lower end and the ground does not have time to absorb as much.

When the entire field has been watered and the surface has become sufficiently dry for cultivation,

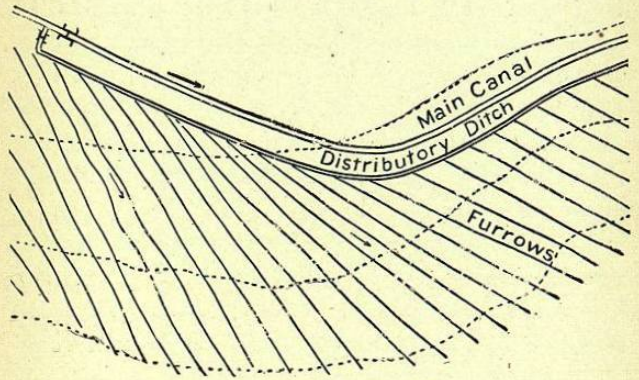


FIG. 56. — Application of water by furrows.

the furrows are usually ploughed out and a thin layer of the top soil is stirred to make an open porous covering or mulch, preventing excessive evaporation and allowing the air to enter the ground. Without such cultivation a hard crust may be formed, which, although retarding circulation and apparently impervious, yet permits continual evaporation. The loosening of this crust breaks the capillary connection with the moisture beneath, and thus lessens the loss of water.

The fields of small grain, after sowing, are usually rolled with a device known as a marker. This consists of a heavy roller upon which are projections

so arranged as to make small parallel furrows. These are rolled in the direction of the desired slope, so that the water can flow down the marks through the grain, as it would in furrows through a corn field. The rapidly growing grain shades the surface, and prevents the formation of crust, rendering subsequent cultivation unnecessary even if it were practicable. Instead of a roller various devices are used to make these small furrows, the object being to provide channels for evenly distributing the water.

The ditches are ploughed through the fields and water is forced out of them either by putting in temporary obstructions of dirt, boards, or sheet metal or by a small canvas dam. This latter con-

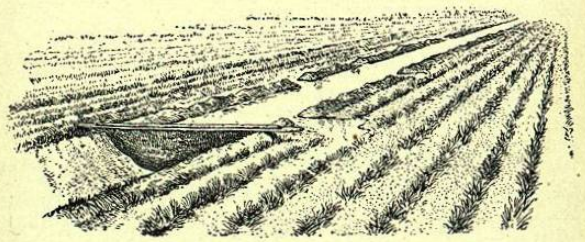


FIG. 57. — Water turned from furrow by canvas dam.

sists of a piece of stout cloth, one edge of which is tacked to a stick long enough to extend across the lateral ditch or furrow. The canvas, falling into the furrow, fits the sides and bottoms, and is held in place by a clod of dirt thrown upon it. Water

meeting the obstruction still further forces the canvas down, making a fairly tight dam, against which it accumulates and overflows into the field, as shown by Fig. 57. After sufficient water has been turned out at this point, the canvas dam (Fig. 58) is pulled up and carried farther down the ditch, where it is again placed in it and another section of the field is irrigated. This method is illustrated in Pl. XXXII.

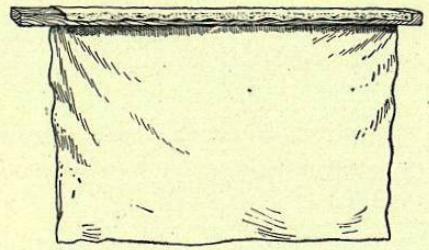


FIG. 58. — Canvas dam.

A drawing of a canvas dam is shown in Fig. 58. There are also given (in Figs. 59 and 60) illustrations of different forms of simple devices for controlling the water flowing in furrows and small ditches, known as tappoons, a word in common use in the Southwest, but not generally employed outside of southern California and Arizona. In Fig. 59 are shown two forms of metal tappoons, these having an oval or rounded outline in order to fit into the furrows. The sheet of metal is pressed down into the soft soil, obstructing the flow. The tappoon is sometimes strengthened by means of a central rib or pin, which projects below, as shown in

the left-hand drawing, and prevents the tappoon from being washed out.

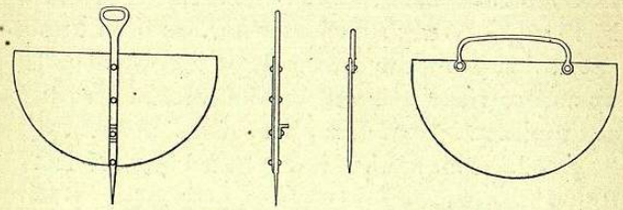


FIG. 59. — Metal tappoons.

