ENGINEER, ARCHITECT AND SURVEYOR.

Vol. I.—No. 4. CHICAGO, JULY 15, 1874. SUBSCRIPTION $2.00 PER YEAR. SINGLE COPIES 20 CENTS.

GRANITE PAVEMENTS.

When the increasing travel in Broadway became too much for the old-fashioned cobble-stone pavement with which that thoroughfare was covered twenty-five years ago, and the street was continually obstructed by repairs, never being free from end to end, the city authorities were compelled to abandon it and accept something more solid, reliable, and better calculated to resist the continuous heavy travel. It was known that the Romans had, 2,000 years ago, laid pavements with square granite blocks, which are still in good condition, and very naturally this method was seized upon, and one, Mr. Russ, obtained a patent for some special details in laying such a pavement, which after him was called the Russ pavement, and was 20 or 22 years ago, laid over several blocks in Broadway, between City Hall and Canal street. It gave at first great satisfaction ,being even and clean, the smooth surface giving no chance for puddles of stagnant water and mud, but every shower washing all the dust and dirt into the gutters. But soon grave defects became evident; the surface of the large blocks of granite became so smooth by the wear of travel, that it was very dangerous for horses. It was seen that the blocks were too large, not affording sufficient foothold for the horses' hoofs between the seams, as had been the case where smaller blocks were used. Attempts were made to cut grooves into the surface, but, singular to relate, the travel had made the surface so hard that no chisel could stand it, and the stone which, when fresh from the quarry, could be cut up with ordinary tools, had become unfit for further manipulation. So this was abandoned as a bad job.

Another defect became apparent—the great difficulty of reaching the sewer, gas, and water pipes under the street. Knowing that the main defect of the former cobble-stone pavement was the unequal sinking of the stones, this was provided for in the patent in such a way that it was altogether overdone. More than one foot of the street surface was dug away, graded, and large irregular pieces of broken stone driven in, so as to give a firm support for the next layer, which consisted of huge flag stones such as used on the sidewalks; on top of these stones screened sand was placed, and on this the blocks of granite before mentioned. It is clear from this that such an arrangement was utterly unfit for a street like Broadway, where continual changes in the buildings on both sides make frequent digging under the street for connections with sewer, gas, and water pipes necessary. Such labor had become difficult and expensive, and at every spot where the pavement has been disturbed for such purposes, it was found either impossible to restore the correct level, or, if this was accomplished, the disturbed locality soon afterwards sank, so after a few years' use, the Russ pavement was in as bad a condition as the cobble-stone before, with the difference of being exceedingly dangerous for horses.

Then the so-called Belgian pavement was introduced. It consists of small cubical blocks of basalt, which being flat underneath, do not sink unequally like the round-pointed cobble-stones; and it was found that the extra precaution of Russ was unnecessary, and the Belgian pavement came more and more into favor, until at last a modification of the same was laid down in Broadway in place of the old Russ pavement, and of several other kinds of a similar nature, which had been tried partly as imitations and partly as improvements on the same. This granite pavement consists of blocks of the same width as the Belgian cubes but twice their height, and about three times as long, their greatest length being placed at right angles to the line of travel. They are simply laid in sand, and being solidly laid together, and flat below, there is no chance for unequal sinking or soaking of the ground beneath by water. The travel in Broadway was found too heavy for the smaller blocks of the Belgian pavement, and the present larger granite blocks are giving so much satisfaction that they have been laid in several other streets of New York and its suburbs, for instance in Atlantic and Myrtle avenues, Brooklyn, two thoroughfares where travel is also greatly increasing.—*Ex.*

WATER SUPPLY.—In Western cities about ⅔ of the total supply is drawn off between the hours of 6 A. M. and 6 P. M., and in Eastern cities between 7 A. M. and 7 P. M.; sometimes as much as one-tenth is drawn off in an hour. Many hydraulic engineers design the pipes of sufficient diameter to discharge ¼ the whole supply in one hour, this capacity also serving to accommodate the probable increase in size of the city.

FOUNDATIONS.

(II.)

Cement is always weakened by sand, no matter how small the proportion of that ingredient may be; so that if both materials were equally cheap, it would be best to dispense with sand altogether in using cement as mortar for building foundation walls. Upon the whole, cement sets most quickly, and unites itself most powerfully to brick and stones, when it is *net* or unmixed with sand, provided only that the joints do not exceed ½" in thickness. This opinion is confirmed by the experience gained in the construction of the Thames Tunnel, where Mr. Brunel who commenced differently, finally adopted the system of using nothing but cement for all his brickwork, which he mixed with sand in equal measures for the foundation and lower part, and with half that proportion of sand for the piers which support the arches; but from the springing of the arches upwards, he used only net cement. If the use of this material had not been discovered, the Thames Tunnel would have been impracticable, for if it had been attempted with the best common lime mortar, the pressure of the earth would have crushed some parts of the brickwork before the mortar was consolidated, and in other parts the lime would have been washed out of the joints.

For the means of comparison with the concrete foundations employed at the (late) Court House of Chicago, I here introduce the following memoranda:

The flour mill, Upper Thames street, London, is one of the largest private buildings in London, the external dimensions being, length 227'.10", width at north end in Thames street 62'.00", width at south end or river front 48'.10". The external walls are 4'.8" thick in the basement above the footings; 3'.2" thick in the 6th story, and 2'.9" in the 7th and 8th stories, and are 90 feet high to the top of the parapets; the footings are seven courses high, each course projecting 2'.4" in regular steps, making the bottom course 7'.4" wide. The river front, or south wall is 6.'9" in the basement, and the bottom course of footings 10 feet; the south wall and flank wall, next the puddle dock, are built of stone in the basement. The whole area of the building was excavated to the depth of 15 feet, and filled with concrete composed of Thames ballast and Portland cement in the proportion of six parts of ballast to one part of cement; the area thus concreted is 238 feet long, 72 feet wide, and 15 feet thick, containing 9520 cubic yards.

At Newcastle, England, considerable difficulty was experienced in getting in the foundations of the middle pier of the High Level Bridge, in consequence of the water forcing itself through the quicksand beneath as fast as it was removed. This fruitless labor went on for mouths, and many expedients tried; chalk was thrown in in large quantities outside the filling, but without effect. Cement concrete was at last put within the cofferdam until it set, and the bottom was then found to be secure. A bed of concrete was laid up to a level of the heads of the piles, the foundation course of stone blocks being commenced about two feet below low water, and the building proceeded without further difficulty.

The New Barbette Battery at Fort Hamilton, New York harbor, mounting 35 15" and one 20" gun, for the length of 1400 feet, including two large powder and four service magazines, is entirely constructed on a concrete foundation varying in thickness from 3½ to 4 feet.

As the permanence of engineering structures depends almost entirely upon the manner in which their foundations are laid, we will now proceed in regular order. The term foundation will be used to designate the bed either natural or artificial, upon which the lower portion of the structure is to rest. There is hardly another subject in which the skill of the engineer is brought to such a test, and where he is obliged to resort to such difficult and daring contrivances, as in the preparation of the bed which is to receive and support the weight of some bold structure; yet by boldness, skill, and perseverance, few difficulties are left unsurmounted, and failures are of rare occurrence, and where such do occur they are generally brought about through false economy, and not a lack of engineering skill. We will now proceed to investigate the nature and construction of the various classes of foundations in the order of their compressibility, beginning with the most substantial.

The first in order is solid rock; this is entirely unyielding, and it is only necessary to ascertain whether the strata is of sufficient thickness to bear the weight of the superstructure without danger of detaching itself from the adjacent portions, and further that it is of sufficient size, or underlaid with a substantial and unyielding bed. It is important in constructing upon rock to level down some portion and to work the more irregular portions into a series of steps; and in building up the foundation to a uniform level, to use as large courses of stone as possible, and also to make close mortar joints to avoid settlement from a majority of joints. Further comment upon this class of foundations is unnecessary, as no difficulties occur except upon such structures as the Light-Towers of Corduan, Eddystone, Bell-Rock, Skerryvore, and Horsburg Lighthouses, where extraordinary efforts are required in battling the elements to get a foothold. The details of these specialties have been sufficiently and repeatedly explained so as not to need re-iteration.

Next in order of incompressibility, but which require confinement laterally, are pure sand and gravel. These yield so slightly as not to affect the stability of the heaviest masses placed upon them. In this and the succeeding classes it will be necessary, not only to secure stability of the superstructure, but also to guard against destructive efforts of an accidental character; therefore it becomes necessary to consider the action of the frost to avoid upheaval, also to consider the close proximity of a stream, the abrasion of which may lay bare the whole, or part of the foundation, and cause the destruction of the structure.

In preparing a foundation in sand it is necessary to go beyond the influence of the frost, but as this is not sufficient in mild climates, it therefore does not become a rule. The base of the structure should then be of such a width, and such a depth, that the compressed prism will be secured by the superincumbent weight of the surrounding sand against lateral motion. After the excavation has been made to a sufficient depth, the bed is prepared by paving the entire surface with cobble or broken stone, similar to street pavement, which is rammed home with a heavy beetle until it becomes stationary, and then filled up with concrete. The foundation of the 20 inch gun at Fort Hamilton was so formed on unyielding clay. The United States Engineers construct foundations of their heaviest military works in this manner in sand, and where the weight of the superstructure alone is considered, the depth is from 3½ to 4 ft. only. Where springs are formed in the bed it becomes necessary to drive a number of piles sufficient to drive the spring away from the locality, and to use a grillage of large flat stones, or of timber, upon the piles after filling the spaces between them with beton or concrete. In using timbers the engineer's aim should be to get them to such a depth that they shall always be saturated and thereby prevented from decay; piles of elm taken from under the old London Bridge were found perfectly sound, although about 600 years old. In the vicinity of streams a substantial foundation is obtained by driving piles. A foundation for a lighthouse was established at Sandy Hook, New York harbor, in the winter of 1868–9, at a point where it was feared the abrasion would be such as would leave the point below high water in the course of a few years. Piles were resorted to; they were of oak 12 to 14 inches diameter at the head; they were substantially shod with iron and a heavy iron band at the top; the weight of the ram was 2200 lbs., and an average fall of 14 feet; some of the piles required as many as 300 blows to drive them 18 feet into the sand; after entering about 8 ft. the effect of the blows was nearly uniform.

