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THE SOUTHWEST AFRICAN RAILWAY.

By DR. ALFRED GRADENWITZ.

THE Otavi Railway is about 360 miles in length, and is probably the longest road of its kind in the German colonies. It was constructed by the Arthur Koppel Company for the transportation of copper ores from the Otavi mines to the harbor of Swakopmund. Lately, however, it has been opened to general traffic, and promises to improve greatly the economic conditions of the colony.

Great difficulty was experienced in securing the necessary workmen for the construction of the road. In fact, no sooner had actual work begun, than the Herero uprising of 1903 broke out and put a stop to the operations. Many of the native workmen left, and it became necessary for the German government to take those remaining into custody, so that in May, 1904, the contractors, fearing too great a delay in the completion of the work, decided to import 300 European laborers. In the meantime, the lack of a convenient railway system had been keenly felt by those in charge of the military operations. Transportation had to be carried out (by means of ox carts) under the most unfavorable conditions, and the volume of freight increased so rapidly that this primitive mode of conveyance soon proved

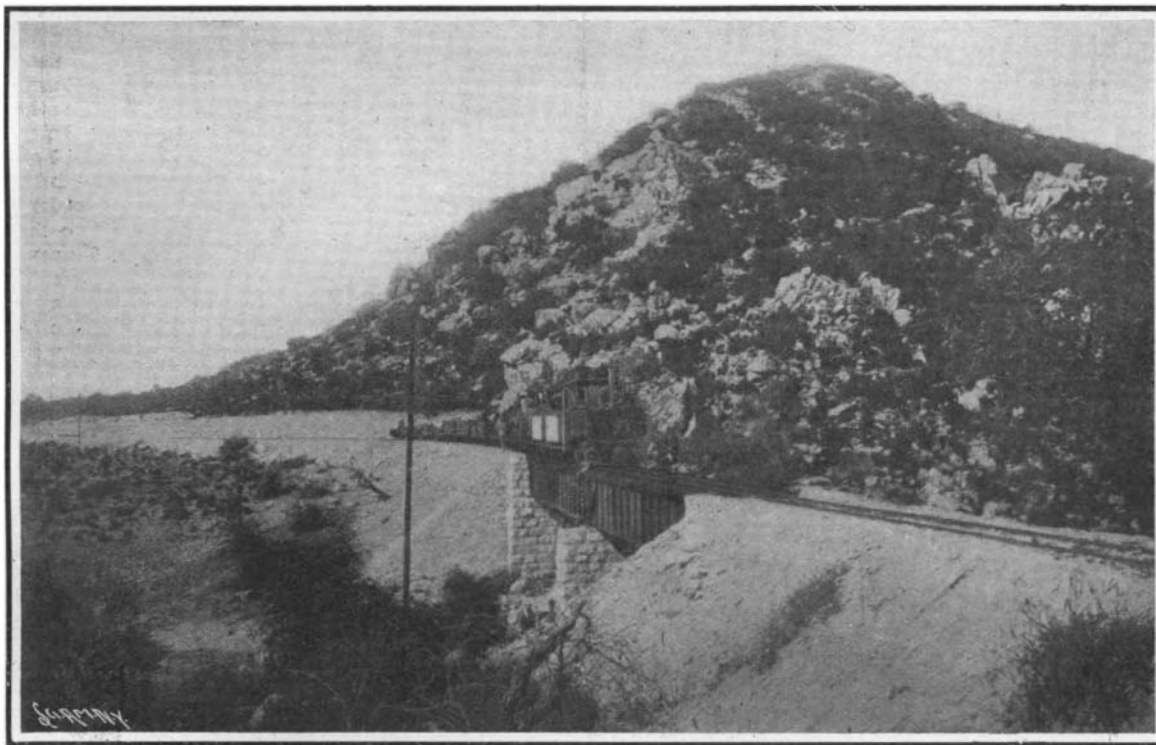
inadequate. Therefore, the government, besides requesting Messrs. Koppel to hasten the construction of the railroad, offered a premium for the completion of the road first, as far as Ouguati, 109.7 miles, thence to Karibib, 118.5 miles, and again from Ouguati to Omaruru. As a result, about 500 Orambos and 750 Italians were engaged by the company. The Italian workmen proved very unsatisfactory, availing themselves of the difficult conditions prevailing in the colony to make excessive demands upon the company and to organize

unceasing strikes. In the spring of 1905 conditions first began to improve, when, through the granting of premiums to the several construction gangs, the work was pushed forward with great rapidity. Furthermore, the contractors succeeded in inducing many Hereros to give themselves up and accept work on the railway. As the rumor of the excellent working conditions and treatment accorded the laborers spread among the remaining rebellious natives, many others offered themselves to the company as willing to work.

