Canal Construction in Colorado.

By

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In a region as arid and as that of Colorado, it becomes necessary to resort to irrigation in order to grow the products for the support of its inhabitants.

One not accustomed to irrigation may ask how can it be profitable to engage in agriculture where you are obliged to irrigate and discharge the increase rent that must necessarily arise in the building and maintenance of canals?

It is accomplished however by the increase in yield; the keeping up of the fertility of the soil, and lastly, the uneveness of a crop by enabling one to apply the moisture when most needed.

It is necessary, in order to make irrigation easy and profitable, not to have streams with high
perpendicular banks or with too great a fall.

The reason is obvious for if such were the case it would be difficult and expensive to get the water from the river because for some distance from the source of the canal the cut would necessarily be so deep that the water could not be taken from it for irrigation.

There should also be a gradual, easy fall to the country.

We have these and other advantages wonderfully developed in eastern Colorado.

The principal river is the Platte flowing in a northwesterly direction with a fall of about three feet per mile. A muddy stream with a sandy, weedy bed and containing many sand-bars.
Its principal tributaries are from the west and flow in a southeasterly direction, with a fall of about seventeen feet per mile. They differ from the main stream in having a rocky bed instead of a sandy one. It has no tributaries on the east capable of supporting irrigation except Plum creek.

The country is slightly rolling and has a gradual, easy fall to the east. The river banks are from 3-8 feet in height.

There is also a gradual, easy slope from the divides separating the streams to the streams.

As the snow upon the mountains is the source from which the water is obtained, it is evident the greater part of the water will flow down the streams during the early part of the
season thus diminishing the supply for late irri-
gation. To equalize this reservoir is nec-
essary to store up the flood waters for use when
the supply diminishes. A few of these can
be found in the mountains at the heads of
the streams but when we come out upon the
plains we find nature has admirably constructed
these. If they are properly used we have the
means of obtaining a very economic and just
distribution of the water for irrigation.

The magnitude of our irrigation system is
small when compared to those of some of the
eastern countries. The northern part of Italy
we find traversed with a network of canals, while
she has an annual rainfall of about 38 ins.
or equal to that of New York.
Egypt has immense canals from which a population of over millions of people subsist on an area no larger than the irrigable portion of eastern Colorado. The harvest of India is made absolutely certain by an extensive system, built by government aid and controlled by it. The same aid has enabled an extensive system to be established in Australia.

While there is an abundance of water in the streams of these countries and in some a sufficient annual rainfall to produce a crop without irrigation yet we find none of the natural advantages so fully developed as in our own state. The river Po from which Italy draws most of her water for irrigation has a fall of only six feet per mile.
The Nile river is the only source of irrigation in Egypt, deposits each year at its mouth an enormous amount of sediment. While this river has very little fall yet it is of sufficient volume to carry this material in suspension but as soon as the water is diverted into the canals which must necessarily have a slight fall the sediment is at once deposited and involves an enormous cost each year to remove the sediment. As a consequence of the slight fall there is considerable seepage which has instituted an extensive system of drainage, besides compelling them to take the water from the canals by water-wheels and steam-pumping engines and thus giving employment to thousands of men.
In India nearly the same is true. The lower Jumna, the largest canal in India having a width of 210 feet runs fifty miles before it comes to the surface of the ground; consequently it is very expensive to build such large canals which on account of their slight fall carry very little water in proportion to their size.

The gradual and uniform slopes which characterize the surface of the plains east of the mountains makes the construction of canals with us a comparatively simple and inexpensive operation.

The low banks and fine soils that form the characteristic features of most of our streams simplify the problem of constructing suitable head-works while the main source of expense in canal construction in the east is, the construction of flumes.
and aqueducts is obviated by the remarkable adaptations of the country and the conditions under which the work has been prosecuted.

The kind of canal best suited to this country is a wide, shallow one; when we say shallow we mean compared with those of eastern countries. The reason is that there is very little rock or flume work and hence most of the expense occurs in the excavation.

With the fall that can be given the canals the excavation can be accomplished by teams and to make this as speedy and easy as possible there must be no high banks to climb.

It is obvious the narrower the canal can be the better, in order, to diminish the waste from evaporation and seepage of which
the former is very great at all times and the latter if flowing through a sandy loose soil until the sediment covers the canal in sufficient quantity to stop this.

The depth however depends upon the character of the country which it is intended to irrigate. If the fall is somewhat steep away from the canal so that the water can be gotten easily onto the lands the canal can be much deeper than if the fall was slight and it was difficult to draw the water from it occasioning quite a strip of unirrigated land along the canal or if it was irrigated compelling the person to go a considerable distance up the canal in order to get his laterals to cover such land.
A deep canal is more economically and easily managed than a shallow one on account of evaporation and seepage, also the bank being of the natural formation is much safer especially in times of flood and there is less expense in the building and maintenance of head-gate and flumes.

