DIFFICULTIES OF MOUNTAIN IRRIGATION ENGINEERING.

BY H. A. CRAFTS.

In the early days of irrigation engineering in Colorado the question of locating a canal was of easy solution. Numerous streams were found flowing out of the rocky gulches and cañons on to the broad plains. The pioneer irrigator appropriated to his use the rich alluvial soils along the borders of the streams and laughed at the man who suggested the possible utility of the table lands that stretched on all sides, producing little save buffalo grass and sage brush. The soil was supposed to be poor even if it were possible to get water upon it. But it was not long before bolder spirits ventured upon the occupation of these lands. And when they were broken by the expenditure of not a little animal force (for the soil in many places was baked as hard as a brick), and the water from the artificial irrigation ditches was turned upon them, they produced wonderful crops, so that in time the bottom lands, which had for so long been considered the only ones available for cultivation, fell into disfavor and in many cases were given up to the herdsman.

The value of the table lands for farming purposes having been demonstrated, there followed a scramble for all such as were favorably situated for irrigation. So that it was not long before not only was the water supply of the various streams appropriated, but all the most favorable sites for ditches were taken up. The first land-holders had, of course, the choice of location, both for lands and ditches. Provided the lands were within reach of water, their lay and quality of soil were the first questions for consideration. Topography was of course considered to some extent, but difficult engineering was not necessarily encountered in the prosecution of these early enterprises. Everything was planned with a view to avoiding mountain construction, so that the location of main ditches was a very simple thing.

The first care was the location of the head gate or the point of tapping the stream from which the water supply was to be obtained. The bank of the stream merely had to be cut to a sufficient depth to permit the water to flow into the proposed canal at the desired head. In some cases a dam or jetty was extended from the lower side of the head gate at an angle, out into the bed of the steam, in order to facilitate the diversion of water. These were usually constructed of cobble stone from the bed of the stream, supplemented by logs, brush, and sometimes straw weighted down with stone. From the bank of the stream the construction of the canal was a matter of mere plowing and scraping.

Our illustrations show the various features of an interesting piece of mountain construction known as the North Fork ditch. In order to cover the land which was designed to be irrigated, the promoters of this work were compelled to follow up the North Fork of the Cache la Poudre for a distance of eleven miles from its confluence with the main stream. The dam and head gate were established in the midst of a rocky gorge, five miles from the base of the outer range of foothills. Intervening was a perfect labyrinth of granite hills, and beyond these a series of limestone and sandstone ridges.

In order to raise the water in the stream to the requisite height, a dam of rock and cribwork was constructed in the bed of the stream. The dam was 50 feet high and 300 feet long at its crest. The thickness of the dam at the bottom is 75 feet and at the top 12 feet. The top of the dam was floored over with three-inch planking, forming a spillway for the entire length of the crest. The dam is set in solid granite, the sills of the cribs being fastened to the rocks by long drift bolts set in lead. From the head gate the water is conducted in a flume ten feet wide and sufficiently high to carry water to a depth of five feet. The flume is set on a grade of 10½ inches to the mile. It is constructed of 6×10 sills, 6×6 posts and 3×6 stringers and lined with 2½-inch planks. The planks before being put in place were dipped in boiling tar and each year are painted on the inside with hot tar, just before the water is turned in. This is done to preserve the wood, which is severely tried by the water, the hot suns, and the dry atmosphere of Colorado.

The flume, after leaving the head gate and crossing a small point of land, is carried across the North Fork itself upon a truss bridge, supported by stone piers. Next was encountered the craggy side of a granite hill. This granite is known in technical terms as "gray whacke" and is one of the hardest kinds of material to work in. Four of these granite hills were tunneled in the progress of this work. The largest of these tunnels is 630 feet in length. The tunnel section is 10 feet wide on the bottom and 6 feet high, the roof being struck on a 4-foot radius. These tunnels were all drilled out by hand and cost $70 per lineal foot.

