fortune in the middle of a desert and retain their composure, so it is reasonable to suspect that there was some picturesque language wasted in the vicinity of Randsburg along about sundown of April 12, 1919. The upshot was the taking of two samples, one from the part of the 15-ft. outcrop that looked best, and the other from the entire 15 ft. The assay-returns from Los Angeles showed 280 and 360 oz. of silver per ton, though strangely

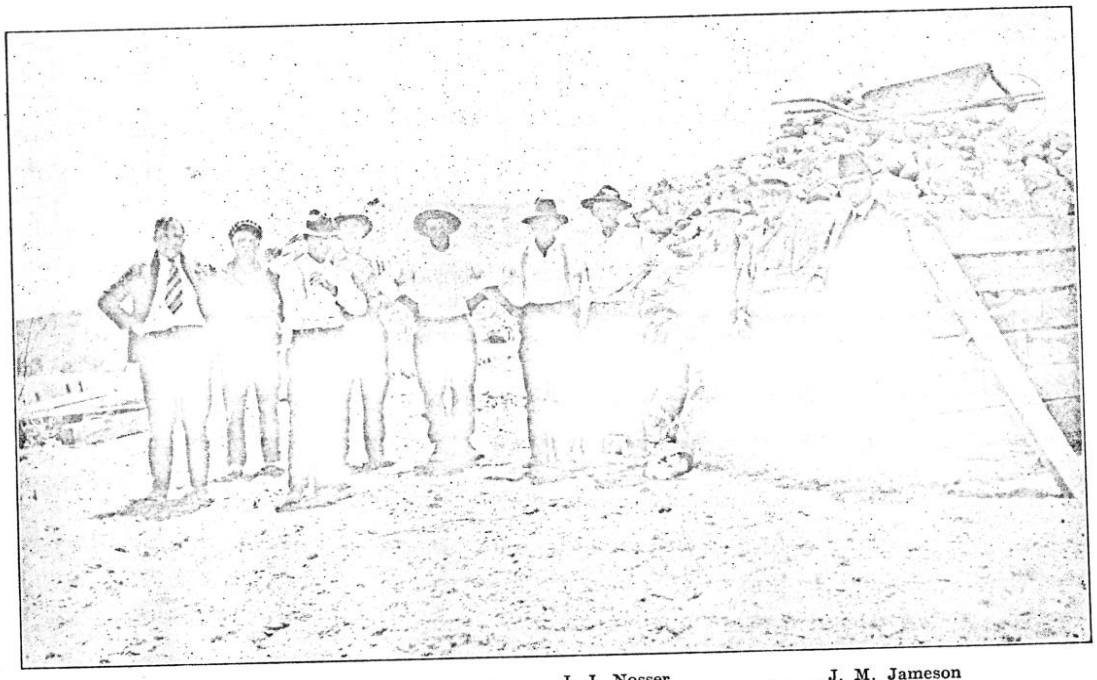


RANDSBURG AND VICINITY

enough the richer sample was the one the men thought came from the entire 15 feet.

In addition to the silver, each sample contained about three ounces of gold per ton. Here I venture to address a few words of admonition, and more particularly of encouragement, to the prospector. Probably 100 men had noticed this outcrop and had examined the rock; many of them had even gone so far as to break up some of it for testing in their pan. But the gold is not free; it will not 'string' a pan, although a ton of the ore contains several ounces of it. The moral is that a prospector must educate himself in the elementary principles of mineralogy; otherwise his work cannot be efficient. The detection of gold that is combined to form other minerals may be difficult, but at least the prospector should familiarize himself with a few dozen common minerals such as hornsilver, as Hamp Williams had done. Looked at from a different angle, these same circumstances hold much encouragement for the prospector. For years this remarkable deposit lay undiscovered, although it was in the path of scores of men whose lives were spent in searching for likely-looking outcrops. The complaint is sometimes made that all the good lodes have been discovered, or that most of those remaining do not appear

on the surface and must be found by costly exploration with diamond-drills, churn-drills, or other expensive machinery. The California Rand mine belies this conclusion; the narrative of its discovery should put new heart in our friend the prospector. There are thousands of square miles of California, Nevada, Arizona, Utah, and other Western States that offer the most attractive possibilities of rewarding his efforts. It is safe to say that there are hundreds of orebodies just as good as that of the California Rand—rich as it is; all that is necessary is to find them. Prospector, take heart! Equip yourself properly with the paraphernalia for making tests, with a reasonable knowledge of minerals, and with the persevering spirit without which no prospector ever succeeded, and go out in the hills. If your courage flags, think of Hamp Williams and Jack Nosser and the California Rand, or, for that matter, of a hundred others whom fortune favored before them—and since.



J. J. Nosser
W. Hamp Williams
J. W. Kelly
J. M. Jameson

THE FIRST LOT OF HIGH-GRADE ORE, A FEW OF THE OWNERS, AND SUNDRY VISITORS

Kelly was a cautious individual; he wanted to be sure. Accordingly he wrote to Jameson at Bakersfield to come out and bring Edward T. Grady with him. During the later period of the development of the K C N, Miss Coons had been pressed for money, and Jameson had agreed to advance $1000 for her. Accordingly it was agreed that Jameson should have half of the quarter interest held by Miss Coons by virtue of her grubstake agreement. Grady was a man of considerable experience in mining and they all had implicit confidence in him. I am told that if he had been so inclined, Grady, with his superior knowledge of business, could have obtained a large share of the mine for himself; that he did not, indicates that the confidence of the others was well founded. He is now making a fortune for himself and his partner from the Grady lease, concerning which there will be more hereafter, but all his transactions with the company seem to be marked by a spirit of square dealing. He sampled the outcrop carefully; the returns from his samples verified the former results, and the probability of opening a bonanza was established.

Investigation revealed the fact that the discovery was made on the Juanita claim (shown on the accompanying map), and that this claim was still valid by virtue of the performance of the annual assessment work. The other claims in the vicinity had lapsed. A man named McCormick, of Los Angeles, had located the claim and had sunk a shaft 130 ft. deep and driven a 75-ft. adit in a fruitless search for gold ore. The shots that had exposed the rock where Hamp and Jack found it were doubtless put in by McCormick's men when they were prospecting. Like hundreds of others who had passed over the outcrop, they were seeking gold, not silver, and they accordingly overlooked the huge deposit of hornsilver. Kelly was delegated to go to Los Angeles, where he obtained from the son of McCormick, who had died in the meantime, a bond and option to buy for $5000. In the meantime the Uranium group of claims was staked, thereby effectively covering what then appeared to be the valuable ground.

As I have related, Williams and Nosser were without money; had they known how far the rich ore would continue below the surface and how wide the vein would be they would have needed none except what was required to buy their grub while they dug out a few carloads themselves. When work was started a huge block of ore [illegible] ft. by 18 ft. in horizontal section and 70 ft. deep was mined, beginning at the surface; and every pound from this pit was shipped to the smelter. Until dividends amounting to $96,000 had been declared, the mine was

literally without a dump. However, this could not be foreseen, and accordingly Williams and Nosser each sold half of his quarter interest for $1000. Alfred Harrell, editor and proprietor of the 'Bakersfield Californian', took an eighth interest, and a group of eight men, including Grady, divided the other eighth equally. Harrell is now president of the company and the leading figure in the administration of affairs; he has been highly successful in directing the general policy of management.

An episode connected with the exercising of the bond and option is interesting for the reason that it involves a nice point of law. Mining claims in California are not community property between husband and wife; however, if both husband and wife contribute funds for the performance of assessment work, it seems that an unpatented claim becomes a community interest. Kelly had neglected to get the signature of Mrs. McCormick on the option, which was being held in escrow in a Los Angeles bank. The terms of the bond provided that McCormick should receive a small proportion of all smelter returns until the $5000 had been paid. He accepted the checks sent him as his share of the proceeds from the first two shipments, but the third draft remained uncalled for in a Los Angeles bank. When two weeks had elapsed and the remittance was still unclaimed, Mr. Harrell at Bakersfield quite naturally became alarmed, particularly in view of the fact that McCormick was a lawyer and would no doubt be aware of his technical rights; obviously, it would not be difficult to establish the fact of Mrs. McCormick's participation in financing the performance of assessment work. Harrell endeavored to get into communication with McCormick by long-distance phone, but the latter apparently did not care to discuss the matter by phone and failed to respond to the call. Thereupon Harrell wired to Jameson, Kelly, and Miss Coons, at Randsburg, directing them to meet him at Mojave that night. In company with Dwight L. Clarke and C. V. Anderson, respectively secretary and attorney for the company, Harrell drove to Mojave and the whole party, comprising the owners of the majority of the shares in the company, made a night ride by automobile to Los Angeles, reaching their destination at daybreak.

The 'board of strategy' held a conference on arrival at Los Angeles. It was finally agreed that, if necessary, as much as $50,000 would be paid to settle immediately with McCormick rather than involve the mine in litigation.

Kelly, who had done the original negotiating, volunteered to interview McCormick. His first move was to tender the unpaid portion of the $5000 with the explanation that his associates, in order to facilitate other financial arrangements, desired to fulfill the terms of the option at once. He then simulated great astonishment when he was informed of the irregularity in the signing of the bond. During the ensuing discussion, intimation on the part of Kelly that his associates might consider the payment of $10,000, to avoid any controversy, failed to arouse any outward enthusiasm in McCormick; Kelly withdrew, ostensibly to communicate the surprising revelation to his associates.

