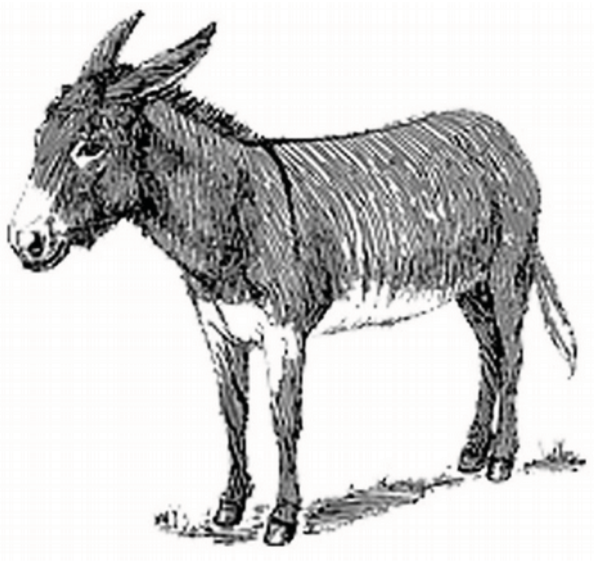
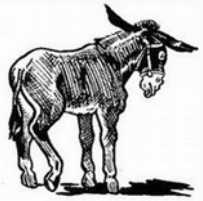
Chapter 4. The Donkeys' Decline.

4.1. Rise over run.
4.2. Aero cables.
4.3. Aero cables. The technology.





Why is this chapter called The Donkeys' Decline?

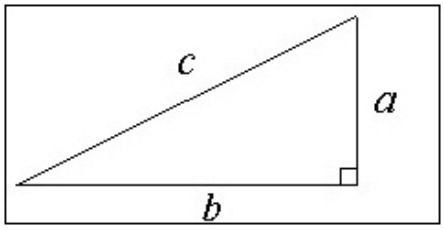
The technological innovations in the sections that follow are about the mechanics of the inclined planes and aero cables that replaced the donkeys or, more correctly, mules.

Although no longer used as beasts of burden they continued to be used as the locomotive force of the railways. They were still pulling lines of ore trucks from El Arteal to Villaricos up to the 1959's.

4.1. Inclined planes.

Inclined planes have been described as the most beautiful machine and the mechanics behind them have been understood for millennia. Using a ramp reduces the force needed to overcome gravity when moving objects up or down. By extending the distance travelled, the run, (c), to achieve the required elevation, the rise, (a), makes it easier to move loads to the same height. A gradient is the ratio of the rise to the run.

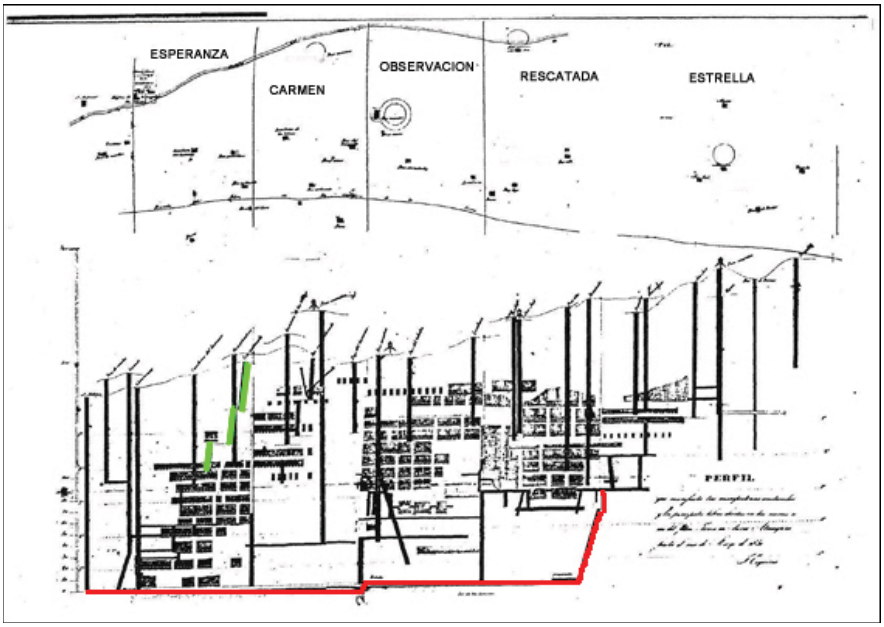
$$Gradient = \frac{Rise}{Run}$$



The tracks in the mountains are themselves inclined planes of between 15 and 20% gradient, the optimum for the mules to ascend and descend. Any slopes steeper than the tracks are either cuttings to allow aero cable buckets to circulate, or, the remains of cable railways. The most basic inclined planes in the Sierra were simply ropes attached to trolleys pulled up a sloping shaft.

A basic inclined plane.