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Next in order are the plastic clays, some of which are capable of bearing the heaviest structures, with no other preparation than the removal of the surface, and placing a bed of plank or flat stones to receive the masonry; a settling will take place almost invariably, but so gradually as to be disregarded. But one thing should be guarded against, that is, of allowing the surface water to find its way under the structure, as the clay will thereby undergo a soaking process, and many buildings in our cities of the North-west are destroyed from this cause alone. The First Presbyterian Church, Wabash ave., Third Presbyterian Church, West Washington St., and the Court House of Chicago, may be taken as a few examples of settling. (Note that these remarks refer to the buildings before the fire). Some of the plastic clays will not bear any considerable weight without the application of artificial contrivance; in them it is necessary to apply an extended timber grillage, or to drive bearing piles, and in either case thus obviate considerable labor, and excessive and unequal settling. We will consider hereafter the relative value of grillage and piles.

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THE GREAT COLORADO RIVER OF THE WEST.

In our first number we commented shortly upon a scheme recently brought forward for reclaiming a portion of the vast desert lying adjacent to this river, and here bring forward some additional observations for which we had not space at the time.

After stating that a survey of the desert was recently made by Messrs. James & Stretch, Engineers, at the instance and expense of Senator Jones, our contemporary, the ***Engineering and Mining Journal***, says:

"The proposition is received with some incredulity by a portion of the press; which is not strange, considering the general ignorance of the remarkable topographical and climatic condition of that region. The existence at the head of the valley of the Gulf of California, of a vast area of deep soil having all the elements of fertility, except moisture, was made known as early as 1854, by W. P. Blake, the geologist of Williamson's expedition in the mountain passes of California. The whole subject, including the possibility of irrigating the surface from the Colorado, is elaborately discussed in his report to the Government, contained in the fifth volume of the Pacific Railroad Surveys. Barometrical observations taken by him showed that a large part of the area is below the sea level; and he pointed out the facts that the waters of the gulf must formerly have extended some 175 miles further inland than they now do, and that the region must have been shut off from the sea by the delta of the Colorado. This gave a fresh water lake, receiving the fine silt of the Colorado for a long period of time, and which finally dried up, leaving a deep and fine alluvial soil, now the desert surface. It was observed that wherever water flowed over this soil the vegetation was peculiarly rank and dense. An analysis showed an abundance of the essential ingredients of a fertile soil, including potash, soda, and phosphoric acid. The Indians in the northwestern end of the desert raised crops of corn, melons and barley, by means of local irrigation from springs. To render that interior valley fertile would not only give us a great region suitable to the growth of cotton, grain, tobacco, and perhaps sugar cane, but it would greatly stimulate mining industry along the Colorado, in Southern California, and in Arizona. It would doubtless favorably affect the climate of the southern counties of California; and in many points of view the subject invites attention. We are constrained to doubt, however, the feasioility of extending the system of irrigation as far as Death Valley, a great distance to the north, and supposed to be shut off from the valley of the Colorado by rocky ranges. Some new and interesting information regarding this point, hitherto obscure, may, perhaps, be in store for us in the report of the engineers, which we hope will soon be forthcoming. The alternative scheme of restoring the Colorado Desert to the Gulf of California, or, in other words, inundating it with salt water instead of fertilizing it with fresh water, may have greater feasibility to recommend it, though it involves a sacrifice of the possibilities of productiveness in the region itself. Blake points out that by deepening the channel of New River, or cutting a canal so low that the water of the Colorado would enter at all seasons of the year, a constant supply could be furnished to the interior of the desert, and that it might cause the bed of the ancient lake to be refilled, and permit navigation from the gulf to the base of the Bernardino Pass. He says that carefully conducted surveys by the *level* are essential in order to ascertain the extent to which this may be accomplished, for, though the barometer is valuable as indicating the heights and differences of level in a general way, the most accurate and delicate instruments are requisite in this case. The belief is expressed that water can be obtained by artesian borings, so as to give running streams at certain points. It is surprising that this has not yet been put to the test. It could be done with comparatively small outlay."

The incredulity of a portion of the press, above alluded to, is partly on account of their belief that the diversion of the necessary quantity of water for irrigation, from the Colorado river, would seriously impair the navigation thereof. To refute this view we have merely to cite the case of the great canal constructed for the purpose of irrigation, and supplied from the Ganges river, in Northern India; further reference to this great work is made in the various articles on irrigation now in progress in this journal. At Hurdwar, where the Ganges leaves the mountains, the visible or measurable quantity of water in the river flowing per second is 8,000 cubic feet; of this the irrigation canal takes out at this point 6750 cubic feet, and yet the navigation of the river below is quite unaffected, owing doubtless to the large quantity of water which enters and flows through the permeable river bed from a point above the anicnt or dam at Hurdwar, and if the bed of the Colorado river is alike permeable we may reasonably expect the same results. Another objection the public press raise is, that the evaporation of this large quantity of water spread in a thin sheet over the land will be too great to be supplied by the Colorado river, and cite as their reason the fact that three good sized rivers emptying into the Great Salt Lake only just suffice to counteract its evaporation. A mere glance at an accurate map will at once refute this view, for though still partially unsurveyed, what *is* known positively of the Great Colorado River and its tributaries, shows an amount of water contained, immensely greater than that in all the rivers flowing into the Great Salt Lake. We hope that the proposed Government Survey will be put in hand very shortly, and that it will result in this great and useful enterprise soon being carried out.

THE Denver and Rio Grande Railway (3′ 6″ gauge) of Colorado, has proved so great a success, that several other narrow-gauge roads have been projected in that region, among which is the Pueblo and Salt Lake City Railroad, which is designed to run at present from the terminus of the Atchison, Topeka, and Santa Fe R. R., on the Arkansas, up that river to Pueblo. Some difficulty in negotiating its bonds is the only cause of its delay.

THE U. S. PUBLIC LAND SYSTEM.

The *Section* is the unit of the public land system. Its form, dimensions, area, and position, are familiar to every land owner west of the Ohio river, and are so simple, uniform and definite, that misconception of its parts and method of division seem scarcely possible. Yet in the determination of the boundaries, and the subdivision of this simple rectangular figure surveyors have discovered numerous points on which to differ, thereby creating confusion and perplexity in practice, giving rise to endless litigation and expense, and bringing the profession into unenviable disrepute.

In ordinary section surveying the principal points to be determined are, correct location of the section and quarter section corners, and the centre of the section. These once definitely settled, any further division is but a matter of measurement, and the running of straight lines between certain well defined points. Where "witness trees," pits and mounds, or other well authenticated monuments exist, there is no chance for difference of opinion as to the location of the corners which they were intended to perpetuate. The restoration of corners, however, where all evidence of their original location is lost, frequently calls for the exercise of careful judgment, patient investigation and analysis, and much wearisome labor on the part of the conscientious surveyor who desires to arrive as near the truth as possible. At this point many surveyors fail; they see hard work before them, a knotty question to solve, land is cheap, and their client will grumble if extra expense is incurred; they select the easiest method, pocket their fee,secure their client's good-will and future vote, and take the chances of their work being correct or incorrect.

In pursuance of the right method for the restoration of lost corners, the surveyor will, in the absence of any satisfactory evidence by which to identify the original location, trace out the section lines to east and west and north and south, until he discovers monuments whose correct identity and location are beyond dispute, and after chaining on straight lines between these, will divide the distance *pro rata* between the sections measured, according to the lengths given on the government plat, and set his posts accordingly. We have no doubt that every surveyor is frequently called on to do this, and may sometimes have to chain the entire township ere he can find a closing corner. It occurs mostly on the open prairie, where it involves only the labor of walking and chaining; in the timber it would be a rare case where several corners in succession were completely lost, together with all the evidence necessary for their identification.

The section corners being established, the quarter corners will be set in a straight line between them and equi-distant therefrom. The quarter corners of the north and west tiers are exceptions, and will be set at points *pro rata* to the recorded distances between the section corners. This principle of *pro rata* measurement should be carefully attended to. There is no such thing as measuring off an absolute distance in any section without reference to some other distance immediately connected therewith, except it be in the case of a fractional section, one of whose boundaries is indefinite as to position. It is surprising how many intelligent surveyors hardly ever look at the government notes, but with most culpable carelessness and unconcern, chain off "regular" distances, and throw the balance into the adjoining portion of the section. It is a fact that in not one case in ten will the more careful chaining of the private surveyor agree with the original measurements of the government deputy, and therefore a comparison of chains becomes necessary in every case. The quarter corners established, the centre is determined by the intersection of the straight lines run between opposite and corresponding corners. Each quarter section is thus an independent figure, and it is divided into quarter-quarter sections by establishing points, at midway on each of its four sides, and running straight lines between opposite and corresponding corners, except in those cases in the west half mile of the township where it is recorded 20 chains for the width, east and west, of the east "eighties" thereof, and the balance recorded for the west "eighties" thereof; in such case the corners must be located at distances *pro rata* to the recorded distances. And in the north half mile of the township, in similar cases, the same practice will prevail.

THERE are 17 surveying districts and 90 land offices, for the survey and disposal of the public domain. The former are under the direction of surveyors-general, the latter under registers and receivers.

IN Ohio, Indiana, Illinois, Michigan, Missouri, Arkansas, Alabama, Mississippi, Wisconsin, and Iowa, the entire surveying service has been completed, and the records of former Surveyors General have been placed in the archives of these States respectively.

DURING the year ending June 30, 1873, there were 30,488,132 acres surveyed at a cost of $1,217,731.67, and there were 13,030,606.87 acres disposed of. Of this latter amount, 6,073,324.96 acres were disposed of for cash and land scrip amounting to $3,408,515.50, on which commissions were $180,741.75, and other expenses $365,355.15. Total area surveyed to June 30, 1873, 616,554,895 acres; total area unsurveyed 1,218,443,605 acres. There are 369,529,600 acres of public land in Alaska, of which none have yet been surveyed.

