ART. XLI.—*Gases in Kilauea;* by WILLIAM LIBBEY, JR., Professor of Physical Geography, Princeton, N. J.

IN 1865 Mr. W. T. Brigham called attention to the existence of certain bluish-green flames which broke from the crust of Halemaumau during a disturbance of its slag-like surface.

In 1887 Mr. Emerson of the Geological Survey of the Islands and several others identified these same flames. They are referred to in Prof. Dana's book upon "The characteristics of Volcanoes" (p. 119) as being pale in color and of a slightly greenish color rather than bluish. This corresponds with my own observations. In order to test this matter I took with me upon my recent visit to the volcano (Sept. 14th to 25th, 1893) a pocket spectroscope. I did not imagine that I should have such a splendid opportunity or I should have taken a better instrument; however the little spectroscope did good service and the observations may possibly lead to something better later on.

I spent the greater part of three evenings down on the edge of the boiling cauldron in Halemaumau and the observations I made were repeated many times so that I have every confidence in them. As to the conditions I may say that they were exceptionally favorable. The surface of the molten lava was so high during the whole of our visit that it could be reached with an ordinary walking stick. The volcano seemed to be in a very active state as several overflows occurred, and the ebullition from what appeared to be three centers of weakness or disturbance were very remarkable. The lava was thrown into the air for a distance of 40 to 50 feet and as we could approach

* Barus: Phil. Mag., xxxiv, p. 376, 1892.
† Kulik: Theorie und Tafeln der Kettenlinie, Prag, 1832.

these fountains quite closely in two instances, we could form very good estimates of their size and the amount of lava involved in such an outbreak. The surface for a considerable area near one of these centers (for they seemed very constant in position) would sway up and down, at first gently and then more violently, particularly in the neighborhood of the intersection of the fissures which were constantly forming in the crust of slag, then there would be two or three small explosions accompanied by a bumping sound, as though gas had escaped from the mouth of an uncorked bottle; after this there would be a great rush of lava into the air, to be repeated several times; when the surface would become quiet once more.

At the edge of this cauldron, 1000 feet in diameter, I placed myself after dark and for a couple of hours in each instance had opportunities nearly every five minutes to observe the flames which almost invariably accompanied these explosions. At times they would make their appearance along the fissures, in the crust when they would be very short lived; and I failed to get much information concerning them, aside from the fact that they seemed the exact counterpart of the hydrogen flame from a Bunsen burner.

It was the study of the flames which accompanied the larger outbreaks which appeared to promise most return. Getting as near as possible to one of the giant fountains (probably 50 yards distant) I watched for the premonitory symptoms of an outbreak and got all ready for it, and seldom failed to catch indications of the presence of gases.

For a good part of the time there was a continuous spectrum while the spectroscope was directed across the lava. The first thing that impressed me was the sudden appearance and disappearance of broad *bands* of bright light, showing conclusively the presence of gas burning under high pressure. The location of these bands became the next problem and then I longed for a better instrument with a micrometer eyepiece. The first which appeared with constancy was a band in the green, indicating the presence of carbonic oxide in all probability. Then I found on other occasions bands of lighter intensity in the red and blue, and the red and purple portions of the spectrum, thus apparently marking the presence of the hydro-carbons. There were also occasionally noticed upon a full spectrum a large series of dark lines in the yellow and orange, sometimes completely blotting these colors out of the spectrum altogether. These need more careful study before assigning them definitely to any substance or substances.

It is hoped that the above may serve to indicate a point upon which valuable work can be done and that some one will take advantage of it and follow the subject up.