Strange as it may seem, these warlike natives proved not only to be excellent workers, but also better-natured and more docile than any other black men employed in railway construction.

The landing conditions in Swakopmund harbor further hindered the company in their work. The import of merchandise had greatly increased on account of the uprising, and the wharves, which at normal times were quite sufficient to handle the traffic, were found inadequate for unloading the vessels. A special pier, therefore, had to be constructed before the discharge of cargo could be performed with any regularity.

The Otavi railroad runs from Swakopmund practically parallel to the government railroad of Swakopmund-Windhuk as far as Roessing before it turns to the northwest. The ground rises from



THE EPAKO BRIDGE.

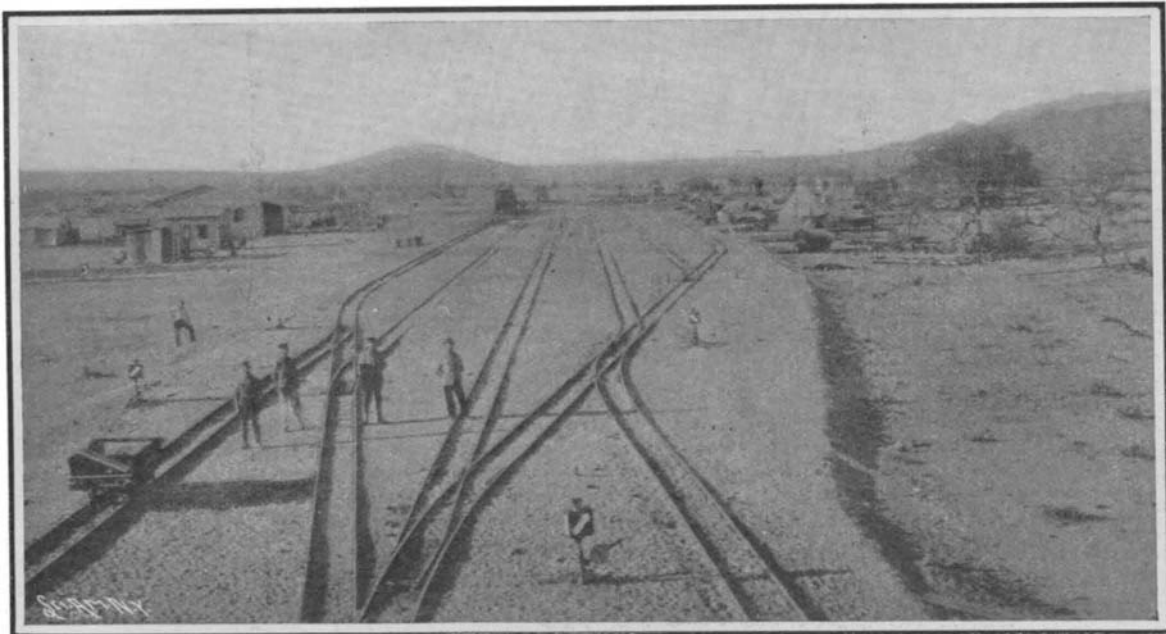


A ROCK CUT IN THE BANKS OF THE OMARURU.
THE SOUTHWEST AFRICAN RAILWAY.

Swakopmund, which is situated 49.2 feet above sea level, to a height of 5,217.9 feet at its highest point. The railway, as far as Omaruru, traverses a desert, passing first through the Namib and then through wide steppes covered with grass and bushes, where scarcely any water is to be found. It may be stated

The trains average between 9 and 16 miles an hour. Although these figures seem very low to us, we must remember that formerly the journey from Swakopmund to Omaruru took two to three weeks, while now it can be accomplished in less than a day.

The railway has been most beneficial to the colony,



USAKOS STATION.

that the borings later made, both by the government and Messrs. Koppel, at such places as had been designated by Herr von Uslar, with the aid of his divining rod, have given very satisfactory results.

The section of the road terminating at Omaruru was completed in September, 1905, after about two years' work, while the section Omaruru-Tsumed, which is about the same length, was completed within a year. The speed in construction in the latter case was largely due to the ample supply of workmen then available and the less difficult country to be crossed.

The track structure of the railway has a weight of 11.05 pounds for every 3.28 feet, it being composed of steel sleepers 4.5 inches in height and 3.3 pounds in weight. The rails are fixed to the sleepers by means of clips and clip-bolts, thirteen sleepers being contained in a rail-frame 29.52 feet in length. Therefore, the track structure of the Otavi railway is considerably heavier than that of the Swakopmund State road, though both are of the same gage.