From hill to hill the ditch was carried in flumes across cañons and gulches, the flumes being supported by bridges, one of which is a steel Fink truss, the others being wooden Howe truss. The total length of flumes is 4,000 feet and of tunnels 1,000 feet. The flumes and tunnels were joined by quarrying the rock down to grade and then cementing the fluming to the sides of the tunnel with Dykenhoff cement. The joints were also caulked to render them thoroughly watertight.

After getting out of the granite hills, ridges of stratified sandstone were encountered, some of which had to be tunneled, while the ditch was quarried out of the sides of others. In fact, one-third of the work to the plains was solid rock work. The original cost of the first five miles of this ditch was $154,000, or more than $30,000 to the mile. The cost of the fluming was $6 per lineal foot, or $35,000 per mile, approximately. With good care it is estimated that the flume will have to be renewed but once in eighteen years.

The principal features of the ditch as it traverses the outer foothills are the short tangents and sharp curves, which are necessitated by the fact that the waterline has to be kept as near as possible below the original ground line. The sharp curves necessitate the protecting of the bank of the ditch, especially in running a full head of water, because of the erosion near the waterline. This action is checked by riprapping, dry rubble walls, or masonry set in cement. The banks also require constant attention during the time of running water to guard against the work of gophers.

At the end of the mountain division of the North Fork ditch, which is 8 miles from the head gate, the canal enters what is known as the "natural channel division," which from a scientific standpoint must be regarded as a failure, the result of a mistake made by the engineer of the original construction. At this point the water was turned into a natural "draw," but not a natural water course. There is a sharp fall here of some 500 feet. The engineer supposed that the water would soon cut a channel down to bed rock and there stop. But contrary to expectation the total length of the division lies through a series of strata consisting of a mass of soft shale and friable soils. The consequence is that the canal has dug its way for the entire length of the division into a chasm in many places from 75 to 100 feet deep. This has had the effect of clogging the first mile of the division with immense quantities of sand, which has to be cleaned out yearly. Large quantities of this sand have also been washed out upon the adjacent land, for which the company has been compelled to pay heavy damages.

This sand is also discharged in large quantities through a series of trap floodgates, located on this section of the ditch. The flood gates are badly planned, being hinged at the bottom and opened by the automatic action of high water. Being thus constructed, it is a very difficult task to close them when once open, without shutting the water entirely out of the ditch. They have to be lifted against the combined weight of the gates themselves and the water flowing over them. It is probable that they will be abandoned and automatic spillways constructed in the shape of a series of long level flush boards, calculated to relieve the ditch of all flood water without disturbing the natural flow of water in the canal below high water mark.

The North Fork, which is in successful operation, including the main ditch and laterals, has a total length of 52 miles. The main ditch is 23 miles in length. It has a carrying capacity of 200 cubic feet per second. The storage capacity of its reservoir system is 600,000,000 cubic feet of water. Five thousand acres of land below it are in actual cultivation. Its present irrigating capacity is 12,000 acres. Whether it will ever be brought to a condition that will compensate for the large amount of money expended upon the mountain division is a question for the future to determine.

A Hotel Silver-plating Plant.

It is a common thing for hotels to have their own laundries, their own electric lighting plant, and their own bottling machinery, but the Hôtel Métropole, in New York, is probably the only one that does its own electro-plating for the purpose of renovating its spoons and forks and other articles from which the silver has been worn off. The plant, which has been in operation for some time, says The Electrical Engineer, of New York, has fully justified the first cost of the outfit, and has shown the economy and feasibility of this novel scheme. The United Electric Light and Power Company, which supplies current to the hotel, leads its high potential circuit into the sub-cellar, where it is transformed to 220 volts by means of two 1,000 light converters. In close proximity to this place the hotel management has installed the silver-plating plant, which consists of the following apparatus: A 2 horse power 200-volt 2-phase Tesla motor running at 1,800 revolutions per minute, belted by means of a counter-shaft to a buffer running at 3,000 revolutions per minute, and a plating dynamo delivering 75 amperes at a pressure of 5 volts; the necessary fuses, an overload circuit breaker, and the conductors, which in this case are hollow copper tubes, leading to the various vats. There are, in all, four of these vats, each holding 25 gallons of liquid, and containing respectively the nickel, copper, silver, and striking solutions. As the operator of this plant is not kept busy constantly, the guests not eating the silver off with sufficient rapidity, he devotes the remainder of his time to the buffing of the silverware.

