

and there may be some portions where it could not be used. I should like more detail on that point.

In the change of grade, he showed us a plate of a trestle tower, which indicated there must be a limit. Take a grade of one in three. On the summit you descend on another grade, and there are a number of wheels required to change from the upward to the downward. These wheels are placed on a circular arc—the steeper the grade the longer the central arc would need to be. I should like to know how that is arrived at.

With these few remarks, I thank Mr. Mackie for his paper.

MR. TOURNEY-HINDE: I have simply a question to ask, which is really only an amplification of one put by Mr. Sinclair. I also am interested to know how the clip described by the author grips the rope; and I would like further to know why it is more difficult to design a clip that will grip a rope on an aerial tramway than one that will grip a rope on a cable tramway? In the latter case, it appears to me that the load must be very much greater, and therefore the friction between the rope and the clip must be very much greater to propel a loaded car on a grade (especially at the moment of starting) than it would be to haul an already attached loaded bucket of much lighter weight up a gradient of one in two or one in three.

THE PRESIDENT: I have a letter from Mr. Julius, who was unable to be present owing to sickness. He has been kind enough to make some notes on aerial rope transport, which I will ask the Honorary Secretary to read to the meeting.

The Hon. Secretary then read Mr. Julius's notes on the subject:

*Notes re Aerial Rope Transport.*

The writer very greatly regrets that, through sickness, he is unable to be present to hear Mr. Mackie's most in-

teresting paper on Aerial Rope Transport, a subject in which the writer has always been greatly interested.

The subject is a very wide one, and an immense amount of interesting matter could be written on same, but Mr. Mackie has given a very clear and concise description of the principles involved, and the various methods adopted in practice.

The writer has always felt that in New Zealand and Australia there is a very large field for the application of aerial rope transport, but there seems to be an extraordinary objection in the public's mind in this country to the adoption of any means of transport other than that of the ordinary rails and truck.

This is a country where cheap transport is absolutely essential to enable industries to be developed and operated upon economic commercial lines, and it is also a country where the distances to be travelled are usually great, and where also the country over which material has to be transported is practically free from settlement or obstruction, and where, therefore, it is generally very easy to make all arrangements for the installation of a ropeway system; but up to the present very little has been done.

Some years ago the writer visited the Dorrigo Ranges to report upon the best means of bringing down Dorrigo pine logs from the top of the ranges to the Bellinger River.

A site for the ropeway was selected, and it was found that a perfectly straight run could be obtained, with heavy standing timber throughout the whole length of sufficient strength to carry the ropeway. In every way the proposition was one for which an aerial system was the best solution.

Tenders were called, and an absolute price obtained for the installation of the whole system; but at last the firms involved decided that they would stick to terra firma, and

they then put in an ordinary tramway system, with wire rope haulage.

The result has been that the first cost of this system was more than three times the contract price for the aerial system, and the operating costs are nearly five times as high as the estimated operating costs for the aerial system.

There is no doubt that for handling this timber from the heights of these ranges on the Northren Rivers, the aerial system is eminently suitable, and the writer feels that it only requires the enterprise of one firm to instal such a system to clearly demonstrate the fact that this system is the only proper solution of the problem.

The writer has, during the past three years, been intimately associated with a ropeway which is being installed in New Zealand for the conveyance of special ornamental building stone from quarries situated at an altitude of approximately 4500 ft., the ropeway being designed to bring down 2-ton blocks from this quarry to the main road, which is some 4000 feet lower. The length of this ropeway is 9000 feet, and in its length there are two clear spans, each of over 2500 feet in length. The ropeway is of the bi-cable, or double rope system, as the individual loads to be carried, and the grades involved, were altogether too great for the single rope system. Unfortunately, the erection of this ropeway has not yet been completed, owing to adverse conditions which have arisen as a result of the War, but much of the work is now completed.

The country over which the ropeway passes is excessively rough and precipitous, and footings for the trestles had to be blasted out of the faces of the various spurs, the operators being suspended by ropes from trees above, it being impossible to reach the trestle sites in any other way.

A temporary ropeway has been installed, chiefly to assist in the erection of the main ropeway; but this temporary ropeway is now being used to bring down stone, and is

capable of handling blocks up to 25cwt. in weight. When complete, this ropeway should be one of the most interesting in service, as the engineering problems involved in its construction have been very great.

The writer may mention that the whole of the material was designed and supplied by the well-known British firm, Messrs. Bullivants' Ropeways Limited.