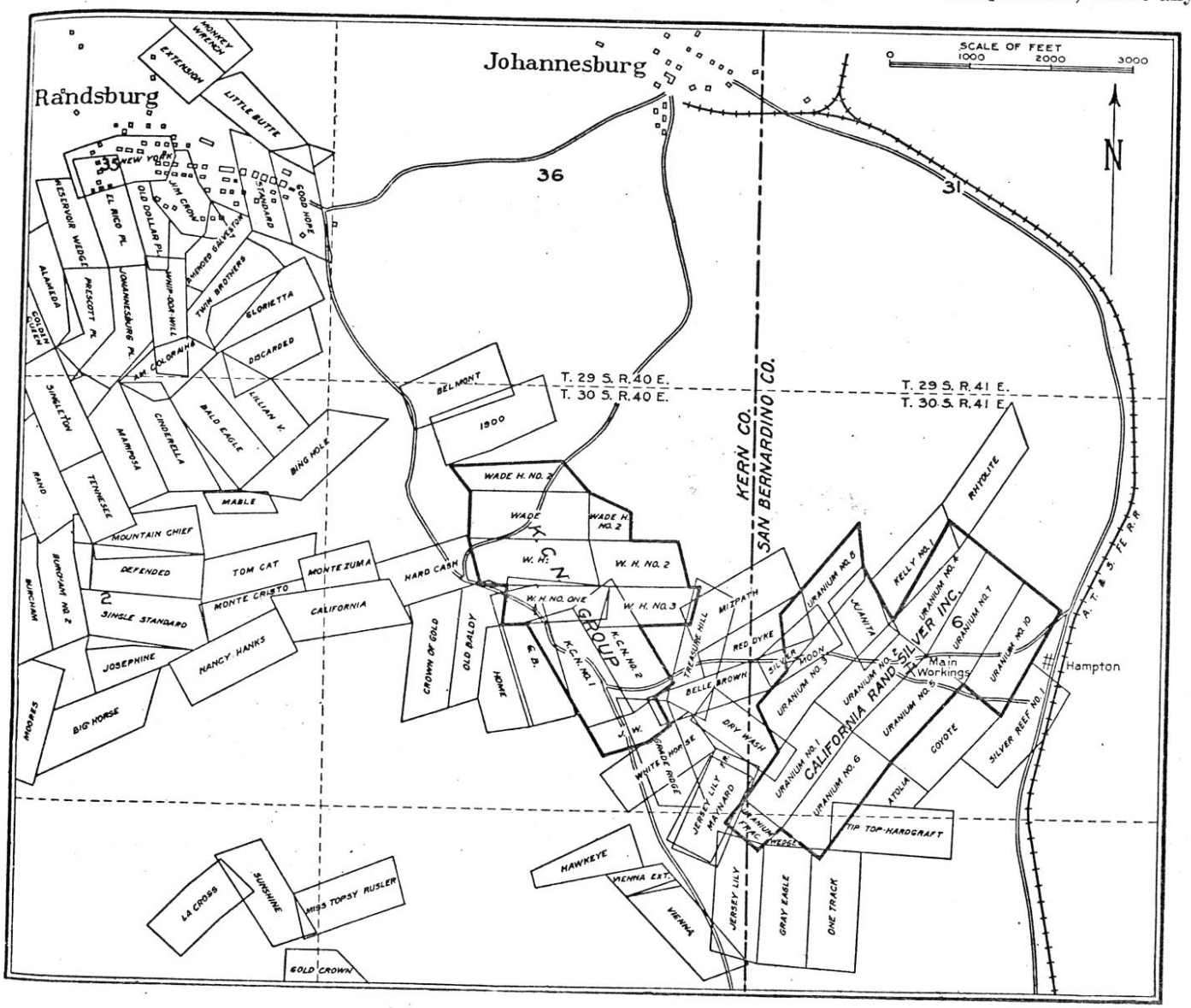
The next move in the negotiations, which had some of the elements of an interesting poker game, was a second visit to McCormick's office, this time by Harrell, Jameson, Kelly, and Anderson, together. Harrell, who acted as spokesman, relates the story of the interview in these words. "After some preliminary sparring, I put the bald query: 'Well now, Mr. McCormick, how much do you want, spot cash, to sign a deed according to the option given to Kelly?' 'I ought to have $15,000', was the reply. 'Bring the deed, signed by yourself and wife, downstairs to the bank', I said; and in fifteen minutes the transaction was complete. An hour later we started on another night ride back to Randsburg, but with a heavy burden lifted from our minds." Riding at night on the desert is exhilarating under any circumstances; added to this was the satisfaction of having cleared their title to the property that they confidently believed would become California's greatest silver mine, and of having 'saved', incidentally, $35,000 in cash. The serenity of the travelers on the return journey to Randsburg doubtless contrasted sharply with their feelings of the previous night when they didn't know whether they owned a mine or not.

Sundry transactions in the stock, which incidentally has never been offered on the open market, are of interest. When the 'pit' was 20 ft. deep, Ben Sill, an oil-operator of Bakersfield, paid $50,000 for an eighth interest, 1/64 of which came from Miss Coons and 3/64 from Kelly. This sale was negotiated by Grady, who also, a little later, sold an eighth interest to a syndicate of Bakersfield men, one-sixteenth coming from Nosser and the same from Williams. The consideration was $105,000, or on a basis of $840,000 for the entire mine, which at that time consisted of a pit-like shaft only 90 ft. deep. That the judgment of the purchasers, or perhaps I should say their luck, was not bad is indicated by the dividends that the company has paid already.

Next comes the story of the Grady lease. In the accompanying photograph there can be seen on the hill to the left a bold outcrop that stands out like a 'dike'. This silicious dike can be traced in a northerly direction along the hillside, where it outcrops about 125 ft. west of the discovery shaft. Surficial indications all pointed to some definite relation between this dike and the ore deposit, and accordingly claims were staked with their side-lines approximately parallel with the strike of the outcrop. Numerous geologists and engineers who visited the district were frank in expressing the opinion that the ore-bodies should be adjacent to this dike, or that they should be found in near-by veins or fracture-zones parallel with it. In order to hasten prospecting of its ground the company encouraged lessees to develop small blocks. The accepted theory that the trend of the dike gave the key to the disposition of the orebodies guided these lessees in the selection of their ground, with the single exception of Grady, who chose for himself and his partner, Ben Sill, a block adjoining the Uranium No. 2 claim

on the south-west. This was in the area known as the 'flat', and the selection was ridiculed by everyone who pretended to be able to fathom the mysteries of local geology. However, Grady started sinking; and he continued to sink persistently through barren schist for 260 ft. At this point the shaft entered high-grade ore in a deposit that appeared to be of considerable size.

The terms of all the leases, including Grady's, were peculiar in that they contained an 'apex' clause. Ordinarily a lease of this character defines certain limiting planes and provides that the lessee may mine whatever ore he is able to find within the included block of ground, irrespective of the strike, dip, or other structural features of the lode or lodes. It is customary to place a comparatively short time-limit upon the operations of the lessee, thereby preventing him from profiting too greatly in the event that he finds large orebodies. However, in the California Rand leases the following provision, quoted verbatim, is made: "together with the right to said lessee to mine said strip for all lodes apexing *wholly* upon said premises, together with the dips, spurs, and angles of such lodes; but to be confined in the working of the same to the boundaries of the end-lines of said leased premises as same are established and shown on the plat attached hereto and made part hereof, and it is distinctly understood and agreed that the said lessee shall not be entitled to work any vein or lode which apexes wholly or *in part* off of said premises, where any such lode shall dip under or pass beyond said leased premises". The italics are mine.



CLAIM-MAP OF THE RANDSBURG DISTRICT

Construed literally, this provision, I am inclined to believe, would leave the lessee little inducement to work at all; there would be small chance of any vein "apexing wholly within the said premises", which consisted of a block only a few hundred feet in lateral dimensions, and the lessee apparently would be deprived of the right to do any mining whatsoever. The intent, I am told, was to convey during the period of the lease, mining rights similar to those of an original claim-holder. If a segment of the apex of a lode on its strike lay within the

vertical planes of the leased block, that segment or portion of the lode lying between the planes through the endlines could be mined on its dip. Extra-lateral rights were to be recognized. Apparently the lawyer who drew the indenture was familiar neither with physical conditions as they exist in the ground nor with the pitfalls of legal phraseology appertaining to 'apex' geology.

However, when it became evident that Grady had found ore, the company officials brought out a copy of the lease and raised the question of apex. No one could tell just where the lode that Grady had found really outcropped, or whether it outcropped at all. Its apex might be underground; it might be within the limits of Grady's lease; or it might not be. The geology of the district presents numerous interesting features, which I shall point out in a later article.

Grady's partner, Sill, was a large stockholder in the California Rand company, and he was anxious to avoid a quarrel. Grady, likewise, saw the disadvantages of a legal fight, and therefore proposed that the company purchase all the rights of the lessees for $21,000. Sill agreed that, if the directors declined to compromise on this basis, he would support Grady, who was convinced that the lessee had a fair chance to prevail in the courts if a law-suit was to ensue.

The company had only the original inclined shaft and it would certainly need another unless the orebodies 'played out'; Grady had spent some $15,000 for equipment and for sinking, and he had opened some rich ore, although neither the extent of the shoot nor the size and trend of the lode had been determined. These were obvious considerations that favored making the purchase, which moreover would prevent any possible dispute in the event that a large orebody was opened. Nevertheless, the officials of the company, largely influenced by the advice of Jameson, who had become general manager, declined to make the purchase for $21,000. That the decision cost them a million dollars or more has been revealed by subsequent events; but whether the decision was a blunder in light of the conditions at the time, is a question that cannot be answered. If it was, Jameson had the consolation of knowing that many another million had been lost by errors of judgment with regard to mining property.

As soon as the offer was refused Grady started in earnest to open his ore. Within eight weeks he had done enough development work to show that at least a quarter of a million dollars was assured; the shoot in one place was 28 ft. thick and the ore averaged more than $100 per ton, with silver calculated at $1 per ounce. On its apparent strike the lode had been opened for 100 ft. and the drifts were still in ore. The lessees' shaft was but 300 ft. from the company's shaft, and the 600-ft. by 300-ft. block lay with its long dimension along the side-line of Uranium No. 2 in the general direction of the strike of the ore. It appeared to be likely that a goodly proportion of the orebodies lay beneath the surface enclosed by Grady's lines. Both Grady and the officials of the company realized this; but both sides were keenly aware of the undesirability of going to court to settle the question of ownership of the ore under the apex clause of the lease.

With a display of practical common sense that does credit to all concerned, and with a spirit of tolerance and willingness to compromise that is only too rare, they put their heads together to find the best way out of the difficulty. From various sources I gather that they were influenced to a large extent by this idea: "There is plenty of silver here to make us all rich if we go ahead and mine it and sell it as rapidly as possible; if we quarrel, the production of ore will be delayed, our organization will be demoralized, and the experts and lawyers will get most of the money. Let's settle the matter once and for all and then bend all our energy toward producing silver while the Pittman Act assures us a good market". If Messrs. Harrell, Grady, Sill, Jameson, and the rest had stopped to analyze their motives I believe they would have discovered some such train of thought, although I suspect that, if the facts since revealed regarding the lodes and orebodies, had been known at the time, the terms of the compromise would have been somewhat less favorable to Grady and Sill. At any rate, the outcome was a settlement by mutual agreement reached within a short time. Grady and Sill agreed to decrease the size of their block to 120 ft. square in lateral dimensions, thereby giving them 60 ft. instead of 300 ft. in each direction along the strike of the lode, and diminishing by more than half the distance in the direction of the dip. A horizontal plane passing through the 450-ft. level of the Grady shaft was also agreed upon as the lower limit of the block. On the other hand Grady was given an extension of six months, or until January 27, 1922, during which to extract his ore. By the terms of the settlement all questions of apex were dropped, the lessees being governed only by the boundaries of the ground. Even though the lessees may have gotten the best of the deal the settlement illustrates the virtues of negotiation and compromise in averting 'war'. Of course, it required cool heads and a lot of common sense.

I may add that plain common sense has been the biggest asset of the men who have been in charge of the California Rand mine. Until recently there has been no one connected with the management of the property in an executive capacity who pretended to be a mining engineer. Jack Nosser was in charge of actual mining at the start and John W. Kelly looked after business affairs for a short time. However, the man who early assumed the management and who guided the destinies of the company until his death in June 1921, was J. M. Jameson. Jameson knew little or nothing about running a mine when he undertook the job, but apparently he had some sound ideas of business and these he applied to the operation of the mine. One engineer who had examined the mine remarked to me that he was astonished that so few mistakes were made, and that the shipments of ore had been maintained with such regularity. Although the orebodies are undoubtedly large and rich, the veins split and pinch, and it is no easy matter to maintain regular shipments of high-grade ore.