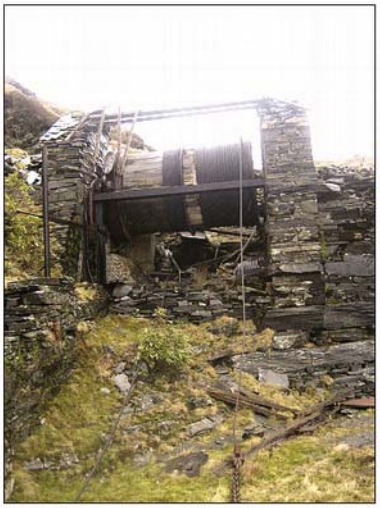
Although not very popular in the Sierra, the mines Esperanza and Carmen both had inclined shafts. This was probably due to the fact that they had “Saxon” i.e. German engineers, who favoured their use. They were extraction shafts rather than access shafts and the kibbles laden with ore were winched up manually. These shafts were known in the area as Mequínez which has no English translation but is a city in North Africa. How, or why, the shafts should be called this is something of a mystery.



Detail from shaft plan. The inclined shafts in the Esperanza mine are highlighted in green.

The development of better, motorised, winches led to far more sophisticated inclined planes or cable railways, capable of operating at gradients of up to 80%.

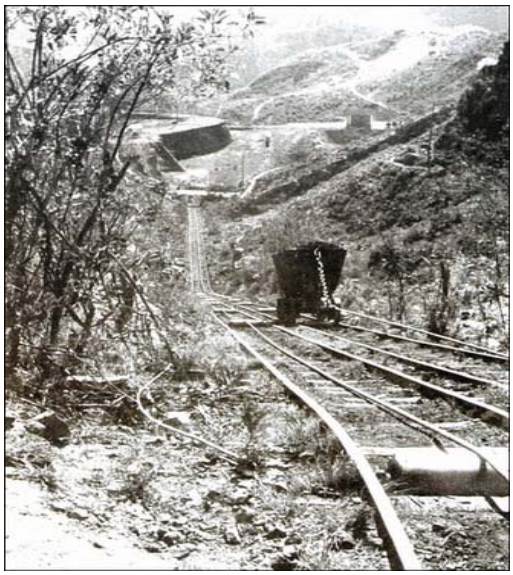
Typically, inclined planes for lowering materials consisted of a pulley or winding drum, situated at the top of the incline, and two lots of wagons, running on rails laid on the slope, attached to a cable which ran round the drum. As one set of wagons were raised the other was lowered. The cable was wound several times around the drum providing sufficient friction to stop cable slippage when a brake was applied. The weight of the loaded descending wagons was used to lift the ascending empties.



A winding drum similar to those used in the Sierra.

Empty and full trucks on a simple inclined plane.

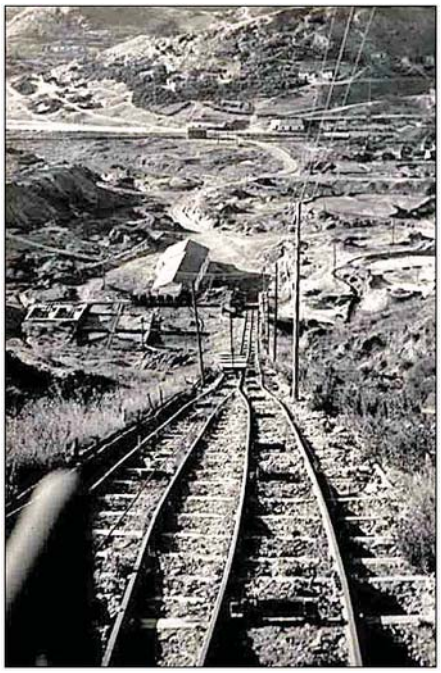
On the incline, the cable was recessed and guided by wooden rollers to prevent it crossing the rails and being damaged by the wagons' wheels. Because this gravity balanced type of plane could be operated without external power it could be used in the Sierra where the necessary water for steam engines was in short supply. The disadvantage was that it required two rails throughout its length so a wide ramp was needed.



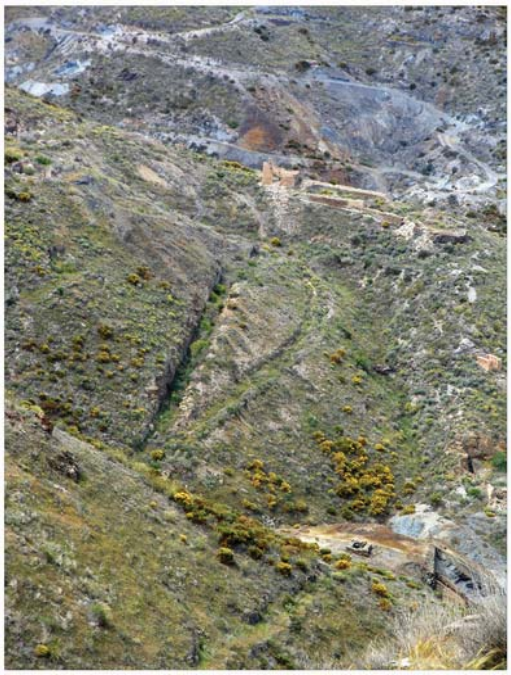
The rollers can clearly be seen in this 1950's photo of an inclined plane at Bédar.
Faro de Bédar. com

Raising loads required a motorised drum. Often, a ballast counter weight was added, running on an auxiliary rail that passed under the descending wagons to assist the lifting of the loaded wagons. The counterweight is known in Spanish as “un mono” meaning monkey, which is also how it’s referred to in English. The Welsh term for it is a “mochyn”, or pig.

