extent of the fissures, which, being usually of small size, will have steeper gradients than those which we usually associate with open channels. The surface of saturation is not level; it bears no relation to the surface of the ground, but inclines towards the outlets for percolation water, and it coincides with free water surfaces. Its position is not fixed, but is slowly altered by discharge and supply; and should supply disturb the hydraulic gradients throughout the surface of saturation, there is a natural tendency to settlement to some position which corresponds throughout with a particular discharge rate.

The conclusions are that where part of the rainfall can percolate to the deeper subsoil, a surface of saturation is formed in the fissure and interstices of the rocks, and that there is a rate of percolation discharge corresponding to each position of the surface of saturation, and such conditions will generally obtain. Where clay immediately underlies the surface soil, discharge conditions are perhaps slightly different, but the author has not had an opportunity of investigating such a case.

Subsoil Storage Reservoirs

The conditions of storage of percolation water may not always be the same as those mentioned, for it is quite possible there are what might be termed natural subsoil, but leaking storage reservoirs, the discharge from which might be considered as from a reservoir outlet pipe. In such a case hydraulic laws would apply, and the discharge would have its related "head" and its hydraulic gradient. The author has evidence in two cases of excavations which pointed to the existence of leaking subsoil storage reservoirs. In one of these cases the volume of water was large, and the annual variation of water level small, sufficient to show that if leakage did occur it could have been continued for at least a year of absolute drought.

In considering how the available quantity of percolation water might be approximately determined from percolation discharge, it will materially assist if we first consider conditions affecting the discharge from a tank. The discharge rate or flow curve from a pipe outlet from an irregularly shaped tank would be of some such form as shown by the firm line E'F in Fig. 3, the rate of discharge at any time being represented by an ordinate of the diagram at that time; thus E'E represents the rate of discharge at the time E. Having the whole diagram, the total discharge is measurable; the total discharge represents the "storage capacity" of the tank, which is thus determined by means of the flow curve alone. Let us call this curve (E'F) the basic curve, and note that any rate of discharge denotes a related position of the water level in the tank, and some corresponding amount of storage. It is quite obvious that if the tank were again filled, the basic curve would be reproduced; and if the rate of discharge at a given time be ascertained, the subsequent rates of flow, or the total available flow, can be foretold from the basic curve, no actual observations of the water levels in the tank being necessary. When a fresh supply of water is poured into the tank, it results in a corresponding alteration in the flow curve, which repeats some part of the basic curve after the supply is stopped, and by means of the basic curve the amount of supply can be determined.

Hydraulic Similarity

This case is illustrated by the dotted line in Fig. 3, which shows the effect of a fresh supply. After the supply has been stopped, the flow curve GH is a repetition of a part of the basic curve. The rate DG being the same as EE' at some point on the basic curve, the curve GH is the same as the curve E'F. It is obvious that the amount of the fresh supply has caused the increase of flow shown by the shaded portion of the diagram, and the difference between the total discharges as shown by the curves C'GH and C'F obviously shows the total amount of the fresh supply. The latter is also measurable in another way; the ordinates EE' and DG are equal, and show that the quantity of water in the tank at the times E and D was the same; hence the total discharge between the times E and D as shown by the curve E'C'G was the net gain, or the amount of fresh supply. Similarly, by locating the time J when the ordinate JJ' is equal to CC', the total discharge between the times C and J, shown by the curve C'GJ', is also equal to the fresh supply. The last mentioned is the method which appears most convenient for ascertaining the amount of gains accruing from rainfalls.

It must be borne in mind that it is a short method of measuring total gain, which, as shown by the shaded portion in Fig. 3, causes an increase of flow over a considerably longer period than that denoted by the time CJ. The aggregate percolation discharge from a drainage area is really a number of discharges from different ill-defined and overlapping areas, and may be likened to that from a series of tanks having various rates of discharge and various rates of supply, making it doubtful whether the principles would hold good; yet the average rate of supply to each tank governs the rates of discharge to a considerable extent; thus, when supplies are small low discharges prevail, and the converse of this also holds good.

The supply to percolation storage is "available rainfall," the governing influence of which is best illutrated by the fact that streams and rivers throughout the country show lowest flows at about the same times. It is now proposed to apply the above-mentioned principles, which are based upon well-known hydraulic laws, to percolation discharge, which is believed or assumed to be subject to the same laws, and should tests indicate agreement, it might reasonably be presumed that the assumption is correct.

Basic Curve of Percolation Discharge

Let us now suppose that after a period of considerable percolation the natural storage of percolation water is as great as it can be, that the stored water receives no further supply, but is exhausted by discharge. The flow curve obtained during this period, hereafter called the "basic curve of percolation discharge," would be a parallel to the basic curve of the hypothetical tank discharge; and whenever similar conditions obtain, some parts of the basic curve should be reproduced between times of fresh supplies. Let us now test the actual stream flow curve to see whether or not it does behave in this manner; for if it does, we might, from these reproduced parts, construct a considerable length of the basic curve. The method of testing is as follows: Reproduce on a diagram the flow curve shown during an absolute drought in which the lowest flow is measured, as AB in Fig. 4. (The curve in that figure is shown by a series of dots for the sake of clearness.) Reproduce a second drought flow curve in which the second lowest flow is measured, as CD, so that the ordinate showing the second lowest rate coincides with the ordinate of the first curve showing the same rate. Then, if the principles apply, a length of the second curve will coincide with a length of the first, and the coinciding portions show a length of the basic curve. Similarly, other drought or rainless period lengths of the stream flow curve can be reproduced until the greatest available length of basic curve is obtained. It is recommended that a tracing of the basic curve be then applied throughout the stream flow to test whether the flow curve in all rainless periods reproduces a part of it. The author tested in this manner the basic curve as shown by EF in Fig. 4, and found that the discrepancies were so slight that they may have been due to variations of evaporation from the stream surface. For accuracy, fine readings are necessary, particularly where the flow curve is almost flat, but in two cases the author obtained basic curves where only rough daily gaugings were given, and these showed agreement with actual flow in rainless periods as nearly as it was possible to ascertain. The stepped curve of daily gaugings was replaced by one passing through the middle points of the horizontal portions. The basic curve as shown by EF in Fig. 4 agreed with the stream flow curve from three to five days after rainfall had ceased; towards the end of this period the difference between the two was slight, but such as to shorten the times at which the basic curve was applicable; and this period was in another case apparently from four to as much as ten days, and in each case varied as the yield from rainfall was smaller or larger.

It will be obvious that the basic curve of percolation discharge is not capable of application at times when there is both surface run-off and percolation discharge, and that