A notable feature is the modest character of the surface equipment and buildings; some managers would have spent an additional $100,000 on unnecessarily elaborate buildings. It is false economy to get along with inefficient equipment when better can be afforded; but a handsome office-building or a steel structure to house the hoist are 'trimmings' that can wait for an advantageous time, without interfering with the production of ore. Frequently, an important function of elaborate surface plants is to afford material for impressive illustrations in prospectuses and otherwise to assist in promoting the sale of treasury stock to the esteemed public; this has never been necessary at the California Rand property. A small group of the stockholders felt that Jameson's policies were not sufficiently progressive. However, during the period of his management, No. 2 vertical shaft was started and sunk 150 ft., and tests were made by seven different metallurgical engineering firms with a view to determining the most desirable treatment for the low-grade ore.

Jameson died in June 1921. He was succeeded as general manager by C. S. Meroney who, first as accountant and later as superintendent, had been his right-hand man. I believe that Mr. Meroney is endowed, among other virtues, with a 'nose for ore'; to him more than anyone else is due the credit for directing the development work and the stoping in such manner that it was possible to maintain shipments regularly.

In June of this year, M. N. Colman was engaged as mill superintendent. He has correlated the results of the metallurgical tests made by the various firms and has designed a 100-ton flotation plant, which is now being erected. The tests of the ore and the design of the plant are interesting; they will be described in the third article of this series. J. M. Fox has recently assumed the position of mine-superintendent; with these two competent and experienced engineers to direct the technical work, under Mr. Meroney, efficient and economical operation seems assured. A valued member of the operating staff is T. D. Walsh, who became mine engineer a few months ago in succession to V. A. Gillis, whose connection with the company was brief. Mention should be made of the valuable advisory work of Morris B. Parker who, in the capacity of consulting geologist during part of 1920 and 1921, assisted in the solution of some of the geological problems and made several estimates of the ore reserves.

The main shaft is inclined at an angle of 15° from vertical; it was 730 ft. deep on August 15. Levels have been established at intervals of from 40 to 70 ft.; eleven of them having been opened to date. The total amount of development work is approximately 12,000 ft., exclusive of that done in the Grady lease. Ore has been mined from all the levels except the eleventh, on which the crosscut has only recently cut the vein. The new vertical shaft is 350 ft. from the original shaft in the direction of its inclination. Sinking has reached the 230-ft. point, the plan being to continue, without interruption, to the 1000-ft. level. The site of the mill was selected so as to permit the economical handling of the ore directly from the skip-bins to the crushers. The estimate of the reserves of mill-ore is necessarily indefinite for the reason that little of it has been actually exposed, but a conservative figure is 100,000 tons of ore averaging $20 per ton, with silver selling at $1 per ounce. Manifestly it has been good policy to concentrate effort on the mining of high-grade shipping ore rather than to develop milling ore.

Grady and Sill, from their lease, have been shipping approximately 60 tons of high-grade ore per day for several months. The resulting royalties net the company from $10,000 to $15,000 per month. The lease has until January 27 to run and Grady estimates that he and his associates will make a clear profit of more than a million dollars as a result of their operations.

Adjoining Uranium No. 5 is the Coyote claim owned by the Randsburg Silver Mining Co., in which John W. Kelly and Ernest Blanck are the dominating figures. Both of them are interested financially in the California Rand Silver, and Blanck is a director of the company. A shaft has been sunk on the Coyote claim approximately in line with the original California Rand inclined shaft and the Grady lease shaft. Recently a vein of shipping ore has been opened on the 500-ft. level from this shaft. This discovery has stimulated others who have been working in the vicinity. Bisbee and Bray, lessees who have sunk a 400-ft. shaft on the Osdick group of claims, which lies south from the Coyote, are employing 20 miners and are hastening work in the expectation of finding ore; and Elkins & Flynn are actively prospecting, by means of a diamond-drill, the Silver Reef claim, adjoining the Coyote on the east. In addition, there are a number of smaller operations being carried on principally by lessees, who hope to 'strike' high-grade near the surface.

Including those employed in the gold mines in the western portion of the district, there are probably 200 men in Randsburg at work, earning from $6 to $8 per day; miners are paid $6 to $6.50, depending upon the nature of their work. This is, I believe, the highest wage-scale prevailing in the United States. The California Rand company has made no reduction in wages since the peak was reached during the War. The policy of the company has been to share prosperity with its employees.

There is one manifest result of high wages; general prosperity! The sight of Randsburg is a tonic for the depressed. It is unfortunate that there is no way to give it general distribution—in bottles, perhaps; it might hasten the return to normality. With the exception of the men who live in quarters supplied by the company at the mine, I failed, during a two-day stay at the mine, to see anyone coming to work on foot. I venture to say that there are more automobiles per capita in Randsburg than in any other community in the United States; and that ratio is a pretty good index to prosperity. Everybody in the small world that centres at Randsburg is hard at work; everybody has money; everybody is optimistic. How different things would be if Hamp Williams had not known hornsilver when he saw it!

(To be Continued)

The California Rand Silver Mine—II

Geology, Development, and Mining

By Arthur B. Parsons

The preceding article recounted the story of the discovery, in April 1919, of this remarkable bonanza of silver ore in the old gold-producing district of Randsburg, near the eastern border of Kern county in California, and of the production within 30 months of silver-gold ore having a gross value of 2¼ million dollars, with the payment of nearly a million dollars in dividends. In this article I shall point out, among other things, some of the interesting geological features of the deposit as they have been revealed by the operations of the California Rand company and sundry lessees, as well as by the work of the Randsburg Silver Mining Co., which owns the Coyote claim, adjoining Uranium No. 5, as indicated on the accompanying map of the district (see Fig. 1). A 500-ft. shaft, from the bottom of which cross-cuts have been run both south-east and south-west, has proved the existence of silver-bearing veins underlying the Coyote claim.

Geology of the District. The country-rock in the productive part of the Randsburg district, including both the older gold 'zone' and the newly discovered silver 'zone', is a highly altered schist, which is classified as "a mica-albite schist of probable sedimentary origin" by Frank L. Hess, who made an examination and report on the quadrangle for the U. S. Geological Survey in 1909. An intrusion of granite cuts across the Rand mountains south of Randsburg; it is roughly crescent-shaped, and is several miles long; in places, it is half a mile wide. The Yellow Aster mine, which is credited with a production of $9,000,000 in gold, is situated at the intersection of this granitic intrusion with the axis of the Rand range of mountains. The ore deposits are closely associated with the granite and with numerous adjacent granite-porphyry dikes that, according to Hess, are "probably connected to it". The intrusion of granite can be traced across the country in a south-easterly direction and can be identified immediately north of the California Rand workings.

Hess describes three different types of ore in the schist-granite area; they are: (1) fault-lodes or deposits along faults in crushed schist and granite; (2) stockworks in granite; (3) fissure-veins, containing quartz in varying quantity. Although the rich silver-bearing ore had not been discovered at the time he visited the district, the physical characteristics of the silver deposits are not dissimilar to those which Hess describes, except that, in the silver zone, ore of the stockwork type is found in the altered schist rather than in a rock that can be identified distinctly as granite. In fact, no silver ore has up to this time been found north of the contact of the schist with the regional intrusion of granite. The summary of the deductions that Mr. Hess made regarding the genesis of the ore is interesting. He says: "It seems probable that, after the intrusion of the granite and the granite-porphyry dikes, a large amount of hot water was squeezed from the granite while it was cooling. The water carried silica, gold, silver, iron, sulphur, arsenic, lime, tungsten, and a little tellurium and titanium in solution, and flowed along the faults and shearing planes and through the broken granite. The minerals were deposited wherever chemical reactions took place". All the geologists who have studied the district appear to agree that the large crescent-shaped intrusion of granite was undoubtedly the primary source of the minerals that were deposited in fractures traversing the complex of schist and granite, to form the gold-bearing deposits. These start from the Yellow Aster and are found at irregular intervals in the contact zone as far east as the Juanita claim. It will be recalled that the early work on the Juanita consisted of prospecting for gold; and that the original discovery of silver ore was made in the district some years later near the south-eastern end of the claim.

The California Rand Mine. The lode on which the Juanita claim was located is at the contact between the schist and the granite of the regional intrusion. This contact strikes south-easterly and dips at a low angle (about 30°) to the north; the side-lines of the Juanita claim are approximately parallel to the strike of the contact. A second intrusion is the silicious dike—called porphyry by some geologists—that strikes approximately at right angles to the schist-granite contact, and which determined the direction of the side-lines of the Uranium claims at the time they were originally located. This dike can be seen outcropping boldly on the hill south-west of the mine. The outcrop appears to mark the foot-wall of the intrusive mass; it can be traced through Uranium No. 1 and Uranium No. 2 to a point about 100 ft. north-west of the company's No. 1 shaft, but it disappears as soon as the granite area is reached, presumably because the intrusion could not penetrate the granite, which is regarded as being older. A 105-ft. shaft, sunk 330 ft. north of No. 1 shaft, and near the north end-line of Uranium No. 2 was in granitic rock for 60 ft., at which depth it entered the schist. A north-west cross-cut in the schist passed through a hard formation that presumably is the east-west dike. If this be the case, the dike is about 60 ft. wide at this point.

One hypothesis for the deposition of the ore is based on the theory that the granite shattered the adjacent schist and formed the north-south fractures that have now become the silver-bearing veins. The subsequent intrusion of the silicious dike re-opened these fractures and probably introduced the silver-bearing solutions. The fissured area near the schist-granite contact was particularly receptive not only because of its physical condition, but perhaps because of its chemical characteristics; that is, the minerals deposited at the time of the intrusion of the granite may later have reacted chemically to stimulate the precipitation of the minerals that formed the rich silver ore. At any rate the silicious dike seems to be the dividing line between the gold and the silver zones of the district, even though it may develop that some other intrusion, which subsequently may be found, brought the enriching solutions.

The point of discovery was 120 ft. east of the foot-wall of the dike, on a line that represents the prolongation of the Juanita contact-vein. The vein itself cannot be traced beyond the dike, although the contact swings and takes an easterly course through Uranium No. 2 and No. 5. No. 1 shaft was started at the discovery-point and followed a wide lode, with a well-defined foot-wall, commonly known as the 'shaft fracture'. A drift on the second level of this fracture has been followed for a total distance of 510 ft., including some work from the 105-ft. shaft mentioned above.