"A knowledge of science attained by mere reading, "though infinitely better than ignorance, is knowledge "of a very different kind from that which arises from "contact with fact."—*Huxley*.

IRRIGATION IN INDIA.

(II).

In continuation of this subject we now give a short account of the works undertaken under British rule up to 1867, under the ordinary arrangements of the Indian Public Works Department, and of those subsequent to 1867 undertaken by a Special Irrigation Department of the P. W. D.

In the Punjaub, nine original schemes have been proposed and six districts of native canals kept in repair and added to. Of the original schemes, two were not sanctioned five either still under consideration, or sanctioned, and not yet commenced, and two are either completed or in process of construction. Of these two one is the Fordwah canal, 105 miles long, constructed in 1867 at a cost of £15,000; the other, the Bari Doab canal of which 212 miles of main canal out of 247 miles, are finished to a certain extent, and 692 miles of tributaries.

Of the native canals, those of the Indus and Derajat have been kept in repair and 108 miles added to them. The Lower Sutlej canals, 632 miles long, have also been kept in repair, but only 11 miles added thereto. The Khanwha and Nowrunga canals have been remodelled, and their revenue raised from £120,000 to £190,000.

The Bari Doab canal was commenced in 1850, and the main canal is not yet finished; the original estimate being $530,000. The main canal was to be 247 miles long, of which 212 miles are at present finished, and 692 miles of distributaries; the branches, three in number, of 84, 61, and 74 miles; main channel 120 feet broad and 5½ feet deep. In 1856 it was found that the cost of the canal would not be less than £1,350,000. In 1859 water was first admitted into the canal, and it was then found that the declivity of the bed was too great, the consequence being extensive channellings out in the sandy tracts, and deep holes below the falls. It was also found that the minimum discharge from the river Ravi, (the source of supply) was found to be only 1414 cubic feet per second, and the maximum 2529 cubic feet; though in 1848 the minimum discharge of the river was calculated at 2753 cubic feet; the permanent supply was therefore less than the works was designed to carry.

In 1870, *eleven years* after this discovery, the works were remodelled, and two of the branches proceeded with, but the estimate had risen to over two millions sterling or about four times the original amount. In 1870, the acreage under irrigation was 279,210, it may now be 300,000; value of water rates levied was £39,606, and of increase of land assessment due to irrigation, £26,142, in all £65,748, or about 5 pr. ct. on the outlay; water rate being estimated at one eleventh of the value of the crop. The Bari Doab Canal is with the exception of the Son canal in Bahar, the most modern of the greater works of irrigation carried out by the P.W. D., with the benefit of the experience gained by the construction of the Ganges, Eastern and Western Jumna canals. It may therefore be considered their best, and done under the most favorable of their auspices.

In Sindh but little has been done by the British, the native canals being neglected and allowed to deteriorate. One new canal 63 miles long has alone been opened; it was commenced in 1861, and finished in 1870, and irrigates 140,000 beegas (8-5 acre) yielding a revenue of £210,000.

In the Northwest Provinces, large irrigation works have been carried on by the British, they are the West Jumna canal commenced in 1821, East Jumna, commenced in 1823, and Ganges canal, commenced in 1848. The Western Jumna canals were not even approximately finished until 1846, and even then the full amount of irrigating power was not developed. The cost of the original works up to 1846-7 was 119,405*l.*, and total outlay of all sorts up to 1871-2 was 282,517*l.* It was carried on in the most desultory manner. This canal illustrates more clearly than any other, the immense renumerative power of canals of irrigation; the returns on the investment of 282,517*l.*, of capital, amounting for the year 1872 alone, to 74,518*l.* in water rate and 37,256*l.* in increase of land assessment, or 111,774*l.* in all, or nearly 40 pr. ct. per annum; in 1846 the returns were 67,289*l.*. or about 55 pr. ct. on the capital expended up to that time.

In the famine of 1837 the crops saved by irrigation from this canal were valued at nearly 1,500,000*l.* sterling or fifteen times the amount of capital sunk up till then.

The main canal lines are 445 miles long; in 1866 the water courses were in all 728 miles long, and the acreage irrigated 447,171, yielding by water rate alone about 70,000*l.*: the volume discharged is 2800 cubic feet per second, and the whole tract under water command is about 1200 square miles. Extraordinarily productive as this canal is, it is still more surprising that its head works on the Jumna are still temporary, and that a permanent head, estimated at 215,000*l.*, for this and the eastern Jumna system of canals combined has not yet been commenced, although half a century has elapsed since these canals were taken in hand!

The Eastern Jumnâ Canal is like the West Jumna Canal, a restoration and enlargement of an old native work. It was commenced in 1823, and water was admitted through its main canal in 1830. It consists of 130 miles of main canal and 619 of distributaries, watering a tract of about 1800 square miles; it is in embankment for 40 miles, the water level being from 6 ft. to 12 ft. above the level of the country; it had an average annual discharge at the head of 1025 cubic feet per second in the year 1864.

This canal shows also the large reproductive power of irrigation works in hot climates. The capital account from 1823 to 1830 amounted to 31,124*l.*, in 1837 it had increased to 46,000*l.*, and then yielded 10,084*l.* in water rate and about the same amount in increase of land revenue, or in all about 20,000*l.*, or 44 per ccnt.; the value of crops saved was nearly half a million sterling, or eleven times the value of the canal, while the acreage irrigated was rather small, only 96,000 acres. In 1846-47 the capital account had reached 81,460*l.*; in that year 106,705 acres were watered, yielding as water rate 12,175*l.* and as increased revenue 14,965*l.*, in all 27,140*l.*, or about 25 per ct. on the capital. In 1871-72, a very unfavourable year, the capital account had reached 200,000*l.*, the acreage was only 192,749 acres, but the water rate levied was 32,881*l.*, and the increase of land revenue being somewhat about the same sum, the returns must have been at least 30 per cent.

The Ganges Canal, commenced in 1848 and opened in 1854, is the third of the large Indian canals made by the British; it is the largest and as yet the most satisfactory. It was ill-designed, having been like the other canals, entirely in the hands of military men; the inclination of the bed was far too high, its bed levels retrogressed, its falls were damaged, and it could not carry its full supply until about 1866-67, when a large additional outlay had been made. In fact the whole of the canal, main and branches, had to be remodelled throughout, and the distributaries had been so badly laid out, that hundreds of miles of them have been abandoned at different times. The remodelling of the branches was not finished in 1872-73, and the head works are still temporary, no permanent dam being yet finished, and possibly not yet commenced.

This canal is of large size. It had an annual average discharge at the head of 4346 cubic feet per second in 1864; the main canal is 348 miles long, the main branches 306, and the distributaries 3078 miles long; irrigation commences at 22 miles from the head works, the tract under command of the water being 320×50 or 16,000 square miles. It crosses the river Solani in embankment for 3 miles, having an aqueduct 920 ft. long in fifteen arches of 50 ft. span, about 30 ft. high. The acreage irrigated was in 1864, 449,788; in 1865, 566,517; in 1866, 634,725; in 1867, 513,457; in 1868, 1,098,400; in 1871, 767,000. No information as regards the capital account is forthcoming, except that in 1864 the total outlay amounted to 2,058,714*l*. and in 1871 to 2,382,140*l*. The only details of returns is:

Year.	Water rate.	Increased Land Revenue.	Total.
	£	£	£
In 1867	136,353	80,017	216,371
" 1868	244,156	161,260	405,416
" 1871	66,234	unknown	100,000 probably.

It, therefore, in spite of the bad management expended on it, probably now yields 4 per cent., and has yielded 10 per cent. In 1866 the value of the crops irrigated amounted to more than million, or half the value of the works, while its irrigating power was in its infancy. It might under good management and good engineering yield as much and more than the Eastern and Western Jumna Canals, or from 40 to 60 per cent. in exceptional years, or half that in ordinary years, when its irrigation is fairly developed.

The Lower Ganges Canal is a project commenced in 1871 that will complete the irrigation of the Ganges and Jumna Doab; it will have the head works, or weir at Rajghat, have a capacity equal to the Upper Ganges Canal, and has an estimated cost of 1,825,000*l*.

In Rohilkhand the Indian Government has not yet sanctioned any general and comprehensive scheme of irrigation. In 1840, a small canal, the Naginah, was opened; there are also the Muradabad canals; two others, the Paba and the Kailas, have been recently commenced. In the Dehra Dun, from the river Toude five small canals, in all 97 miles long and irrigating 11,039 acres, have been made or restored under British rule. In Mairwara and Rajputana, between 1836 and 1846, the political agent restored or constructed 2065 tanks, having an area of 8675 acres and irrigating 14,826 acres. Since then nothing has been done.

In Bahar, the construction of a portion of the Son Canal project was commenced in 1870, the weir and 22 miles of main canal are in progress; the estimated cost of these works is 3,775,000*l*.

In Bengal, the Midnapur Canal, principally intended for navigation, was opened in 1871, and will be open throughout this year; as the rainfall is abundant, irrigation is generally not needed in this part of the country, and is considered a grievance.

In the Narbada Valley, in Nemar, the lake of Lachma and 105 other tanks, and the great Chuli and Mandleshwar tanks, on the Madras system, were restored by the political agent in 1846.

In Gujrat, on the Tapti, one work is sanctioned; in Khandeish, the Girna project is commenced; the Jamda Canal was opened in 1869; the Mukti reservoir, near Dhulia, is being being constructed, and the Hurtola tank is nearly completed.

