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## **AERIAL ROPE TRANSPORT.**

(By J. W. MACKIE.)

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The transport of material by means of Aerial Ropeways is more or less in its infancy in this country. Why it should be so is somewhat puzzling, as in countries where the cost of labour is only about half of what it is in Australia, Ropeways have been fully established for many years, and have proved beyond all doubt to be the most economic method of transport yet evolved, especially so where a continuous output and great distance has to be dealt with.

Many of the world's mines are situated in positions almost ungetatable, where the primary cost of laying down a railway would necessitate a huge expenditure of capital, and probably, if the only way to convey the material from the mines to the works had been by railway, many of the richer mines now working would never have been developed. This especially is the case in Spanish speaking countries, and the general physical conditions of Australia are in many ways similar to the countries mentioned.

All over Australia rich deposits of ore are lying almost untapped, simply because the heavy cost of transport over the rough country will not permit of their being mined and transported at a profit, and I here contend that the installing of Aerial Ropeways will yet be the key to open up these rich fields and so help towards the development of this country.

**History.**—It might be of general interest if we were to briefly glance through the early history of Aerial Ropeways.

The earliest record of a Ropeway as now understood appears to be that contained in the chronicles of the town of Dantzic, which state that in the year 1644 a Dutch engineer, Adam Wybe, constructed an Aerial Ropeway from Bishoffsberg, or Bishop's Mountain, to convey earth and material for the construction or repair of the city ramparts. This Ropeway consisted simply of endless ropes running on pulleys attached to posts. To this rope a large number of small buckets were fixed, the rope was thus made to both support the weight of the buckets and move them along.

With the advent of wire ropes some three-quarters of a century ago, the commercial development of Aerial Ropeways began to make headway.

About 1860 a notable ropeway was erected in the Hartz Mountains by Baron Von Ducker. A double rope, or bi-cable, system, possibly the first of its type, was built by the same gentleman in 1867.

In the same year a patent was granted in England to Charles Hodgson, who erected a number of Ropeways, principally on what may be termed the single-rope system, by which one endless moving rope both supports and carries the load. His specifications also included the double-rope type, or that comprising two fixed cables along which the carriers were hauled by another separate endless rope. This latter system was generally adopted and approved by engineers on the Continent of Europe, and, in course of time, in spite of its disadvantages, became a comparatively efficient means of transport.

**Types.**—Aerial Ropeways may be broadly divided into three distinct types. Firstly, the double rope or bi-cable system, in which the loads are suspended from carriers or small trolleys running along fixed cables, and drawn or controlled by a separate traction rope. Secondly, the single-rope system, in which a single endless moving rope not only supports the loads, but carries them along. The third type is usually referred to as a *blondin* or cableway, and consists of one single span with a carriage running backwards and forwards, from which is suspended a skip which can be raised or lowered at will.

Although the single rope was first in the field, its development was, for a considerable time, neglected, owing to the impossibility of negotiating any average grade with the type of clips or rope attachments then in vogue.

The single rope system has always been admitted as that being the best for light loads, but there was always a prejudice against using it where steep gradients had to be overcome. Many standard works on the subject still encourage this idea, but I think, ere this paper concludes, I shall have convinced you of the error they make.

The truth of the matter is that, wherever the various leading Ropeway Companies have made their influence felt by installing a plant, the general trend of opinion is towards the type seen and known.

Both systems have good points in their favour, and it takes a considerable amount of skill and knowledge of the actual working of the two types to determine which is the most suitable to instal.

While I happen to have been attached to the firm which, by its absolute faith in and close study of the single rope system has brought it up to its present state

of perfection, I do not hesitate to say that the single rope has its limits, although not in the way most people would imagine. In almost all cases where the material carried permits of its being split up into comparatively small quantities and so distributing the weight, a single type ropeway would be the most suitable one to instal. Individual loads, however, up to 25 cwts. net, are at present being worked on more than one single rope installation, and it is rare indeed to have even a double or bi-cable ropeway carrying anything in excess of this.

