indeed, much more frequently sought than obtained. The language is plain, and the geometrical illustrations are numerous and good. The serious faults of the book are sins of omission. We look in vain for the customary chapter on the change of the independent variable, and we find a strange limitation in the treatment of the important subject, 'maxima and minima.' The author here contents himself with the discussion of functions of a single variable. The use of symbolic methods, involving the extension of the mathematical laws for the combination of quantity to the symbols of operation, is necessary in the modern differential calculus. In this work the principle introduced is explained in an excellent manner, but a fuller exemplification of its legitimate outgrowth is desirable. More illustrations should be given, especially of the symbolic method of extending Taylor's formula to several variables. The chief strength of the book lies in the chapters relating to the theory of plane curves. In not a few cases we find greater detail and thoroughness than in the corresponding chapters of its predecessors. On the whole, while no decided novelty of treatment is shown to those acquainted with the best works hitherto published, the production is a creditable, useful treatise, without other faults than those mentioned above.

THOMAS S. FISKE.

THE ALKALI LANDS OF CALIFORNIA.

THE term 'alkali soil' is used in California, and the western states generally, to denote any soil which contains an unusual amount of soluble salts, particularly when they render their presence manifest by an efflorescence on the surface. These salts may be simply an excessive amount of the neutral salts found in minute amounts in all soils, or, in those soils more properly designated as alkaline, they may consist in part of carbonate of soda.

By the natural processes of evaporation at the surface and capillary rise from below, these salts tend to accumulate near or at the surface, thus producing the efflorescence above noted, and also destroying or injuring the crop by their corrosive action on the root-crown.

In the actually alkaline soils, i.e., in those containing carbonate of soda, another injurious effect is also observed. The alkali prevents what is known as the 'flocculation' of the clay contained in the soil; that is, it keeps in the finely divided condition seen in 'puddled' clay. Such a soil can never be brought into proper tilth; even the most thorough cultivation only succeeds in breaking it up into larger or smaller clods, and leaves it in a condition entirely unsuited for the growth of crops.

These alkali soils are somewhat abundant in California, notably in the otherwise extremely fertile San Joaquin valley; and the characteristics outlined above have been tolerably familiar for years. It was not, however, until it was discovered that the process of irrigation, so essential in the dry climate of that region, was serving to extend the area of these alkali soils, and even developing them where they did not exist before, that the magnitude of the problem which they present was generally appreciated.

The pamphlet under review is a summary of investigations carried out at different times at the College of agriculture of the University of California, and in connection with the U. S. census of 1880 by Prof. E. W. Hilgard, than whom there is probably no one more eminently qualified to deal with the question scientifically and practically.

According to Professor Hilgard, the immediate source of the alkali is usually to be found in the soil-water, though it would appear, that, in some cases at least, the lower strata of the soil itself may contain either these salts or compounds which readily yield them by weathering. When reached by digging, the soil-water is not necessarily perceptibly salty or alkaline; but as it evaporates at the surface, and is supplied from below, the soluble salts are concentrated in a very shallow layer at the surface, the solution becoming strong enough to kill crops, or even depositing the solid 'alkali.'

It is thus evident that the most important factor in determining the amount of alkali which accumulates at or near the surface of the soil is the amount of soil-water brought up from below by capillary action and evaporated; and any thing which increases the evaporation will tend to increase the amount of 'alkali' deposited, and to make its presence perceptible in spots where before it was not present, or present in such minute amounts as to produce no harmful effects. This, irrigation, as ordinarily practised, does. If the irrigation-water is used somewhat sparingly, so that it all finally evaporates from the surface, two effects follow: first, the greater amount of water passing first downward, and then upward through the upper strata of the soil, tends to exhaust it more thoroughly of its alkali, concentrating all of it at the surface; second, by irrigation the soil is moistened to a greater depth than it was by the rainfall only, and thus a greater amount

Alkali lands, irrigation, and drainage in their mutual relations. By E. W. HILGARD. Sacramento, State. 8°.

of soil is exposed to this leaching action, and more alkali put in circulation, particularly if these lower strata are rich in alkali or materials yielding it.