In the Madras Presidency Sir Arthur Cotton and his school of Madras military engineers have carried out systems of deltaic canals, in the deltas of the Godavari, the Krishna, the Pennar, and the Kaveri; these consist of long low dams across these rivers at the heads of the deltas, from which canals irrigating the deltas radiate. Those on the Godavari amount to 840 miles of channels irrigating 225,032 acres, but designed to irrigate 780,000; these works were sanctioned in 1844, and hence we assume that they are not perfectly completed yet. Those on the Krishna irrigate 144,591 acres; in 1866 an extension of irrigation to 430,000 was proposed, and the works, having this object in view, are now going on, 1873. Slowly as irrigation works progress in Northern India, the Anglo-Indians of Southern India far surpass them in want of rapidity. The Pennar deltaic canals irrigated 37,874 acres in 1863. The Kaveri canals, aided by the Kalerun dam, raised the acreage of 630,612 acres in 1836 to 716,524 in 1850, giving a return of 23¼ per cent. on the outlay. The total acreage under irrigation in the Madras Presidency is 3,300,017 acres, of which only about one-third is that of the deltaic canals, the rest being from old native tanks, or rather from such of them as have not been allowed to fall into entire disrepair. In Mysor there still exist in working order a large number of small dams on the various rivers, having channels of an aggregate length of 1203 miles, and yielding a revenue from irrigation of 37,182*l*.; there are about 9000 tanks, and out of 29,064 square miles of area of the catchment basins of the various rivers of Mysor, no less than 26,287, or nearly 60 per cent., have their drainage intercepted by tanks, and utilised in irrigation; but these are old native works. The great Periar project, in which it is proposed to divert the waters of the Periar towards the western coast, and irrigate the greater part of the large province of Madura, is not yet even sanctioned, and the project for vast reservoirs near Balari to supplement the canals from Kurnal to Kadapa and Nellor, made by the Madras Irrigation Company, and about which we shall treat under a separate head, can hardly be said to have been started by the Government.—*Engineering*.

IRON ORES OF LAKE CHAMPLAIN.

In a paper recently read before the Iron and Steel Institute of Great Britain, Mr. Geo. W. Maynard of New York gave a considerable amount of information regarding these ores and also concerning the various minerals of coal and iron found in the United States. He stated that the principal coal-fields are four in number yielding at present between 300 and 400 millions of tons, whereas about 50 years ago their yield was only 300 to 400 tons. The Champlain ores show a remarkable richness and freedom from phosphorus. The author classified them as, unaltered magnetite, peroxidised magnetite, or *martite*, and titaniferous magnetite. Washington county ores give by analysis from 42 to 43 pr. ct. of sesqui-oxide of iron ($Fe_2 O_3$), from 17 to 19 pr. c. of protoxide (Fe O), and a mere trace of phosphorus. Essex county ores give 45 to 51 per ct. of metallic iron, and .36 to .14 pr. ct. of phosphorus. Another ore gave 65 pr. ct. of metallic iron, and .21 pr. ct. of phosphorus.

Other ores gave as much as 60 to 80 pr. ct. of sesquioxide. The author showed by a history of the various smelting companies of the Champlain district the great expansion of the iron trade therein. In some ores titanic acid was present to the amount of 14 to 16 pr. ct. with 44 pr. ct. of metallic iron.

In answer to some inquiries Mr. Maynard stated that generally individual ores were not employed by themselves, but usually two or three different kinds were smelted together, and the pig-iron produced was admirably fitted for foundry services.

ENGINEER, ARCHITECT AND SURVEYOR.

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168 Washington Street.

CHICAGO, ILL., JULY 15, 1874.

CONTENTS.

OUR ILLUSTRATIONS.

EXAMPLES OF SEWERS AND FAULTS IN BUILDING THEM.

We are glad to be able to congratulate our readers upon our first appearance with illustrations, and these too of a kind which we hope will prove of value to many.

As the population of a settlement increases from a village to a town, and from a town to a city, a growing demand increases to an absolute necessity, and a system of sewerage is then designed and constructed according to the requirements of the probable population of a time some years ahead.

Figures 1 to 11 represent various sections of Main Sewers in use in many different localities, both in this country and Europe, and methods of constructing the same according to the most improved principles.

Figure 1 is a section of the great Fleet Sewer, London, Eng., at its mouth, and figure 2, a section further up the same. Of these two forms figure 2 is the best, as the flat invert of figure 1 tends to promote deposit; but as the outfall is washed twice a day by the tides of the river Thames, the flat invert is not disadvantageous in this particular instance.

Figure 3 represents the main collecting sewers proposed last year for New York City, and in process of construction as the Dock Works advance. Their object is to intercept the main cross-town sewers near their present outfalls, and convey the sewage into the rivers on each side of the city, into the spaces *between* the new bulkheads as they are built. Height being an object here, the necessary area of section is gained by extension laterally, the breadth thus being greater than the depth; under these circumstances the form of section is a good one for the purpose.

Figure 4 is a section of one of the Westminster Main Sewers in London, Eng., which failed on account (it is said) of defective workmanship, and was replaced by the sewer shown in figure 5. Figure 6 shows a sewer of a better form of section than either of figures 4 and 5; in figure 4 the sewage would form a deposit assuming a shape shown approximately by the dotted lines or after the manner of that in figure 9. The following quantities also show in favor of figure 6 in point of cost of construction; excavation is taken as an average depth of 20 feet in each case.

	Fig. 6.	Fig. 4.
No. of Bricks required per mile	924,140	1,378,080
Cubic yards of brickwork, per mile	2,272	3,388
" " " excavation, "	19,555	25,240

Figure 5 is not so well calculated in form to withstand the vertical pressure of the earth above the sewer, as figure 6, and costs more in construction.

Figure 7, though largely used, is a very ineffective form, as deposits settle in the lower angles of the sewer and the horizontal pressure of the surrounding soil frequently pushes inwards the rubble-stone walls, thus contracting the water-way and forming leaks between the walls and the stone sills.

Figure 8 is a good form for sewers of moderate depth below the surface of the ground, as for a given sectional area, the circle, as is well known, presents a smaller perimeter than any other figure in geometry.

Figure 9 is a section of the Aqueduct of the Pont du Gard, near Paris, showing the form which the deposits from the water assume, in spite of all the efforts of the scientific French engineers. An examination of this figure and of the dotted lines in figure 4 will suggest one of the reasons why figure 10 is the *best* form for general use which can be adopted.

There is a great deal of truth in the principle of constructing engineering works of forms very similar to those which nature makes for herself. For instance, the best form for the interior of a blast furnace is that which the fire has cut out for itself in similar furnaces, in precisely analogous cases; the "lines" of a ship are laid down to approximate to the forms of the curves of the waves; the most economical form of long-span

EXAMPLES F S

FAULTS IN LDING

SLES
FIG 2,3,-½
FIGS 10 11,-⅛

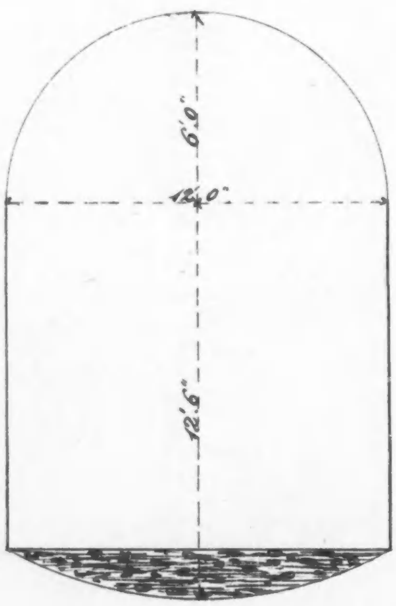


FIG. 1.

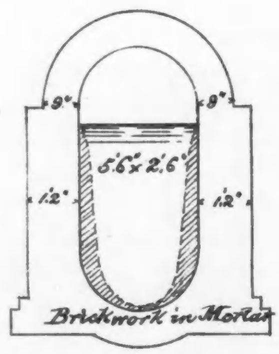
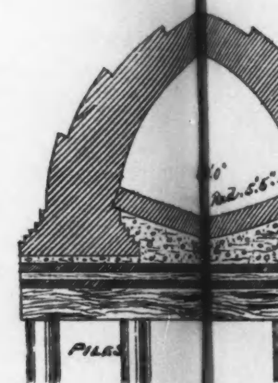
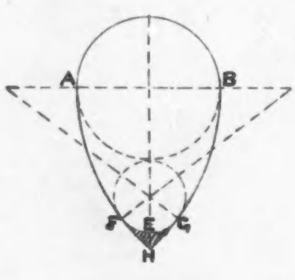


FIG. 4.





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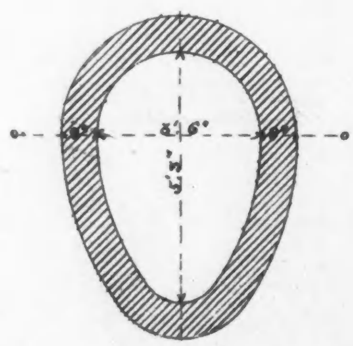

FIG. 6.

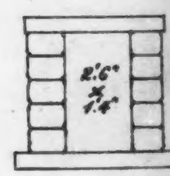

FIG. 7.

FIG. 12.

FIG. 14.

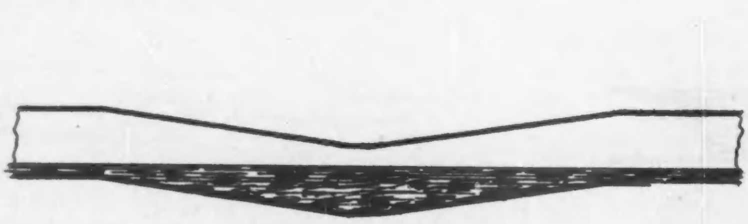

FIG. 13.

FIG. 15.

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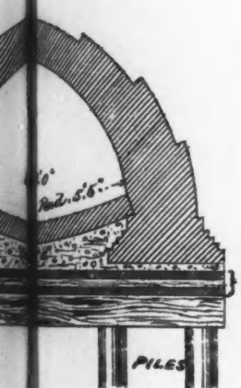
FIG 2,3,-1/n

FIG 0 11,-1/8



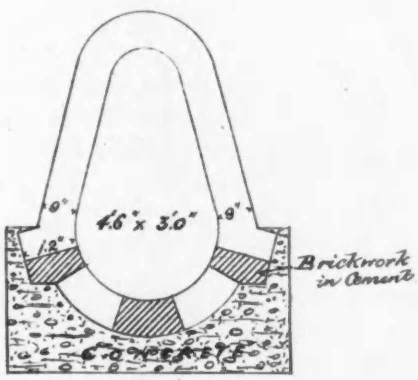


FIG. 5.

