

of the crack indicates that there is still some compression in the columnar rock of the ridge, which will remain as an initial stress in the future, tending to restore the ridge to its original position.

Obviously, the ground under the power-house, and the structure itself, have also been subjected to very great stresses due to the movement of the ridge. The fact that the building nearly regained its old position shows that the foundation is uncrushed and well capable of taking its normal load. Also, it may be said that the various concrete structural elements have very well withstood the severe condition temporarily imposed upon them through the rock-movement.

#### REMEDIAL MEASURES.

If it were assumed that, at any time, any part of the ridge could break away from the adjoining country, leaving open cracks of some magnitude, it would be hardly possible to suggest any preventive measures, at a reasonable cost, which would remove the possibility of a recurrence of trouble similar to that which occurred on the 7th June, 1930. The remedial measures to be taken must, therefore, be focused on the necessity of preventing any such cracks from forming in the future.

It may safely be assumed that the block of country in which the crack has occurred was in stable equilibrium before the river was diverted into the headrace, so that any remedial measures should be directed to maintaining the hydrological conditions in the state in which they originally existed.

The question arises as to whether the presence of the existing crack has increased or lessened the possibility of future earth-movement. At the present time there is about the same amount of water draining into the headrace as would correspond with the hydrological conditions existing before the plant was built. The conditions of equilibrium of the block of country are, however, not the same. The crack has separated the country into two parts, removing whatever support existed between them prior to its development. Even if the crack is filled with concrete the conditions will still not be the same. Due to the elastic properties of the rock, tending to bring the ridge back to its original position, the ridge will be exerting a greater pressure against the country to the west than was formerly the case. This residual stress in the ridge will tend, of itself, to prevent the formation of similar cracks in the future. It might thus be said that the damage that occurred at Arapuni on the 7th June provided the means of giving the ground an additional stability to that existing when the works were first begun.

I have come to the conclusion that the hydrostatic pressure of the water on the bottom and sides of the headrace will not, in itself, cause a dangerous earth-movement, provided such remedial measures as are proposed below are carried out.

As regards the future, it is the forces brought into play due to the soakage of water into the ground that need the most careful consideration.

To those who share my conviction that the impounding of water in the headrace brought about an increased penetration of water into the rock, and that the effect of this, together with the elastic properties of the rock, has been the primary cause of the damage, it may seem logical to attempt to safeguard the stability of the ground in future by means of preventing as far as possible the absorption of water. There is, however, reason to believe that such measures, if carried out too extensively, might lead to serious trouble. This will be easily understood if one calls to mind the effect of changes of moisture on the appearance of clay surface. When a clay ground surface which was originally saturated with water becomes thoroughly dry, very extensive cracks are produced; in some cases fissures as much as 2 in. wide are produced within a few feet of one another. As is well known, this effect depends on the capillary and colloidal properties of a water-clay mixture. The water evaporates from deeper and deeper layers of the soil, and at the same time capillary forces cause water to be raised from the lower strata, causing thereby a contraction of the soil, of which the cracks give ample evidence. It is not suggested that the columnar rhyolite tuff has all the properties of a clay from the physical point of view, but the analogy may serve to make clearer the meaning I wish to convey.

Phenomena of a similar nature would, undoubtedly, occur if the ridge between the headrace and the river-gorge were, for instance, covered with an impermeable