BOLIVIA, HER PEOPLE AND HER TIN

By PAUL SCHÖNIG

Before the outbreak of the Greater East Asia War, southeastern Asia (Malaya and the East Indies), with its 113,000 tons annually, contributed more than half of the world's entire tin production. The taking over of this area by Japan has resulted in the serious problem of how the Anglo-Americans are to manage without this tin. The usual answer to this question is: They will get it from Bolivia.

So much depends on this issue that we have asked a specialist to analyze it for us. The author is an engineer who worked for many years in Bolivia and who is at present in Japan. He is probably unsurpassed by anyone in East Asia in his knowledge of the subject. In view of the fact that the question of Bolivian tin involves not only engineering but also, to an unusual extent, transportation and labor problems, the following article also deals with the country and the people in general.—K.M.

HERE in jagged outline, there in more gentle curves, the Andes stretch away through the western part of Bolivia. The mountains are torn apart by wild, bizarre fissures, and everywhere there are mighty, snow-crowned peaks rising into the clouds. The valleys look as if their sides had been forced together by a huge, savage hand, and often they narrow down to canyons three thousand and more feet deep. The narrow motor roads seem to hang over the chasms, and it often happens that motorists are overcome by giddiness and violent nausea. The drivers must concentrate intensely. It is by no means a rare occurrence for motorcars and trucks to plunge over the edge.

In spite of all their dangers, the mountains of Bolivia have a strange attraction for the traveler. The dry air sharply outlines every ridge, every peak and formation and, through its plastic effect, makes them appear startlingly near. Mountains, valleys, and lakes are usually named according to their appearance: for instance, Mt. Illampu ("the tender"); the range of Quimsa Cruz ("the three crosses"); Amaya Pampa ("the valley of the dead"); Laram Ccotta ("blue lake"), etc. Most of the names are taken from the Aymará and Quechua languages. These are the old Indian languages of Bolivia, Quechua being the language of the Incas and Aymará dating back to pre-Inca times.

When one rides along the narrow, precipitous mountain paths on a mule, one involuntarily clings close to the steeply rising mountain wall. At one time I had to build a hydroelectric plant in the Quimsa Cruz region. The motor track ended on a rock buttress, and the power plant was to be erected more than three thousand feet below in a narrow valley. The rocky side of the mountain dropped sheer into the valley at an angle of 78 degrees. It was the first time in my life that I had ridden on so dangerous a path, and, although the mule was used to such inclines and very carefully set one foot in front of the other, I could not rid myself of the constantly recurring thought that one slip on the part of the animal would be enough to end both our lives.

HIGH COUNTRY

Although Bolivia is almost four times the size of Germany, her population is estimated at a mere three millions. Nine tenths of this population live in the highlands of the Andes, so that the remaining two thirds of the country, the vast tropical plains of eastern Bolivia, can hardly be called inhabited. The western, populated part of Bolivia consists of the western Andes (which form the border toward Chile and Peru), the eastern Andes, and the high plateau between those two main ranges. This plateau, called the *Altiplano*, starts from Lake Titicaca in the north and ends on the Argentine border in the south. Lake Titicaca, the highest navigable lake in the world, is 12,644 feet above sea level. The *Altiplano* has no outlet to the sea, and the waters of Lake Titicaca flow through Lake Poopo to the salt lakes of Uyuni, which are more than 12,200 feet above sea level.

Only a few hours away from the high plateau, on the other side of the eastern Andes, there are the most marvellous tropical and subtropical valleys. What a contrast: on the one side the highlands with their poor barley, potato, and millet fields, and on the other side the valleys with their luxuriant vegetation containing oranges, lemons, bananas, coffee, vines, figs, and peaches! There are *fincas* (ranches) on which the products of three climates are grown: barley, wheat, oranges, sugar cane, etc.

The *Altiplano* is not level but rolling country. In places, low ranges stretch across it, and here and there hilly domes rise out of the plateau. Part of it consists of wide, clayey plains covered with glistening sand; other parts show sandy pampa formations covered with sparse grass and cut by little streams; in places there are the shining mirrors of small lagoons, which partially dry up during the dry winter months. The climate is severe, and a strong wind blows almost continuously. If one is traveling by car and a shower of rain overtakes one, the smooth, clayey surfaces turn immediately into a soapy, slippery mass. The wheels lose all their friction, and it becomes impossible to steer the car. Very often the only thing to do in such cases is to stop and wait till the pampa has dried up again.