I don't think that the more complex type of cable railways, those with gauntlet, or interlaced, tracks, were used in the Sierra. This type was used where there was a need to restrict the width of land needed. The track was shared by both the ascending and descending wagons for most of the length. At the centre of the run, a refuge, or lay-by track allowed the wagons to pass each other. Gauntlet track inclined planes are generally much longer than those found in the Sierra.



The passing point on a Gauntlet track.



The intriguing curved inclined plane.

When I first saw the cuttings in the above photograph I was mystified by them. It looked liked a double inclined plane. Were there such things as curved inclined planes? Had it been an ascending or descending system?

Then, when researching the Palmer monorail system on a Basque website, I came across the term “cadena flotante” or floating chain. I entered the term into the search box and there, among the pictures of floating necklace chains, was a line of wagons on a curved inclined plane attached to a raised chain rather than a cable. Such a system could have been used on a Palmer monorail.

An artist's impression of a “cadena flotante” or “floating chain” curved inclined plane.

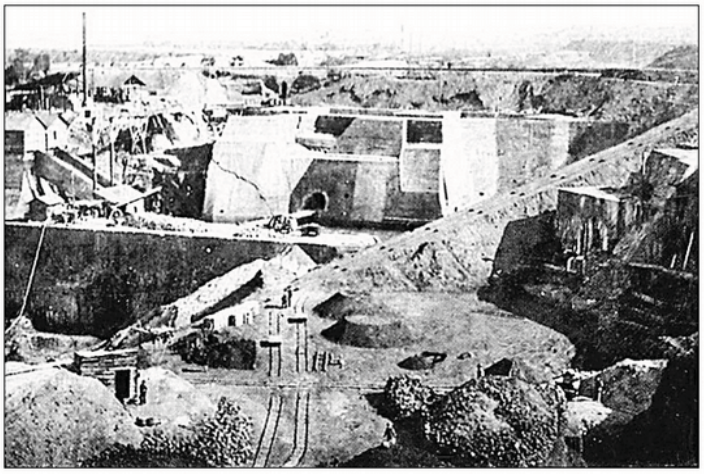
I later realized that I had been barking up the wrong tree about both the Palmer monorail and the curved inclined plane. The straight run was the line of a normal inclined plane and the curve was a lower gradient path up to the top. As mentioned earlier, this plane had a useful working life. Built initially to carry ore up to the aero cable, it was later used to carry ore down to the tunnel leading to the massive inclined plane on the other side of the mountain.

Luis Siret's inclined planes in Las Rozas were what is known as the tank type. The fixed, angled platforms on which the wagons rode, can be seen in the picture. The incline isn't operating, so there are no wagons riding on them.

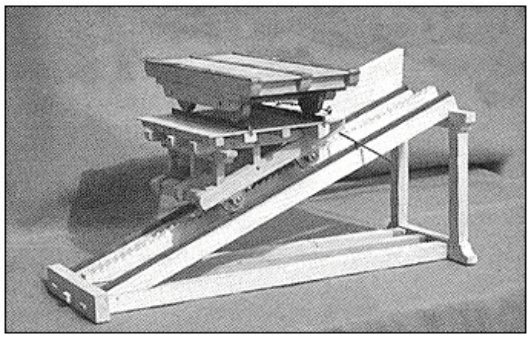
The inclined plane can be seen on the right of the picture.

Also note the curved and straight track that feeds the inclined plane.

The tiny black dots on the plane are trucs.



The Decauville name for these fixed platforms was “trucs” which from modern French translates as “thingys” or “whatsits”, i.e., those things that we temporarily forget the name of.



Model of a Decauville truc.

Since the load was being raised on the Las Rozas planes, there would have been a powered winding drum. I don't know what the motive power was initially, but would have been electrically powered after 1905. Given the steep gradient of the Argentífera's massive inclined plane down to Cala de las Conchas it would have been a tank incline. As the railway was a Decauville system, the plane was most likely a Decauville system too.

There are the remains of an inclined plane at República Romana. I had assumed that it only carried ore down from Luna II which is situated just above it. Antonio Jódar informed me that it also carried ore from El Boletín where it had been calcined in an oven built into the mountain. This information explained the mystery of the remains of some rail track that can be seen there.

Above left, remains of the inclined plane at República Romana.

Above right, the mine Luna II.

Left, the entrance to the calcination oven at El Boletín.