The ore at the surface was oxidized, with flakes and bunches of hornsilver. A peculiarity was the alterna-

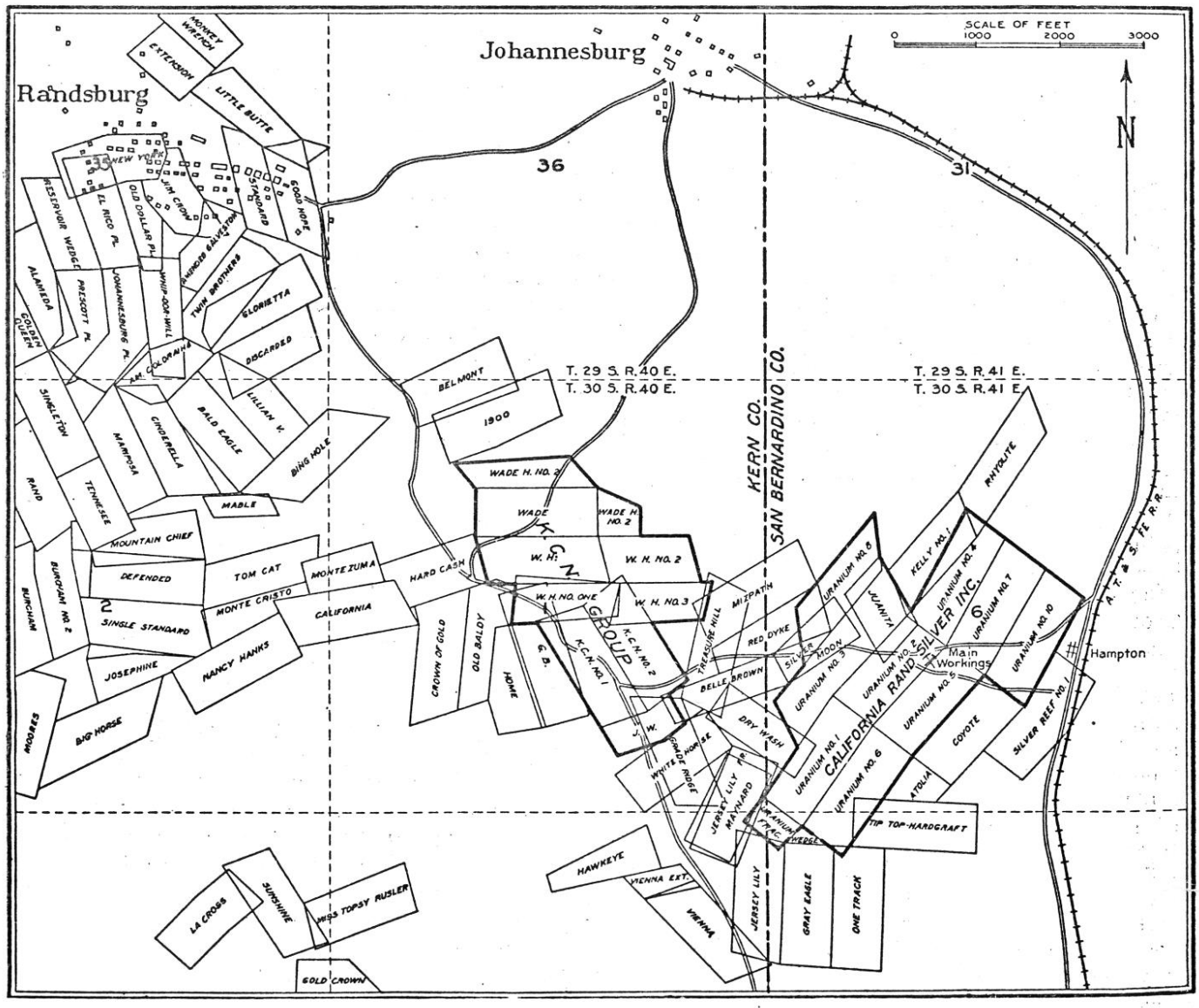


FIG. 1. CLAIM-MAP OF THE RANDSBURG DISTRICT

tion of thin layers of hard and soft material, the soft being far richer than the hard. These layers dipped only from 5° to 15°, to the east, and, as progress was made in sinking, there was constant speculation as to whether each successive lean layer would be underlain by a rich one. The pessimists were sure that the deposit was only a freak, and that after a few lenses near the surface had been mined the bottom would be reached, and it would remain only to follow the layers horizontally to the limits of the orebody. For the first 50 ft. the 'shaft' was a pit approximately 18 by 22 ft. in lateral dimensions, dipping to the east about 78°. As I mentioned in the

previous article, every pound taken from this pit was shipped as ore. A simple but reasonable explanation of this 'bedded' deposit is that the 'beds' are really flat veins formed by the filling of fractures in the schist, and that the coincidental impregnation of the intervening layers with silver-bearing solution made the lower-grade 'beds'. Or, it may be that some of the layers of schist were more porous or more soluble than others and that the ore-carrying solutions, accordingly, deposited more of their burden in them. The oxidized ore is doubtless enriched by secondary precipitation from descending

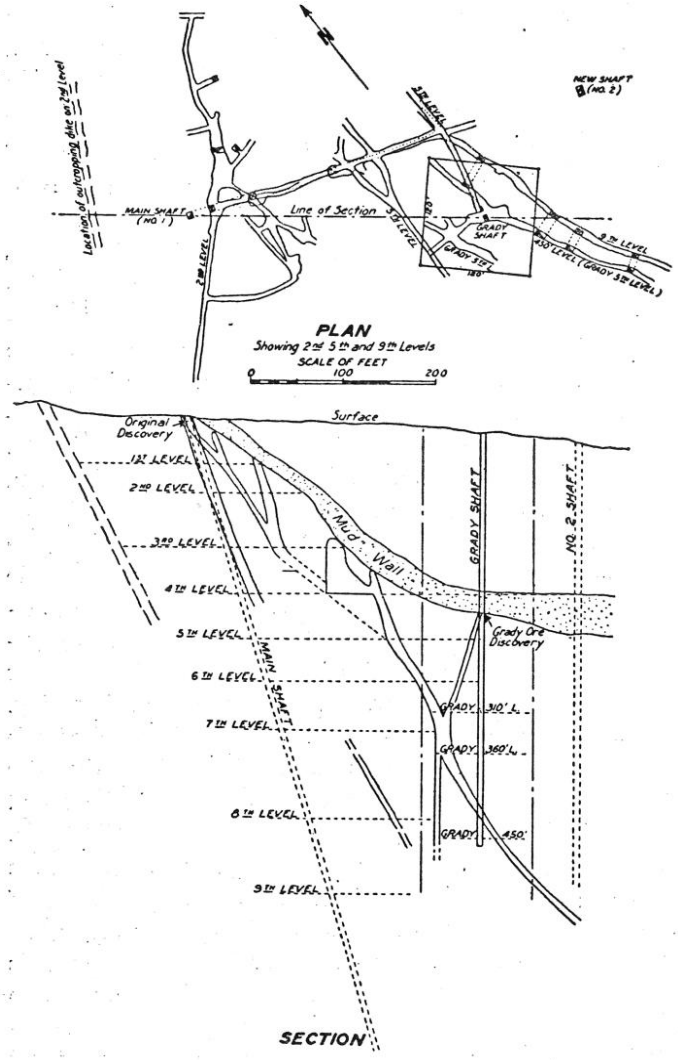


FIG. 2. SHOWING PART OF THE WORKINGS OF THE CALIFORNIA RAND MINE. THE 2ND, 5TH, AND 9TH LEVELS ONLY APPEAR ON THE PLAN.

silver-bearing solutions. Such ore is not found below the 150-ft. level.

The foot-wall of the dike has been reached by crosscuts on the first and third levels as indicated on the accompanying drawing, Fig. 2. This section is taken through the collars of the main No. 1 shaft and the shaft on the Grady lease, so that No. 1 shaft, being off the plane of the section, does not appear to coincide with the dip of the shaft-fracture.

This section also shows the 'mud wall'—the foot-wall of a fault-zone—that has decapitated every branch of the vein except the single outcrop that formed the discovery vein. Had erosion stopped a short time—geologically speaking—before it did, it is probable that even the luck of Williams and Nosser would have failed to find the ore. It is this 'mud wall' that makes it necessary to sink on the Coyote claim and the others lying to the east, in order to prospect. The presumption is that the wall extends indefinitely, though fortunately it appears to flatten, so that the distance necessary to sink in order to pass through it does not increase rapidly.

Fig. 2 also shows the Grady shaft and the boundaries of Grady's block of ground from which he expects to take more than $1,250,000 before his lease expires. It appears that if Grady had selected a spot 20 ft. farther east for his shaft he would have had to sink to about 430 ft. before finding ore instead of cutting it at 200 ft. The chief interest attaching to Grady's mining, however, is the fact that he selected his lease-block in a direction that to everyone else appeared to be entirely off the trend of the ore. A dozen leases were granted in Uranium No. 1, in No. 2, and in No. 4, but no one except Grady considered No. 5 as being worth while. Grady, it appears, was more impressed than others by the fact that rich ore at the point of discovery was near the juncture of the Juanita vein with the north-south dike. He took samples along the surface in the direction of the northerly prolongation of the dike, but failed to find indications of silver, and therefore abandoned the idea of taking a lease in that direction. There remained the possibility that the Juanita vein might have some remote connection with the orebodies. He could not find the contact between the schist and the granite on Uranium No. 5, and accordingly he projected the line of the Juanita vein across Uranium No. 2 and selected the site for his shaft on this projection. In view of the fact that his lease contained an apex clause, it is hard to see why he wanted to be so close to company ground in the direction of the dip of the veins, unless he failed to appreciate the significance of the apex provision. The story of the threatened litigation and the compromise was told in my earlier article.

It should be remembered that at the time the compromise was made, development in the company workings had advanced only to the fourth level; accordingly, no evidence existed to show that the main vein made a junction with Grady's vein. Although the large branches of the main vein dipped easterly, it seemed clear that the Grady discovery-vein dipped in the opposite direction and that a segment of its apex lay within the lease-block, which originally extended 175 ft. farther east than is indicated in the drawing. The latter represents the smaller block as agreed upon at the time the controversy was settled. If the case had been decided on its merits it seems probable that Grady could have established right to the ore in the branch vein between the points where his shaft first cut it, just below the mud wall, and the point of intersection with the main vein. An interesting question would then arise as to what further ore, if any, would rightfully be his. Could he follow the vertical portion of the vein below the junction? or could he prove

that the wider easterly dipping portion of the vein, below the junction, was part of his vein? The answer to these questions would involve a detailed study of the geologic and mineralogic characteristics of the veins and of the ore. Such a study has never been made, but the problem is interesting nevertheless. Still another possibility existed: he might have established the contention that the Juanita contact vein was the true lode and that the north-south veins were branches or spurs from it. If Grady could have done this, the side-lines of Uranium No. 2 and No. 5 would have become end-lines and he could then have mined the ore between the common side-line and his other parallel line. Such a contention, however, would be exceedinly far-fetched in view of the mining done in the workings both of the company and of the lessee. On the 50-ft. level the shaft-fracture, striking N. 30° E., has produced shipping ore for a distance of 220 ft. On the lower levels the shoots of sulphide ore have been developed for more than 200 ft. in a general north-south direction, and the veins have been followed for greater distances, although they do not contain ore throughout their length. The existence of north-south veins of distinct identity must be conceded. Incidentally, I may mention the fact that one of the directors of the Randsburg Silver Mining Co. intimated to me that a contention based on the identification of a main east-west lode might be advanced by his company in an effort to make good its claim to ore that underlies its Coyote claim but that is found in north-south veins that presumably apex in Uranium No. 5. In a recent letter to the stockholders of the California Rand company, Alfred Harrell, the president, says: "The one disquieting feature in connection with our property grows out of activities in the immediate neighborhood of our mine". He urges that "our orebodies must be protected against encroachment".