Science Notes.

An interesting experiment has just been started on the Philadelphia, Wilmington, and Baltimore Railroad in order to find out which is the best wood for telegraph poles. Some forty-two have been set up in order to test the life of the various woods employed. There are six chestnut poles, creosoted; six pine poles, creosoted; six chestnut poles, woodiline; six set in broken rock, six in clay, six in the ordinary manner, and six to have a hole bored near the ground so that they can be saturated with oil.

There are now about 350 public libraries in Great Britain, says Science. These libraries contain over 5,000,000 volumes and isssue about 27,000,000 books each year. The annual attendance of readers is about 60,000,000. In comparison with these figures the following, recently published, will be interesting: There are 844 public libraries in Australia, with 1,400,000 volumes; 298, with 330,000 volumes, in New Zealand; 100, with 300,000 volumes, in South Africa. In Canada the public libraries contain over 1,500,000 volumes. In 1896 the United States, according to government statistics, possessed 4,026 public and school libraries, containing 33,051,872 volumes.

A national astronomical society is about to be organized in this country. Heretofore the astronomers have been in the habit of meeting together once a year at the annual meetings of the American Association for the Advancement of Science, they constituting a large part of the membership of Section A, Mathematics and Astronomy. The number of observatories and the number of men now devoting themselves to astronomical research make the formation of a separate astronomical society advisable. It is probable that the new society will be one of the "affiliated societies" of the American Association for the Advancement of Science, which hold their annual meetings at the same time and place.

Mr. McNicholl, the general traffic manager of the Canadian Pacific Railway, estimates that fifty thousand people have gone to the Klondike this season, and that twenty thousand of them will return to their homes without reaching the gold fields. Each man carried with him an outfit costing several hundred dollars, and his traveling expenses were not less than $250 or $300, making a total average expenditure of not less than $600, or a total investment of $30,000,000 in pursuit of the phantom. Thus far less than one-fifth as much has been brought away, taking the miners' own statements as correct; and the total output of the Klondike country this year is not expected by the most sanguine to exceed $10,000,000. In other words, the gold hunters will get back about one-third of their investment.

An extended study of the phenomena of insomnia by De Menaceine, a Russian authority in medicine, brings him to the conclusion that it is characteristic of persons who blush, laugh, weep readily, and whose pulse is apt to quicken upon the slightest provocation. Loss of sleep, however, he admits, most frequently results from overwork of either mind or body; overstrain of either kind dilates the bloodvessels of the brain and eventually paralyzes them, extreme cold producing the same results. Experiments also show that exercise of the emotions causes a rush of blood to the brain, and sleeplessness, if occurring near bedtime. There is a common theory that sleep is required in proportion to the scarcity of red corpuscles in the blood, and thus all persons do not correspond in their need of sleep, and many authorities agree that the need of sleep depends upon the strength of consciousness.

Mr. Kempster B. Miller, one of the best known telephone experts, is the instructor at the International Correspondence Schools, of Scranton, Pa., on the subject of telephony. The course is a remarkable one, and, like the other courses of this school, it is taught by mail. The telephony course is intended for electrical engineers, switchboard designers, inspectors and employés of telephone manufacturers, promoters and officers of telephone companies, members of construction boards, telephone superintendents, those in charge of interior systems, chief operators and operators, electricians in the navy and merchant marine, members of the Signal Corps of the army, street railway superintendents, etc. Few of the technical schools in this country give instruction relating to telephony, and the importance of the subject has not been sufficiently appreciated by electrical engineers. The course is intended not only to give the theory of telephony, but also to give an excellent idea of the practical work of the installation of the complete systems. The course commences at the beginning, which is acoustics, and takes the student from the fundamental principles of sound through the theory of the multiple system; from the construction of the simplest private line through the complexities of the great multiple switchboard, the construction of which involves the use of thousands of miles of wire and hundreds of thousands of soldered joints. The instruction papers are most valuable, and we are sure that those who take this course will obtain a competent knowledge of the subject.

