No one appears to have considered the effect of oceanic precipitation in the middle geologic ages.

It is sufficient for this discussion to divide the earth's geologic history into three periods; the fluid age, the crust-steam age, and the crust-ocean age. During the crust-steam age the crust increased gradually from nothing at all to an effective thickness, including the layer of partial solidification, of several miles. During the larger part of this age, the water now forming the oceans was probably all in the atmosphere. The period of oceanic precipitation was probably quite extended on account of the heat liberated by condensation as well as the increased admission of solar radiation due to the clearing of the atmosphere.

At the time when liquid water began to exist in quantity, the cooling of the earth's crust had progressed far below the freezing-points of nearly all the materials of the crust, and the most plausible assumption is that the crust was of considerable thickness. It is also probable that the earth's surface was fairly level, the flatness depending upon the uniformity of distribution of rock materials of different densities.

Consider now the effect of superposing on this early crust a great quantity of material of low density, namely, the water of the oceans. Near the borders of the great oceans, we should then expect to find a severe outward thrust of crust comparable in mass to the mass of the ocean, but in volume less in inverse proportion to its density.

The isostatic conditions would further lead us to look for the accommodation to this displacement material farther inland, in a general continental elevation increasing toward and up to the border ranges.

This suggestion is put forward for what it may prove to be worth. Whatever may have been its consequences in detail, if the isostatic condition has been even approximately adhered to during the earth's history, the precipitation of the oceans must have had a profound effect on the elevation and depression of portions of the earth's crust. With more definite knowledge of the physical properties of geological materials it should be a mere mathematical problem to determine what those effects have been.

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Washington, D. C.,
September 12, 1911

MUSICAL ECHOES

The phenomenon of musical echoes has been known for a long time and has secured recognition in the text-books on sound. Thus we read:[1]

> Frequently, a sharp sound, such as the clapping of the hands or of two boards together, is reflected in a room or a corridor with smooth, parallel walls as a more or less musical sound. A similar effect is often observed when one is walking near palisading, each footstep of the observer being followed by a musical ring. The effect is only noted after some sudden sound, and may often be heard very distinctly on clapping the hands or on knocking two stones together.

The Greek Theater at the University of California presents a pronounced musical echo, the conditions being especially favorable to the production of the phenomenon. The seats are made up of a series of large concrete steps that are semicircular in shape and that rise regularly towards the back. If an observer generates a sharp sound in front of the stage at the center of the circles of steps the sound passes out symmetrically and strikes the steps in perpendicular planes and is reflected and diffracted back to the source of sound. The pulses of sound reflected from the successive steps follow each other regularly and thus set up a musical sound which is heard by the observer.

It occurred to the author that the pitch of the sound might be determined. The method of experiment was to generate a musical echo as already described and to compare the pitch of this sound with that of an adjustable turning fork. A check on the final result was found by calculating the pitch from the relation $n = v \div \lambda$ where n is the pitch of the sound, λ the wave-length and v the velocity of sound at the temperature of the theater. It is

[1] Poynting and Thomson, "Sound," pp. 31, 32.

to be noted that the wave-length is equal to *twice* the width of the steps (see Fig. 1). The advancing wave of sound xy strikes the first step and part of the wave is reflected. When xy reaches the second step, the sound from the first step has already traveled back a distance equal to the width of the steps. Therefore, the distance between the reflected pulses of sound—the wave-length—is equal to *twice* the width of the steps. It should be noted also that this phenomenon shows clearly the diffraction of sound. The fact that an observer can hear the separate pulses of sound at any point in front of the steps, indicates that the sound must spread out from each step as a center of disturbance.

The results of the observations follow. The observed pitch as determined by an adjustable Koenig fork was 226 vibrations a second. The pitch was calculated from the relation $n = v \div \lambda$ from the following data. The observed temperature was 22° C., hence the velocity of sound[2] was $v = 33{,}200 + 61 \times 22 = 34{,}542$ cm./sec. The width of the steps was 76 cm., hence $\lambda = 2 \times 76 = 152$ cm. Finally $n = 34{,}542 \div 152 = 227$ vibrations per second.

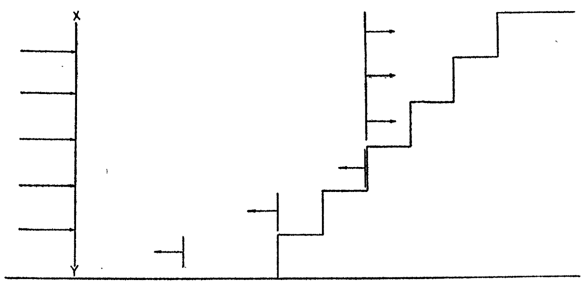

FIG. 1

The agreement between the observed and calculated values is closer than one would expect. The pitch of the fork was not corrected for temperature. Another source of error lies in the fact that the outgoing pulse of sound struck the steps at an angle rather than perpendicularly, so that the wave-length was somewhat greater than twice the width of the steps.

[2] Poynting and Thomson, "Sound," p. 21.

A second example of a musical echo was observed when a sharp sound was reflected from a set of bleachers on the athletic field at the University of Illinois. The pitch was determined, as in the former case, although the conditions were different and not so favorable. The bleachers were constructed of wood and were situated in a long straight row. If a rifle was shot off at some distance in front of the bleachers, an observer heard the reflected musical echo distinctly. The data taken follows. Temperature = 25° C., velocity of sound 34,725, width of steps = 73.5 cm., $n = 236$ vibrations per second. The pitch as observed by a tone variator was 235, although other observers nearer the bleachers obtained a value 241. The agreement between the calculated and observed pitches is as close as could be expected.

Aside from the novelty of the experiment, it is interesting to learn that the pitch of the echo is so definite. The notes given out in both cases cited is about a tone below middle C, hence where an observer expects a musical echo from steps about 30 inches wide, he can anticipate the result very nearly by first humming the expected tone.

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SOCIETIES AND ACADEMIES

AMERICAN MATHEMATICAL SOCIETY

THE eighteenth summer meeting of the American Mathematical Society was held at Vassar College on Tuesday and Wednesday, September 12–13, extending through two ses-