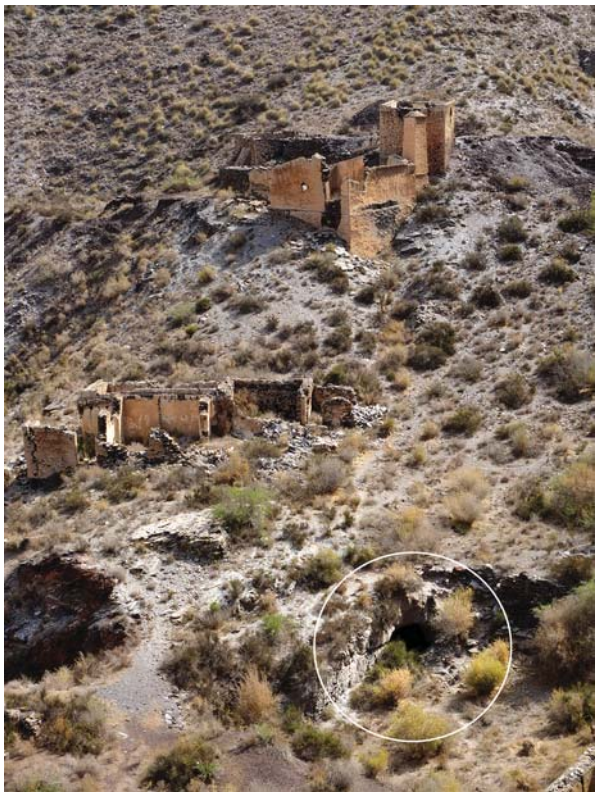
Above, the last remnants of the rail track.

Another of the Argentífera's holdings, the mine Centinela in the Barranco Chico de la Torre, has an oven of a very similar design to that at El Boletín. Calcined ore from Centinela was also taken to República Romana by rail. In this case, a cutting for the track was made from the mine into the neighbouring Barranco de la Torre de Tierra, and from here the line would have followed the contours of the hillside. There is no trace of it today, so I'm not sure whether it ran to the inclined plane or took a lower route and ended at the circular structure at the base of the plane. Ore was passed into a tunnel leading from the circular structure, where it was raised to the loading platform of an aero cable.

Above, the oven at Centinela. The entrance is above the wall and the top of the oven can just be seen (highlighted) at the top right of the photo.

Right, the cutting between the Barrancos Chico de la Torre and de la Torre de Tierra.

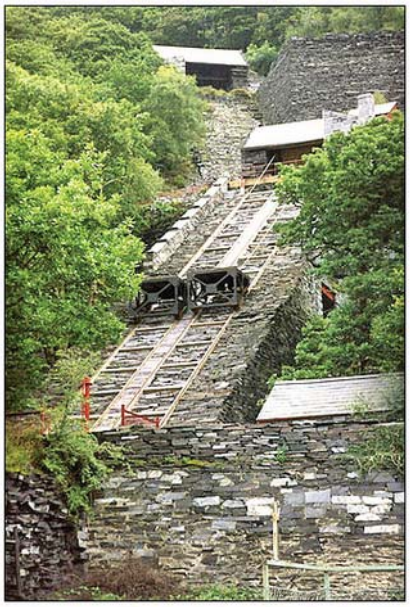
Above, the tunnel entrance in the circular structure.



Right, the ore passed via the tunnel (highlighted) to the loading station.

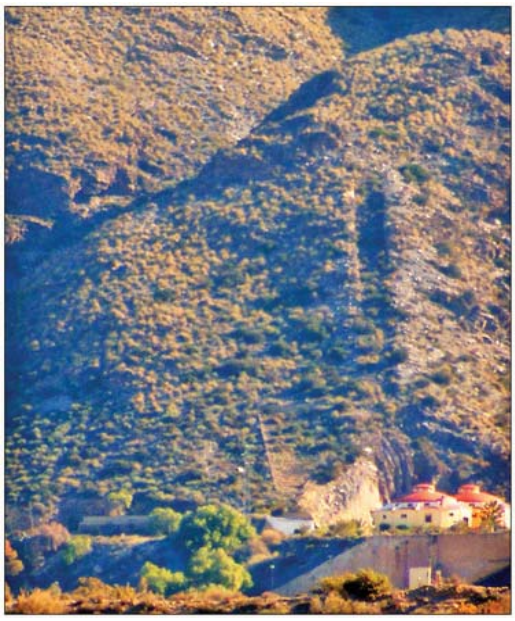
This poses the question, if the ore was calcined and taken by aero-cable to the coast, then why is there a blast furnace at República Romana? Presumably, one system predates the other, but which way round?

There is a short, steep plane at El Arteal, most likely a tank incline, possibly built before the civil war, but I don't know what it was used for. I think that there may have been a lavadero at the base of it as this area is frequently wet.



The steep inclined plane in El Arteal would probably have looked like this restored one in the Dinorwic Quarry

What looks like an inclined plane above the bath houses in the picture below, is actually a cutting to give clearance for the buckets on the aero cable running down from Manchego.