Stated briefly, the advantages and disadvantages of both systems may be summed up as follows:—

Taking the single rope system first, one advantage is that the rope is subjected to even wear throughout its length, as, by constantly moving, each section or part of the rope has to accept the various strains in rotation. Further, it can be readily inspected and greased while passing through the terminals. The simplicity of construction, facilitating the employment of unskilled labour to handle, and the low first cost of installing, are also greatly in its favour. The first disadvantage may be stated as being the difficulty of constructing a ropeway of sufficient strength to support heavy individual loads and be flexible enough to go round a terminal wheel of small enough diameter to keep the gauge of the ropeway to reasonable proportions.

As an instance, take the case of a ropeway intended to convey, say, 40 tons per hour, individual loads being 5 tons net. A rope having a breaking strength of 90 tons would be required if undue sagging were to be avoided. The terminal pulley, to prevent injury to this size of rope, would require to be at least 15 ft. in diameter, which diameter determines the gauge of ropeway. A terminal gear for this gauge would be very heavy and expensive, and, in the general run of affairs, would

absolutely prevent the installing of a ropeway plant. The second disadvantage to the single rope system is the difficulty of constructing a clip that will grip the rope sufficiently to carry the loads up even moderate gradients.

There is now, however, a patent clip on the market which safely negotiates grades of one in two, and I might mention here that there is already installed in this country a Ropeway at Kandos, near Rylstone, where the average grade up to the side of a hill over which the Ropeway runs is a little steeper than one in three.

Such grades permit of the single Ropeway being used on practically the severest country.

The double or bi-cable system undoubtedly has the advantage over its rival system, where comparatively short lines of heavy capacity are in question; in short lines, if only a single rope were installed, the life of the cable would be very short owing to the constant bending of the cable when passing through the stations.

The load, being hauled along by means of a small tractor cable, permits of the design of a clip, through which the rope cannot slip, and so makes possible the negotiation of very steep grades.

Where heavy capacities are contemplated, the gauge of the ropeway can be kept down to reasonable proportions by the employment of the bi-cable system.

As to the disadvantages of this system, we will confine ourselves to the main ones. The ropes are subjected to uneven wear on the top surface, due to carrier pulleys, and on the under surface over the trestle saddles. The wear is also very severe on steep gradients and over ridges. The cost of a bi-cable system is usually very much in excess of its rival, the single rope, and this is usually the main determining factor with most prospective buyers.

**Spans.**—In this country especially there seems to be a great deal of doubt as to the length of spans possible, which may be safely negotiated, and also the nature of ground over which an Aerial Ropeway can be worked. Generally speaking, the limit of span possible is governed, firstly, by the strength of cable which would be considered the most economic for the capacity to be handled, and, secondly, by the amount of sag or dip it is possible to allow the rope.

In both types of Aerial Ropeway spans up to 1,000 yards have been accepted under ordinary working practice, and distances even greater than this have been successfully negotiated by the engineers of the large Ropeway Companies.

**Nature of Country.**—In speaking of the nature of country over which a Ropeway can be constructed, we might safely say that the most broken or mountainous country offers no difficulties which cannot be overcome at a cost which is impossible in the extreme when compared with any other type of transporting appliance, and, further, for ordinary undulating country a Ropeway can be installed to easily compete in first cost with a tramway, and then beat it out of all question in the running costs and upkeep.

**General Details.**—We might confine our attention now to the general construction, layout and conditions of erection for the various types of Ropeways. I propose dealing with the single rope system first, as being the Ropeway which ought to have first consideration by reason of its simplicity and general adaptability.

In this type the employment of a single endless rope for both supporting and moving the loads along reduces the necessity of complicated gear to a minimum. See Plate No. 1. The rope, which is of Langs' lay construc-

tion, and made up on six strands of seven wires each, with a Hempen core, passes round the terminal sheaves, which lie horizontally in the Stations. It is then supported along the line on pulleys carried on either steel