There is no doubt that much of the great ropeway work in the world has been designed and carried out by one or other of two extremely well-known German firms, both of whom have had their representatives in Australia, who have succeeded here and there in obtaining contracts for ropeways, but it is to be hoped that in future such well-known British firms as Ropeways Limited, or the Bullivant Company will be entrusted with the ropeway work in this country, which undoubtedly provides a very large field for such schemes.

THE PRESIDENT: We have had the pleasure to-night of listening to a very interesting paper on a very interesting subject, followed up by a very interesting discussion.

From the remarks that have been made, it seems clear that full advantage has not been taken of the benefits to be derived from certain schemes of aerial transportation which can be installed; but it is only by bringing these schemes to the notice of the public that we can expect them to be advanced. It is by such papers as Mr. Mackie has read to-night that the public really is educated. There are two points which stand out very prominently in Mr. Mackie's paper: The first is his warning against thinking that the science of ropeway construction is as simple as it appears. There must necessarily be very intricate calculations. Think of the different strains which have to be taken by a trestle on the top of a hill and one in a hollow. Take the trestle in the hollow first. Supposing the rope is loaded up a good distance along. If the trestle is not

high enough, the rope may be floated off the wheels. In the converse case, if the trestle on the top of the hill is not properly designed, it might have to take too big a load, and then collapse. There are a number of things like that which occur to one, and I can quite understand that the ropeway manufacturers have a set of formulae which they preserve very carefully.

The next point which strikes me in connection with this paper—and it is a very important one—is that Mr. Mackie, without going too far into detail, has brought out matters of such interest as to make us wish to know more about the subject. That, I maintain, is the true art of writing a paper—to make one long to know more, so that, at a later date, if one should happen to run across the same subject in another place, one's mind will at once hark back to a time like this, and one is able all the more intelligently to understand what he is reading about.

Mr. Mackie, at some inconvenience to himself. I believe, brought this paper forward one month, and in passing a vote of thanks to him for the trouble he has taken, I would like also to express to him the very deep personal gratification I feel for the labour he has bestowed on the subject for our benefit. (Applause.)

I will now call on Mr. Mackie to answer the questions that have been put.

MR. MACKIE: First of all, gentlemen, I must thank you for the very kind attention you gave to me when reading my paper; and secondly for the vote of thanks which you have passed to me. There are quite a number of questions here, and I do not think I can answer every one of them as fully as I should like to do, because, firstly, that would take up too much time; and, secondly, I am not permitted to give out certain information, because I am under bond to my London firm.

With regard to the various types of ropeways that are in use, on passing the "Herald" office to-night, I noticed an illustration in the "Sydney Mail" of yesterday, showing an aerial ropeway which is in operation for taking the wounded Italian soldiers down from the top of the Alps.

The first gentleman who spoke—I will not mention the names of the individual speakers, because I am not acquainted with them—mentioned the great difficulties engineers experienced in the erection of ropeways over great heights. Mountain sickness was referred to. In the Durazzo ropeway, which is 11,000 feet high, some of our engineers had to stay on a different altitude over a month before they could proceed to the highest point. In some cases they were two or three days waiting on the top of ridges before they could proceed with the taking of the preliminary survey, on account of the rarity of the air affecting the heart. There is the question, also, of the water regulator. There is one system in Mexico where something like 2000 horsepower is developed—the surplus is used for electric lighting purposes and pumping water.

I have been picked up once or twice for saying something about the ignorance of engineers. In my preliminary paper—in the draft—I said something about consulting engineers. I should not have said that. I should have said the engineers on the mines I had visited in various parts of Australia. I find, as a rule, they know nothing about ropeways, except probably what they have seen in some pamphlet. They go about it as if they were installing something solid, like a railway, utterly regardless of cost and efficiency in handling material.

There are two books I could mention on the subject of ropeways, one written by Zimmer, which is very complete, in a sense, but, as some gentleman remarked, it is rather like a copy of a few catalogues; the other by Taylor, a more

recent publication, but more on the surface than Zimmer's work.

With regard to the pulleys, four on one side and two on the other—on the loaded rope—the rope carrying the loaded buckets, there is a greater strain—a greater weight per yard. This has got to be distributed over a certain number of pulleys, each pulley carrying only a certain load. In some cases you may take it that the maximum load would be about 500lbs. Although every pulley on a ropeway would not carry that amount, the aim of the ropeway engineer would be to work out the minimum number of pulleys over the whole line, each taking, as nearly as possible, 500lbs. In some cases, in the valleys, of course, huge spans can be covered by carrying only one or two pulleys. Mr. Bragg referred to the danger of the rope floating. That is rather a ticklish problem to work out in most ropeways, as the strains are so varied. In most cases they are able to so place the trestles that they will just take the exact amount required of each pulley; each separate trestle takes an exact weight—that is, there are four pulleys which would be taking 450lbs., and each is working on a sort of utiliser—a balance beam like the reverser of a body car underneath the railway. If one pulley were used there would be too great a pressure on one portion of the rope. Supposing one pulley was doing the work of four on one point, the rope would be standing a divided pressure over four different points, and that would very soon destroy the rope.