4.2. Aero cables.

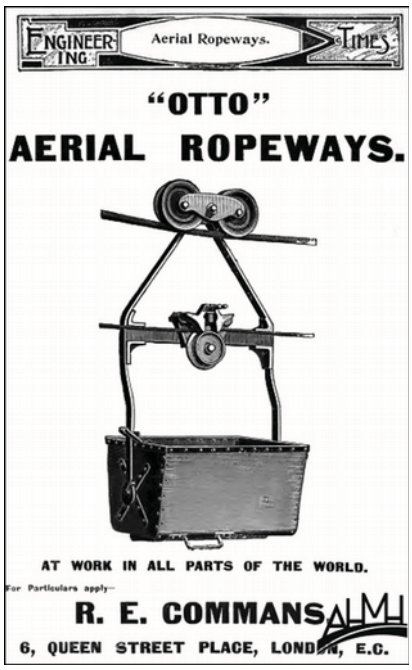
While the Jaroso to Cala de las Conchas line was the first aero cable in the Sierra, others followed as technology finally came to the Sierra. One was installed in 1903, at the República Romana mine in the Barranco del Torre. Known as the Violeta cable, it served to carry the iron ore from the adjacent mines to a loading station in the Cala de las Picotas, a distance of more than 2 kilometres, It was constructed by the engineer, Karl Bahlsen and was an Otto system, an early type of tri-cable, powered by a steam engine. The cutting which allowed the passage of the buckets through the top of the Sierra can be seen from the Cuevas-Los Lobos road.

The remains of the Violeta loading station at República Romana.

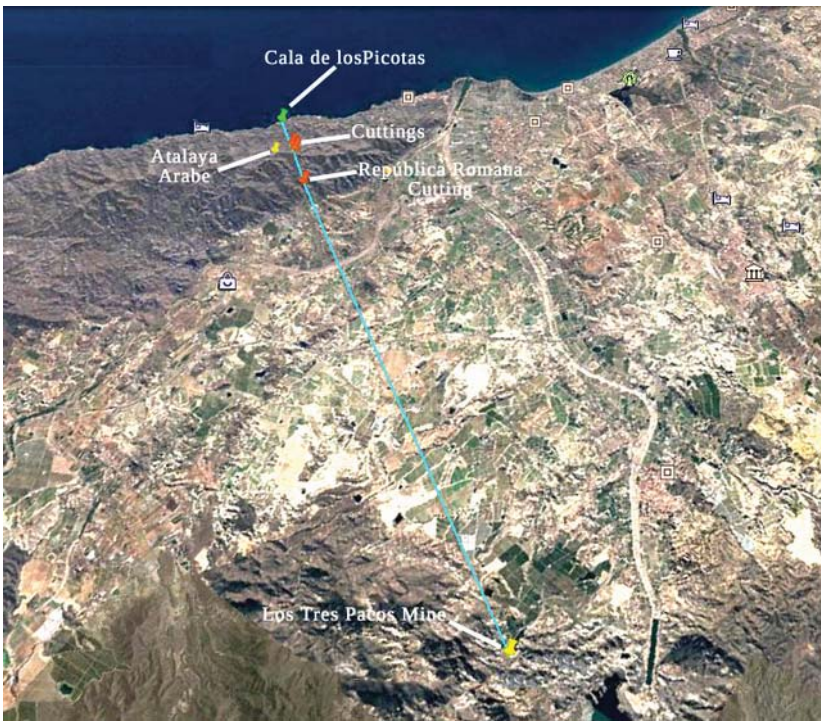
The cutting made for the buckets to clear the summit

Above, remains of the Violeta terminal at Cala de las Picotas.

Right, the Otto bucket.



Less than 200 metres from the terminal station of La Violeta is the terminal station for another aero cable. This one didn't originate in the Sierra Almagrera but passed over it, a mere 170 metres from the Violeta cutting. This one ran from the mine Los Tres Pacos in the Sierra Almagro, near Cuevas, and was 13.5 kilometres long. It wasn't a Man from Bilbao but a Woman from Bilbao, the widow of one Pedro Gandarias, who headed the company responsible for it. Constructed in 1912, it was a Bleichert-Otto tri-cable system, with a motor powered by steam generated electricity. It was in operation until the Civil War. When it was dismantled, the cables were cut into small sections and sold as souvenirs.



The line of the Los Tres Pacos aero cable.

A tri-cable system similar to the type used on Los Tres Pacos line.
Adurcal.com

The building in the foreground is the loading station at Los Tres Pacos.

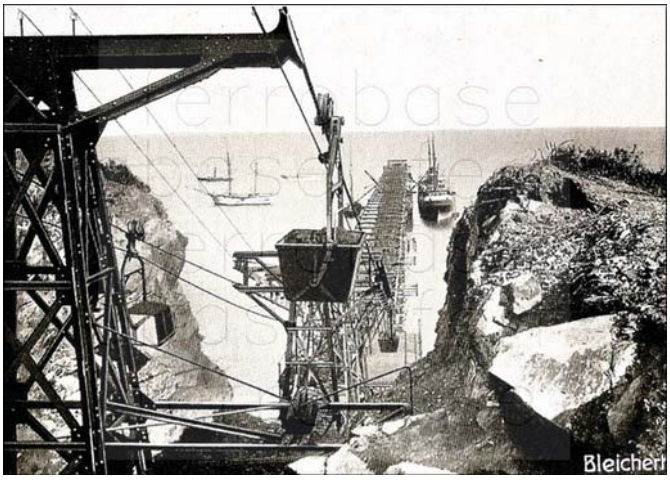
The cutting on the right was made for the Los Tres Pacos cable, the one on the left was for the railway line from Centinela.