If, on the other hand, the water is used lavishly but without proper provisions for drainage, evil effects are produced in a somewhat different way. In this case the level of the hydrostatic water of the soil (its water-table) is brought nearer the surface. The water has a less distance to rise by capillary action, hence rises more abundantly and for a longer time, and an accumulation of alkali is brought about. In one or other of these ways is brought about the phenomenon well described in local nomenclature as the 'rise of the alkali,' — a thing which is threatening most serious injury to the irrigated lands of the San Joaquin valley.

All these and other points are brought out most plainly in detail in the report before us. One interesting point deserves special mention. Analysis shows that the alkali of these soils is in many cases rich in plant-food, often containing phosphates and potash salts in practically inexhaustible quantities, and not infrequently considerable amounts of nitrates; and that, if its excessive accumulation can be prevented, the soils containing it will prove extremely fertile.

The question of remedies is fully considered. When irrigation is practised, the prime condition of success is a thorough system of drainage, combined with an occasional flooding with a large quantity of water, in order to wash out the soluble alkali into the drainage in case the rains of the rainy season do not accomplish this sufficiently. Drainage may, further, so lower the water-table as to greatly diminish the amount of water rising through the soil, while the roots of plants can readily penetrate to considerable depths for a supply of water. The author is very emphatic in his statements that irrigation without provision for drainage is suicidal.

Second in importance to drainage, is thorough cultivation of the surface in order to diminish evaporation. Mulching has a similar effect. This necessitates, however, the cultivation of crops admitting of tillage. Hitherto wheat has been the staple crop of the region under discussion, regarding which Professor Hilgard remarks that "it would really seem as if, in the broadcast culture of cereals, the farmers in the alkali districts had made the worst possible selection for the permanent good of agriculture in their region." As crops suited for alkali soils, he suggests alfalfa (a deep-rooting crop, which shades the ground and thus diminishes very largely surface-evaporation) for a forage-crop, and also roots, where these can be utilized for feeding purposes. As crops for sale, he suggests, first, cotton; then the castor-bean; further, fruits, especially raisins and prunes; and possibly sugar-cane and sorghum.

As supplementary to drainage and tillage, certain chemical antidotes may be employed. Land containing carbonate of soda is greatly benefited by gypsum; a double decomposition yielding, in the presence of water, carbonate of lime and sulphate of soda, both relatively innocuous as compared with carbonate of soda. Soluble earthy and metallic sulphates and chlorides may be precipitated by lime, or sometimes by calcareous marl even.

It is evident, however, that these chemical antidotes only change the nature of the alkali, but do not remove it from the soil. Indeed, they tend rather to add to the amount of easily soluble matters in the soil, and, when the amount of alkali is at all large, are to be looked upon simply as adjuncts to the measures before mentioned.

Thus far the irrigation-water itself has been tacitly assumed to be pure. In fact, however, this is by no means the case; and a most important part of Professor Hilgard's work upon this matter has been his examinations of the water available for irrigation. The water of Tulare Lake, for example, — one of the large bodies of water that had been counted on for purposes of irrigation, — was found to contain so much alkali, especially carbonate of soda, as to render it unfit for irrigation. Kern Lake and Buena Vista Lake were found to be even more alkaline than Tulare Lake. These waters, *when concentrated in the soil by evaporation*, must rapidly increase its content of alkali, and prove fatal to all cultivated crops. Even the purer waters of the rivers were found to contain more or less alkali; and in regard to them all, the necessity of combining drainage with irrigation is to be emphasized.

A most interesting and instructive appendix to Professor Hilgard's report is constituted by the report of the '*reh* committee' for the Aligarh district, northern India, *reh* being the Hindoostanee equivalent of 'alkali.' From this it appears, that, in the irrigated districts of northern India, the same phenomena have been observed as are now developing themselves in California; and the government is now confronted with the necessity of carrying out difficult and costly remedies, or apparently of abandoning altogether or in large part its system of irrigation. In regard to the question of remedies, the Indian committee is substantially at one with Professor Hilgard, making due allowance for the fact that in India the question is one of remedying an existing evil, while in California it is as yet largely one of prevention.