These tappoons sometimes consist merely of a board of sufficient width to extend across the furrow. In case it is desired to let a certain amount of water pass this point, one or more holes are bored in the tappoon, these being closed by a plug when not in use.

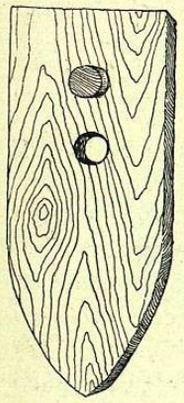


FIG. 60. — Wooden tappoon provided with outlets.

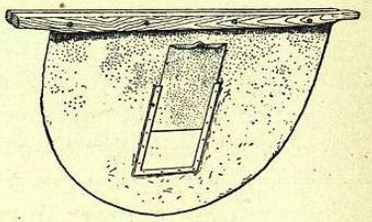
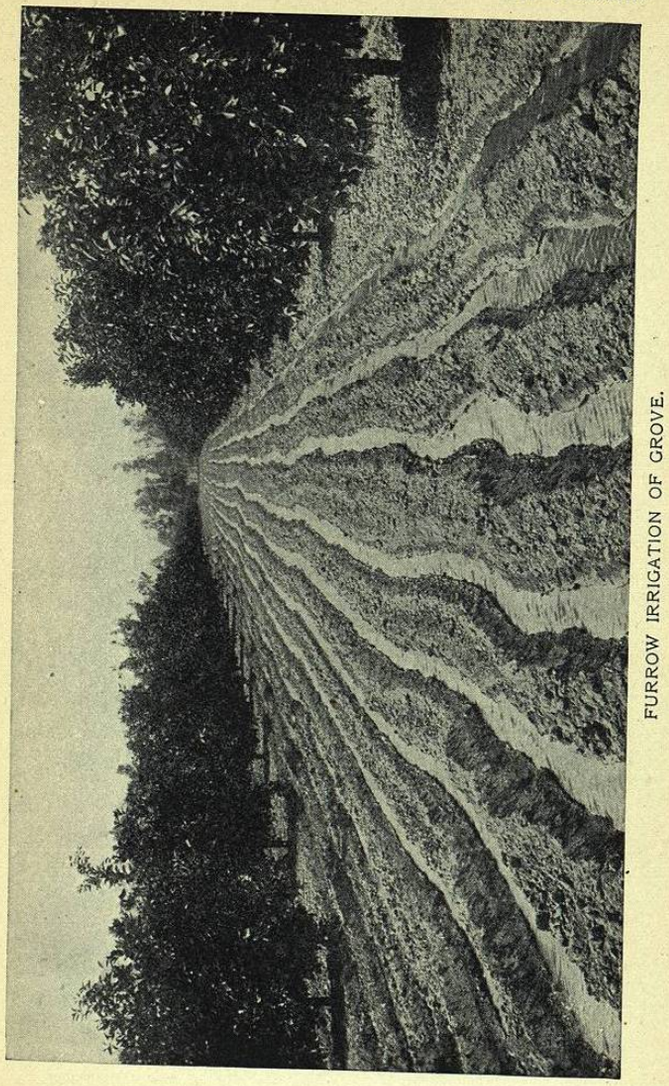


FIG. 61. — Metal tappoon with measuring gate.

A more elaborate device of this character is shown in Fig. 61, being a small portable metal



FURROW IRRIGATION OF GROVE.

dam or tappoon, with a rectangular opening for measuring roughly a certain quantity of water. This can be provided with a sliding door or gate, permitting the passage of a stream of water of a given number of square inches. If the pressure is maintained at from 4 to 6 inches above the centre of the opening, the delivery can be computed in miner's inches.

WILD FLOODING.

With care it may be possible to dispense with checks or furrows and to apply water with considerable uniformity. For grass land, clover, alfalfa, and similar forage plants it is not feasible to provide furrows, and water must be applied by what is usually known as "wild flooding." That is to say, it is led to the upper part of the field and there turned loose in such a way as to cover the surface with a thin layer. Much care is required to do this, far more than when checks or furrows have been made. To get the water to the right places it is usual to provide through the fields shallow depressions which serve to guide the water. From these it spreads out in thin sheets. The system is illustrated by accompanying diagrams, in which the attempt is made to exhibit the distributing laterals through the fields and the course taken by the water in coming from these.