There are also other difficulties for the motorist in the pampa. When one is overtaken by darkness, for instance, one very easily loses one's direction. The pampa is crossed and recrossed by thousands of motor tracks, and there are no actual highways. And then there are the mirages one meets with on such level stretches of the pampa. One seems to be driving toward a vast blue lake which constantly moves back or, at times, disappears entirely. It is a strange experience to see a car or a truck move through this lake, drawing a huge cloud of dust behind it, or to see a herd of unnaturally enlarged llama grazing in the lake. Sunset on the pampa is a thing of incredible beauty. The colors change from deepest red to the most exquisite blue-mauve and finally to an almost black blue-gray. And when the pampa is already entirely covered by darkness, one can still see the snowy summits of the Andes shining dimly.

THE ALTITUDE

A newcomer finds it very hard at first to stand the climate at these altitudes. In addition to the usual mountain sickness, he is liable to heart and breathing trouble during the first few weeks. He also feels disagreeably chilly, so much so that he cannot get warm even in a well-heated bed. It usually takes about two years for him to become entirely acclimatized. The climate actually forces one to lead a very sober life, for, in order to feel fresh during the day, one needs ten hours of sleep. On the other hand, it is an interesting fact that, through the strong increase of red corpuscles in one's blood, one can take large quantities of alcohol without getting drunk.

The strong radiation of ultraviolet rays at those high altitudes has a noticeable influence on the nervous system, and everyone becomes more or less nervy and irritable. Through the intensive sunlight and the flying dust of the pampa, the eyes are constantly irritated and there are many cases of conjunctivitis. The skin does not turn brown in the sun, but red. Furthermore, the low humidity of the air causes great changes in the skin. It becomes very brittle, almost like leather, and the lips are very liable to crack. Many people, therefore, suffer from deep chaps which are hard to heal. The dryness of the air also makes itself unpleasantly felt in the nose and throat. Strangely enough, however, the Indians are practically not affected by all these complaints.

All movements of the body are also adjusted to the altitude, that is to say, they automatically become slower. Great exertion is only possible for a few moments, for one is immediately overcome by difficulty in breathing and chills. I remember one occasion, on one of my many motor trips shortly after the rainy season, when the back wheel of my car slipped down into a ditch, so that the rear axle was resting on the ground. I was alone, and there were neither houses nor Indians far and wide, so that I had to jack up the car myself. To do this job, which could easily have been completed in half an hour at sea level, I took about three hours, and I was so exhausted that I had to rest half an hour before driving on.

PEAKED CAP AND PONCHO

As can be expected in these latitudes, the sun shines mercilessly during the daytime. But at night it becomes disagreeably cold in the pampa, and in the winter months the temperature drops to 15 degrees centigrade below freezing point. Shortly before sunset, an icy wind blows down from the frozen heights of the Andes. Then again steel parts at a height of 17,000 feet may assume a temperature of more than 150 degrees Fahrenheit (60 degrees centigrade) during the day.

To protect them against the icy wind the highland Indians wear a kind of peaked cap made of coarse, homespun wool in gay colors and with long earflaps. On top of this, they wear a thick felt hat as protection against the sun. This combination naturally looks rather curious. The Indian takes great pride in his hat, just as he shows a rather childlike attitude in many things. If one wants to secure the help of an Indian to replace a flat tyre, for instance, the only way to do this is to snatch away his hat and tell him that he will only get it back again after he has given his help.

The Indians wear white woollen trousers and a coarse shirt made of the same homespun llama wool, as well as a brightly colored, six-foot-long cummerbund, called "*faja*." To protect themselves against cold and rain they wear a sort of cape, the poncho. This poncho consists of a large square piece of cloth made of thick llama wool and usually woven in gay stripes. In the center of the cloth there is a slit, just large enough for the head to go through. Worn in this way, the poncho looks like a three-quarter-length cape. Sometimes, however, one can see the poncho worn like a huge scarf wrapped around the neck of an Indian. At night it is used as a blanket.

