than two centuries ago was of this type, as are also to be all the units of the Miami system.

The Spillway: Definition and Description

In its ordinary use the spillway is a device for conveying, over or through the crest of a dam, the surplus inflow from above in such a way as not to endanger the integrity of the dam. Its purpose is negative rather than positive. It plays no active part in the dynamic functions of the dam, as a penstock and other appurtenances do, but simply stands guard to see that the dam shall not be wrecked by any inflow in excess of that which its purpose of utility requires.

The successful operation of the spillway requires that it satisfy three vital conditions. It must have sufficient capacity to prevent overflow of the dam, because such overflow is always dangerous, and, in the case of earthen dams, fatal unless promptly checked. The spillway must have sufficient structural resistance to withstand the tremendous strain of deep overflow. Means must also be provided at the point where the overflow strikes the level of the stream below to neutralize the energy developed in its fall without danger of undermining the dam. Inadequate satisfaction of these conditions is more common than the engineering profession likes to admit, and Professor Mead very properly says that "perhaps there has been no more frequent cause of the failure of dams than inadequate spillways."

Inasmuch as the spillway requires a certain depth of overflow to be effective, and as it sometimes happens that the resulting elevation of water surface above the dam may be objectionable, the escape of water in such cases may be accelerated by the use of sluiceways, movable gates, flash-boards, and similar devices, all of which are under direct control. These serve the primary purpose of the spillway in facilitating the escape of surplus water, but lack the automatic character which is a distinctive feature of the true spillway.

The writer has defined the spillway, in the common acceptation of the term, as a safety device pure and simple. In the following discussion he will treat of it under a somewhat broader conception—one based not at all, or at least only incidentally, on the negative consideration of safety, but on positive considerations of utility. It will fulfil a vital function in the purpose of the dam as an agency of flood control, and will be a direct means of extending the application of the detention principle to cases heretofore considered of doubtful feasibility.

Elements of Control

As a preliminary to this section, it may be observed that the combined function of dam and spillway which denotes the true detention principle is universally exemplified in nature. In almost infinite combination its elements of control may be found in actual operation. Every lake or pond which has an outlet is a case in point.

It is manifest that the moderating effect of detention reservoirs, whether natural or artificial, is the combined result of three co-operating factors, two of which are, or may be made, subject to artificial control, but the third is not. These are the storage capacity of the reservoir per unit depth at any level, the spillway capacity per unit length, and the duration of the flood wave. In perfectly general terms, this moderating effect increases with the area of the reservoir and diminishes as the length of the spillway, or the duration of the freshet, increases; but these variations in result never follow in exact ratio the variations in the factors which produce them. In some conditions the correspondence is close, in others it is widely divergent.

Assume first fixed conditions as to spillway length, and as to duration and volume of flood wave or inflow into the reservoir. The moderating effect of the reservoir would increase with an increase of area, but, as a rule, in slightly greater ratio. For example, with an area in one case twice as great as in another, the same quantity of storage would raise the larger surface half as much as it would the smaller, if the outflow in both cases was the same; but the outflow would not be the same. The flow over a spillway increases in faster ratio than the depth—generally much faster—and to cut off half the depth from the top would reduce the outflow by more than half. This is slightly compensated, however, in increased storage and elevation of surface due to restricted outflow; but, unless the spillway is relatively large, this effect would be small, and the reduction of outflow would remain more than half.

With fixed conditions as to area, volume, and duration of flood wave, the regulative effect will diminish with an increase in length of spillway, but in somewhat less ratio, because the greater outflow will diminish the height to which the reservoir surface will rise and consequently the outflow per unit length of spillway. Thus, if the spillway were doubled in length, the outflow, with fixed conditions as to the other factors, would be something less than doubled.

Much more difficult to follow than either of the foregoing cases is the effect of variations in the time factor, or the duration of inflow into the reservoir. It can only be stated, as a general proposition, that the regulative effect on the flood wave of given volume is greater as its duration is less; but there are so many qualifying conditions—as, for example, the relative size of spillway and the distribution of inflow during the freshet period—that no conclusion of general applicability seems possible.

Indeed, the whole problem of the inter-relation of these several factors seems to be too complicated to be expressed in any general formula which will embrace them all, and it seems destined to remain simply a problem in "particular cases"—the making of specific assumptions, and the determination of each group by itself. That is what would be done in practice anyway, but it would be a satisfaction, nevertheless, to have a general formula.

Prevalence of the Reservoir Idea

In passing from the general principles just discussed to their specific application, it may be stated at the outset that there is a deep-seated belief in the lay mind, and to a less extent in the mind of the expert, that in reservoirs is to be found the solution of the flood problem. As the writer stated some twenty years ago: "To store the surplus water in the flood season and use it in the season of drought ought, apparently, to strike at the root of the whole difficulty. * * * Why so obvious a remedy has never yet been extensively applied," the writer at that time traced to a prohibitory disproportion between cost and resulting benefits. Although this is true, as a broad generalization, it will be more useful to the student of these questions to give some of the specific details on which the generalization rests. They may be summarized briefly as follows:

Deficiency of Sites.—This sometimes arises from an actual absence of physical sites, but more often from the lack of those which are economically feasible. Along the main valleys of the lower Ohio, Missouri and Mississippi there are no sites whatever into which the main streams