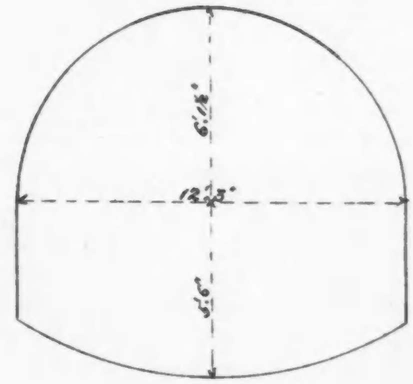


FIG. 2.

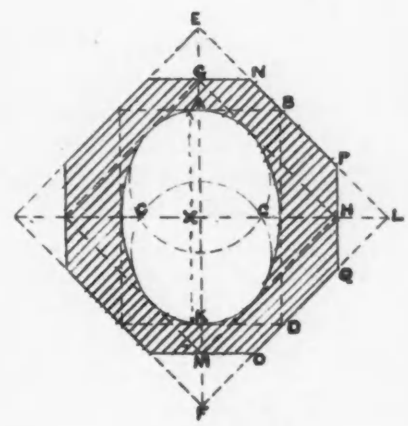


FIG. 11.

FIG. 8.

FIG. 9.

FIG. 16.

FIG. 18.

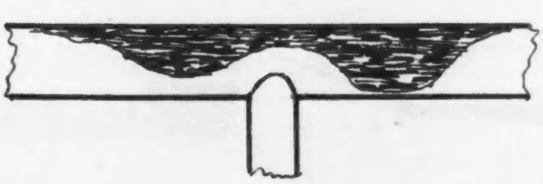


FIG. 17.

FIG. 19.

Drawn by Geo. H. Frost & Chas. J. Moore
168 Washington Str, Chicago, Ill.

bridge is one in which the principal members are built together in forms approximating closely to the curves formed by the lines of direct thrust and compression in a solid beam; and lastly we here see that the best form of closed sewer, the "egg-shape" or "oviform" approximates to that made by the water itself, as exemplified in the case of the Pont du Gard. In the form of a sewer the principal points to be attended to are the pressures of the surrounding material, and the necessity to reduce to a minimum the friction between the contained fluid and the sides of the sewer. The greatest pressure on a sewer being that due to the weight of the earth above it, an elliptical form (such as figure 11) with the longest diameter vertical, would appear to be the best; but the necessity of lessening as much as possible the surface of the sewer in contact with the sewage, in order to reduce the friction brings us to the conclusion that the modified ellipse or "oviform" section (figure 10) is the best, especially as the amount of frictional surface becomes a most important element when the flow through the sewer is very small.

A simple method of designing this form is given in fig 10. Determine the greatest diameter A B,then all the other dimensions are functions of this diameter. Calling the length of this diameter D, we have for the other dimensions: Diameter of invert circle=.5 D; Radius of sides of sewer=1.5 D; Vertical depth of sewer=1.5 D. Area of the sewer=area of a semi-circle of diameter D + area of segment of a circle of 1.5 D radius, and .5 D versed sine; the area of the semi-circle$=\frac{.7854\ D^2}{2}=.3927\ D^2$; area of the circular segment=.086061 D; therefore,area of sewer$=.3927\ D^2+.086061$ D a very simple expression. This area will be slightly in excess of the actual area of the sewer, but only by the small amount F E G H enclosed by the sides of the sewer produced, and the invert.

Figure 11 shows a simple method of drawing the form of an oval or elliptical sewer, and the thickness of brickwork necessary.

The depth, X, of the sewer being determined, draw the two circles as shown for the invert and top of diameters$=\frac{2}{3}$X; the intersections C, C, of the circles form the centres from which to draw the sides of the sewer.

To determine the necessary thickness of brickwork, draw A B and K D tangents to the top and invert of the sewer, and B D a tangent to the side at the centre; make A E, K F on the line of the depth of sewer produced, equal to A B or K D. Through B and D draw E B L and F D L; these lines give two of the five sides of the brickwork. Parallel to E L and F L draw the dotted lines G H and M H tangents respectively to the upper and lower circles of the sewer; though G and M draw the horizontal lines meeting E L in N and F L in O; through H draw the vertical line P H Q, then the line M O Q P M G is the boundary of the brickwork on one side of the sewer, the other side is formed by the same operation.

Area of the sewer $=\frac{x}{2}\times\frac{2x}{3\times 2x}\times 3.1416=.5236\ X^2$.

Figures 12 to 19 are examples of common faults to be met with in many if not *most* sewerage systems, chiefly committed through carelessness or ignorance on the part of both contractors and superintendents of the work; the shaded portions in every case show deposits in the sewers occasioned by these faults.

Figure 12 shows a case where the mouth of the pipe is laid too low, or has sunk since being laid, the flow of the sewage being thus retarded, and depositing solid matter as shown.

Figures 13 and 16 are examples of the harm done in laying pipes over too soft a stratum; planks or cordwood should have first been placed to secure a sufficiently solid bed before laying the pipe. In Figure 16 the cemented collar has been forced off the joint and broken, the lower portion projecting into the pipe, retarding the flow of the sewage, causing some of it to escape through the open joint into the surrounding soil, and depositing the remainder as solid matter in the pipe.

Figure 14 is another case where two contractors working on different lengths of sewers have joined their work in a defective manner, owing to errors in the levels, thus forming the deposits shown.

Figure 17 shows the form of the deposit made by entering a junction at *right angles* to the main pipe, a great and fundamental error.

Figures 15 and 18 represent the harm that arises from effecting a junction with the main sewer at too low a level. In figure 15 the house drain shown is filled with deposit even half way up its bend; the noxious effects of this stagnant mass of refuse and putrifying matter *in a house* are too obvious to be enlarged upon. Figure 18 shows a junction of a sub-main, with a main sewer on the level of the invert of the latter. The liquid mass flowing down the sub-main meets the water in the main sewer, slacking its speed thereby and depositing the solid matter which in time chokes up the pipe, unless the sub-main is frequently *flushed.*

Figure 19 shows the manner in which the cases in Figures 15 and 18 ought to have been built; the branch entering the main at a height some distance above the invert of the latter.

These cases are all from actual practice.

NEW YORK AND BROOKLYN BRIDGE.—Gov. Dix, of New York State, has signed the bill authorizing the raising of money, by the cities of New York and Brooklyn, to complete this great and for some time delayed work.

HON. S. S. Burdett is Commissioner of the General Land Office.

FIRE-PROOF CONSTRUCTION.

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In some patented "fireproof constructions" the floors and ceilings of the rooms are made of a certain composition moulded into the forms of arches sometimes tied at their feet with wrought iron rods, sometimes merely abutting on cast or wrought iron girders supported on columns.

Not unfrequently much stress is laid by the advocates of a patent on the refractory nature of the ingredients of which the arches are composed. In view of the facts above stated, the architect or builder designing to use such patented "fireproof construction," must be wary, and guarded in accepting the statements of its advocates regarding the refractory nature of the materials and must not believe unless they are supported by well authenticated experiments, or until after being a witness himself to such experiments.

[*To be continued.*]

OUR NOTE BOOK.

It has been truly said that we learn as much from the the failures of others, as from their success. In Engineering this is especially true and a careful study of the difficulties met with in the construction of great engineering works teaches us much, even if these difficulties are so many and great as to become insurmontable by those carrying out the enterprise and thus cause its final abandonment. The inventive faculty is aroused and stimulated by a careful study of these difficulties; in fact it may be said that no great and radical improvement has ever been brought out except under the pressure of a great necessity, an *urgent* want, an absolute and stirring conviction that something of the kind must be done.

These remarks though trite to many, must ever be kept in mind and form one of our springs of action. In view of this fact we reprint from the pages of an able contemporary the articles on "Irrigation in India," which are now appearing in these columns.

They will repay perusal, showing as they do, what great loss is the result of a vacillating or procrastinating policy in Engineering undertakings. Something may be gleaned from them also in respect of the care and judgment necessary in dealing with hydraulic works, those in which the alteration of natural, or the construction of artificial water channels form the principal feature.

WE are pleased to note the interest that is being manifested by surveyors, in several parts of the country, on the subject of practical surveying. We are in receipt of numerous letters during the past month on the subject; some we have published for the benefit of our readers, while others have been filed away for future reference. This interest augurs well for the profession, and we feel assured that as our paper becomes more widely known, surveyors will recognize its value as a medium for the interchange of opinions, and produce thereby a greater uniformity of practice than now prevails, and eventually greatly elevate the standard of professional ability.

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Without therefore, taking up time or space to argue, or prove my position, I will proceed to state what in my opinion is the proper method to divide the quarter section mentione.d

If as supposed by your correspondent "E. B. O.," the N. W. ¼ of Sec. 6, be 40 chs. N. and S., then the Government plat will show the length of the north lin of said quarter, from the ¼ post west, to the quarter quarter corner, as marked on the plat, to be 20 chs.; and from the quarter quarter corner to the N. W. corner of the Section is marked as being 17.60 chs., making 37.60 chs. across the north end of said quarter section. If, therefore, on measuring said line I find it corresponds to the measurement given on the plat, I would set my quarter quarter corner 20 chains west of the ¼ post and 17.60 east of the section corner, thus giving to each just what his patent calls for, and also what the government plat shows is contained in each subdivision. If however, the actual measurement differs from the length of the line as given on the plat I would divide the excess or deficiency *pro rata* between the divisions, precisely on the same principle that I would re-set the ¼ post on the same line and section if missing. In the latter case you would hardly re-establish it exactly midway between the section corners if the plat showed that the west half of said section line was 2.40 chs. short, simply because some man's deed called for the *west half* of section 6.