ARTISTS IN COLOR

According to their wealth, the women wear two, three, or more colored woollen skirts, one on top of the other, a white woollen blouse, and a homemade, natural-colored hat with a narrow, turned-up brim. As an added protection against wind and rain they wear a gay cloth, which is also used for carrying, especially for carrying babies.

The colors of all these garments vary between brilliant red, green, mauve, and yellow. On holidays, when the Indians gather to dance, and with the monotonous, gray mountains as a background, this provides a gay and beautiful spectacle. They show an incredible endurance in dancing, going on day and night without interruption to a monotonous melody consisting of only five notes. In the highlands, the Indians even wear their fantastic old feather headdresses at such festivals, and sometimes one can see hideous Inca masks.

All the garments are dyed by the Indians themselves, although they now use modern aniline dyes which they buy by the gram at the regular Sunday markets. A purchase of this kind often takes hours, and the customers sit on the ground in front of the seller with an extraordinary endurance, hard to understand for the foreigner, while trying to make up their minds. They are wonderfully gifted in the art of dyeing. The cloth is woven on the most primitive of looms, consisting really only of a frame and a few pieces of wood. The spinning is done by the women while walking or while looking after the llama herds. The fabrics show unusual beauty in their designs and resemble the old fabrics of the Incas, which can still be seen in museums.

Those Indians who do not work in the mines live on agriculture and husbandry and usually dwell together in clans. There are communities with a purely communal management which in most cases are quite wealthy. The Indians live in windowless mud huts roofed with turf or pampa grass. The furnishings consist of a few skins, which serve as sleeping and sitting accommodation, and of an open fire-container something like the Japanese *hibachi*.

The Indian lives mainly on rice, maize, or millet soup, which he cooks together with dried llama meat and vegetables. He also eats potatoes, which after the harvest he leaves out to freeze in the cold winter nights, thawing them again in the hot sun of the daytime, till they are quite dried out and most of the starch has turned to sugar. To the foreign palate, these potatoes, called "*chunios*," taste revoltingly sweet. The most popular drink is *chicha*. It is made from chewed maize, which ferments through the admixture of saliva and is brewed into a strong alcoholic drink by repeated boiling.

Since life is very hard in the highlands and there is no vegetation, nothing for the eye to delight in except the gigantic panorama of the mountains, the people living there are all joyless and more or less sullen. On the other hand, the inhabitants of the valleys and the lowlands are gay, easygoing, and carefree, as well they may be, since Nature makes them a gift of almost all the necessities of life.

MINING IN THE CLOUDS

After Malaya, Bolivia is the largest tin-producing country in the world. She also produces lead, zinc, copper, antimony, tungsten, bismuth, mercury, selenium, cobalt, molybdenum, manganese, gold, and silver. As can be seen in our map, the tin deposits are to be found in a strip running the entire length of western Bolivia. The mines are situated on the high slopes of the eastern Andes, most of them at an altitude of 15,000 to 17,000 feet. However, there are a number of important mines whose shafts lie higher than 17,000 feet. Transportation forms one of the major problems for the mines. The laying out and the construction costs of roads are a heavy burden. Where it is possible to build roads, the gradient must not be steep in view of the great loss in power suffered by engines as a result of the altitude.

During the rainy season from December to April, the roads are washed out, and quite often whole parts of the roads are carried away or buried by landslides. The tires of the trucks slip in the mud and dig deep ruts and holes, so that, by the time the dry season starts, the roads have become almost useless.

Many mines are so situated that it is quite impossible to construct a motor road, or only at a cost far beyond the means of the mine. In such cases, all transport must be made by mule or llama. Of course, such transport is very slow and limited in quantity and weight in comparison to motor transport. A mule or a llama cannot carry more than fifty pounds on each side. As a result, those mines which are only accessible by mule path can rarely be equipped properly, since it is hardly possible to transport any large or heavy machinery parts to them. I remember an occasion when several 1,200-foot lengths of wire cable, each weighing almost two tons, were needed for the construction of a cable conveyer and had to be carried to the mine by chains of a hundred and fifty mules. Although each animal carried a comparatively small load, a whole chain of mules plunged over the side during the first attempt.