In Fig. 62 the broken lines are contours, or points of equal elevation. The supply ditch is

seen following along one of these, with gradually descending grade. From this are laterals or temporary ditches following down the leading ridges. On each side of these temporary ditches are slight elevations of the nature of check levees,

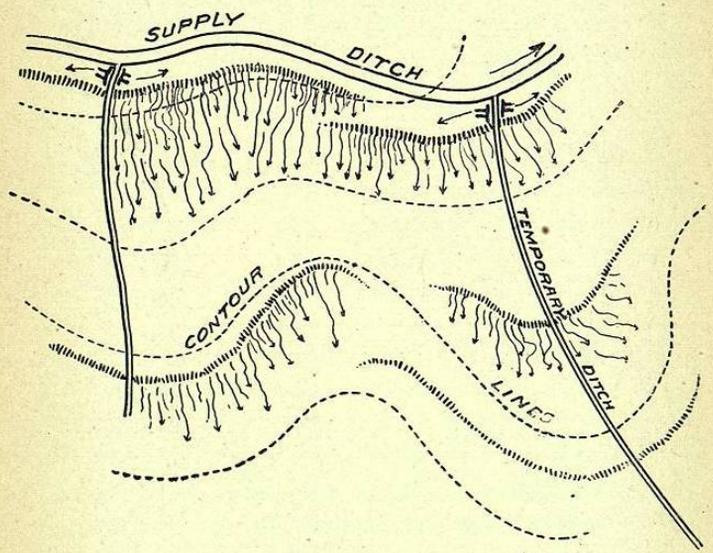


FIG. 62. — Plan of wild flooding.

which tend to throw the water outward along the contours. Spreading along above these, the water gradually overflows and finds its way down the slope in a sheet or numerous rills, as indicated by the irregular lines.

In order to thoroughly wet the field, the irrigator

takes advantage of all the smaller ridges or inequalities, running the water out upon these, and not allowing it to escape into the depressions until it has thoroughly wet the surface. Not all the water will soak into the ground, and the excess

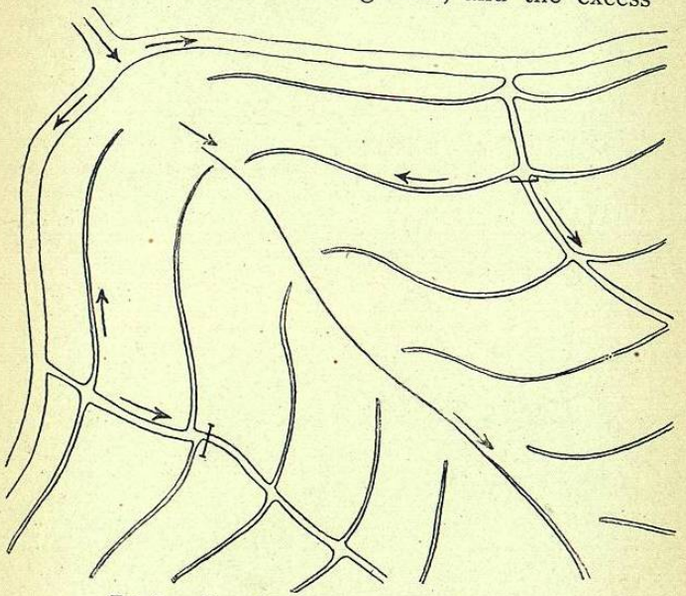


FIG. 63. — Plan of distributing water on rolling lands.

which collects in the depressions is again conducted out along contours to the next lower series of ridges. The general theory of applying water is shown by Fig. 63, where the temporary ditch is subdivided to flow around the head of a slight depression. The direction of the arrows

shows the way in which the streams of water are supposed to be distributed, gradually vanishing into the grass land or cultivated field. A portion of the stream reappears in the depressions, as indicated by the line and arrows in the centre of the drawing. This stream, when it attains considerable size, is gradually conducted out and used on lower portions of the field.

ORCHARDS AND VINEYARDS.

In the localities where the best orchards and vineyards are located, usually water is in greatest

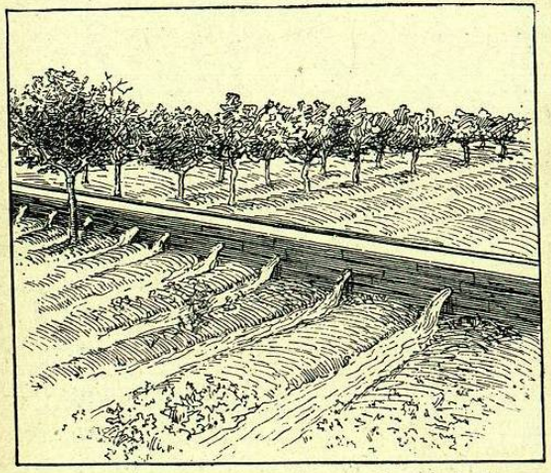


FIG. 64. — Box for distributing water in an orchard.

