

## CHAPTER IV.

### CONVEYING AND DIVIDING STREAM WATERS.

#### DIVERSION FROM THE STREAM.

THE greater part of the water used in irrigation is taken from the river or creek by natural flow or gravity. The cost of lifting or pumping water is usually too great to be profitable for the production of ordinary crops, and therefore most irrigation systems must be planned with reference to the relative altitude of the lands to be irrigated and the source of water.

The streams issuing from the high mountains descend with rapid fall toward the lower valleys, where, as a rule, the slope is less and the water moves more slowly. The lands to be irrigated in the valley are, for the most part, along the river, but at a higher elevation than the stream which they border. They are, however, in part at least, lower than the water farther up-stream; and if a canal or ditch is begun on a gentle grade above the head of the valley and carried out along the banks of the stream, it can be kept at a higher elevation than some of the valley land. In the

narrow gorge or canyon above the valley the stream may be falling at a rate of 10 feet per mile. Water will flow in the ditch if a fall of only 2 feet per mile is given to it. Starting on this grade from the river, at the end of the first mile the water in the ditch will be 8 feet above that in the river, and at the end of the tenth mile will be 80 feet higher, and will thus cover all land which is less than 80 feet in altitude above the stream at this locality.

In the accompanying diagram (Fig. 22) the letter *A* is at the head of the valley and *B* at the lower end. The river, *E*, flows with winding course from *A* to *B*, with agricultural land on each side sloping gently toward the river. Some point, *C*, back from the river can be found which is lower than *A*, and a canal line on a gently descending grade, less than that of the river, can be taken out from *A* and beyond *C*, following the contours of the side slopes. The land between the canal and the river is lower than the canal, and lateral or distributing ditches can be taken out toward the stream. These can be constructed directly downhill, or, if the slopes are too steep, can be carried off diagonally.

In planning an irrigation system, it is usual to begin at the highest point of the tract of land or valley to be irrigated, and run a trial line on a slightly ascending grade (a foot, more or less, to a mile), following this line as it meanders in and



out along the slopes, and continuing it through the upper end of the valley and into the canyon from which the stream issues, until the trial line finally reaches water level. Frequently it happens

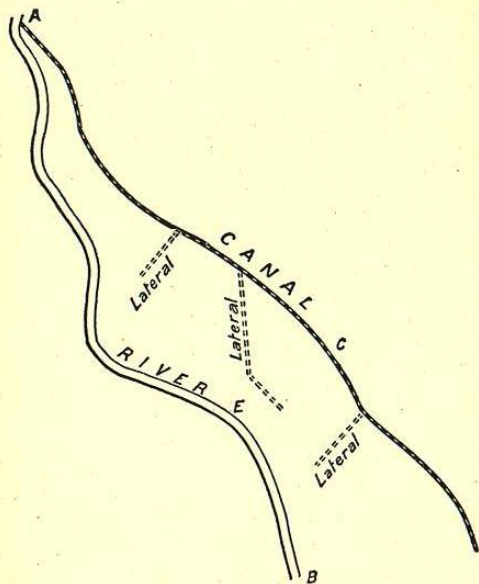


FIG. 22. — Diagram showing method of diverting a canal from a river.

that such a line will wind around bluffs and rocky places where ditch construction may be impossible. In such a case a higher or lower line must be taken. If lower, it is apparent that the higher points in the valley cannot be reached by the water, and it may be necessary to leave unirrigated above the ditch a considerable portion of the fer-

tile land. Thus it sometimes occurs that, even though there is an abundance of water, some of the good land must be left unwatered, as it is impracticable to build a ditch which will reach it.

In the simplest case of laying out a ditch, a farmer takes a straight-edge or board 16.5 feet, or a rod, in length, and tacks on one end of this a projecting block or peg one-half of an inch or an inch in height. When this board is placed horizontally, the lower projecting point will give a fall of one-half of an inch or an inch to the rod. Beginning at a given point, one end of the straight-edge is placed on a stake driven flush with the surface of the ground, and the other end, having the projection upon it, is swung around until it strikes the surface. A stake is driven in here, this stake being lower than the first by an amount equal to the height of the projection or peg. The operation may be reversed if the laying out of the ditch is begun at the lower end. In this way stakes are driven into the ground at intervals of a rod, marking out the course of the ditch upon a slightly ascending or descending grade according as the work is begun from the lower or upper end.