The Violeta terminal is on the right and the Los Tres Pacos terminal is on the left.

Cala de las Picotas seen from the top of the Sierra. A cutting for the Violeta cable can be seen on the left. The los Tres Pacos terminal can be seen on the right.

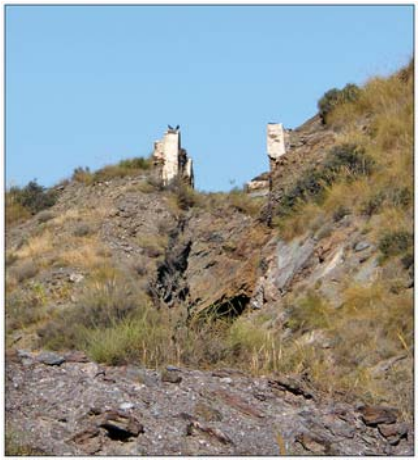
The remains of the terminal at Cala de las Picotas.

I think that this building, pictured above, housed the tensioning mechanism. I haven't found any details of the loading jetty. As it was a Bleichert-Otto tri-cable system it is possible that the cable extended out over the jetty and that the buckets emptied directly into the ships' holds as illustrated by the picture below.

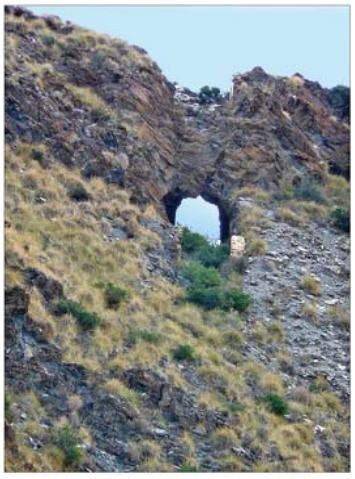


Loading the ships. *Bleichert Lib.*

Two other aero cables intrigue me, obviously constructed at a later date and of a completely different design to the earlier cables. One was from the mine El Boletín and the other from the mine Manchego both owned, in 1903, by the Argentífera. The supports resemble those of pit head winding gear, that is, a pair of brick built, triangular structures. The one from Manchego passed over the Barranco de las Palomas to above the big hole in the rock above El Arteal, and from there down to El Arteal.



The cable supports on both sides of the hole in the mountain above El Arteal.



Obviously, the buckets must have been carried between the supports but I have failed to find out just how they worked. I do know that this one was operational, because there are the remains of a metal bucket which had “jumped” the line somewhere between Manchego and the aljibe, or water cistern, in the barranco.

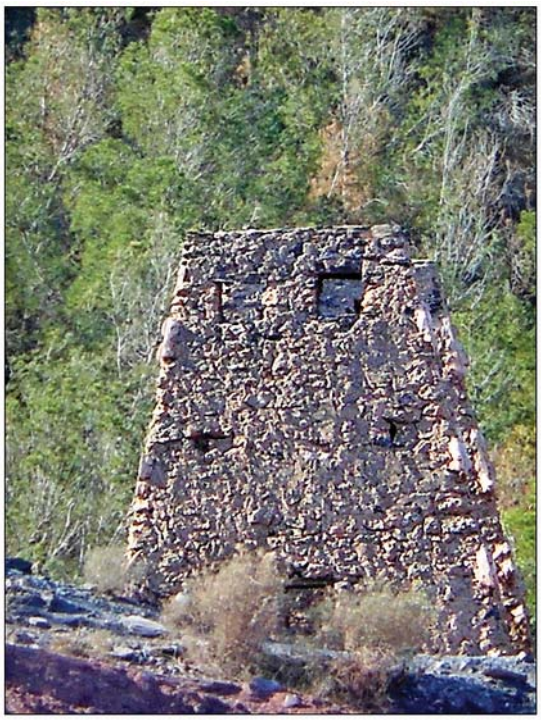
The recently unearthed remains of a bucket that “jumped” the cable.

The cable from El Boletín was a real mystery because ore from there previously went to República Romana and the Violeta cable. This cable from El Boletín, crossed the Barranco Chico del Torre to the mine Garibaldi, and from there down what is known as “Television Hill”, the track parallel to the pine forest. I could not find out where it went to from the bottom of “Television Hill”, whether it went through the gap in the small hills and down to La Muleria, or, veered south down to El Arteal.

The loading station built at el Boletín.

The Eureka moment was when the web site 'MTI minas andalucia' posted pictures of the mine Garibaldi. One of the photos showed the supports and the caption was to the effect that the aero cable had never been operational. Hence its abrupt end.