The Randsburg Silver Mining Co. sank its shaft on the Coyote claim directly in line with the California Rand No. 1 and Grady shafts, or on the projection of the Juanita dike. At 468 ft. a silver-bearing vein was cut, according to reports, but not prospected. At 500 ft. a cross-cut was driven easterly and "278 ft. east of the common side-line [between the California Rand and Randsburg Silver mines] we encountered and are opening up an 8-ft. vein, the direction of its course so far as developed now runs apparently lengthwise through the Coyote and dips toward the east at a pitch of 50° to 60° where encountered, to almost perpendicular in the end of the south drift, now 120 ft. long, on September 17, thus apexing within our claim beyond any question". This is quoted from a circular the purpose of which was to market 50,000 shares of the Randsburg Silver company's stock. However, the company has decided not to ship any ore for the present—whether because it has little to ship, or because it is not sure of the "apexing within our claim without any question" is a puzzle. It is possible that the vein cut in the Coyote, even if it does apex in Uranium No. 5, is not a branch of the main vein but an independent one. In that event it may curve around on its strike so as to leave Uranium No. 5 through its east side-line, in which event the Randsburg Silver company would be entitled to a segment of the vein.

However, the ground intervening between the California Rand workings and the side-line between the Coyote and Uranium No. 5 claims has not yet been explored or developed; when this is done additional light will be thrown on the structural geology, and the questions of apex and ownership of the ore may settle themselves; or it may be that further information will complicate the problems and the outcome will be litigation. A better solution would be a compromise involving the absorption of the Randsburg Silver company by the California Rand company. I do not know that the latter corporation has any desire to acquire the Coyote claim, but if orebodies of any size are developed they could be more advantageously worked by the California Rand than by an independent company.

DEVELOPMENT OF THE MINE. The drawing that shows the section through the shafts indicates the small interval between the levels, the average, down to the seventh, being exactly 50 ft. Two reasons for this are: (1) the fact that development work has never been carried far ahead of mining operations for current production, and (2) the policy of following the ore closely. The high-grade veins split and branch, pinch and widen, both on the strike and on the dip; they are cut by sundry cross-fractures, the intersections usually marking the position of richer ore. For this reason it was desirable to keep close to the ore in order that none might be overlooked, or that time might not be wasted in cross-cutting and drifting in search of the shoots. The running of levels at frequent intervals was pursuant to this policy. The workings on the 90- and 150-ft. levels reached the limits of the shipping ore at points disappointingly near the shaft; accordingly, the development of the third level at 200 was undertaken with some apprehension. The results, however, were reassuring. Ore was taken from long stopes on each of the two vein-systems, one of which strikes nearly north and south, and the other 10° or 15° west of north. On the lower levels connection is made with the Grady workings where the junction of two veins, on both their dip and their strike, has made an oreshoot 27 ft. wide; and on each of the succeeding levels the development is satisfactory.

In addition to the high-grade shoots that have been partly stoped above the seventh level much low-grade ore has been exposed. The tonnage actually blocked out is not large, but the drifting and stoping to produce ore, together with some work done primarily for development, have shown that 100,000 tons of $20 ore is reasonably assured, above the ninth level.

At points where there is no definite quartz vein of rich ore the schist is frequently streaked with small veinlets of sulphide minerals, caused by deposition in a network of small fractures running in all directions. Much of this material will be mill-ore; the line of demarkation between ore and waste will be determined by

assay. In some parts of the mine a single rich vein is too narrow to stope for shipping ore but can be removed with some adjacent rock and sent to the mill.

CHARACTER OF THE ORE. The ore in the oxidized horizon contains chlorides, oxides, and sulphides in flakes or splotches, together with some bromides and iodides, the gangue being relatively pure quartz. Below the third level, at 150 ft., the ore is exclusively sulphidic, the silver-bearing minerals being argentite, pyrargyrite, proustite, and stephanite. An interesting feature is that, in the richest ore, arsenic rather than antimony seems invariably to be the essential constituent. This might be interpreted as indicating that much of the antimony is in the form of stibnite or other minerals that are not silver-bearing. The gold is believed to be associated with pyrite. In addition to ore in which the silver-bearing minerals in irregular patches seem to be enclosed in the silicified schist with an absence of definite walls, the sulphide horizon also contains well-defined veins composed of compact quartz in which the silver minerals are uniformly disseminated, thereby indicating "concurrent deposition", according to Morris B. Parker, who made a number of geological examinations of the mine for the California Rand company. He considers this to be "primary ore, that has undergone no change since original deposition occurred". On the 250-ft. level, ore of this character assayed from 200 to 300 oz. in a vein 6 to 12 in. wide. This is interpreted by Mr. Parker as proving that the high-grade ore is not confined to a horizon near the surface, where secondary enrichment by re-deposition has concentrated the silver.

MINING. The rapidity with which mining operations were commenced in 1919 was due in part to sundry unusually advantageous conditions. The transmission line of the Southern Sierra Power Co., connecting the generating station at Bishop with the Imperial Valley, passed within less than half a mile of the mine; a pipe-line that was originally laid to supply water to the Osdick mill passed directly through the California Rand property; tracks of the Santa Fe railroad company were only three-quarters of a mile distant; and a good highway was ready for traffic to Randsburg or to the railroad-siding. As soon as the shaft was well started, the partners purchased an electrically-driven hoist, built by the Colorado Iron Works company and equipped with a 50-hp. General Electric motor. A little later two 12 by 10-in. Ingersoll-Rand compressors with appropriate motors were installed and a Champion blower with an eight-inch air-pipe was provided to assist ventilation. Additional equipment has recently been purchased for the compressor plant, as the requirements have increased.

There is nothing novel in the methods of mining. The schist lies nearly horizontal and the ground holds remarkably well without timbers. At the point in the Grady lease where the big orebody has been mined the walls of a huge cavern stand without any supporting timber. Overhand breast-stoping, with a few stulls to provide staging from which to drill, has been used exclusively until recently. J. M. Fox, the new mine superintendent, has started a shrinkage stope above the sixth level. The prime object is to provide a reserve of broken ore from which to draw if all the faces happen to 'pinch' coincidentally.

In anticipation of the completion of the flotation plant, which is now in the course of construction, a new two-compartment vertical shaft was started in April 1921. At the time of writing it has reached the depth of 500 ft. and is being connected with the workings, ready to serve as the main exit for ore about the first of next year, soon after the mill is in operation. The new shaft is north and a little east of the Grady shaft and is just above the site of the mill, which was selected so that the plant would be conveniently situated to receive ore directly from the shaft. The primary crusher is to be fed directly from the mine-ore bin; the broken rock will be carried to the mill structure proper on an inclined belt-conveyor. My concluding article will describe the tests conducted to determine the most advantageous method of treating the ore, and sundry features of the proposed flow-sheet.

(To be Concluded)

WHEN war science learned how to destroy thousands at a stroke, to ruin whole cities in the space of a breath drawn in the middle of the night, peace seemed more and more desirable, says Francis P. Garvan, in an address delivered before the Society of Chemical Industry and the American Chemical Society. "As the researchers in the sciences contributed in ever-increasing frightfulness to the power and long-distance application of war weapons, destroying all the romance of industrial combat and nullifying individual courage, men began to see increasing merit in the dreams of those who would abolish war uutterly and who would police the evil doers of the earth as such are policed in our cities. When the creative chemist showed military commanders how an opposing host could be stricken from life on the wings of the wind, laid horribly in death by a vapor as noiseless at the pinions of Azrael; how life could be expelled from great cities by a death dew of acids sprinkled from airplanes, peace became a boon to be prayed for in utter sincerity. Hypocrisy, smiling at gunpowder, blanched before phosgene gas. I do not say that the spread of education and gradual refinement of the spiritual side of man has not played a part in the growth of the ideal, nor that the operation of pure reason has not contributed to the vitality of the desire. I do maintain, with history at my back, that successive inventions of horribly destructive weapons and successive demonstrations of the magnified and unpreventable ruin and misery wrought by one new weapon after another, have been successive shocks to man's long-time notions about the indispensability of war. There was a time when he said that war could not be prevented. Then he began to say that it was disagreeable on the whole, that it ought to be prevented. Now he is beginning to see that it is so frightful that it must be prevented."

The California Rand Silver Mine—III

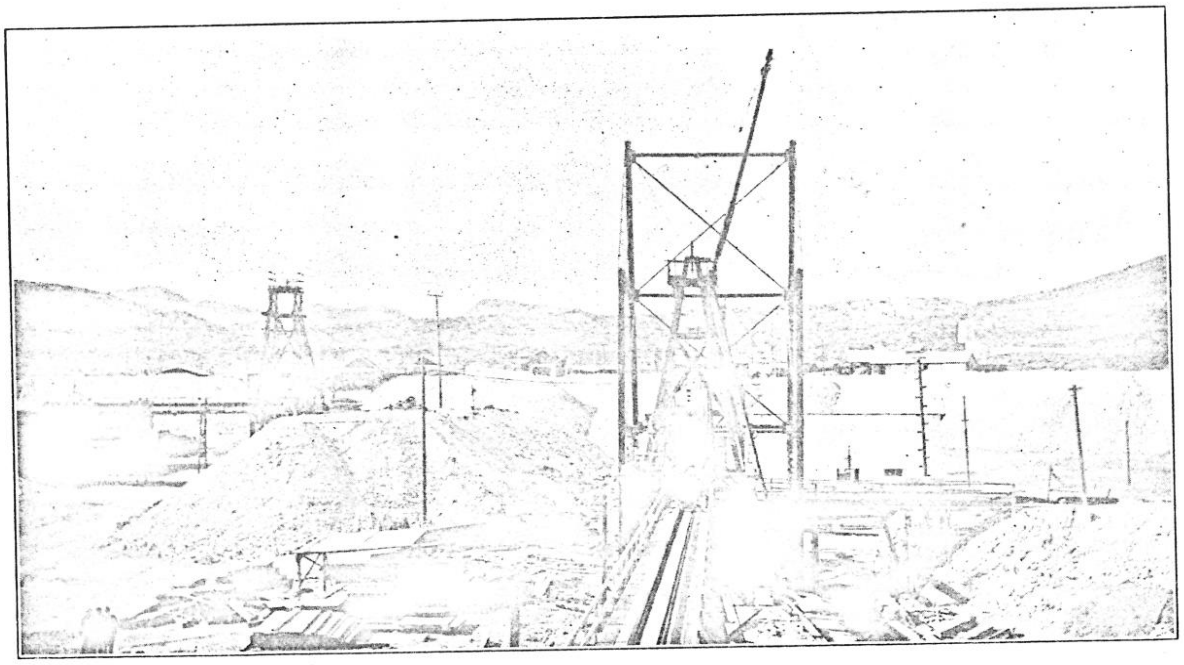
Metallurgy—Concentration by Flotation

By Arthur B. Parsons

The gross value of the gold and silver contained in the ore shipped by the California Rand company since June 1919, when the first consignment of 55.9 tons was sent to the Selby smelter of the American Smelters Securities Co. on San Francisco bay, is $2,878,946, as shown in the accompanying summary. These figures are taken from the official smelter returns and are calculated on the basis of the market price of silver on the day settlement was made. The net return after deducting the freight-charges paid to the railroad, the Government tax, and the deductions and charges made by the smelting company is only $2,101,394. The difference is $777,552, or approximately $25 per ton, which may be considered as being the average cost of marketing $100 ore. This high cost results partly from the long haul and the prevailing high scale of freight-rates and partly from an unfavorable smelter contract. Obviously the question of marketing the product was of prime importance in determining the most suitable method of treating the lower-grade ore of the mine. It will be informing, therefore, to give some details regarding freight-rates and smelter-charges before starting the discussion of the metallurgic problems. The following schedule applies to shipments from the siding near the mine on the branch line of the Santa Fe railroad from Barstow to Johannesburg. The rate is based on the net smelter return.