The accompanying figure (23) shows an effective form of levelling device used by irrigators. It consists of a straight-edge or board, from the ends of which pieces extend diagonally upward to form a support for a plumb bob. This is adjusted so that when the straight-edge is horizontal the plumb



bob will fall opposite a fixed point. The same results can be obtained by using a carpenter's level, but the device shown can be constructed by any person of ordinary skill, and will suffice for laying out ditches for irrigation or drainage.

The ditch having been staked out in the manner above described, or better by means of surveying instruments, a furrow is ploughed along the course,

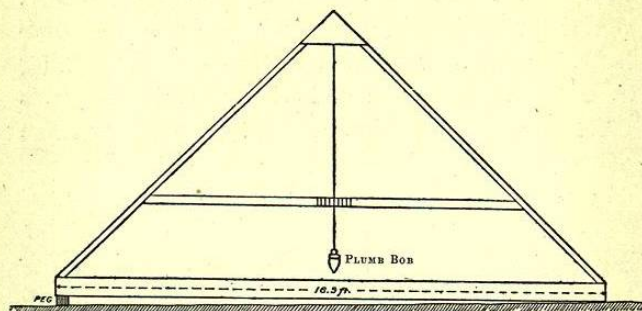
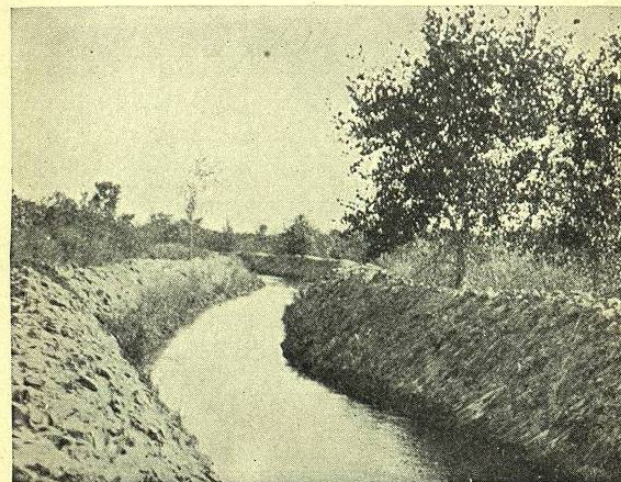


FIG. 23. — Levelling device for laying out ditches.

and the earth thrown out by shovels or scrapers (Pl. XIII, *A*). Near the upper end of the ditch it may be necessary to blast away the rocks, and at intervals along its course depressions must sometimes be crossed by means of wooden flumes. As far as possible, however, ditches are carried up into and around depressions in the surface of the ground, in order to avoid building these wooden structures, since they decay rapidly and are sources of considerable expense. (See Figs. 36 and 48.)



*A.* DIGGING A DITCH FROM A RIVER.



*B.* THE FINISHED DITCH.



For the purpose of digging large ditches or canals, a number of farmers usually combine, forming an association which may be incorporated. Ownership is usually based upon the proportion of labor contributed by each member, and this in turn is determined largely by the amount of land owned and to be irrigated by each person. These associations may be simply partnerships without any written agreement, or may be formally organized with constitution and by-laws, and be incorporated under the laws of the state. Frequently stock is issued, each share entitling the owner to receive a certain amount of water from the ditch, or a definite proportion of the whole amount available at any particular time. Sometimes these shares specify the time of day, so that one man receives the entire flow of the main ditch or a lateral from six o'clock in the morning until noon, and his neighbor, being entitled to less water, receives the entire flow from noon until two in the afternoon; and so on throughout the day and night.

These associations or corporations elect their own officers and manage their affairs in the same manner as any other business concern. The most important official, however, after the treasurer, is the person charged with the management of the canal. He is usually known as the "watermaster" or "ditch-rider"; or, in Spanish-speaking communities, as majordomo or zanjero, from the word "zanja" (usually called sankha), the Spanish term



for irrigation ditch. It is his business to see that all stockholders or owners receive a fair amount of water, using various means for measuring or dividing it, as described on a later page.

The greater number of ditches and canals now in use within the arid region have been built by individuals and associations of this character. In a relatively few instances large works have been constructed by corporations issuing stock to persons who were not landowners, and borrowing additional capital upon bonds. Several canals have been constructed in this way, but as a rule these have not been financially successful, and development is not continuing along this line.