demand, and extraordinary care must be taken to secure economy in its use. The necessary supply

A. FURROW IRRIGATION OF VINES.

B. FURROW IRRIGATION OF ORCHARD.

is conducted, often by cement-lined ditches and by wooden flumes, as near as possible to the trees and vines, and is then turned out into furrows between the trees as shown on Pl. XXXIII. One of these boxes or flumes is shown in the drawing (Fig. 64). The water, issuing from small apertures in the side of a wooden box, falls into the furrows and is immediately conducted to the vicinity of the trees.

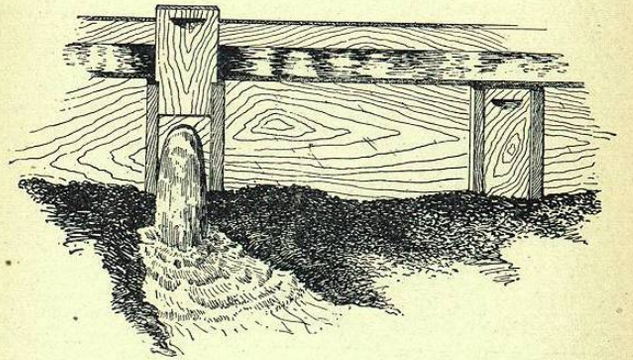


FIG. 65. — Outlet from side of small flume.

The accompanying illustration (Fig. 65) shows the outlet from the side of one of these small flumes or distributing boxes. These small gates are placed at intervals of from 3 to 5 feet or more, and a number of them are opened at a time, each delivering water into a furrow. These furrows having received a sufficient quantity, the small gates are closed and another set opened.

Some irrigators still adhere to the method of irri-

gating trees in small pools or basins, although this is not regarded as desirable because of the tendency of the roots under these conditions to develop near the surface. It is claimed, however, that water can be more economically used in this way. The following figure (66), made from a photograph taken in an orchard near Los Angeles,

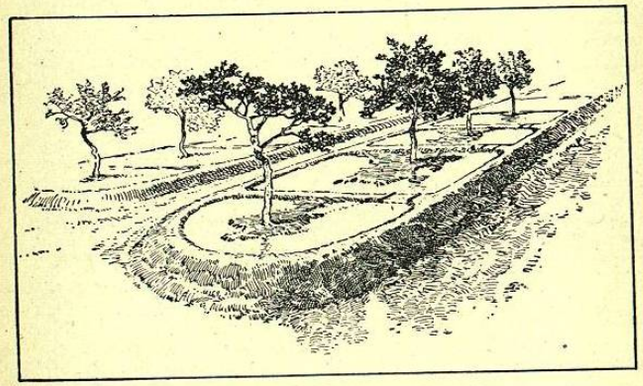


FIG. 66. — Orchard irrigation by pools.

California, shows the lower end of a system of small basins into which an orchard is divided.

The soil on the side-hills is often excellent in quality for the production of fruits, and the elevated portions of a valley are frequently freer from frosts than the bottom lands. For this reason orchards have been set out on sloping lands, and methods of irrigation have been adapted to the ground. The next figure (67) shows one

of the ways in which a small stream of water is conducted down the slope. If allowed to flow freely this would wash for itself a deep channel. It is therefore confined in a small wooden flume, dropping vertically at short intervals. Along the horizontal portions of the flume small outlets are arranged, and water is taken from these into furrows leading along the contour of the ground.