The depth employed is in the proportion of three feet to a width of from twenty to twenty-five feet but very few of the canals in the district I have spoken of being what are considered large canals.

The grades employed at present are less than were used on those first taken out.

They were from four to seven feet per mile but experience has taught this is too much
because with such grade the bed will cut and wash and beside the canal cannot be made to cover so much land.

From two to three feet per mile is now employed on the larger canals, some of the smaller ones having a slightly larger grade.

The head-gates are almost universally of wood, the structure being held in position by piles driven into the earth. The gates are usually one set placed in a framed frame of varying lengths, the gate being placed near the upstream end directly next the water's edge but it would be better if they were placed about the center of the structure so as to get the weight of water upon them. The number of gates for each head-work varies according to the size of the canal and the depth of water in front of them.
The water for irrigation is taken from the c泉水 by what is termed measuring boxes. There is no form universally used because the law is so vague upon this subject. However they are generally a wooden box from 12 - 18 feet long with a width and height varying according to the amount of water necessary to be taken through them. They have a gate at the water edge which moves vertically by which the water is let into the box; another at the back or lower end for the purpose of measuring the water moves horizontally.

The amount of water flowing through is determined by the statute inch which is in substance as follows: "every inch shall be considered equal to an inch square orifice under a five inch
pressure and a five inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water, the aperture through which it is to be measured to be six inches perpendicular inside measurement for all measuring over twelve inches which may be square; the slides for such to move horizontally.

A practical unit of measurement is very much needed because there are so many ways of constraining the present meaning of the law that under different circumstances there may be a difference of 50% in the discharge.

The slope at which the box is set; whether the discharge is in air or not; whether there is a check in the back end to diminish acquired velocity; the manner in which the box is set in...
the bank or the amount of water to be measured are all elements that might increase or diminish volume and hence the uncertainty attached to this method.
To illustrate canal construction we will describe the work of building one and append drawings of cross sections of the canal; plan and elevation of the flume; a drawing of the headgate; also one showing the discharge at different depths and one showing the curves of discharge and velocity at the different depths.

Required to construct a canal that will carry 400 cuf. per sec. of line with a fall of .06 ft. per hundred feet; slope of banks 1 to 1 and a depth of 3.5 feet.

The volume of water that will flow through any canal is determined by multiplying the sectional area by the velocity.

In the formulae \( v = \sqrt{\frac{4 \times f \times c}{a \times b}} \)

\( a = \text{area}; \quad v = \text{velocity}; \quad f = \text{fall per mile}. \)
\[ p = \text{width perimeter}; \quad c = \text{coefficient of resistance}. \]

To determine the size of the canal on the bottom to carry the given volume with the given depth and fall we have recourse to a sort of "cut and try" method of substituting values in the above formulae, i.e., we assume some given width and substitute values for the letters until we have determined a width in which the area multiplied by the velocity obtained equals the required volume.

We have calculated that it would require a breadth on the bottom of twenty-eight feet and with the slopes one to one and a depth of three and five-tenths feet would require a breadth of thirty-five feet at the top.

The following table shows the results of the computations for the different depths.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Force</th>
<th>Formulate</th>
<th>Velocity</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot;</td>
<td>14.25</td>
<td>29</td>
<td>$v = \frac{\sqrt{axr_0}}{px^8} \times 50$</td>
<td>1.04</td>
</tr>
<tr>
<td>1'</td>
<td>27</td>
<td>31.82</td>
<td>$v = \frac{\sqrt{axr_0}}{px^8} \times 76$</td>
<td>1.07</td>
</tr>
<tr>
<td>1'6&quot;</td>
<td>44.26</td>
<td>32.6</td>
<td>$v = \frac{\sqrt{axr_0}}{px^8} \times 80$</td>
<td>2.14</td>
</tr>
<tr>
<td>2'</td>
<td>60</td>
<td>38.46</td>
<td>$v = \frac{\sqrt{axr_0}}{px^8} \times 80$</td>
<td>2.14</td>
</tr>
<tr>
<td>2'6&quot;</td>
<td>74.26</td>
<td>36</td>
<td>$v = \frac{\sqrt{axr_0}}{px^8} \times 80$</td>
<td>2.86</td>
</tr>
<tr>
<td>3'</td>
<td>93</td>
<td>36.45</td>
<td>$v = \frac{\sqrt{axr_0}}{px^8} \times 80$</td>
<td>3.11</td>
</tr>
<tr>
<td>3'6&quot;</td>
<td>118.95</td>
<td>37.9</td>
<td>$v = \frac{\sqrt{axr_0}}{px^8} \times 90$</td>
<td>3.52</td>
</tr>
</tbody>
</table>

In the drawings we have represented the castle as thrown upon both sides. Usually this is not the case but instead it is all thrown on the lower side.

The flume rests upon piles and the planks forming the bottom lie crosswise of the channel.

The gates, of which there are one set, are made of wood.