Net return per ton	Freight-rate per ton
Under $30	$6.29
30 to 40	7.50
40 " 80	9.10
80 " 150	11.35
150 " 200	13.00
200 " 300	15.40
Over 1000	32.60

In addition there is a war-tax of 3% on the freight.



No. 2 SHAFT AND THE TRESTLE LEADING TO THE MILL

The freight to either of the plants in Salt Lake valley or to one of the smelters in Arizona would be higher than to Selby. However, if one of these smelters should offer sufficiently attractive charges, the difference in freight might be overcome. It seems probable that the California Rand company could at least induce the Selby smelter to make more liberal terms by negotiating with some other company to treat its ores. In any competition the Selby people, of course, would have the advantage because of the lower freight. Here follows a typical calculation of the settlement made by the smelter under the terms of the present contract.

Analysis of the Ore

Gold, oz	0.29	Sulphur, %	4.9
Silver, oz	88.8	Arsenic, %	1.14
Silica, %	80.1	Antimony, %	0.48
Iron, %	4.8		

Credit

	Per ton
Gold, 95% of assay at $20 per oz.	$ 5.51
Silver, 95% of assay at 99⅝c. per oz.	88.05
	$93.56

Debit

Arsenic and antimony, penalty on combined content of $2 per unit	$ 1.24	
Treatment, at $9 for $50 ore with 10% of the value in excess of $50, and up to $100	12.96	
		14.20
Net value of ore delivered at smelter		$79.36

One consignment (No. 302) contained 61,968 lb., net dry weight, of exceptionally high-grade ore. It assayed 1.4 oz. gold, 1336.1 oz. silver, 5.1% arsenic, and 5.8% antimony. The following summarizes the deductions and charges per ton of ore:

Penalty on arsenic and antimony	$19.80
Treatment	14.00
5% of silver	66.56
5% of gold	2.36
Freight	32.60
Tax	1.00
Total	$136.32

It has been proved to be not only possible, but practicable, to make a flotation product containing approximately 1300 oz. of silver per ton; one of the metallurgic problems will be to determine the final economic advantage or disadvantage of doing so.

One other factor in developing the best plan of metallurgical treatment is the lack of an ample supply of water near the mine. The nearest adequate supply is at Hinkley, 47 miles distant and at a much lower elevation. Pumping is out of the question even though a pipe-line of that length were feasible. The California Rand company owns some property about 5 miles east of the mine on which a water-shaft is now being sunk. At 130 ft. this shaft developed only 1500 gal. per day; however, it is expected to cut a known water-course at a depth of approximately 300 ft. Hope is entertained that a flow of some importance will result, but the actual supply, of course, is doubtful. The Randsburg Water Co. has some wells in the same vicinity, from which it supplies the town, but it has no appreciable excess to sell to the mining company. The only sure source is the railroad company's wells near Barstow. The Santa Fe company will supply the water without charge in order to get the resulting traffic, for the water must be hauled to the mine in tank-cars. The rate is $28 per car of 10,000 gal., and as the estimated requirements to mill 100 tons per day is 50,000 to 60,000 gal. the railroad will have a profitable business; and the California Rand company, on the other hand, will be obliged to make every effort to conserve water and to recover as much as is reasonably possible from the mill-tailing.

A third consideration, of an economic rather than of a distinctly metallurgic character, but one that has a bearing on the determination of the mill flow-sheet, is the royalty on the use of flotation. On account of the com-

PRODUCTION RECORD, CALIFORNIA RAND SILVER MINE

	Month	Production, tons	Gross-value	Freight-charge	Tax	Treatment-charge	Net return Gold	Net return Silver
1919	June	55.90	$2,465	$352	$11	$440	$350	$1,312
	July	301.22	21,561	2,280	68	3,038	1,384	14,793
	August	707.55	148,753	7,884	237	9,303	4,036	127,293
	September	384.48	28,984	3,097	93	3,918	1,362	20,514
	October	648.36	30,518	4,056	122	5,906	2,340	18,095
	November	216.81	36,885	2,216	66	2,803	1,782	30,018
	December	656.57	84,536	6,356	191	8,114	3,194	66,681
1920	January	187.19	24,262	1,915	57	2,487	702	19,204
	February	345.02	47,419	3,566	107	4,421	1,840	37,486
	March	343.18	92,183	4,299	129	4,631	2,515	80,609
	April	173.96	22,234	1,739	52	2,264	634	17,545
	May	649.88	70,615	5,691	171	7,336	2,423	54,993
	June	636.72	38,981	4,581	137	5,199	2,103	26,961
	July	323.96	22,268	2,853	86	2,978	1,422	14,928
	August	1,227.16	100,127	10,927	328	12,347	4,858	71,667
	September	1,132.54	101,844	10,895	327	12,018	5,546	73,059
	October	622.80	54,170	6,847	205	6,637	2,285	38,195
	November	2,034.61	156,638	20,736	622	20,018	8,897	106,363
	December	2,806.63	299,481	32,421	969	31,705	14,137	220,249
1921	January	982.93	82,601	10,680	319	10,137	6,074	55,388
	February	806.56	96,691	9,883	296	9,723	4,580	72,208
	March	1,321.45	136,531	15,227	456	15,596	7,132	98,120
	April	1,045.50	89,283	11,305	336	10,975	7,818	58,819
	May	1,740.24	108,795	14,236	427	16,658	5,420	72,054
	June	1,587.02	119,585	13,806	414	18,284	7,702	79,378
	July	1,794.32	190,428	17,887	537	25,477	8,175	138,351
	August	1,556.11	175,813	16,098	482	22,279	6,148	130,804
	September	1,717.30	151,531	16,004	480	20,920	4,525	109,601
	October	1,839.24	130,937	15,868	476	20,502	1,942	92,147
	November	2,284.44	212,827	21,892	656	29,984	5,735	154,559
	Total	30,129.65	$2,878,946	$295,597	$8,857	$346,098	$127,061	$2,101,394

parative smallness of their mine, the officials came to the conclusion that they could better afford to pay the royalties demanded by the Minerals Separation company than to fight it; accordingly they signed a license contract that provided two alternative methods of determining the royalty. These were: (1) a flat rate of 2½% on the value of the ore treated, or (2) 5c. per ounce of silver, and 50c. per ounce of gold recovered from any portion of the ore that might be treated by flotation. This high royalty made it imperative to investigate alternative methods of treatment with a view to reducing to the minimum the amount of precious metal to be recovered by flotation.

The following metallurgical engineering firms made tests on the ore: Hamilton, Beauchamp, Woodworth, Inc., of San Francisco; General Engineering Co., of Salt Lake City; Colorado Iron Works, of Denver; the Southwestern Engineering Co., of Los Angeles; and Minerals

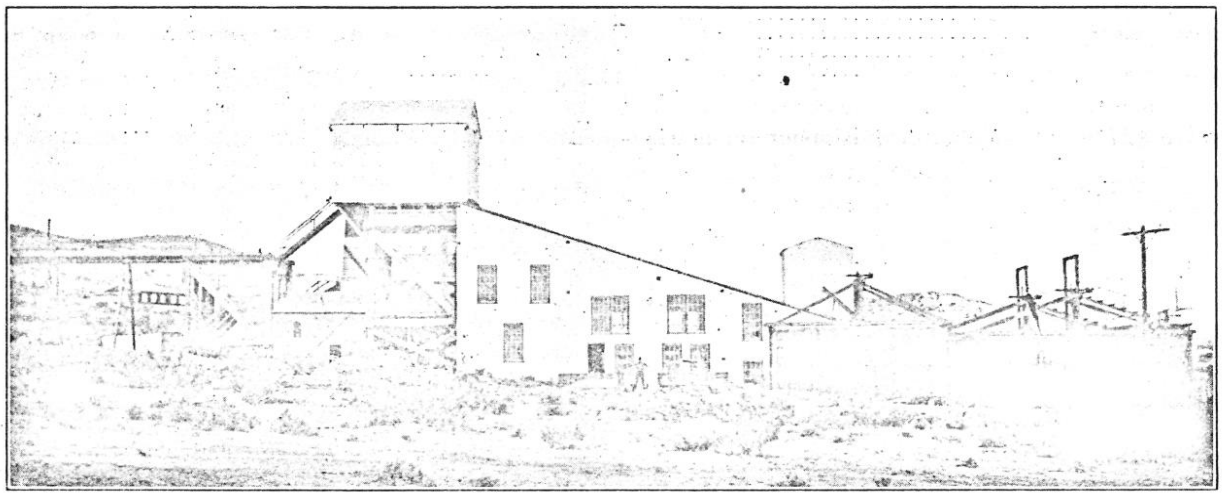
2. Selective flotation, in which the endeavor was made to obtain a small quantity of very high-grade silver concentrate. The principal object was to lessen expenditure for freight.

3. Table-concentration of ore crushed to 30-mesh, followed by re-grinding of the table-tailing and subsequent flotation. The principal object was to lessen the royalty on flotation.

4. Selective flotation, as in (2), followed by concentration on tables to recover most of the pyrite with its associated gold, which would be dropped in the selective flotation.

5. Selective flotation, as in (2), followed by cyanidation of flotation-tailing to extract most of the remaining gold and silver.

6. 'Bulk' flotation, followed by cyanidation of the middling and tailing combined.



A VIEW OF THE MILL LOOKING NORTH

Separation company. The results of all their tests indicated that at least 96% of silver and 80% of the gold unquestionably could be recovered from the sulphide ore with a product of good grade and a satisfactory ratio of concentration. There is to be treated approximately 10,000 tons of oxidized ore, which, of course, does not respond as satisfactorily to concentration by flotation. The main problem, however, is the treatment of the sulphide ore from the levels below 150 ft.; in this the important ore-forming minerals are argentite (Ag_2S), pyrargyrite (Ag_3S_3Sb), proustite (Ag_3S_3As), and stephanite (Ag_5S_4Sb); besides these silver minerals there is the pyrite, with which most of the gold appears to be associated.

The most comprehensive tests were made by the firm of Hamilton, Beauchamp, Woodworth, Inc. I shall discuss sundry interesting features of their excellent report. Eight distinct processes or combinations of processes were tried. They were as follows:

1. Straight flotation (Mr. Beauchamp calls it 'bulk' flotation) of the entire feed with a view to obtaining a satisfactory extraction of both gold and silver with a low tailing.

7. Cyanidation of the raw ore.

8. Concentration on tables followed by cyanidation of the tailing.

The tests demonstrated that only the first three schemes need to be considered from the standpoint of 'economic' realization, although some interesting results were obtained in the other tests. I shall refer to them by number.