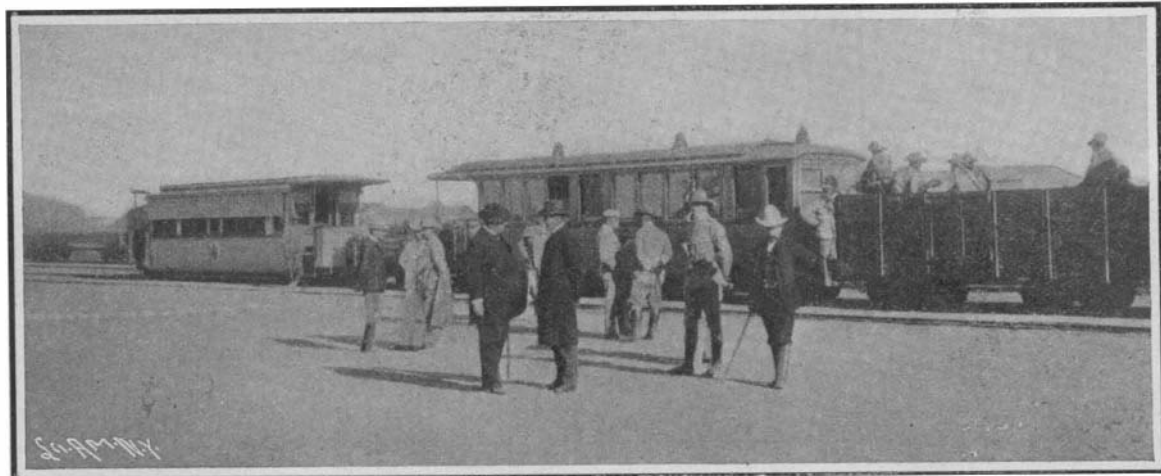
The Otavi railway uses 100 bridges, all of which are of iron, and it has 5 large stations and 42 smaller ones, situated at different points on the road. All the station buildings and employees' houses are built of corrugated sheet iron. A large repair shop has been installed at Usakos, while smaller shops are located at different points on the railway. The road owns in rolling stock 36 three-quarter coupled engines, 3 passenger cars, 1 inspector's car, 20 tenders, 190 flat cars of 10-ton capacity, 20 closed freight cars of 8-ton capacity, and 5 cattle cars. This illustrates the extensive use of the road for conveying merchandise of all kinds into the interior.

A monthly carrying capacity of 2,500 tons was proposed when the road was under construction, figuring that the Tsumed mines would be in full operation. This estimate, however, has been exceeded, to a great extent, although the operation of the mines has as yet not been started.

first by improving the economic conditions, as shown by the rapid development of villages situated in the neighborhood of the road, and secondly by assisting the military operations against the rebellious Hereros.

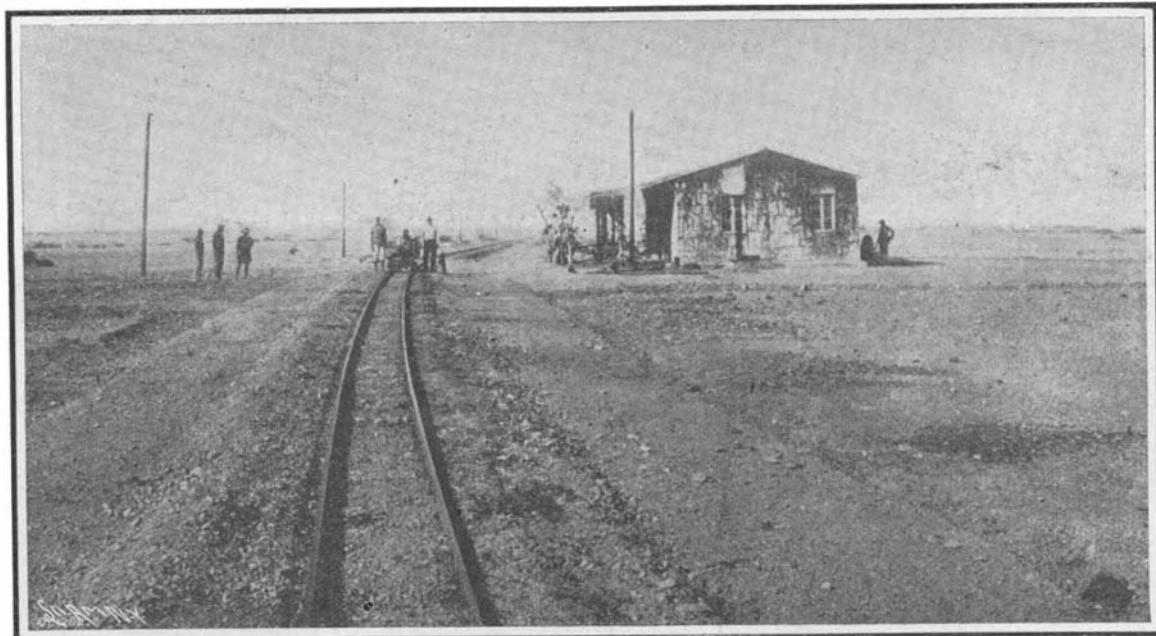
MARGIN FOR IMPROVEMENT OF THE STEAM ENGINE.