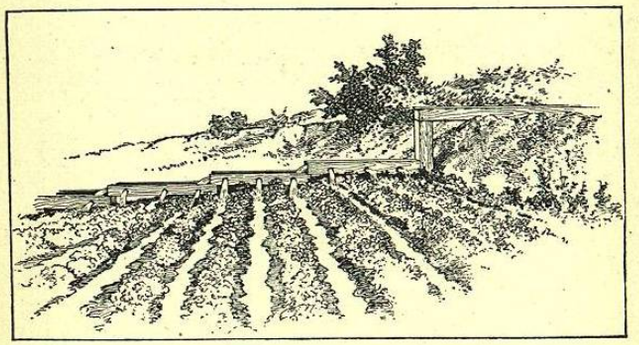
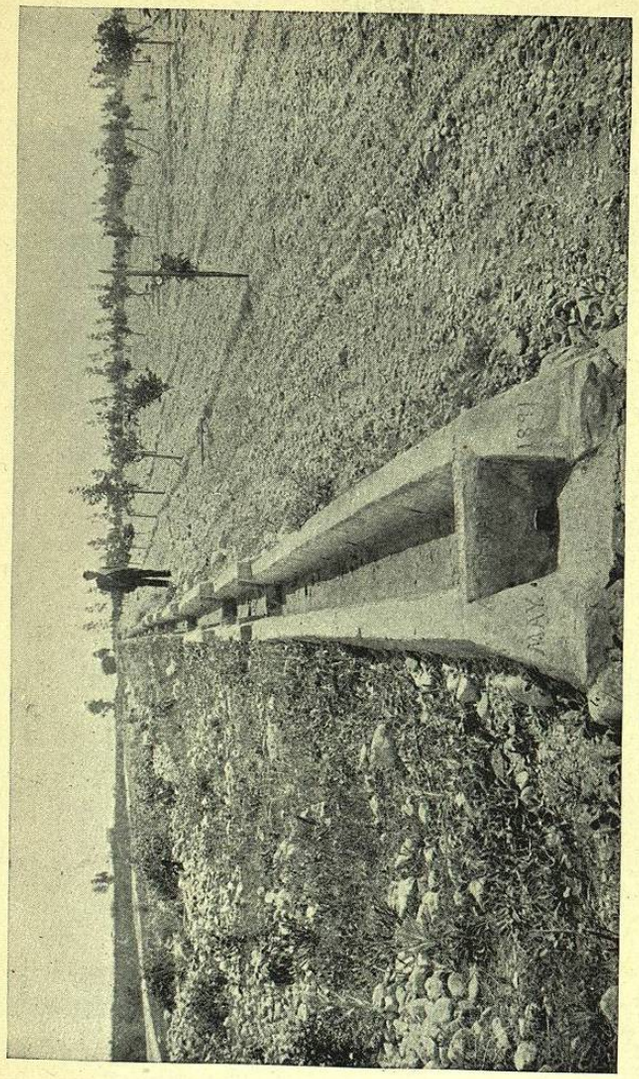


FIG. 67. — Irrigation on slope with stepped flume.

Care is usually taken that the water shall not actually touch the tree trunks; it is kept far enough away to wet the ground within the radius of the roots, to encourage these to spread outwardly as far as possible. After the water has traversed the furrows through the orchard until it has reached the far end, the supply is cut off, and the ground is tilled as soon as the surface dries sufficiently.

On Pl. XXXIV are given two views, the upper one, *A*, being of furrow irrigation of vines, and the lower, *B*, of similar methods of irrigating a young orchard. In both of these views water is shown as applied lavishly, especially in the lower, where the soil is apparently being washed away. Such use of water is possible only where large amounts are to be had, although even where there are small quantities it is sometimes economical to store this in small tanks or reservoirs and run out a large volume at once, in order to give the ground a thorough wetting; by so doing the water can be distributed more uniformly to all parts of the orchard. The course of the water is being directed by the irrigators, who by means of long-handled shovels keep the furrows open or close them by throwing in clods of earth, constant attention being given to the course of the water, so that it will not accumulate in depressions.

The next view, Pl. XXXV, shows a young orchard for which a distributing system, designed for permanence and economy of water, has been constructed. The distributing ditch is of cement and is provided with a series of drops or small falls and gates by which the water can be raised and forced to flow out through small apertures in the sides. The character of the cultivation which follows the application of water is shown by a view of a more mature orchard, Pl. XXXVI.



CEMENT-LINED DISTRIBUTING DITCH.

SUBIRRIGATION.

In order to reach still greater economy, attempts have been made to conduct the water beneath the surface immediately to the roots of the trees, thus preventing waste by evaporation from the surface of the ground. Various devices have been tried, but few of these have been successful, owing to the fact that the roots of the trees rapidly seek out the source of water and develop there, entering the openings from which the water issues, or surrounding the pipe by a dense network. Porous clay tiling has been laid through orchards, and also iron pipes perforated so as to furnish a supply of water along their length. A machine for making cement pipe in place has also been invented and successfully used. Small trenches are dug through the orchard between the trees, and the pipe-making machine deposits the material in the trench, which is filled as soon as the cement is set. Water is thus distributed underground where needed.

In a number of orchards where the subsurface irrigation has been unsuccessful because of the roots stopping up minute openings beneath the surface, the system has been reconstructed and water brought to the surface at or near each tree by means of small hydrants, shown in Fig. 68. Vertical pipes are placed at short intervals, leading to the level of the ground, and in these are small