#### DISTRIBUTION OF FLOW.

The pioneer, coming to a new portion of the arid country, first sought a stream from which water could be diverted upon arable land. As a rule he laid claim to the whole flow and built a ditch, small at first, taking only enough water to supply the land which he could cultivate during the first year or two. From time to time, as more land was brought under irrigation, the ditch was enlarged by being widened and deepened, more and more water being taken from the stream as needed. In the case of associations of farmers, the same course has usually been followed, the ditch or canal being at first small and built in the quickest and cheapest manner possible, and then

gradually enlarged to take a greater and greater proportion of the water in the river.

Soon after the first settler or association took out water in a ditch, others would begin similar works a few miles above or below the first, each in turn generally claiming all the water to be had at the particular point where the head works were located. If the stream is of considerable volume, sufficient to fill all of the ditches, no difficulties arise; but sooner or later the increasing size and number of ditches and canals result in diminishing the flow in the river to such an extent that it becomes dry, and water does not reach the ditches farthest down-stream. This scarcity of water first becomes apparent during the latter part of the crop season, in July and August, when the streams, as shown by Fig. 16 (p. 65), are lowest and the need of water is greatest.

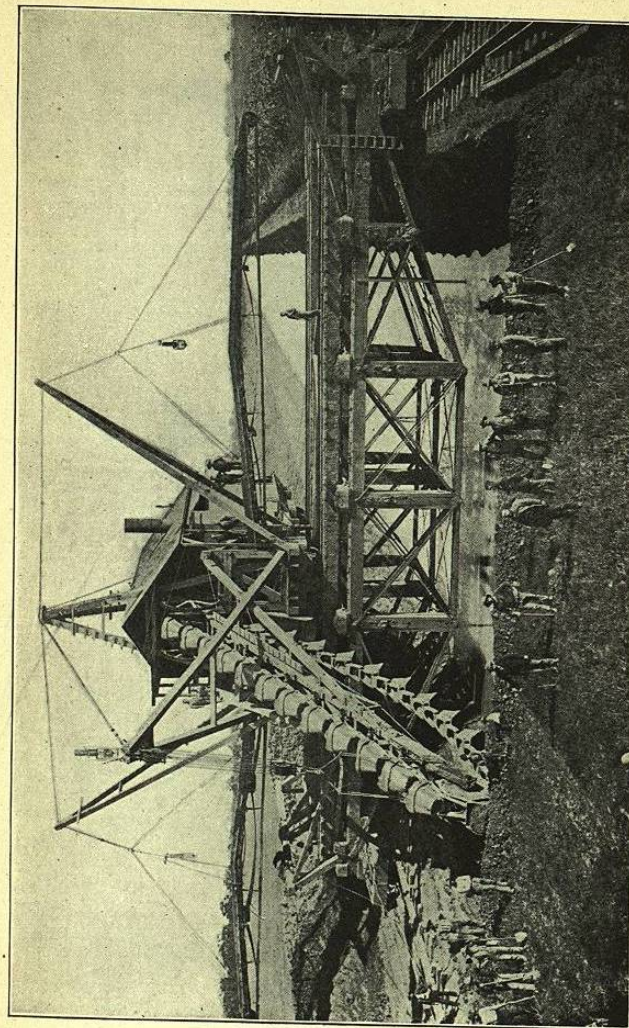
It usually happens that the ditches lowest down-stream are those which were built first, and which under the customs prevalent in arid regions are entitled to priority of right to the use of the water. The farmers under these lower ditches, seeing their crops wither and orchards which have reached maturity die for lack of water, are tempted to take desperate measures, and going up-stream, forcibly close the head gates of the upper canals, tear out dams in the river, and let down needed water for their farms. Thus has come in some parts of the arid region, a time when, owing to scarcity of water,



lawlessness has prevailed, and every man has endeavored to obtain for his own crops as much as possible of the scanty supply.

The necessity for rules and regulations governing the division of water from the streams early became apparent in all localities where development has proceeded to any considerable extent, and various schemes have been devised for such regulation. Along some of the rivers, the farmers and canal companies, becoming weary of the frequent controversies among themselves, have voluntarily joined together, and after much debate and experimenting have finally agreed upon rules by which a division of the water has been made. Where these matters could not be thus settled, court decisions have been obtained. Such, for example, has been the result along many of the streams of California, the arrangements being complicated and difficult of ready comprehension by the stranger, but well understood by the irrigators themselves and all based upon experience and local needs.