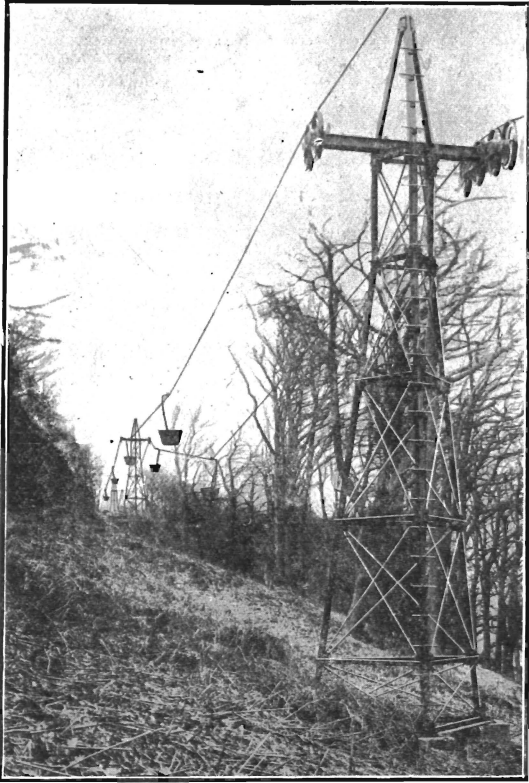


Fig. 1.

or timber trestles. On this rope buckets are hung, being partially attached to it by means of clips fitted in a small carriage, technically termed boxheads. No two makers of this type Ropeway use the same clip, but the one made by Messrs. Ropeways, Limited, of London, is undoubtedly a most efficient one.

Most clips for this system are made on the principle that the weight of the load operates a scissor-like set of jaws which grip the rope, while the successful clips just referred to simply sit on the rope, and, by means of two small projections on the inside of the clips, lock themselves automatically on to the rope and can only be unseated by direct lifting.

In ordinary practice they negotiate grades of 25 deg., while gradients of 33 and 35 degrees have been successfully and efficiently tackled. See Plate 2.

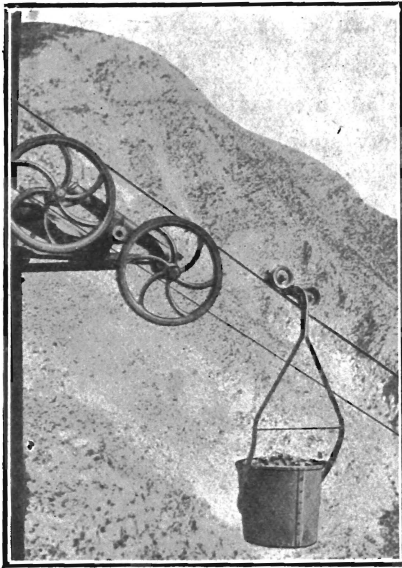


Fig. 2.

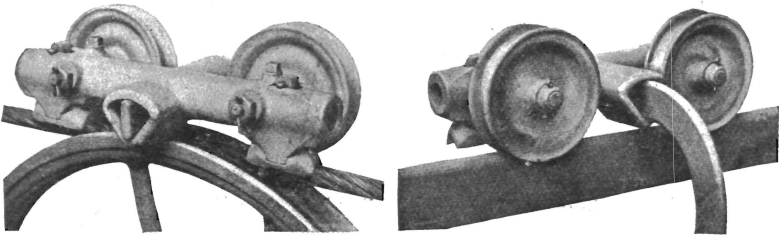


Fig. 3



Plate 3 gives a very good idea of the construction and build of the carrier or boxhead, and shows quite clearly how the clips are fitted into the boxhead, as also the respective duties of the clips and small runner pulleys. These pulleys are for use only when the carriage is running round the shunt rails on terminal stations.

Clips which employ the scissor action for gripping usually go right round the rope, and have a tendency to distort it, especially when passing over the trestle pulleys. They are also very much limited in the grade they can negotiate, and are largely responsible for the lack of favour shown to the single ropeway, as makers were inclined to experiment at customers' expense.

**Terminals.**--The terminal gear for this type of ropeway is extremely simple. See Plate 4. In the driving station the gear is usually an arrangement of spur and

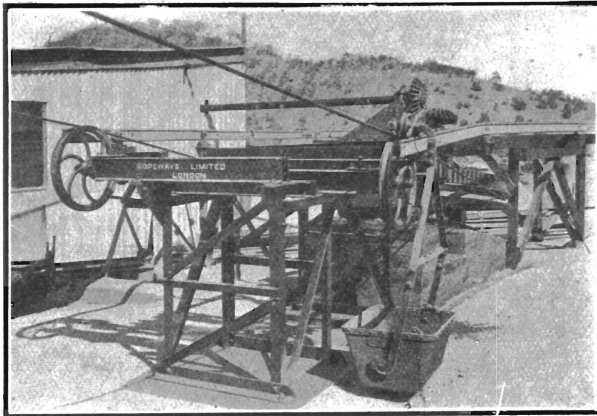


Fig. 4.

bevel gearing coupled up to the large terminal wheel, around which the rope rides in a V shape groove. The high tensions employed, and the large diameter of the sheave, as a rule do away with the necessity for gripping

the rope in the V, and in average practice the rope rides directly in a groove having a similar radius to the rope itself.