1. Straight flotation of sulphide ore only.

Conditions of Test

Ore	80 mesh
Machine	Mechanical agitation
Circuit	Alkaline
Pulp dilution	4:1
Time of agitation	4 min. for concentrate; 11 min. for middling

Reagents	Pounds per ton of ore
Water-gas tar	1.0
Stove-oil	0.7
Hardwood-creosote	0.2
No. 5 pine-oil	0.1
Sodium sulphide added in form of 10% solution	2.0

Results

		—Assay—		—Content—		—Distribution—	
Product	Weight, %	Gold,	Silver, oz.	Gold,	Silver, oz.	Gold, %	Silver, %
Heading	100.0	$3.10	28.25	....	.....	....	...
Concentrate	7.6	30.59	281.22	$2.325	21.371	67.78	82.2
Middling	8.4	9.09	45.16	0.763	3.793	22.26	14.6
Tailing	84.0	0.41	1.00	0.344	0.84	10.04	3.2

Analysis of Concentrate

	%		%
Arsenic	4.39	Iron	25.0
Antimony	2.03	Insoluble	23.6

'Eliminating' the middling, the following is the result:

Product	Weight, %	Combined value	Content	Distribution, %
Heading	100.0	$29.43	....	....
Concentrate	9.0	310.70	27.96	95.65
Tailing	91.0	1.41	1.27	4.35

Later I shall show the reasons that justify the conclusion that the return of the middling for re-treatment will not increase the precious-metal content of the tailing.

Carrying out the calculation similar to that made on a previous page for the smelter returns on shipments of ore, it is found that the concentrate made would yield from the smelter $253.99 per ton. If from this be deducted $7.77 (2½% of $310.72, or the assay-value of the ore, for payment of flotation royalty), the net economic realization per ton of concentrate is $246.22. Then

Assay-value of concentrate	$310.72
Economic realization	246.22
Loss per ton of concentrate	64.50
Percentage lost on content of concentrate	20.70

The concentrate from one ton of ore contains gold and silver worth $27.96, of which 20.7% is spent for marketing and for flotation royalty, leaving a net recovery of $22.18; or, based on the original ore, a net recovery of 75.8%. The flotation royalty would be 64c. per ton of ore milled.

2. Selective flotation of sulphide ore only.

Conditions of Test

Ore	80-mesh
Machine	Mechanical agitation
Circuit	Neutral
Pulp dilution	4:1
Time of agitation	5 min.

Reagents	Pound per ton of ore
P. E. collector-oil	1.0
Hardwood-creosote	0.3

Results

		—Assay—		—Content—		—Distribution—	
Product	Weight, %	Gold,	Silver, oz.	Gold,	Silver, oz.	Gold, %	Silver, %
Heading	100.0	$3.10	28.25	.....	....	...	...
Concentrate	2.20	50.64	1215.55	$1.114	26.74	31.7	92.6
Tailing	97.80	2.48	2.17	2.400	2.12	68.3	7.4

Analysis of Concentrate

	%		%
Arsenic	5.12	Antimony	7.74

Combining Gold and Silver

Product	Weight, %	Combined value	Content	Distribution, %
Heading	100.0	$34.42	....	...
Concentrate	2.2	1266.19	27.85	86.0
Tailing	97.8	4.65	4.52	14.0

The calculation of smelter returns on this concentrate shows that the net return after deducting freight, treatment, and penalties would be $1125.66 per ton. The flotation royalty would be 2.5% of $1261.64, or $31.54, leaving a net economic realization of $1094.12.

Then

Assay-value of concentrate	$1261.64
Economic realization	1094.12
Loss per ton of concentrate	167.52
Percentage lost on content of concentrate	13.28

The concentrate from one ton of ore contains gold and silver worth $27.85, of which 13.28% is spent in marketing and flotation royalty, leaving a net recovery of $24.15; or, based on the original ore, a net recovery of 74.5%. The flotation royalty would be 63c. per ton of ore milled.

3. Concentrating on tables followed by flotation of the tailing. The ore, crushed to pass 30-mesh, was concentrated on a quarter-size Deister-Overstrom concentrating table, making a finished product and a tailing. The tailing was re-ground and concentrated by flotation under the following conditions:

Ore	80-mesh
Machine	Mechanical agitation
Circuit	Alkaline
Pulp dilution	4:1
Time of agitation	15 min.

Reagents	Pounds per ton of ore
P. E. collector-oil	1.0
Hardwood-creosote	0.3
No. 5 pine-oil	0.1
Sodium sulphide	1.5

The proportions and analyses of the heading, the two concentrates, and the tailing produced follow:

Assay

Product	Weight, %	Gold,	Silver, oz.	Arsenic, %	Anti-mony, %	Iron, %	Insoluble, %
Heading	100.0	$4.77	26.88	...	...	...	...
Table-concentrate	8.0	40.00	202.50	2.67	1.83	28.85	25.0
Flotation concentrate	5.1	20.80	198.00	5.77	2.85	22.0	24.0
Tailing	86.9	0.62	0.70	...	...	...	...

Making the same calculations as before the following data are obtained.

Assay-value of table-concentrate	$241.73
Economic realization	192.58
Loss per ton of table-concentrate	49.15
Percentage lost on content of table concentrate	13.28

Obviously in the above no deduction need be made for flotation royalty.

From the net recovery per ton of flotation concentrate, $162.33, must be deducted the flotation royalty of 5c. per ounce of silver and 50c. per ounce of gold recovered by flotation. This amounts to $9.90 in this particular instance, leaving the economic realization $152.43.

Then

Assay-value of flotation concentrate	$218.16
Economic realization	152.43
Loss per ton of flotation concentrate	65.73
Percentage lost on content of flotation concentrate	30.1

Reduced to the basis of one ton of ore milled, the loss in marketing table-concentrate will be $3.92 and in marketing flotation concentrate $3.38, making a total of $7.30 per ton, which on the heading assay, of $31.65, leaves a total net recovery of 76.93%. The flotation royalty is approximately 50c. per ton of ore milled.

Summarizing the results of the three methods:

	Metallurgical extraction, %	Economic recovery, %	Difference, %
1. Straight flotation	96.65	75.8	20.85
2. Selective flotation	86.00	74.5	11.50
3. Tabling and flotation	96.60	76.9	19.70

Before discussing these figures I shall state briefly the reason or reasons why each of the five alternative schemes proved impracticable.

4. It was impossible to obtain a satisfactory tailing when concentrating the flotation tailing. The colloidal slime interfered with the efficient separation of the pyrite with which the gold is associated.

5. A combined extraction of 49.1% of the gold and 98.7% of the silver was obtained by cyaniding the tailing made by selective flotation as follows:

	Gold extraction, %	Silver extraction, %
By flotation (in concentrate)	31.7	92.6
By cyanidation	17.4	6.1
	49.1	98.7

Apparently the gold is not readily amenable to cyanide; moreover the cost would be too high to justify cyanidation.

6. The following figures show the results of a test in which bulk flotation was followed by cyanidation.

	Gold extraction, %	Silver extraction, %
By flotation	73.6	86.64
By cyanidation	11.7	13.20
	85.3	99.84

Apparently it would be more economical to carry the flotation further and thereby avoid cyaniding.

7. Cyanidation of the raw ore was not only expensive, but failed to extract the metals.

8. Concentration preceding cyanidation indicated that cyanidation need not be considered seriously.

It happens sometimes that the return of a middling to the head of a flotation circuit will produce a considerably richer tailing in actual operations than is indicated by tests on clean ore, although it has been demonstrated repeatedly that the extraction obtained by properly conducted laboratory work can be duplicated or improved upon in a well-designed mill. A satisfactory method of determining the effect of re-treating middlings is the 'cycle' test, which may be performed as follows: A sample of the ore is divided into five or more equal lots. The first lot is 'floated', under the conditions previously found to be most desirable, to make a concentrate, middling, and tailing; the middling is added to the second lot and the flotation operation is repeated, the resulting middling being in turn added to the third lot of fresh ore for floating. This process is repeated until all the lots have been used, each tailing being reserved for assay. The results of such a series of tests conducted by Hamilton, Beauchamp & Woodworth on California Rand sulphide ore are shown in the following table:

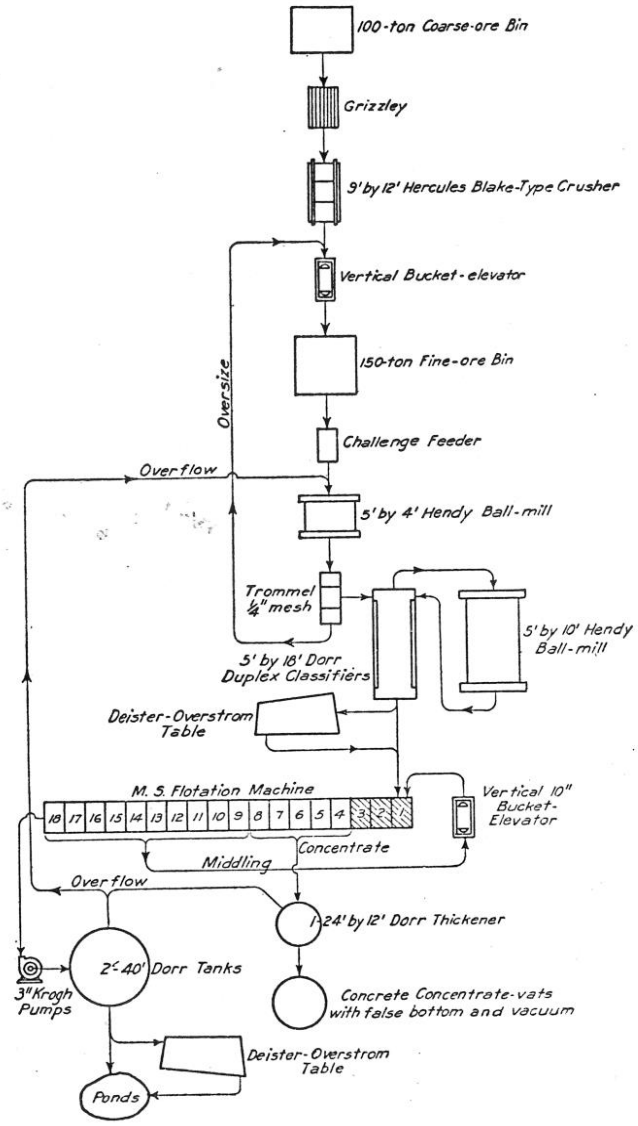
		Weight, %	Assay—Gold,	Assay—Silver, oz.	Content—Gold,	Content—Silver, oz.	Distribution—Gold, %	Distribution—Silver, %
Heading		100.00	$3.10	28.25	....	....	....	...
Concentrate		12.08	23.56	200.16	$2.846	24.180	84.80	88.8
Middling		3.60	8.27	66.50	0.298	2.390	8.88	8.8
Tailing No.	1.	13.04	0.41	0.80	0.053	0.104	1.04	0.4
" "	2.	18.00	0.20	0.80	0.036	0.144	1.07	0.4
" "	3.	18.32	0.20	0.80	0.037	0.147	1.09	0.4
" "	4.	18.48	0.20	0.80	0.037	0.148	1.10	0.4
" "	5.	16.48	0.41	0.80	0.067	0.132	2.01	0.7

The fact that the assays of tailings are virtually uniform indicates that the return of middlings for re-treatment will have no ill effect on the extraction, and warrants the 'elimination' of the middling and the averaging of the tailing assays as a basis for calculating the results.

A number of pertinent facts were revealed in the course of testing. It was found that the ore, which is easily crushed, produces a high proportion of 'colloidal' slime. If the ore is ground to pass a 100-mesh screen the following are the requirements for settling or thickening.