My theory is that both lines date from the 1930's when Luis Siret negotiated, on behalf of the Consorcio de Almagrera, the licence to carry ore from the Sierra on the El Arteal - Las Rozas - Villaricos railway. Whether the Argentífera still owned those mines or had sold them to the Consorcio I don't know but, if anyone knows the answer, please let me know.



Left, the aero-cable supports on "Television Hill"

Right, the sight-line from Garibaldi to the top of "Television Hill" looking towards Las Herrerías.

Line of the cable from El Boletín.

Line of the cable from Manchego.

The picture below that mtiblog posted in 2017 fascinated me. It shows an aero cable passing over Garrucha beach in the 1960's.

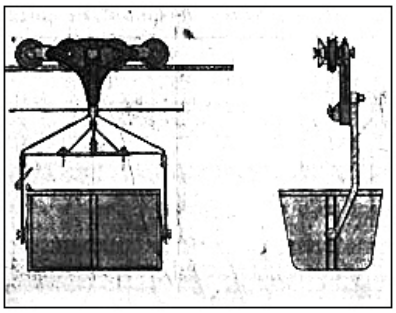
I knew there had been an aero cable there in the early part of the century. It was part of an elaborate, integrated system of linked cables for the transport of iron ore from the Sierra de Bédar to the coast. It was also far more sophisticated than the one in the above picture, being an Otto tri-cable system.

The tensioning station of the old Garrucha aero cable. El Obrerismo Consciente.
M. I Ruiz Garcia.

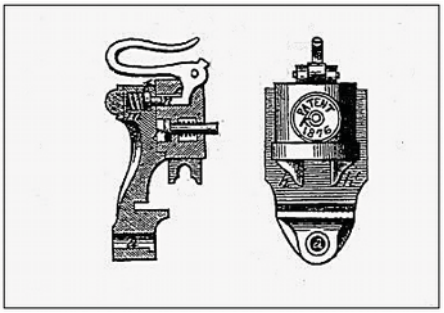
Further research revealed that the one in the 1960's picture belonged to a company called Hierros de Garrucha S.A. and was built in 1953. Like the renaissance of El Arteal, this was another post Civil War reactivation of workings paralysed in the 1930's. Ore was brought into Garrucha by lorry and off-loaded into big hoppers. The cable ran for 700m from the hoppers to the quay of the harbour. It closed in 1970.

You have to hand it to the people on the beach, sunning themselves under a somewhat primitive mono cable. Rather them than me!

4.3. Aero cables. The technology.
The Bleichert-Otto tri-cable system, like the one at Bédar and Los Tres Pacos, used two fixed steel ropes, one for the ascent and the other for the descent These carried the buckets, while the third was a continuous tractor cable providing the movement. The buckets were fitted with grooved wheels that sat on the fixed cable, and were attached to the tractor cable using special couplings.



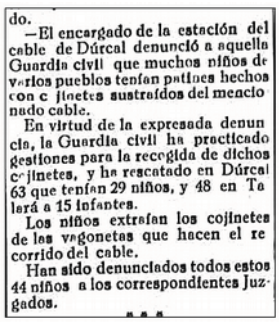
Note the grooved wheels on the bucket arms.
adurcal.com



Bleichert couplings used to attach the buckets.
Km130 tranvia aéreo

This system allowed the buckets to pass over the stanchions.

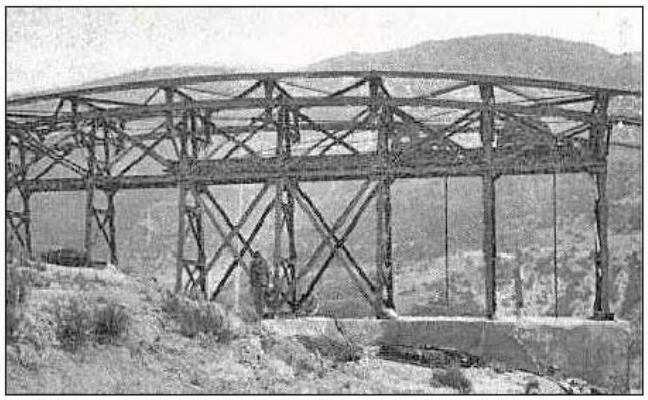
The fixing mechanism between the bucket and the fixed cable was the target of young thieves who used them as roller skates.


do.
—El encargado de la estación del cable de Dúrcal denunció a aquella Guardia civil que muchos niños de varios pueblos tenían patines hechos con c jinetes sustraídos del mencionado cable.
En virtud de la expresada denuncia, la Guardia civil ha practicado gestiones para la recogida de dichos cojinetes, y ha rescatado en Dúrcal 63 que tenían 29 niños, y 48 en Talará a 15 infantes.
Los niños extraían los cojinetes de las vagonetas que hacen el recorrido del cable.
Han sido denunciados todos estos 44 niños a los correspondientes Juzgados.

