THE WATER SUPPLY OF HAVANA, CUBA.

UNTIL recent years the water supply of Havana came from the Almendares River. During the nineties the present water works, deriving the entire supply from large springs at Vento on the south bank of the Almendares Rivers, was completed. The Vento Springs and the covered aqueduct leading its waters under the Almendares River and into Havana are the pride of the city of Havana which has erected an imposing monument to the engineer by whom the work was conceived. The Vento Springs are surrounded by masonry walls sloping outward from the springs except on the side nearest the Almendares River, where they are vertical. The surface water running down the slopes of the masonry is caught in a gutter which discharges it into the Almendares. At the top of the masonry and some distance removed from its margin another gutter catches the surface water of the region sloping toward the springs and discharges this also into the Almendares. The water flows direct from the spring into the covered aqueduct. The provisions for maintaining the water in its original purity from the time it issues from the ground till it is discharged, either into the reservoirs near the city or direct from the faucets in the city, are ideal.

There has been some speculation as to the origin of the water issuing from the spring at Vento. The water is beautifully clear and rather warm, having a temperature of 26° C. at the time of our visit. The Almendares River, flowing but a few feet away, also has clear water except after heavy rains, and its water at the time of our visit was slightly colder than that of the springs. It is possible that the Vento Springs derive their water from the upper courses of the Almendares, though this is so highly improbable that the suggestion may be left out of consideration. The springs being situated on the south side of the lower course of the Almendares, the region across the river—that is the region north of the river—may be excluded as a possible contributing source of the supply of the Vento Springs. The region about the springs is composed of coralline rock. In such porous material conditions under which territory on one side of a river may contribute to springs located on the opposite side of a river are impossible.

The most probable origin of the Vento water supply can best be understood after a general statement of the conditions of the surrounding region.

The southern slope of the provinces Guanajai, Havana and Matanzas is largely drained by underground streams. The streams arising in the hills and mountains, forming the watershed between north and south drainage, run above ground for a distance and then disappear underground. The Ariguanabo River thus runs into a bank at San Antonio de los Baños and disappears among fallen rocks. A few yards away from its 'sumidero' the water can be seen running in its underground channel through an opening in the thin roof of the channel. A few yards further on a dry cave leads down to the water, which at the end of the dry cave disappears among fallen rocks. Other rivers disappear in a similar manner. They can not be followed in their underground courses because they completely fill them. The underground waters and the channels in which they run can, however, be reached in places through sink-holes. The streams reappear, in part, at least, in a number of 'ojos de agua,' some near the coast south of San Antonio. The region drained by underground streams is comparatively flat, with frequently no indications of surface streams and their erosion, and extends westward to near San Cristobal where the first permanent surface stream is observed. At Artemisa and Candelaria stream beds contained pools of water in March, 1902.

From San Cristobal to Pinar del Rio there are many small perennial streams. Eastward from San Cristobal the cave region has an unknown extent. Poey limited it to the jurisdiction of Guanajay, but it certainly extends as far east as the meridian of Matanzas and from reports probably beyond Cienfuegos. East of Rincon there are, however, frequent river beds, all but one of which were dry during the time of our visit. This main cave region belonging to the southern slope

sends a tongue northward from Rincon to the Vento on the Almendares River in the northern watershed. Aside from the 'Ojos de agua' along the edge of the cienegas skirting the southern coast there are two notable places where underground rivers find an exit; the one at Vento, as already mentioned, supplies the entire city of Havana with its water, the other serves to make the region about Guines a garden, its waters being used for irrigation. Other subterranean rivers in all probability have a subaqueous exit to the south.

The large spring at Vento is the only one on the northern slope as far as I know. The exact origin of the supply issuing from the Vento Spring has not been traced. But the region north of the Almendares River, being shut out from a possible contributing source, it undoubtedly derives its water from the tongue of the system of underground streams thrust into the northern slope. An examination of the best available map and the levels of the Western and United Havana Railroads makes it seem quite certain that the Vento Springs derive their water from the region immediately south of Vento and north of Rincon and Bejucal. This region contains various sinks without surface outlets, as well as dry sink-holes. A notable sink-hole in this region is that at Aquada on the United Havana Railroad. This is very broad, shallow and dry during the dry season but the water rises to stand over ten feet deep on the railroad track during some of the wet seasons. All of these probably drain into the Vento Springs.

It behooves the health authorities of the city of Havana to exercise the strictest guard over the region between Vento on the north and Rincon and Bejucal on the south. Any contamination of sink-holes in these regions is sure, during the wet season at least, to contaminate the underground streams leading to Vento. An examination of the underground channels in the Lost River region of Indiana has shown the main underground channels to be provided with numerous smaller tributary channels which in ordinary weather do not carry water, but which do carry water into the main stream after a long rain. At such a time any filth that may have accumulated in any of the sink-holes over one of the tributary streams is sure to find its way into the main stream. The same is very probably true of the Vento supply, although on account of the nature of the region it is not possible to follow the underground channels. At present some of the sink-holes between Rincon and Vento are used as cess-pools and receivers of sewage.

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NOTES ON PHYSICS.

GROUP AND WAVE VELOCITY.

The question was raised at the Pittsburg meeting of the American Association, in a private discussion of Professor Brace's scholarly vice-presidential address, as to the physical distinction between wave and group velocity of light. Undoubtedly the best physical discussion of this matter is to be found in the remarkable chapter on plane electromagnetic waves in Chapter IV., Vol. I., of Heaviside's 'Electromagnetic Theory,' especially in his discussion of the generation of tails. A simple conception of the distinction between wave and group velocity is as follows: Imagine a stretched rubber tube with a series of equidistant weights suspended from the tube by helical springs and imagine a train of say one hundred equidistant similar waves to be started along this tube. The head of this wave train, as it runs out at full speed (wave speed) upon the previously stationary portion of the stretched tube, exerts upon each element of the tube a series of periodic forces, and because of the suspended weights these periodic forces require some perceptible time, ten or fifteen cycles, say, to establish the full oscillatory motion corresponding to the full amplitude of the wave train. Therefore, although the head of the wave train runs out on the tube at full speed, there is a gradual rise in amplitude from the extreme head backwards towards the middle of the train. Furthermore, as the main portion of the wave train leaves a portion of the tube this portion of the tube persists for an appreciable time in oscillations of diminish-