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MR. EDITOR.—Your correspondent E. B. O., Co. Surveyor, as appears in your last issue, asks your opinion as to the proper division of N. W. ¼ of Sec. 6; one man having a patent for the W. ½ of that N. W. ¼, containing 70.4 acres and another having a deed for the E. ½ of the same ¼, containing 80 acres "more or less."

Your answer, I think, does not meet this case fully. The usages of the land department do not always divide fractional quarter sections equally, and I am not aware that they ever issue a patent for "more or less," but always for a specific quantity, according to the government survey, which in their estimation is always correct.

In the subdivision of a section, we have less to do with the quantity of land than with the length of the exterior section lines. Section 6 has no N. or W. ¼ posts, set by the deputy surveyor, and the first thing for the county surveyor to do, is to set these ¼ posts, and to do so, the N. and W. section lines must be measured and compared with the original; if they agree, then set the N. quarter post, 40 chains west of the N. E. corner and the west quarter post 40 chains N. of the S. W. corner of the section. Then to quarter the section run direct lines to the corresponding quarter posts on the opposite sides of the section and fix the centre at the intersection of that line.

To divide the N. W. quarter of the section; if the measurement of the south line of the section from the south quarter post W. agrees with the original, set off from the N. quarter post, west 20 chains, and run a line to a post 20 chains west of the south quarter post. This divides the N. W. quarter into halves, whether they are of equal size or not. To divide these halves into quarters of the quarter section referred to, if the east line of the section from the E. quarter post to the N. line of the section, agrees with the original, then set off from the W. quarter post 20 chains north, and run a line east to a post 20 chains N. of the east quarter post.

This process will meet both the inquiries of E. B. O. But if the present measurements of the said lines do not agree with the original, then these divitions on the section line must be made in the same proportions as the original, as indicated above.

The probabilities are that the 70.4 acre and the 80 acres in the first inquiry and the 38 acres and 40 acres in the second, are the original quantities, as conveyed by the government, and the division should be made pro rata, to correspond with these numbers. Very respectfully, B. K.

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EDITOR.

COMPASS NEEDLES.

Though of late many surveyors have adopted the transit instead of the compass, there are still a great many, if not the majority, who run their lines exclusively by the latter; and as regards correctness, depend entirely on the delicacy of the needle. It is a fact, however, that most surveyors complain about their needles because they have not got the requisite sensitiveness. In most cases the cause of this is, first, the improper form of the needle, and, second, the loss of magnetic power in the poles.

In regard to the first point, long years of experience in handling needles has shown to makers that light needles are always more sensitive than heavy ones, and, therefore, that all superfluous metal in the middle should be avoided, and, except at the extreme ends, the needle should be of a uniform breadth throughout its whole length, and should always have the greatest thickness in a vertical direction, which however is not the case with a great many needles. A light needle has besides other advantages, that of not wearing the centre pin blunt as quick as a heavy one.

The loss of magnetic power in the poles is caused by the steel not being hard enough. A needle perfectly hardened on both poles loses little, if any, magnetic power, while one that is blued does it to a considerable extent in a short time. If a needle loses magnetism the north pole rises, while the south will sink; the rise and fall of the poles is therefore an index for the loss of magnetic power. Experiments that have been made

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In regard to the first point, long years of experience in handling needles has shown to makers that light needles are always more sensitive than heavy ones, and, therefore, that all superfluous metal in the middle should be avoided, and, except at the extreme ends, the needle should be of a uniform breadth throughout its whole length, and should always have the greatest thickness in a vertical direction, which however is not the case with a great many needles. A light needle has besides other advantages, that of not wearing the centre pin blunt as quick as a heavy one.

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Should a needle have lost magnetism, it can be charged again without even taking the compass to pieces, in the following manner: raise the lifter up to the glass plate, and pass the south pole of a common horse shoe magnet, close to the glass, over the north pole of the needle, slowly, from the middle to the end; in the same manner pass the north pole of the magnet over the south pole of the needle. Sometimes it suffices to repeat the operation two or three times.

LEO STRASSBERGER.

ILLINOIS AND ST. LOUIS BRIDGE.

This great work was formally opened on the 4th inst., and a description of the same slightly condensed from the *Chicago Tribune* will interest our readers.

Much controversy was aroused at the time of its first proposal and a convention of twenty-eight engineers was appointed to examine and report on the whole subject. The convention reported against the "Eads plan," and in favor of the "Boomer plan," an arrangement of "Post" trusses in two spans of 350 feet each, and four of 264 feet.

Nothwithstanding this, the Illinois and St. Louis Bridge Co. to which Capt. J. B. Eads was Engineer had already commenced the operations which have recently been so successfully completed.

The bridge has three spans, the centre of 515 feet in the clear, the side ones each of 497 feet. Each span is composed of four ribbed arches of cast steel. The double ribs or members extending from pier to pier enable the arch to preserve its shape under all circumstances of unequal pressure upon its parts, and obviate the necessity of a spandrel bracing. A moving load has no effect on the curve of this double arch, however unequally distributed its weight may be.

The upper roadway for carriages,horse-cars,and pedestrians, is 50 ft. wide between the railings, the roadway being 34 ft. wide,and the sidewalks each of 8 ft. Below the carriage-way are two railway-passages, each 13½ ft. wide in the clear, and 18 ft. high,extending through arched openings of equal size in the abutment and piers. Five stone arches, each of 20 feet, carry the tracks over the levee on either shore. They are inclosed by cut-stone arcades of 20 arches, supporting the carriage-ways. On the St. Louis side brick arches carry the tracks to Third street, where the tunnel is entered conducting to the up town Union Depot, and the carriage way is continued on a level grade over the regular track to Third street. On the Illinois shore the railways curve off to the north and south, immediately after crossing the last one of the stone arches, and with a descending grade of one foot in a hundred, extending about 3,000 feet, and supported on iron trestle-work a part of way, reach the grade of the railways on the Illinois side. The carriage-road descends with a grade of five feet in a hundred, immediately after the railway tracks curve away from the bridge.

It will be a long time ere an accurate statement of the cost of the bridge can be given. Col. Fladd, in conversation with the representative of *The Chicago Tribune*, gave the following as approximating very nearly to the exact expenditures for the bridge:

Land damages	$ 700,000
Caissons and foundations	500,000
Masonry,	1,300,000
Eastern approach,	500,000
Superstructure,	700,000

To this total of $4,700,600 is added about $1,250,000 for miscellaneous, contingent, and incidental expenses, bringing the amount up to $6,000,000. The tunnel which will be completed Aug. 11 was placed at $1,200,000. With an addition of $3,000,000 for charter, interest, discount, financial operations, management, consolidation, etc., the total expense will be nearly $10,500,000.

The bridge contains 104,000 yards of masonry, the tunnel 60,000. There have employed 2,600 tons of steel and 3,000 of iron. The Victoria Bridge at Montreal contains 22,000 tons of stone in all; there are 45,000 tons in the eastern abutment pier of the St. Louis bridge.

Twenty two lives were lost during the work, including the twelve from caisson disease. Nine men were killed on the piers, and one on the superstructure. All of these lives were lost through the carelessness of their owners, as nothing connected with the machinery or staging broke, gave way, or proved defective. The working force was 1,000 strong.

The contractors were as follows:—James Andrews, Pittsburgh. Superstructure—The Keystone Bridge Company, Pittsburgh, Pa. Eastern Approach—The Baltimore Bridge Company, Baltimore, Md. Tunnel—Jas. Andrews, Pittsburgh, Pa., and S. Kramka, St. Louis, Mo. Iron and Steel—The Midvale Steel Company. The estimated annual income of the bridge is placed at $1,000,000 which in thirty years should pay off the bonds. The sources of revenue besides the twelve railroads centering at the city are the teams from the eastern shore with coal, flour, produce, etc,, and pleasure and business traffic. Fifty thousand teams have hitherto crossed the ferries annually, besides coal-vans carrying 900,000 tons of coal, so that the estimate of income is not considered out of the way.

The question of the effect of the bridge upon navigation has been very recently discussed. As to passing under the bridge, there is little danger to be anticipated on that account. The flooring of the bridge is sixty-nine feet above high-water mark, affording ample height for the passage of steamers. The tendency of the great masses of masonry in the piers, standing as they do in the middle of a river running rapidly through a contracted channel, will almost undoubtedly be to promote the formation of ice gorges in winter, and possibly to change the direction of the current forming here shoals and there eating away the shore. Upon this point, however, the only safe opinion will be that expressed by experience, for the Mississippi is the most capricious of rivers.

Ground was broken Aug. 20, 1867. Capt. Eads says that in 1851 he had occasion to examine the bottom of the river near Cairo; "65 ft. below the surface," says he, "I found the bed of the river, for at least 3 ft. in depth, a moving mass, and so unstable, that in endeavoring to find footing on it beneath my diving-bell, my feet penetrated through it until I could feel the sand rushing past my hands, although it was standing erect at the time" This same sand-current proved a serions obstacle to progress on, at least, two occasions—once when it scoured away and caused the sand placed inside to equalize the pressure to burst the caisson; once when, after the current had forced out some bolts, its friction prevented the dam from setting.

There was another peculiar obstacle to overcome at the west abutment. For years steamers had been in the habit of shedding their cast-off smoke-stacks and grates and throwing their refusee stone and cinders into the river beside the levee. There, too, lay the hulls and machinery of two steamers burned at the big fire of 1849, the whole presenting a mass of iron 12 feet thick. Brobdingnagian chisels, formed by arming oaken beams with steel cutting edges, were hammered down with pile-drivers through the mass of ragged metal; a double course of sheet-piling followed; the coffer-dam was enclosed; the usual work of excavation and pumping was carried on, and Feb. 25, 1868, the first stone of the abutment was laid 57 feet below the city directrix (ordinary highwater mark,) on the bed-rock of the river. In the first course of the foundation is embedded the crank of one of the burned vessels of 1849.