The gearing should never be connected direct to the motor engine, but either belt or friction drive should be substituted, as by gradually getting the ropeway under way much sweeter running is assured.

If a Ropeway is too suddenly thrown into motion, the buckets are apt to rise and fall along the entire line very excessively, and, where clearances are small, there is always danger of fouling, and probably upsetting a bucket, which might cause trouble when ropeway is under way.

The gearing on the tension terminal is also simple. See Plate 5. The big terminal wheel is fixed

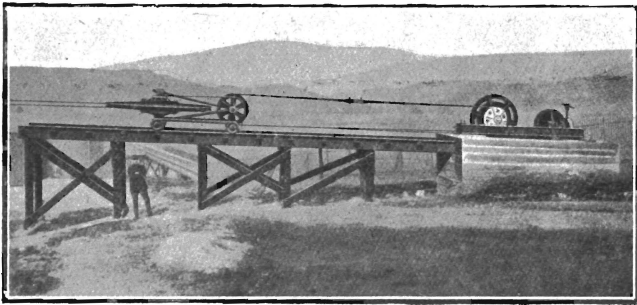


Fig. 5.

on a trolley running on rails, and is held in place, and, when necessary, pulled back, by an anchored winch. This winch is designed to automatically take up the tension and stretch a main rope, which is, as a rule, an important item in ropeways of any average length.

The automatic tension is generally maintained by means of a constant floting weight. By this means the stretch is absorbed and taken up without interfering with the actual working of the ropeway, it all being performed while the Ropeway is in motion. Indeed, this is the

better time in which to manipulate ropes, as the actual conditions are better under control, and any slight variation can be more readily ascertained when the ropeway is at rest.

Plate 6 gives a very good idea of the layout of a tension terminal, and also an elevated station for unloading into railway trucks.

The station frame work for the various terminals is governed by each different condition of loading and unloading. The usual type is extremely simple, as may be noticed from the one or two plates which have been and are to be shown, but in some cases, especially where large depositing terminals are necessary, the framework becomes a very expensive item, and, in some cases, has been known to cost considerably more than the entire other work of the ropeway.

The shunt rail for carrying the skips or buckets around the station can be taken to any desired position, and is usually carried on very light frame work.

The setting out on the drawing of the trestles for a single ropeway is, if I might say it, a work of art, and in nine cases out of ten an amateur at ropeways would only design a job which would end in disaster. The number of pulleys required on each trestle is determined by the total rope pressure at each point, and each pulley along the line has to carry a certain load, and the various strains and loads which go to make up the total are very varied. See Plate 7. Most ropeway makers have their own private formulae for ascertaining and working out these strains, and I can assure you that, only by long, and in some cases bitter, experience, have the now leading companies secured a set of constants, etc., by which they can with confidence design the work to give the excellent results now obtained.