In some parts of the arid region the states have undertaken the regulation of disputes, and have created special boards or tribunals to consider the matter and apportion the water. For example, in Colorado, where the state is divided into districts, each embracing a single stream, the regulation of the waters is intrusted to state officials known as commissioners. The districts are grouped to-



DREDGE CUTTING LARGE CANAL OF CENTRAL IRRIGATION DISTRICT, CALIFORNIA.



gether to form divisions corresponding to the principal river basins. Each division is under the charge of a superintendent, who supervises the work of the commissioners. Superintendents, in turn, are under the state engineer. It is the duty of these officials to regulate the head gates in time of scarcity, carrying out the decrees of the state courts, cutting off water from the new ditches in order that the older priorities may be supplied, following the decrees made by the courts as to the order of priority and amount of water to which each ditch is entitled.

In Wyoming the state engineer is empowered to ascertain the amount of water flowing in the stream, and with the superintendents forms what is practically a court for the hearing of cases and the adjudication of claims to the water, the principal facts having been ascertained by observation and measurement in the field rather than by testimony of interested parties, as in Colorado. This has sometimes been regarded as theoretically the best method; but practice has raised some doubts as to its applicability in states where developments have proceeded farther.

While there is little uniformity among the different states as regards the control and distribution of water, there are certain underlying principles which are discussed on page 286 under the head of Irrigation Law; and, more than this, there is a gradual tendency toward evolution along lines



which experience has shown to be best suited to American conditions. The first stage of development is the construction of small ditches, each conducting water from streams sufficiently large to supply all needs. The next stage is where the increase in number and capacity of the ditches has resulted in scarcity of supply and in competition among the claimants for water. The third stage is one of mutual adjustment and division according to court decrees or agreements reached by arbitration. The next stage, one which is being gradually reached, is the adjustment of interests so as to allow an apportionment of water in such a way as to increase its economical use. For example, instead of dividing the water strictly according to priority and thus wasting considerable portions in forcing it down the stream to lower ditches, the scanty supply is so distributed as to give the greatest benefit to the greatest numbers.

The last stage of evolution of water distribution is that in which, all or the greater part of the interests being mutually adjusted, the united efforts are directed toward water storage and conservation of the supply by building reservoirs and by adapting the methods of irrigation to suit the fluctuating quantities.

The accompanying figure (24) illustrates the manner in which ditches have been constructed at regular intervals along a stream, taking water out on one side or the other. In this figure the

ditches are numbered in geographical order from the head waters down, and the lands irrigated under them are indicated by shading. The order of priority in the use of water is not that of the position along the stream. For example, No. 22,

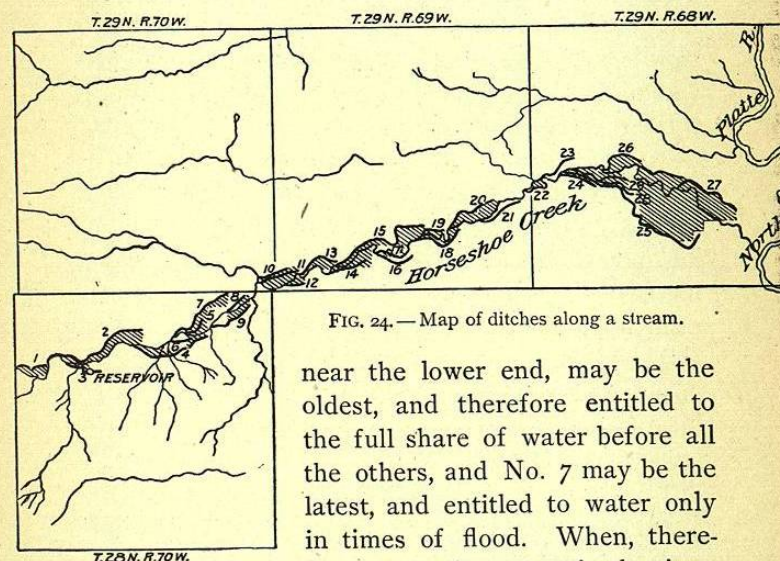


FIG. 24.—Map of ditches along a stream.

near the lower end, may be the oldest, and therefore entitled to the full share of water before all the others, and No. 7 may be the latest, and entitled to water only in times of flood. When, therefore, a scarcity occurs in the river,