The plenum pneumatic system for sinking the foundation was adopted with radical improvements and alterations, instead of following the original plan, which was to sink the foundations of the piers by means of large caissons, open at top and bottom, to serve only the purpose of allowing the removal of the sand at the side of the piers down to the bed-rock of the river, while inside of them wooden caissons containing the masonry were to be sunk. Alterations were demanded not only because of the strong current and treacherous sand-beds to be encountered, but because of the great depth below the surface at which work was to be prosecuted. Seventy feet had hitherto been the limit of actual experience, while at St. Louis, even if the eastern pier were sunk at the most favorable season, the men had to work at a depth of from 90 to 100 feet below the water-line.

In making the caissons, the air locks were placed at the bottom of the shaft, and partly within the air chamber, and a central shaft provided with a circular stair in lieu of ladders. By these means, as compared with the old caisson, where the air-locks were at the top, the men were exposed for a shorter time to the effect of the compressed air. A water-packing for the pumps made the air cooler than it usually is under compression, and a new sand-pump was invented that materially expedited operations. A stream of water was forced down through one pipe, and caused to discharge near the sand into another pipe in an annular jet, and in an upward direction. The jet created a vacuum below it, by which the sand was drawn into the second pipe or pump, the lower end of which was in the sand. The force of the jet naturally drove the sand up to the surface as fast as it entered the second pipe. The superiority of this pump consisted in the fact that the requisite supply of water for keeping the sand in a fluid condition was constant, while the suction pipe was inserted directly in the sand. It was scarcely possible for the pump to become clogged, and it worked admirably, even with the pipe nineteen feet deep in sand. One of these, of three-inch bore, discharged ten cubic yards of sand in an hour, taking up and throwing out stones two and a quarter inches in diameter with as much facility as sand.

The usual process of constructing and sinking the caissons was followed in all essential details.

The caisson for the eastern pier was launched Oct. 17, 1869. It was 82 feet by 60, and 28 feet high, and weighed 250 tons. The material was wrought-iron plates, strengthened by every appliance. The roof of the air-chamber was nine feet above the cutting edge of iron, supported by two longitudinal walls of timber and transverse iron girders. About 500 feet from the Illinois shore, a break-water, with ice-apron, had been built. In the lee of this were driven the guide-piles. To this point the caisson was towed Oct. 18, 1869, the false bottom removed, the air-chamber filled with compressed air, and the work of sinking began, screws hanging from beams resting on the guide-piles keeping the caisson steady in its descent through the water, and so obviating the danger of its overturning. The caisson was lowered safely through water varying from 20 to 30 ft. in depth, and into the sand, there over 70 feet deep. Bedrock was reached Feb. 28, 1870, 93 feet 4 inches below the surface of the river, and 120 feet below high-water mark. The filling of the air-chamber and shaft with concrete was concluded May 27, 1870. The masonry, of course, had been laid as the caisson descended.

In laying the masonry, another machine, invented by Capt. Eads and Col. Fladd, proved of great service. One man directed the operation, and twelve hydraulic rams furnished the power. These lifted at once twelve seven-ton blocks of granite from the stone-barges by derricks, and, by travelers running on wire cables, placed them in precisely the position desired by the masons, the operation taking but three minutes. This apparatus laid 325 cubic yards of stone in one working day of ten hours.

The caisson for the west pier, 82 by 48 feet, was launched Jan. 3, 1870, and the first course of masonry begun on it Jan. 15. A light lining of white pine staves was used to keep the water out of the main shafts, and the iron shell only carried to a height of 20 feet above the roof of the air-chamber, and then, the masonry was carried on without any outside covering, thus effecting a great saving both in iron and labor, and greatly expediting the work. The caisson was sunk through 20 feet of water and 50 feet of sand.

The original intention had been to place the foundation of the eastern abutment on piles driven inside of a coffer-dam 50 feet below water, covered with 20 feet of concrete. As the boring, however, only showed a depth of 128 feet, 8 feet more than at the eastern pier, it was resolved to lay the foundations on the solid rock, an operation involving an additional expense of $250,000, but leaving no possibility of accident. The caisson was constructed of wood, with the exception of the air-locks (which were of increased dimensions), and a thin iron shell covering the sides and roof of the air chamber. The sides, too, were only carried up 12 feet,and elevators were substituted for stairs. The caisson was begun April 6, 1870, and launched Nov. 4. The men reached bed rock March 28, 1871, 136 feet below high-water mark, or 104 feet below the water surface.

The laying of the piers completed, to carry them up and place the superstructure was a work without special difficulty or interest. In February, 1874, the span of the last arch was completed. By the 20th of April the bridge was finished, but a delay of fully a month was caused ere it was opened to the public by a wrangle between the contractors and the Company. June 9, Gen. W. T. Sherman crossed on the first locomotive, and drove the last spike.

June 30, the first test was made, and under a weight of 70 tons, the centre arch showed a depression of less than one-quarter of an inch.

After two days of preliminary work, a final and severe test of the bridge was made under the supervision of Capt. James B. Eads, Chief Engineer, Assistant Chief Engineer Col. Henry Fladd, and Messrs Schultz, Klemm, Varetman, Schmidt, Cooper, and Devan; also, Shaler Smith, Engineer of the Baltimore bridge, and D. W. Katte, Engineer of the Keystone Bridge Company, assisted in the tests. Col. Carrington, U. S. A., was also pessent, and expressed great satisfaction at the result.

Fourteen locomotives, averaging forty tons each, were used. Seven of these engines were placed upon the track of each arch, which produced a deflection of 2½ inches on the centre arch, which is 520 feet long,and 2⅛ inches on the side arch, 500 feet long.

Seven locomotives were then placed on each track, and both trains, weighing an aggregate of 560 tons, moved abreast over each of the three arches. This caused a deflection of 3½ inches in the middle arch, and 3 inches in the side spans. This was regarded as the severest possible test to produce distortion of the curve of the arches, but none were perceptible. Ten engines were then coupled in one train, and ran over each track on each side of each arch, covering the entire track of each span, producing the severest twisting strain, but the deflection was only 2½ inches in the centre arch. The locomotives thus coupled were run at a speed of ten miles per hour. The heavy traffic on the upper carriage way was uninterrupted.

There was no side-motion whatever during the tests, and the result agreed almost exactly with the theoretical computation previously made, and the trial was satisfactory in the highest degree. The defections were all below what was previously calculated upon.

These results agreed to a fraction with the results of the calculations made in 1868 by Messrs Fladd and Pfeiffer and analyzed and corrected by Prof. Chauvenet, Chancellor of Washington University.

LAW AND LEGISLATION.

An abstract of decisions of the Supreme Court of the United States and of the courts of the various States in the Union upon questions relating to boundaries, surveys, etc.

59. The rule that monuments control in boundaries is however not inflexible; and in a case where no mistake could reasonably be supposed in the courses and distances, the reasons of the rule was held to fail, and the rule itself was not applied. Davis v. Rainsford, 17 Mass., 207.

60. A conveyance by metes and bounds will carry all the land included in them. Belden v. Seymour, 8 Conn., 19. Jackson v. Ives, 9 Cow, (N. Y.), 661. Although it be more or less than is stated in the deed. Butler v. Widger, 7 Cow. (N. Y.), 723. Jackson v. Sprague, Paine, 494.

61. Where a party agrees to convey a tract of land, described as containing a certain quantity and by boundaries, he shall convey according to the boundaries, and cannot withhold any excessive quantity. Lubank v. Hampton, 1, Dana. (Ky.), 343.

62. When a grant calls for a stake at a given distance, and it is proved that a white oak, one hundred and thirty four poles beyond the distance called for, was marked as the corner, it was held that the white oak, though not called for in the grant, was the true corner of the grant. Holland v. Overton, 4. Yerg. (Tenn.), 482.

63. An actual survey is evidence of the land granted, although the calls of the grant do not cover any part of the land. Garner v. Norris, 1 Yerg. (Tenn.), 63.

64. Where a grant for 1280 acres of land was made in 1794 and called to begin "A quarter of a mile above the mouth of a creek at an ash on the bluff of the river," and in 1809, the land was resurveyed, the surveyor beginning at the ash on the bluff, which was newly marked and in actual measurement, the ash was found to be 96 poles from the mouth of the creek, it was held that this was the beginning corner of the tract, although it could not be proved that it was marked at the beginning corner upon the original survey. Garner v. Norris, 1 Yerg. (Tenn.), 62.

65. A survey of a town by commissioners appointed for that purpose by the legislature, is conclusive as to the boundaries of lots. McKean v. Tait, 1 Overl. (Tenn.), 199.

66. A surveyor may, by protraction in making out his plat and certificate, throw off lines to make the proper quantity. In such case, the Court will not pursue the marked lines over the lands excluded and protracted off Bishop v. Arnold, Peck. (Tenn.), 366.

67. If the surveyor, at the time of surveying a junior tract of land, run the elder adjoining tracts without regard to the calls therein or correcting the variation, then, to ascertain the beginning of the junior tract at any future period, the elder tracts must run without regard to the calls therein or any allowance for variation. Webb v. Beard, 1 Har. & J. (Md.), 349.

68. An entry may be given in evidence to fix the boundaries of a survey. Smith v. Buchannon, 2 Overt. (Tenn.), 305.

69. Where the original boundaries of a tract of land cannot be found, and it is afterwards re-surveyed, if the resurvey reasonably conforms to the calls of the grant, the grantee will hold the land contained in the resurvey against the State, or persons who have entered the land after the resurvey. Garner v. Norris, 1 Yerg. (Tenn.), 62.

70. If the grantee cause the lines to be run and marked in reasonable conformity to the calls of the grant, though they were incorrectly marked, yet if done in honesty and good faith, such re-marking is good against the State and subsequent enterers, and after the grant is plainly marked out, the owners thereof are estopped to claim the boundary they themselves have made. Davis v. Smith, 1 Yerg. (Tenn.), 496.

71. To establish a beginning and other corners of a grant, it is not indispensably necessary that they should be marked, if they can be established by other descriptions sufficiently certain to enable the surveyor, chain-bearer, etc., to find them. Rucker v. Vaughan, Peck (Tenn.), 272.