SCIENCE has been defined as classified knowledge, or



GOVERNOR VON LINDEQUIST LEAVING OMARURU.

facts arranged with reference to their relationship. Certain it is that no condition is more important for the study of any problem than the orderly arrangement of all facts bearing upon it, and their reference to such fundamental principles as may serve to bind them into a coherent whole. Nowhere, says the Engineering Record, is this more forcibly illustrated than in the



SIGNALMAN'S CABIN IN THE NAMIB.

THE SOUTHWEST AFRICAN RAILWAY.

In August 4,000 tons of government and private goods were carried, in September 6,500 tons, and in October 9,600 tons, and in addition to this a monthly average of 2,500 passengers. This capacity speaks excellently for a railway whose gage is only 600 millimeters (23.4 inches).

study of the conditions affecting the improvement of the steam engine, or more generally the steam power plant as a whole. During the past hundred years and more the steam engine has been made the subject of numberless modifications and improvements, all looking toward a higher measure of economy. It will be

of interest to consider briefly the more important of these various improvements with reference to the cycle of the steam engine, their relations individually to the problem, and the conditions imposed on each by reason of physical conditions beyond our immediate control. The entire cycle of the working substances in the steam engine includes the boiler feed-water heater, and condenser, as well as the steam cylinder, and this entire experience or cycle must be kept in mind in any study of the conditions for improved economy. In considering the cycle of the steam engine it is most convenient to start with some standard or ideal, and then to study the various possibilities of improvement under two heads—first, those which have reference to the improvement or lifting of the ideal; and second, those which have reference to the closer realization of the ideal, whatever it may be. Thus we may have a series of ideal cycles or sets of conditions for which the values of the efficiency may be 18, 20, 22, 24 per cent. It is obviously of importance to understand clearly the steps which shall enable us to improve this ideal from the lower to the higher values. Again, if we succeed in a final realization of only 70 per cent of our ideal, the actual values will be from 12.6 to 16.8 per cent, while if by improvement in the conditions the measure of realization could be lifted to 80 or 90 per cent, the final values would be correspondingly improved. For convenience we may call the first of these efficiencies the ideal or cycle efficiency, and the second the process efficiency. As the final value will be the product of these as practical factors, it is clear that it may be improved in either of two ways—by raising the ideal and keeping the process efficiency the same, or at least preventing a decrease of such amount as to offset the increase; or otherwise by raising the process efficiency while holding the ideal at a fixed value; or still otherwise by some combination of those which shall insure a net increase in the product of the two. In order to clearly grasp the distinction between these two factors of the final efficiency, the first or ideal efficiency must be carefully defined. This may be most conveniently done by defining the cycle to which it is assumed to relate. Any ideal cycle might, of course, be employed; but the one most commonly accepted by engineers when dealing with the

steam engine is the so-called Rankine cycle, which consists of the following items or steps: First, heating of the water in the boiler from the temperature of the condenser to that of boiling, and then vaporization at this temperature to the condition of dry and saturated steam; transfer to the cylinder of the engine without condensation or change of physical condition, and then expansion under adiabatic conditions down to the pressure and temperature of the condenser. Then condensation at fixed temperature and pressure back to the condition of liquid, and transfer to the boiler, thus completing the round. For such a cycle the efficiency may readily be shown to depend on the two limiting temperatures, that of boiling and of condensation, and, in general, to increase as the range between these two is increased. With this understanding it follows that the ideal efficiency is determined solely by the upper and lower temperatures of the cycle, while the degree to which we are able actually to realize these values gives the measure of the process efficiency. From this new point it will then be a simple manner to classify the various items which may enter into the problem of the improvement of steam engine efficiency, and to note the character of their limitations and what degree of improvement may be fairly expected of each. Thus the general advance in steam pressure means a continuous lift in the upper temperature and a corresponding improvement in the ideal efficiency. The limitations to improvement in this direction are found in the fact that as the pressure is increased there is an increasing tendency toward heat loss by radiation, and likewise the need of a constantly increasing ratio of expansion for the steam. If the conditions are not met there will be an increasing loss in the process efficiency, and thus in the end a loss in the one which may offset the gain in the other. Mechanical difficulties enter also, and having in view the various limitations in this direction, it does not seem likely that any very considerable further advances can be made in steam engine efficiency by increase in steam pressure alone. Again, any decrease in the lower temperature, such as a change from non-condensing to condensing, or any improvement in the degree of vacuum, means a dropping of the lower limit of the cycle