Only very few mines are lucky enough to be adjoining a State highway. With road conditions as they are in Bolivia, the life of an American truck of the best make is reckoned at not more than 20,000 to 25,000 miles. A set of tires lasts about 10,000 miles. So these two factors, road construction and means of transport, represent a considerable adverse influence on the production cost per ton of ore in comparison with other tin-producing countries, as, for instance, Malaya. To this must be added the long and expensive railway transport from Bolivia down to the Pacific coast as far as the ports of Antofagasta and Arica in Chile.

ALL ABOUT TIN

The tin deposits of Bolivia are known as the largest and richest tin-lode districts in the world. As in Malaya, the main tin mineral is stannic oxide ($Sn\ O_2$), which makes up ninety per cent of the entire tin production. However, it is found very rarely in its pure state in Bolivia. The tin ores are usually of a complex nature, that is, they are closely intermingled with other minerals and often sprayed infinitely finely into the stone. Consequently, the dressing and concentration of the ores for the smelting stage very often cause great difficulty. Especially the removal of the pyrites ($Fe\ S_2$), which are often present, calls for rather complicated and expensive plants.

It can be said in general about the Bolivian ores that, in comparison with the Malayan ores, their mining and production costs per ton of ore concentrate are considerably higher, in fact, with regard to all other tin-producing countries, the highest. The average production cost for one ton of refined tin in Bolivia has been calculated at US$500 to US$600, while it is estimated at a little more than half that amount for the Malayan mines.

The tin contents of the excavated material in Bolivia, which at the turn of the century still averaged 12 to 15 per cent, have constantly decreased through the rich minerals having been exhausted and through poorer deposits having been worked. Today the content varies between 1 and 5 per cent, averaging approximately 2.4 per cent. The total Bolivian reserves of visible and probably existing tin ores have not yet been officially estimated. According to a rough estimate made by Professor F. Ahlfelds, the present Government geologist of Bolivia, 430,000 tons of refined tin may be counted upon in the tin ores. Ores with less than 1 per cent tin have not been included in this estimate.

THE QUESTION OF POWER

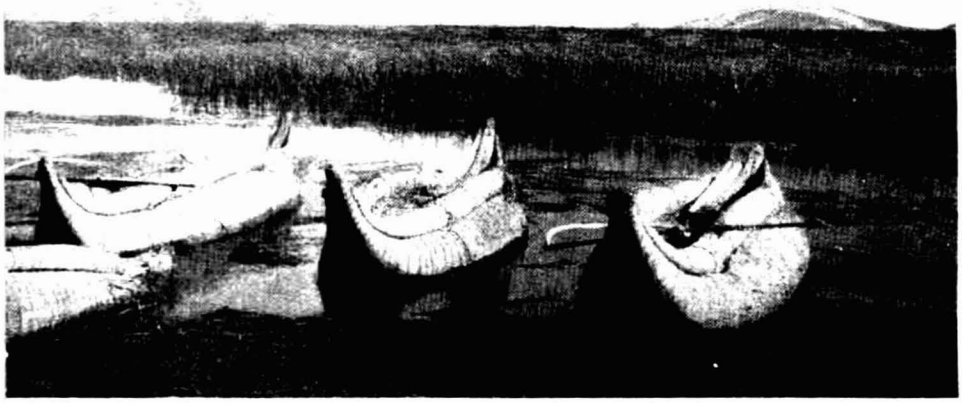
The supply of power to the Bolivian mines for running the large mining and dressing plants will always remain a great problem. So far only a few large mines could afford the capital required, for instance, to build expensive hydroelectric

The San Antonio mine in the Huayna Potosi massif of the eastern Andes. This camp is 15,700 feet above sea level

BOLIVIAN TIN MINES

Machinery being transported down a rock wall almost 3,000 feet high and with a slope of 78 degrees. The machinery is to be used for the construction of a hydroelectric plant

An Indian woman culling ore at the San Antonio mine



Lake Titicaca, 12,644 feet above sea level, on the border between Peru and Bolivia. It is the highest navigable lake in the world. In the foreground are some *balsas*, Indian craft made of dried reeds. These are woven so closely that no additional waterproofing is necessary. Reeds are used because there is no wood available in the highlands of Bolivia