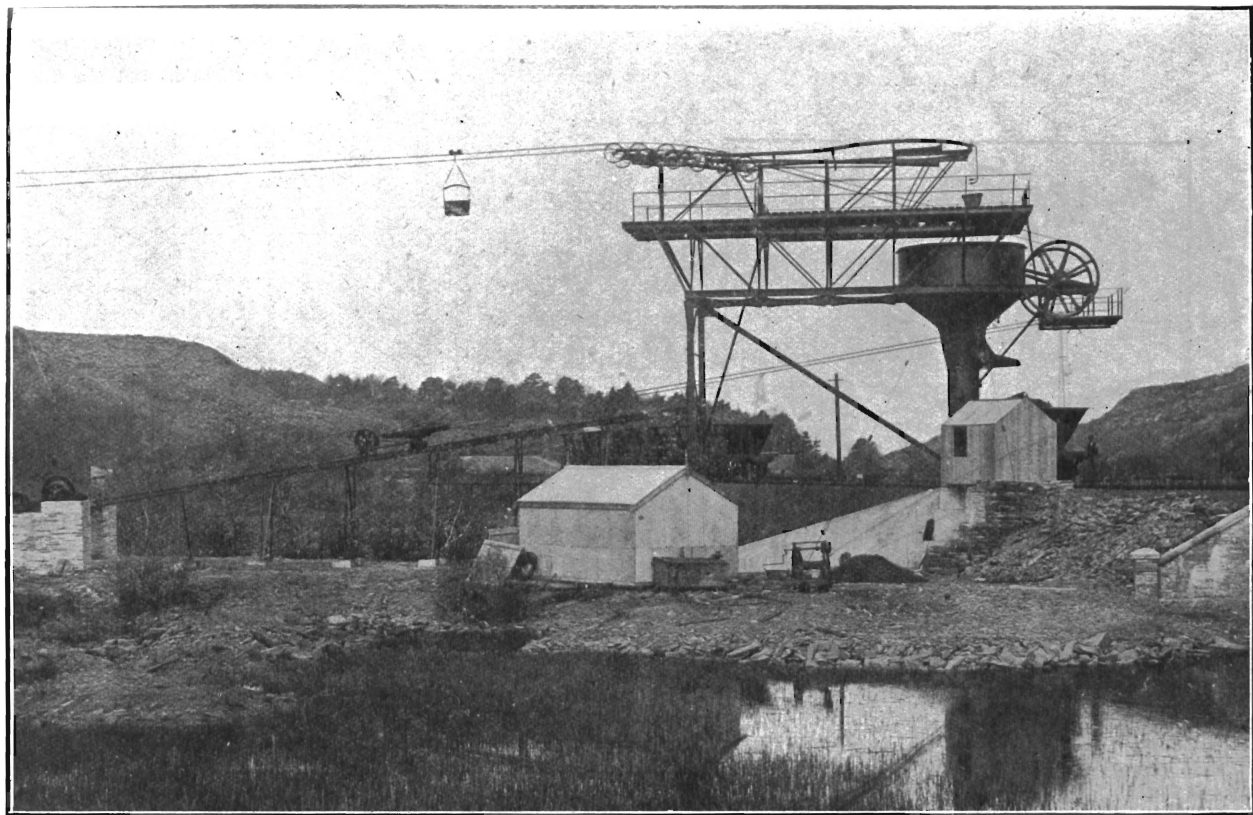


Fig. 6.

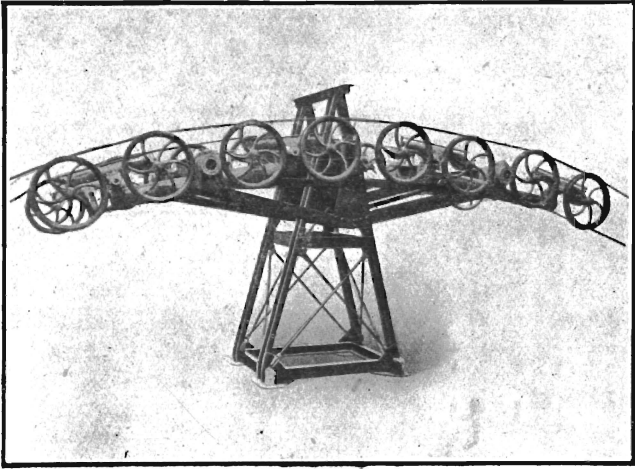


Fig. 7.

**Ropeway Action.**—The action of the ropeway is entirely simple, and only requires brief notice for reference purposes.

The bucket, which has moved along with the rope, arrives at the station, and is carried over the entrance vertical sheaves. It is then lifted by means of two small pulleys on the carrier or boxhead previously described, which run on to a shunt rail running around the station, and by so doing release the rope, which now passes round the horizontal sheaves.

The bucket can then be pushed by hand, or, as in some ropeways, pulled automatically round to either the loading or unloading point, and after being filled or emptied, is again pushed round to the outgoing rope, with which it automatically engages and then proceeds along the line to the other terminal.