located, and the saturated brine thus formed filled all interstices in the adjoining salt-body. By the leaching of such solutions into each deeper level opened in the mine, a line of maximum activity of circulation was gradually formed, which was followed also by solutions not yet saturated, with additional leaching, and the final creation of open channels as the result.

An example on a large scale of such a channel in rock-salt, created, however, without the aid of mining operations, was recently described by H. Winklehner, who found, among other striking phenomena of lixiviation in the rock-salt of the islands of the Persian Gulf, a horizontal natural channel or adit on the Island of Larak, which he was able to follow for about one mile. It expanded in places to caverns 39ft. high, without ever extending outside of the salt.

In precisely the same way were formed the channels in other less soluble rocks, such as limestone, when, the level of the entrance being above that of the exit of the ground-water, a line of maximum activity of circulation was established between the two points. This line, and the cavities developed along it, would not, indeed, always have the regular parabolic course, but would be dependent upon various influences of the stratification, the presence of rocks of unequal solubility, or even an intermixture of impermeable rocks. A mass of the latter, occurring on the line connecting the two points named, might cause the channel to bend up and down, or even in places to assume an upward inclination.

Figs. 2 and 3 illustrate these conditions. S is the soluble, I the impermeable rock; *a*, the entrance-point and *z* the outlet-point of the ground-water; *a b c z*, the line along which approximately a channel might be made, if the impermeable rock were not present. In its presence, the dissolving current must take another road, *a d z*, following more or less the contact between S and I, and in Fig. 2, descending to a depth proportioned to the relation between the original rock-interstices and the hydrostatic head, while in Fig. 3 it first surmounts the dam formed by the impermeable rock, and then plunges towards the outlet *z*. We see that in this way various channels may originate at the contact of permeable and impermeable rocks, as indeed we find them often in nature.

But when to these factors fissures are added, the conditions are essentially changed, for the circulation follows in preference the open fissures, and, if they pass through soluble rocks, enlarges them by solution.

Sometimes the position and the level of the outlet are altered—as, for instance, in the progressive erosion of valleys; and it may then easily happen that the new channel, representing the new conditions, will take a totally different direction, crossing the line of the old one.

Siphon-action is to be observed in soluble much more frequently than in permeable rocks, as the frequency of intermittent springs in limestone indicates. Such springs presuppose the existence of a siphon-like channel, through which the ground-water cannot flow to escape from the lower leg until the water-level has risen to the top of the bend of the siphon.

We have seen that the ground-water may traverse deep fissures leading to soluble or permeable rocks, and may follow such rocks for considerable distances. When the ground-water, warmed in depth, has an opportunity to reach the surface, such as is given in Fig. 6 by the difference, H, in level, a thermal spring is the result—a so-called *acrotherm*, if its water is not highly charged with minerals, and not unlike the ground-water of the place.

Artesian wells present an analogous case, also explained hitherto by the principle of hydrostatic pressure (see Fig. 7). The outcrop of the permeable layer has been assumed to be necessarily higher than the mouth of the well, in order to account for the rising of the water above the latter level. The cause has been conceived as the operation of communicating pipes, the drill-hole being one leg, and the permeable layer the other; and it has been overlooked that the latter is no open pipe, but a congeries of rock-interstices, in which the water has to overcome a great resistance, and that, perhaps, in level regions no hydrostatic head at all can be demonstrated. Certainly the powerful factor of the higher temperature, and in some cases the gaseous contents, of the ascending water were omitted from the calculation.

It would be a matter of surprise to me if the purely hydrostatic and strictly mathematical views heretofore current on this subject had not led to disappointment. In Fig. 7, the conventional diagram of an artesian well is introduced, for the purpose of stimulating further thought on the matter.

The Filling of the Open Spaces formed by the Vadose Circulation.—This is very important genetically, since it is a matter subject to current and direct observation, and capable of furnishing many conclusions applicable to inaccessible subterranean occurrences.

We can observe spaces on the bottom of which, frequently, the ground-water which excavated them is still flowing, and which are therefore filled for the most part with air. Liquids carrying various minerals drip into these spaces and leave a part of their contents on the walls; the cause of deposition being, on the one hand, the evaporation of a part of the liquid, or, on the other hand, such changes as the loss of carbonic acid precipitating as carbonate the soluble bicarbonate of lime; the oxidation of soluble ferrous to insoluble ferric oxide; the reduction of ferrous sulphate by organic matter to sulphide, &c. The form and structure of these precipitates vary at different parts of the walls. On the roof occur the *stalactites*, and on the floor (if it be not covered with water) the corresponding *stalagmites*. The wall-deposits have characteristic forms likewise; so that we can recognise by the appearance of any piece of the deposited mineral the place where it was formed. But from water covering the bottom of the cavity only horizontal deposits can originate. Sometimes the cavity is contracted, so that its whole cross-section is occupied by the liquid. If it is accessible to observation, we can then see that the deposits from the circulating liquid cover the walls uniformly.

This can be much more clearly observed in artificial conduits, where precipitation occurs. We find, for instance, in the pipes which convey concentrated brine the walls uniformly covered with a deposit, mostly of gypsum. But if air or gas is admitted into the pipes the deposit occurs only at