SCENES FROM BOLIVIA

Dance in an Indian village The music is provided by reed pipes and drums. The man in the photograph on the right is specially costumed, while the men and women in the lower photograph are wearing their ordinary clothes, with the typical gray felt hats, worn on top of woollen caps, and gaily striped ponchos. The mud huts are roofed with grass or slabs of turf, as there is no straw in those regions

plants. The prevalent source of power for the mines is the Diesel engine. However, from an engineering point of view, these Diesel plants are very uneconomical at the altitudes at which they are used. The lack of oxygen at elevations above 13,000 feet reduces the output of a motor by more than 40 per cent, in addition to an increased fuel consumption. It is an interesting fact that the Diesel engines in the Bolivian mines are supplied almost exclusively from Europe, especially Germany and Switzerland Until a few months ago the North Americans refused entirely to supply Diesel engines for such altitudes, openly admitting that their engines work unsatisfactorily at those levels, if they work at all.

In this connection I must mention the long-standing project of erecting a tin-smelting plant in Bolivia in order to reduce the high freight costs. The realization of this project has, aside from political reasons, always foundered on the problem of power supply. The smelting of tin, from a technical point of view, is an art which requires years of experience in order to carry it out economically. For that reason, tin-smelting plants are to be found in only a few countries, such as England, Holland, Germany, Malaya, Japan, and China. The United States erected a smelting plant during the Great War which was closed again and dismantled immediately after the war because it was so uneconomical. In the present war the USA has again begun to erect a tin-smelting plant. According to reports in the American press and technical periodicals, this time the plant is to be built with all the experience of the British, and a complete staff of engineers and experts has been enlisted in England for that purpose. The plant was to be in operation early in 1942.

POSSIBLE INCREASE

The Bolivian tin production has constantly been increased during the last three years, and in 1941 it reached a record high of slightly more than 4,000 tons per month, that is, an annual production of approximately 50,000 tons. This increase can be traced chiefly to the fact that England, the tin pool of the world, stabilized the price of tin immediately after the outbreak of war and increased it by about 35 per cent. In addition to this, the Bolivian Government, after signing a tin-supply agreement with the United States early in 1941, saw itself forced to grant additional financial aid to the mines and to assist especially the small mines through extensive credits, so that many small and long-abandoned mines were worked again.

A further increase of production by as much as 20 per cent is perhaps possible if the mechanization of the mining process is systematically extended and the dressing plants are enlarged accordingly. This increase could be produced especially if the necessary machinery is obtained for dressing the vast stocks of poor ores (less than 1 per cent tin content) which up to now have been thrown on the pit heaps; for experience has shown that the quantities hauled almost always lag behind those that can be dressed. However, any addition to the machinery means an increased demand for power, and that brings us back again to the problem of power supply, which must be solved before any other.

WHENCE THE TOOLS?

I am convinced, however, that this possible increase of 20 per cent will founder on the nondelivery of the necessary machinery, since, owing to the readjustment to war supplies, the USA industry is simply not in a position to supply. In addition to this, the terms of delivery for purely commercial goods have become so absurdly long that it is questionable, quite apart from increasing the production of tin, whether it will be possible to maintain the present level of production. A mine constantly requires large quantities of tools, drill steel, building material, and especially spare parts for its machinery. In view of the poor adaptability of North American industry, the supply of spare parts for at least half the machinery used in the mines, which is of European origin, seems very doubtful.

No other industry must reckon with as large a wear and tear of machinery and tools as the mines. The general scarcity of tools was already felt in the middle of 1941. Furthermore, there were almost no shipments at all of dynamite, an indispensable explosive for the mines of Bolivia. The powder factories of Brazil and Chile are not nearly able to cover Bolivia's demand for explosives. Moreover, the quality of these South American explosives is inferior to those made by the Nobel concern, as they show great variation in their explosive power and in their speed of detonation and thus cause some uncertainty in the blasting process.

WHENCE THE LABOR?