Mr. McEwin brought up the point that I spoke rather too highly of Ropeways Limited—not too highly; but perhaps too much of them. Of course, I have been attached to the Company, but apart altogether from that, I know that Ropeways Limited have made the study of ropeways their one and only feature; they undertake no other class of engineering, while all the other ropeway companies, or

companies that make ropeways, only make them as a sort of secondary consideration to their works, and they do not give the same careful study and specialisation to them that Ropeways Limited do. For thirty years Ropeways have done nothing else but ropeways, and, with the exception, perhaps, of Bleichert's, have supplied the greatest number of installations in the world. I will admit that Bleichert's have done some magnificent work all over the world—especially in passenger carrying ropeways.

Mr. McEwin suggested various rope schemes around Sydney Harbour. While many of them could be worked, and put in at a reasonable cost, there is always, of course, the trouble of the span. I do not know what the span is between Cockatoo Island and the mainland, but it would entail a very high tower, and if an intermediate tower were wanted, the depth of the Harbour would have to be taken very seriously into consideration. I think, however, that is a case where a ropeway could be made with sufficiently high towers at either end. The buckets could run from the railway terminus up fairly high towers, and be carried by one span right over to the island. It is fairly high above the water level, and large buckets could be run down on an easy grade to some point on the Harbour foreshore. However, these are matters more for the city engineers.

Mr. Poole referred to the clips slipping at North Mt. Lyell. I know a little bit about that, because I was in the office of a Scotch Company when the rope was being designed, and I also saw the reports. The North Mt. Lyell clips were on the saucer principle. They will only take grades of about one in three. I do not think there is any case in which they have gone more than that. In fact, I have had myself to take down a ropeway built on that principle, and re-erect a new ropeway.

Mr. Harricks asked some questions regarding the angles at which ropeways could be worked. All systems provide

for as many angle stations as may be required to get round any obstacle. In the single rope system, where an angle is put in, there is always a great deal of extra wear and tear on the rope, and that, if possible, should be guarded against. Ropeways can pretty well face any variation in altitude, and it is very rarely necessary to go round an angle, even of the smallest degree.

With regard to the Irvinebank Mine, the actual fall was something in the neighbourhood of 50ft. in the  $3\frac{1}{2}$  miles in favor of the load. In the case of the Kandos ropeway, also  $3\frac{1}{2}$  miles; that is 7 miles of rope—weighing something in the neighbourhood of 35 or 40 tons, the whole of that rope can be moved by a couple of men on a driving wheel. That proves that there is very little friction on the single rope system. Something like 600 pulleys must be moved, and there is a tension of about 5 tons on each rope—that is, 10 tons pulled on the terminal wheels; yet the whole thing can be moved, without the buckets, on just the weight of the rope—about 40 tons—by two men on the driving wheel on the countershaft.

I was asked about the average diameter of the terminal wheels. That, of course, is determined according to the capacity carried. In a ropeway of, say, 20 tons, the wheel would be about 7ft. 6in. diameter, and up to about 100 tons per hour it would rise to about 10ft., or, if it was going up to 15ft, the steel work and the trestle work and the frame work all through would have to be largely increased, and it would be a question, in undulating country, whether the ropeway could compete, in first cost, with a small railway.

That brings up the question of ropeway versus tramway on the sugar fields. Some of the sugar companies' representatives had seen ropeways working very successfully on the

tea plantations; but all the sugar fields in Queensland I saw were fairly flat. On a sugar field, the success in handling material is to be able to pick it up at various points all over the field. An aerial ropeway, under such conditions, if a great number of stations were installed, would become very costly; it would run, I can well imagine, to 50 per cent. at least more than the first cost of putting in a 2ft. gauge railway. The produce of the fields could be stacked at different points, and picked up by the railway, without the need of any type of station. The railways could be laid and run anywhere—whereas, with a ropeway, all the produce would have to be carried to one point, and that would add to the cost of handling.

On the question of the clip, I think it will be best explained by a rough sketch. (Mr. Mackie drew a rough sketch.)

I think I have now dealt with all the questions that have been put to me, and, in conclusion, I thank you, gentlemen, once again, for your kind attention

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