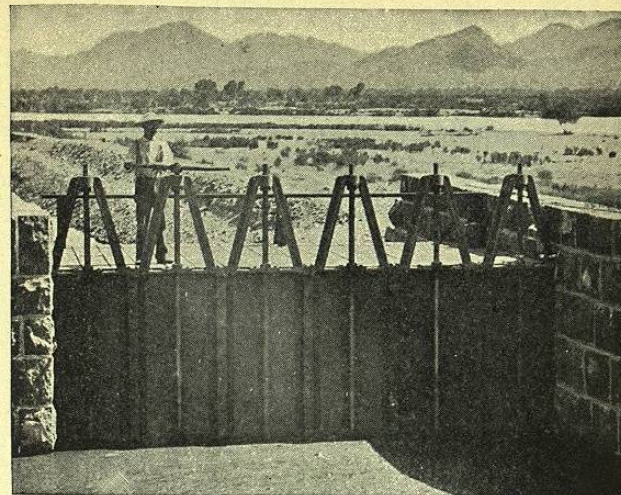
No. 7 is at once closed down, and then No. 10, if it happens to be the next as regards recent construction, and so on, one ditch after another being deprived of water in order to supply the oldest ditches with the needed amount, until finally, in extreme drought, the ditch first constructed receives the entire flow. With increase of discharge of the



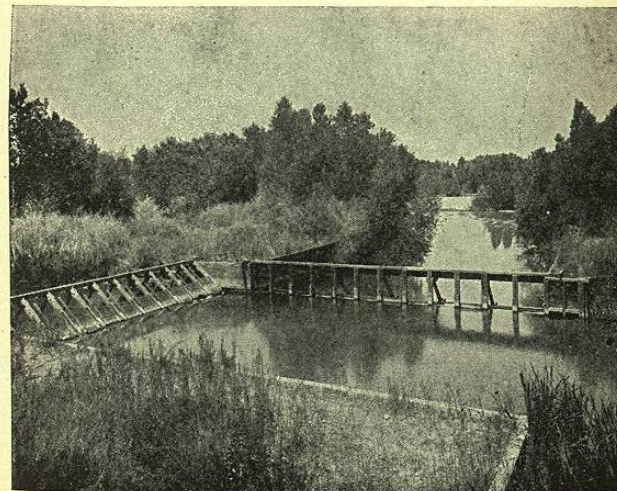
stream, the head gates of the ditches are opened in the order of date of priorities until, in times of flood, all are opened.

After a ditch or canal has received its full supply, or the quantity to which it is entitled, there usually arise among the various irrigators many conflicting demands in times of scarcity, the condition being comparable to the claims made by the canals upon the main stream. In the early days, when there was plenty of water in the river, and the ditch or canal carried more water than was needed, each user took all he chose, flooding his land freely, sometimes drowning out and destroying portions of it, and running the excess over the roads and neighboring grazing land. With the gradual widening of the cultivated area, the need for water has increased, and attempts have been made to check the waste; but the older irrigators, accustomed to the lavish use of water, have been loath to restrict themselves, even though it has been demonstrated again and again that better results could be had by using less water.

It has usually been found necessary for the irrigators to appoint or elect one of their number to serve for a season as watermaster, and to apportion to each claimant a certain amount of the water, or assign certain days and hours during which water can be used. The watermaster must, when the supply is scanty, go along the canal and see that the various head gates are closed or opened to



A. MASONRY HEAD-GATES OF CANAL.



B. TIMBER REGULATOR.



receive the determined quantity of water, locking these so that they cannot be tampered with after he has left. Often the quantity of water has been settled only after vexatious lawsuits or neighborhood quarrels, and great tact is required to preserve friendly relations during times of scarcity, when some crops must be left to wither under the intense summer heat, in order to save others whose owners enjoy older or prior rights.

#### DAMS AND HEAD GATES.

At the upper end of each ditch it is usual to construct some device by which the amount of water entering from the river can be regulated. Without this, flood waters would fill the ditch beyond its capacity, overflowing and washing away the banks. In times of low water, also, the stream may fall to such an extent that it must be raised somewhat by a dam and forced into the ditch. At all times it may be necessary to regulate the flow in order to apportion the water fairly to all concerned.

In the case of the simplest ditch, a small dam of brush and stone, illustrated in Fig. 25, is usually built diagonally into or across the stream bed as the water becomes low in the summer, and this is made tight by means of sod and earth. Such a dam is usually washed away by high water, but can be replaced at small labor and expense. More permanent structures are sometimes built of timber