It is quite impossible to compensate for all these shortages and difficulties by employing more men to work in the mines. Only a Bolivian highland Indian can work at such altitudes, and the number of these Indians is constantly on the decrease. And all attempts to settle lowland Indians in the mines have failed because of the incredibly hard working and living conditions there. They live in mud huts with corrugated-iron roofs, containing a sort of kitchen nook with a small stove with a tin chimney. With the exception of the holidays, the life of a miner is uniformly dull and without any variation whatever. Since he has to work twelve hours a day, there is no time left for anything but sleeping. The mining buildings lean close to the mountain side, and the shaft entrances are at the summit. The dressing plant starts just beneath the lowest shaft. All the other buildings, the machine house, the office, and even the living quarters of the managing personnel, are completely devoid of decoration, so that the whole camp is as dreary-looking as can be. It is no wonder that all attempts to settle lowland Indians at the mines by forced recruiting have failed, as these men very soon desert and run away into the jungles of the near-by tropical valleys. For the same reason, the efforts of several of the large mines to bring Chilean and Peruvian workers to their camps have also failed.

In addition to this, tungsten is again very much in demand since the outbreak of war, so that countless little mines have sprung up in Bolivia which are worked mostly by hand. Since these small enterprises have a very slight overhead and can at present obtain high prices for their tungsten, they are in a position to pay far higher wages than the large tin mines.

COCA AND BOOZE

Furthermore, in view of the mentality and the living conditions of the Indians, it is impossible to achieve an increased production on the part of the individual worker. As almost everywhere else, the mines in Bolivia work day and night, but with only two shifts, so that the Indians are underground for twelve hours. During this time they eat almost nothing and keep going by chewing coca, the dried leaves of the coca shrub, which was planted in Bolivia as early as in the days of the Incas. The leaves contain cocaine, which quickly renders the nerves of taste and of the stomach insensible and puts the chewer into a drugged state. The extraordinary endurance of the Indian, without taking any food, is ascribed entirely to the taking of coca. The average daily consumption is a good handful, that is, almost half a pound. The chewing of coca produces a penetrating and, for the foreigner, disagreeable odor which it took me a long time to get used to. Through the undernourishment and the effects of the cocaine on the body, most of the men look emaciated, tired, and dull, and drag themselves listlessly about their work.

The chewing of coca has become, like smoking, a vital necessity to the Indians. For that reason, the mine owner must guarantee always to keep the necessary supply of coca on hand at the mine, and it has become the custom to include a daily minimum of coca in the wages. Beside alcohol, coca chewing is probably chiefly responsible for the continuous degeneration of the Indians. The taking

of coca leads to a sort of mental enfeeblement, even in the case of comparatively young men.

Alcohol adds its share. It is consumed during the many Church and national holidays (more than fifty every year) in unbelievable quantities of generally doubtful quality. After a holiday, often no more than ten per cent of the shift descend into the mine, and it is sometimes a week before the entire shift is back at work again.

So, as I have said before, an increase through raising the level of the individual worker's production is quite impossible. I must add with regard to the aforementioned mechanization of the mining methods that the Indians as a rule refuse to work with mining machines and pneumatic drills. They are usually distrustful of machines.

USA WORRIES

In 1938 the total tin consumption of the United States amounted to exactly 50,000 tons. On the basis of available figures, the annual requirements must have risen to more than 100,000 tons on account of the rearmament program as well as the growing supplies of canned goods to Great Britain. By the end of 1940, a stock of approximately 50,000 tons of tin had been laid in as war reserve, so that if we add shipments in 1941 (approximately 75,000 tons from Malaya and half the Bolivian production, i.e., 25,000 tons) the USA would on December 8, 1941, have had at most some 150,000 tons of refined tin at her disposal. Hence these stocks would cover exactly the requirements of two years.

As I have proved at length, an increased production of the Bolivian mines can hardly be counted upon. On the contrary, it is not impossible that there will soon be a certain decrease. Furthermore, there was, for instance in May 1942, a decrease of ten per cent in the quantity of tin shipped from Bolivia to the USA as compared to the average shipments of the previous months. This decrease was a result of German and Japanese submarine activity. Therefore a disastrous shortage of tin is bound to occur in the United States in the near future. It is a well-known fact that forty per cent of the entire tin requirements of the USA are used in the manufacture of tin sheets, that is to say, indirectly for the canning industry. On the other hand, it cannot be assumed that the USA will succeed, as Germany has, in replacing tin cans by cans made of aluminum; for, in spite of all efforts and the construction of new plants, the American aluminum industry cannot even cover the requirements of the airplane industry. Consequently the United States will, even after the war, still be dependent on other sources of tin in addition to Bolivia.