72. When a tract of land is re-markable, and the re-marking reasonably conforms to the grant, such re-marking is conclusive upon the State; and the State, the grantee, and all persons claiming subsequent to such re-marking are estopped from denying the lines so marked. Houston v. Bolton, 1 Yerg. (Tenn.), 481.

73. A safe rule in questions of boundary is to compare the calls in the grant with the artificial and natural marks found on the ground, and if there be a fitness, it is better to rely on the evidence they afford, than on the proof of loose statements about boundary. Payton v. Dixon, Peck. (Tenn.), 148.

*LEVEEING ON THE UPPER MISSISSIPPI.**

Levees, embankments, walls, bunds, and dykes are synonymous terms, in different countries and ages, for works which reclaim lands, villages, and cities from rivers and seas.

The Euphrates by ancient Babylon, the Nile in Egypt, the Rhine in Germany, the Po in Italy, the Thames in England, the sea along the fens and bogs of Ireland, and the North Sea, with its raging tides and lofty waves, have been driven from fertile lands and brave cities by embankments. And all the way down the centuries and in all the countries the historian tells us of heroic people who have, by a wonderful fortitude and patience, conquered the waters of the rivers and the waves of the seas, reclaiming waste places, and filling them with bounteous harvests and prosperous cities.

Our own country is destined to achieve in this respect the greatest glory of the nations by reclaiming from the grasp of the mightiest of rivers thirty million acres of the richest lands in the world.

Toward this great end two thousand miles of levees have already been constructed, and fifty millions of dollars expended in the work.

When the engineer De La Tour, in 1717, laid out the City of New Orleans, and directed that a dyke be constructed in front of the city to protect it from overflow, he little thought of the great movement he was then inaugurating. On that day the levee history of the country commenced. Since then the banks of the river and its tributaries for many hundred miles have been leveed, and the water hitherto allowed to overflow the country without restraint is now confined in its proper channels.

Leveeing in the South has been for many years the most important of all public works, and the proper maintenance of the levees is the life of the people.

Leveeing overflowed lands has not been attempted till recently, to any considerable extent, on the Upper Mississippi.

It remained for a few enterprising farmers residing on a district know as the Sny Island, in Pike County, Illinois, to be the first who dared to attempt such a work.

This tract commences about twelve miles below Quincy, and extends down the river fifty-one milles.

The physical characteristics of the river in this vicinity, the description of the tract reclaimed, the levee law, and the machinery by which it is carried out, the plan adopted for the construction of the levee, the result thus far attained and the principles evolved, with whatever facts and data that may be of interest to the engineer, are subjects that will be severally treated of in this paper.

Whether the river was once a vast lake with a water-line one hundred and fifty feet above its present high-water mark; flooding the whole country east to Indiana and north to the Great Lake, or whether it was once a deeper, wider, and more rapid river, free from its sandy bed and flowing without obstruction over the rock now found one hundred and fifty feet below the present low-water mark, and in a subsequent age deposited the sand and spread out this tract of land which we are now leveeing, are questions more curious than important.

As we find it, it is a river with a bed of sharp, clean sand to the rock. It has a velocity of from two to four and a half miles an hour, a difference between high and low water of from twenty to twenty-two feet, waters comparatively clear, its changes slow, its curves easy, and its position nearly permanent from year to year. On the west it follows the line of the bluffs; on the east it flows along a rich tract of alluvial land six or seven miles wide, the soil of which consists of a black sandy loam from three to ten feet deep. The plane of the tract at the upper end is ten feet below high-water mark, and at the lower end about eight feet below the same level. In this respect it follows the law governing the formation of sand-bars, which are always higher comparatively at the lower end.

The district is divided its entire length by a slough or bayou about four hundred feet wide, which is generally parallel to the river, but now and then finds its way to the bluffs on the east, and then turning comes nearly to the river on the west. Connecting it occasionally with the river are cut-offs, which act as outlets or inlets, according to the comparative heights of the bayou and the river. From the peculiar meandering nature of this bayou it received the name of "The Chenal Ecarte"—the lost channel—which has been abbreviated in common parlance into "The Sny."

The river, like all streams that carry sediment in solution, deposits the larger portion of its burden on its immediate banks in times of flood, and thus builds, as it were, in part, its own barrier to the lands lying remote from its banks.

This formation makes a water-shed from the river toward the Sny.

The river breaks through this natural ridge occasionally, causing deep sloughs and cuts through which the river pours its overcharge before the banks are submerged. The water thus escaping from the river finds it way into the back country, and finally to the Sny, and is poured into the river again many miles below at the mouth of the Sny.

The Sny also receives the rainfall of the bluffs and high lands for many miles back by means of several creeks, which, rushing down through the breaks in the hills, go meandering across the district till they unite with the Sny.

Along the banks of these creeks, as well as along the Sny, its various tributary sloughs and the river, considerable timber is found of the character usually seen on alluvial tracts.

The water in the low grounds, sloughs, and ponds rises and falls with the river.

When the river is low, the whole district is dry, except in the deepest sloughs and in the Sny. As the river rises, the water gradually shows itself coming up in the low places near the river and the Sny, keeping below the level of the river but rising as long as the river rises.

In digging wells at any season of the year in any part of the district the water will be found near the level of the water in the river. When the river is nearly ready to overflow its banks and the current is rapid, there can be seen a perceptible flow in the ponds from north to south.

The district lies in one of the most valuable and best farmed counties of the State, the market value of whose lands in the vicinity of the district is from seventy-five to one hundred dollars per acre.

Across the river on the Missouri side are Hannibal, Louisiana, and Clarksville. Three railroads pass through the district and two bridges connect it with Missouri. The value in the market of the land in the levee district before the levee was commenced varied from three to thirty dollars per acre, much the larger portion being near the smaller figure.

The valuable character of the land surrounding, and the expectation that the overflowed lands would increase rapidly in value with the levee completed, made it very important that great care should be taken in assessing the taxes which were to be levied upon the tract to pay for the construction of the work.

A general levee law enacted by the Legislature of Illinois three years ago permits a majority of the land owners

* A paper read before the Civil Engineers' Club of the Northwest by E. L. Corthell, Chief Engineer of the Sny Island Levee.

in any district needing levees or drainage to reclaim their lands. The whole matter of administration is in the hands of the Court of the County through which the levee passes. Commissionners are appointed by him to make the necessary contracts, to issue bonds to be used in carrying the work forward, and to have entire charge of the construction and maintenance of the levee.

The Court also appoints a jury of twelve men to assess the benefits and damages caused by the work. On their assessment the taxes are apportioned by the Auditor of State, the bonds for the payment of the work done are registered by him, and the State becomes the custodian of the funds raised by taxation.

The high-water lines along the bluffs on the east were dividing lines between the improved and cultivated lands of considerable value, and the overflowed lands of the levee district which were worth much less in market value though in richness of soil they surpass the former. It was, therefore, important that these lines of demarkation—one of them existing but once, and that twenty-one years ago—should be found to assist the jury in their work of assessment.

The contour lines made by three prominent high waters were used—those of 1851, 1858 and 1867—the former the highest in the memory of man on the Upper Mississippi, and the others respectively two and four feet below it. These lines, following all the irregularities of the ground, were run from one end to the other of the district.

In order to ascertain correctly these contours, the slope of the river was used, as ascertained by levels on the preliminary levee line along the river. These levels were checked with the level of the contour lines afterward run and were correct within one-tenth of a foot in one hundred miles of line. The fall per mile measured on our line between Hannibal and Louisiana, a distance of twenty-nine miles was 0.499, or practically six inches. The levee line was platted on a map of the district, which showed the section lines. The high-water elevations, as found, were put on the levee line every thousand feet, and these heights were transferred on the map to a point near the bluffs on the east at right angles to the axis of the river.

The high-water mark at Hannibal was then transferred by level across the district to the point under the bluffs, where the level of 1851 high-water struck the ground, and from this point the three contours were run, each in length about sixty miles. The fall for each one hundred feet was calculated, and by sending the level in advance and allowing it to seek its height through vast fields of corn and thick woods, now closely hugging the bluffs and now running far out into the district; following the level with a transit line to mark the path. Connecting the transit lines with the land lines and established corners and platting close up to the work, we succeeded, by taking great care and using much patience, in following the erratic line made by the river so many years before. The fact that we struck closely every reliable high-water mark along the bluffs, to the great wonder of the people, proved our work to have been performed correctly. These contour lines, with the various land lines and the levee line showing the right of way of two hundred feet, were platted on township maps on a scale of one thousand feet to one inch.

All lands lying between the high water of 1867 and the river were considered to be overflowed by ordinary high water, and were all put into one class—that paying the highest tax. The tract lying berween the water of 1858 and 1867, and that between 1851 and 1858, received a tax proportioned to the frequency of the overflow of those years, and the records of the high waters for one hundred years back were examined to obtain this comparison.

As the lower end of the district was not inclosed by the levee, a disturbing element in the grades was introduced by the lines made by the back water of these three high waters around the end of the levee. As the fall of the district per mile corresponds to that of the river, the high water of 1851, being eight feet above the plane of the district, will flow back sixteen miles behind the levee, and the other high waters in proportion to their height above the district. The new grades made by these back-water lines were merged into the corresponding high water grades. The areas made on each tract by these various lines in the different grades were carefully calculated and placed in the assessment book of the jury, with the tax per acre, and the total amount against each grade. The amount of land in each tract on the levee line taken for the construction of the levee was placed also in the assessment book under the head of "Damages." This book was the report of the jury to the court, who approved of their finding, after an equalization of the assessment at a meeting of the jury, with the people whose land was to be taxed.

[*To be continued.*]

ADVERTISEMENT.

Throughout the United States and the Dominion of Ca ada, there are certaiu places which, by their location and natural advantages, are peculiarly adapted to the development of some great manufacturing enterprise. There are mineral regions which only need to be placed in a strictly truthful position before the public to be appreciated and attract the attention of capitalists. There are great tracts of agricultural and grazing lands in the South and West which are practically unknown, but which, if properly brought to the notice of the right parties, woul soon create a demand therefor, and ultimate settlement.

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