Final ratio Water : solid	Area per ton of ore per 24 hr., sq. ft.
3 : 1	6.8
2 : 1	11.7
1 : 1	20.0

A depth of 8 ft. in the settling-tank was adequate. It was found that the extraction of gold, associated with the pyrite, was greatly improved by using sodium sulphide or sodium carbonate in conjunction with oils such as those named in the tests already described. The 'dropping' of the pyrite by the non-use of these additional reagents was the basis for the proposed selective flotation. However, the use of either sodium sulphide or



FLOW-SHEET OF THE MILL

sodium carbonate had the effect of deflocculating the slime to such an extent that settling and the recovery of the water were almost impossible. Mr. Beauchamp, in an effort to prevent this, tried substitutes for the sodium salts, and demonstrated that calcium poly-sulphide, made by boiling lime with sulphur, would raise the pyrite successfully in the flotation cells without deflocculating the slime. All of Mr. Beauchamp's tests were made with mechanical flotation apparatus.

The General Engineering Co. made a series of tests on

a composite sample consisting of 80% sulphide and 20% oxidized ore and one test on sulphide ore. In this test the ore was ground wet in a ball-mill, with lime in the proportion of 2 lb. per ton of ore; 96% of the product passed a 65-mesh screen. The ground ore was floated in a Callow rougher-cell followed by a cleaner using 0.35 lb. of T. T. mixture (composed of ¼ thio-carbonilide and ¾ ortho-toluidine) and 0.1 lb. of aldol per ton of ore. The flotation tailing was concentrated on a Wilfley table. The summary of this test shows:

		Assay		Content		Recovery, or loss	
Product	Weight, %	Gold, oz.	Silver, oz.	Gold, oz.	Silver, oz.	Gold, %	Silver, %
Flotation concentrate	9.00	1.060	285.45	9.540	2569.05	65.70	93.40
Table-concentrate	2.10	0.890	28.80	1.869	60.48	12.87	2.23
Total concentrate	11.10	1.028	236.89	11.409	2629.53	78.57	95.63
Table-tailing	88.90	0.035	1.35	3.112	120.02	21.43	4.37
Heading	100.00	0.145	27.50	14.521	2749.55	100.00	100.00

This shows a ratio of concentration of 9.01:1 if the two concentrates be combined, with an extraction of 78.57% of the total gold content of the ore and 95.63% of the silver.

An analysis of the concentrate obtained from one of the tests on a composite sample indicates the approximate composition of the product that will probably be made in the new mill. This follows:

Constituents	%
Copper	0.11
Insoluble	30.6
Zinc	None
Sulphur	30.8
Arsenic	4.06
Iron	28.5
Antimony	1.62
Gold, oz.	1.280
Silver, oz.	255.30

The General Engineering Co. made an estimate of the cost of milling that is interesting. The figures are based on a 100-ton plant using Callow cells, assuming that water can be supplied to the plant by gravity, and that power can be obtained at 1c. per kilowatt-hour.

Power

Crusher, rolls, and elevator	30	hp. for	8	hr.	240	hp-hr.
Roller-mill, feeder, and classifier	125	" "	24	"	3000	"
Blower	20	" "	24	"	480	"
Table and pump	5	" "	24	"	120	"
Settling and filtering	15	" "	24	"	360	"
Total					4200	

Power, cost per ton		$0.294
Labor at a scale of $4.50 per day		0.57
Steel for rod-mill, 5 lb. per ton of ore at 6c		0.30
Miscellaneous repairs and incidentals		0.25
Flotation reagents:		
0.35 lb. T.T.	10.50c.	
0.10 lb. aldol	4.00	
2.0 lb. lime	2.00	
License for reagents	3.00	
	19.50c.	or 0.195
Total		$1.609

The most significant feature of these figures is the small cost of flotation reagents—only 19.5c. per ton of ore. The power required for flotation is, of course, small; the estimated cost is about 2.7c. per ton of ore.

The Minerals Separation company made a series of tests, the results of the final one being as follows:

	Weight, %	Gold, oz.	Silver, oz.	Iron, %	Recovery, or loss Gold, %	Silver, %
Heading	100.0	0.14	36.54	4.4	100.0	100.0
Concentrate	7.3	1.20	483.60	28.5	60.4	96.9
Tailing	92.7	0.06	1.25	2.3	39.6	3.1

Screen-Analysis of Feed

	%
On 80 mesh	2.0
" 100 "	3.0
" 150 "	3.0
" 200 "	18.0
Through 200 "	74.0

The above data are part of the information that was available to M. N. Colman when he was engaged last July to design and supervise the erection of the concentrating plant. Details of the plan of treatment are shown by the accompanying flow-sheet, in which it will be noted that straight or bulk flotation in a Minerals Separation machine has been selected. The reasons for this choice were outlined to me by Mr. Colman. The advantages of flotation had been proved conclusively. It had already been decided by the officials of the company that a license would be obtained from the Minerals Separation company; accordingly the possible advantage of the pneumatic cell in saving 60c. per ton in royalties was not a factor to be considered. Moreover, sundry tests seemed to indicate that the smaller operating cost that would be obtained by using pneumatic cells would be approximately offset by improved recovery of the gold and silver in a machine using mechanical agitation. The choice of the Minerals Separation machine in preference to some other device using mechanical agitation was based on the belief that it was more nearly fool-proof than others, and that there would be less likelihood of experiencing temporary difficulty when the plant started to work. One of the principal considerations was to build a plant and get it in regular and successful operation in the shortest possible time.

Reverting to the comparison between the results of the three schemes of concentration—(1) straight flotation, (2) selective flotation, and (3) tabling and flotation—it will be observed that there is little to choose between them so far as the economic recoveries are concerned. The differences are so small that they might be accounted for by allowable discrepancies in the experimental work.

The apparent advantages of the third method are due entirely to the lessened royalty arising from the fact that only a portion of the ore is given flotation treatment. Against this must be placed the more complicated flow-sheet, and additional equipment, which would include provision for further grinding, and additional classification, and dewatering of the table-tailing before flotation; as well as, of course, the concentrating tables themselves. Moreover, if the extraction by tabling for any reason dropped appreciably, the flotation royalty calculated on the per-ounce-of-metal basis would increase rapidly. Mr. Colman concluded that the margin on which he had to work was not sufficient to justify the more complicated flow-sheet.

Selective flotation offered numerous attractive features: simplicity of flow was combined with high economic recovery, and at the same time a tailing was made that contained 68% of the gold and 7% of the silver, or 14% of the total precious metal in the original ore, which might be impounded and profitably re-treated at a later date. The construction of the plant is such that selective

flotation of this character can be performed if it should appear advisable, but the intention is to use calcium poly-sulphide and obtain the maximum recovery as outlined under the discussion of straight flotation.

It will be noted that two ball-mills are provided and that stage-crushing will be practised. As a matter of fact this equipment is probably sufficient to grind 200 tons through 80-mesh. The apparent over-capacity will make it possible (*a*) to install tables for a preliminary table-treatment, if that should become advisable, without delay or inconvenience, or (*b*) to double the capacity of the plant by merely adding a second flotation unit and the necessary thickening-tanks.

Two Deister-Overstrom tables are to be used; one is a 'pilot' to reveal the character of the feed at any given time for the guidance of the operator of the flotation department. Part of the feed will be by-passed to the table, the concentrate and tailing being returned together. The second is styled a barometer because its function is to indicate the result of flotation. It is expected that almost no silver minerals will appear on this table.

The flotation machine is the new 18-cell M. S. type without separate compartments for frothing. It is proposed to use the first three compartments for agitation exclusively, and to start skimming froth at the fourth. Five compartments will make a finished concentrate, whereas the product from the final ten will be returned to the head of the cell.

Both the General Engineering Co. and Hamilton, Beauchamp, Woodworth, Inc., recommended a revolving vacuum-filter, but the present plan is to dewater the concentrate in a Dorr thickener and to collect and dry it in a concrete tank having a false bottom and being connected with a vacuum-pump. For 10 tons of concentrate per day this arrangement should work satisfactorily.

As I showed at the beginning of this article, the marketing of a 250-oz. concentrate is an expensive procedure, so that the concentration of 25-oz. ore in the ratio of 10:1 is not an adequate solving of the economic problem. The only satisfactory shipping product appears to be bullion; and the reduction of the concentrate to bullion at the mine probably will be accomplished eventually. Among the methods suggested are (*a*) smelting in an electric furnace, (*b*) smelting in an oil-fired reverberatory, and (*c*) chloride volatilization. It will cost approximately $55 per ton to market 250-oz. concentrate with a moisture content of not less than 10%, and the probability of saving from $25 to $40 per ton by local treatment is sufficient to make thorough experimental work highly attractive. Incidentally, this problem is a factor that may strongly favor the selective scheme of flotation; it may be that a small quantity of very rich concentrate can be smelted far more cheaply than three times as much that assays only 250 oz. Mr. Colman is investigating the question thoroughly and a successful treatment is likely to be developed, with a consequent saving of several dollars per ton of ore.

The photographs for the accompanying illustrations were taken at a later date than the photographs that were reproduced in the first article on the California Rand mine, which consequently do not show the mill. On page 13 is shown No. 2 shaft, the mine-dumps, and the mill-site soon after the contractors, Cahill & Vensano of San Francisco, commenced construction work in September. The second photograph was taken in December, after the plant had been finished. Early in the month the machinery was 'turned over' for the first time, the smoothness of mechanical operation speaking well for the work of the construction engineers. Treatment was commenced on December 15 on $10 ore. A recovery of more than 90% of the silver was made and this will doubtless be improved as soon as operation is properly systematized. The heading will be increased to approximately $30, the grade of ore used in making the tests; this change will have a favorable influence on the recovery, and it is confidently expected that the results indicated by the test-work will be fully realized.

EXPERIMENTS by repeated impact tests show that too much emphasis is often laid on the advantage of high resistance to a single impact. L. Guillet, who writes in 'Rev. Met.', states that failures are most often caused by the development of cracks from repeated stresses; the Stanton repeated-impact test was selected for comparison, and tensile and Brinell hardness tests were also made. In some instances the number of blows needed to cause rupture was found to rise with increasing values of the elastic limit, notwithstanding that the resilience had meanwhile dropped appreciably, in some cases as much as 50%. The extent of the increased resistance to repeated impacts in these cases, however, varied considerably with the height of fall of the tup, and the frequency of the blows, it being most marked when the fall was small (about 1.3 in.) and the frequency low (60 blows per minute). The author concludes that it is far better to have a steel with moderate resilience and a high elastic limit, rather than high resilience and low elastic limit.

THE results of gas-producer tests with Alberta coals, according to a Canadian Department of Mines bulletin, show that it is possible to operate the producer for considerable periods with all the fuels tested, except one; but less than one-half can be recommended for continuous operation in this producer. In order that a fuel may be suitable for use under commercial conditions it must be of a character which will permit it to pass regularly through the producer without necessitating excessive poking; it must not pack, cake, or clinker in such a way as to form channels which will prevent the even access of air to all parts of the fuel (this requirement outweighs all others); the coal must be capable of yielding a good quality of gas continuously, which, if required for use in an internal-combustion engine, must be fairly free from tar and lampblack. This condition is of great importance, unless the plant installed for generating a power-gas for burning in internal-combustion engines is large enough to warrant the installation of special scrubbers and tar extractors.