The newspaper article, from March 1933, reports the theft of the cable fixing mechanisms by children from Dúrcal who used them as roller-skates! The Guardia recovered 63 sets. Forty-four children, 15 of whom were under 7 years old, appeared before the courts. Which poor child had only one skate?

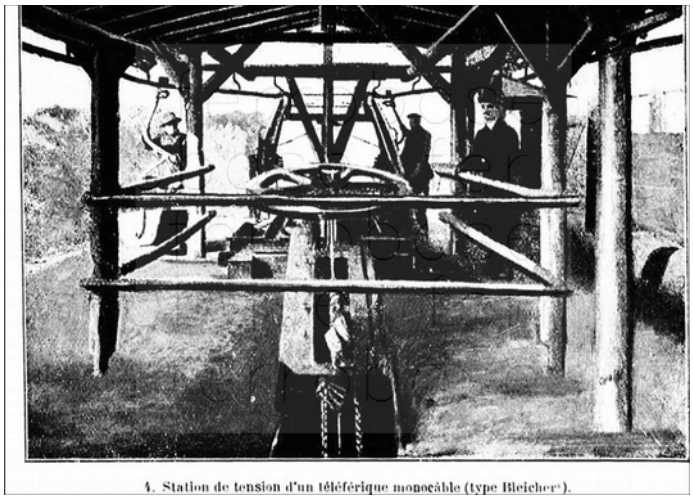
The fixed cables were anchored at one end and kept tight by a tensioning device at the other.

The overhead cables were kept taut by suspending blocks of concrete which were in pits below ground level. The picture shows the cables from which the blocks were hung.



Aero cable tensioning station.
adurcal.com

The same system was used on mono cables to maintain the tension of the single cable.



Mono cable tension station. *Bleicher Lib.*

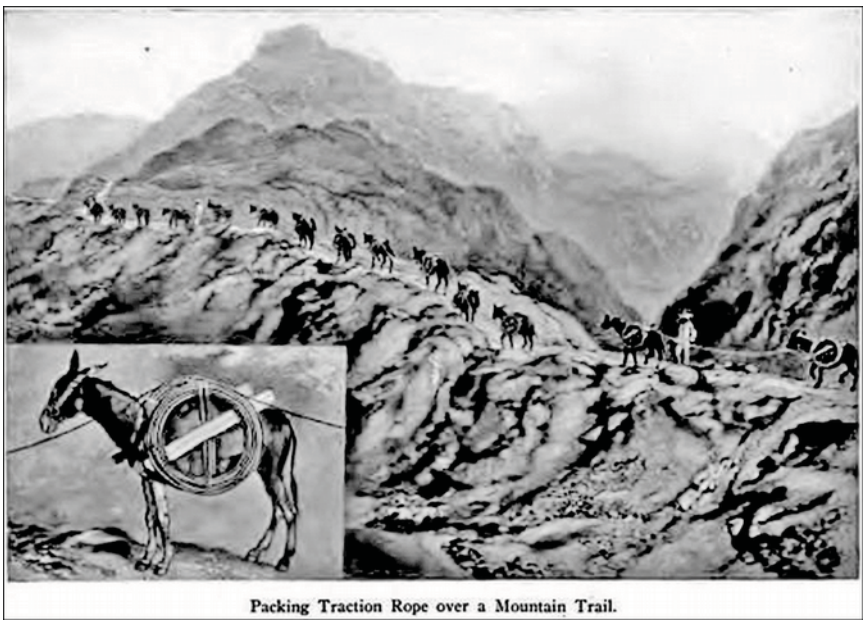
Maintenance was relatively simple, the carrier wheels on the stanchions required greasing weekly with a mixture of oil and grease. Men climbed up to do this wearing spiked shoes, but no safety harness. Climbing a 27m high, wooden pylon situated half way up a windswept mountain isn't my idea of fun. They were, however, in relative terms quite well paid. (If short lived.) Apparently, it was possible to detect potential problems with the system by ear. Daily inspections were carried out with the men listening to the buckets passing over the supports.

An aero cable maintenance team.

One question that I asked myself was “How did they get the miles of cable into position on the mountain?”. Well, now I know. Strings of mules were laden with 115kg of coiled wire, with a 5m to 7m slack section between each animal. The slack section was held by a man, in order to prevent it from trailing on the ground. As simple as that! However, it must be said that this system was not without dangers. Since the mules were linked together by the cable, if one fell over a precipice the others followed. The constructor of a 2 mile long aero-cable in Mexico recorded the details of one such accident:

"During the conveyance of the section of rope to the upper terminal an accident occurred which was productive of very considerable delay, and demonstrated the difficulties attendant upon the operation. The head mule, at a point where a rise immediately followed a steep descent, started to take the rise with a rush until checked by the rope, which threw him backwards over the bank, he taking two other mules with him, and had not the last of these caught on a tree, the rest of the train would have followed."

Extract from an article in Lowtechmagazine.com.



Packing Traction Rope over a Mountain Trail.

The mule train in action. *Lowtechmagazine.com.*

The donkey was used for its own demise!