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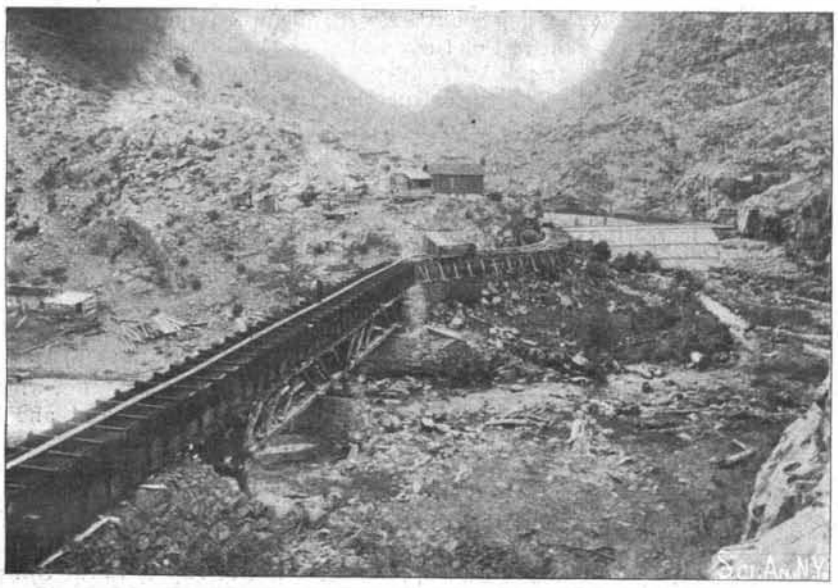
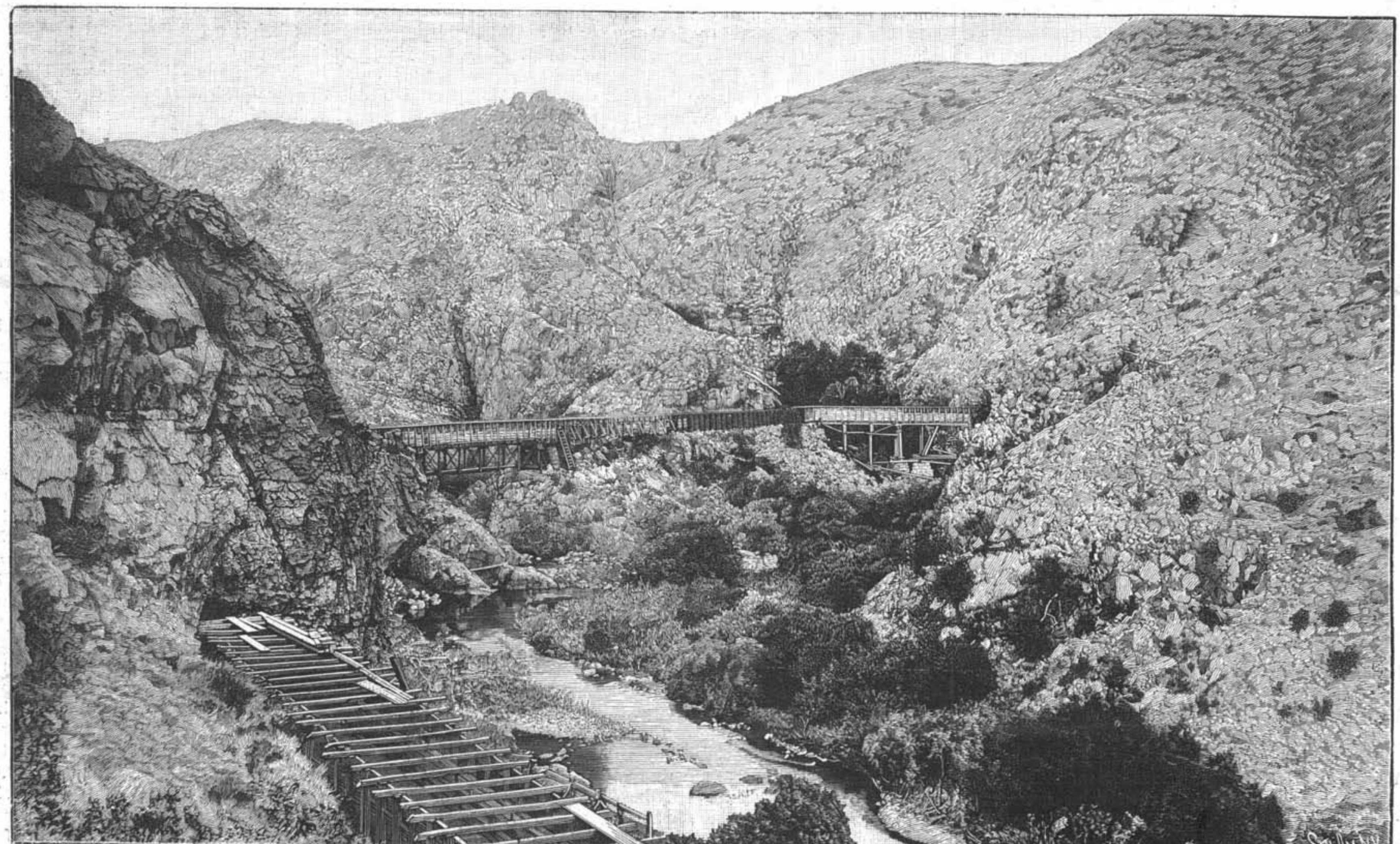
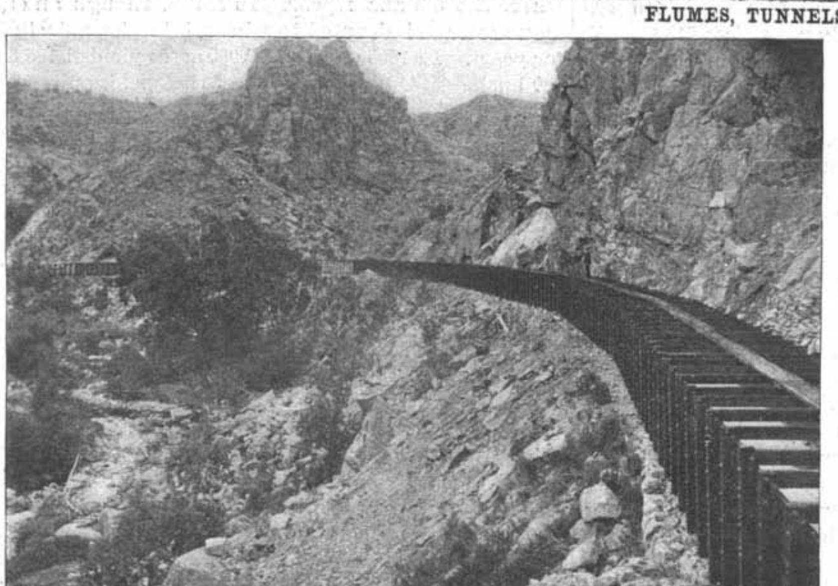


DAM AND HEAD WORKS, NORTH FORK DITCH, COLORADO.

TUNNEL BENEATH A HIGHWAY.



FLUMES, TUNNELS, AND TRUSS BRIDGES.



THE LONG FLUME.

NATURAL CHANNEL DIVISION.

IRRIGATION IN COLORADO—SOME DIFFICULT ENGINEERING PROBLEMS.—[See page 214.]

Total length of main ditch and laterals, 52 miles. Irrigation capacity, 12,000 acres. In actual cultivation, 5,000 acres.