12-1891

Irrigation

L. Foster
South Dakota Agricultural College

C.A. Keffer
South Dakota Agricultural College

SOUTH DAKOTA

AGRICULTURAL COLLEGE

AND

EXPERIMENT STATION

BROOKINGS, S. D.

BULLETIN NO. 28.

DECEMBER, 1891.

DEPARTMENT OF AGRICULTURE.

IRRIGATION.

DUTCHER & BREED, BROOKINGS

The Bulletins of this Station will be sent free to all residents of the State who will apply for them.

Mail for the Station should be addressed to the Director, and that for any special department to the officer in charge.

IRRIGATION.

LUTHER FOSTER, Director. CHAS. A. DUNCAN, Irrigator.

The subject of irrigation is of great importance to the people of South Dakota, and especially so to those living in the strip of country known as the "James River Valley."

This strip lies in the great artesian basin of the Dakotas and wherever wells have been put down to the water bearing strata, water has been obtained in abundance. But the people in general, are unacquainted with the methods and effects of irrigation and many questions arise regarding it. Some of the most important of these questions are as follows: Will it pay to put down an artesian well for the purpose of irrigation? How much water will be required to irrigate a certain area of land? How can water be distributed over the land? When to irrigate and how much water do certain crops require? Will the artesian water be injurious to vegetation? Will the filling of natural reservoirs and channels increase the precipitation enough to insure a crop?

It is not only the object of this bulletin to give the results of the experiments carried on by the Experiment Station, in irrigation and to answer as best we can these questions, but, to give as well, some ideas regarding fall and winter irrigation and a decription of some of the methods used in Colorado and other states which may be of use in this state.

ARE WELLS PROFITABLE?—Will it pay to put down wells for irrigation? The soil is very productive when there is sufficient moisture, and of course should be very valuable, but where crops cannot be depended upon, the value of the land is greatly diminished. With water for irrigation, land is insured from drouth. A comparison ofthe cost price of land here with the irrigated land of other states shows that the increase in value would be enough to put down the wells.

In Colorado improved land with a perpetual water right is worth from $40.00 to $100.00 an acre, while in other states the price is still higher. A perpetual water right for 80 acres of land in Colorado is worth $2000.00. As the water supply depends on the snow fall in the mountains it is to some degree uncertain. Many of the canals can only furnish water during the high water season so the only crops which can be raised are those which depend only on water during the early summer.

The wells of South Dakota flow from 500 to 3000 gallons per minute and this flow is throughout the year, giving the advantage of having water for irrigation at any time desired.

The value of these wells may be increased by storeage reservoirs and by utilizing their water power. In cost they vary from $2,000.00 to $5,000.00. Compared with a water right in Colorado, a well privilege would be worth from $2,000.00 to $12,000.00, depending on its flow; and this would be true if the well only flowed for three or four months during the growing season.

Amount of water required--A question frequently asked is, how much water will be required to irrigate a section of land? This depends to some extent on the surrounding circumstances. The amount will vary with different soils, different crops and the annual rainfall. It is estimated in Colorado that a constant flow of 450 gallons per minute through the irrigation season (ninety or one hundred days) will irrigate thoroughly only fifty-five acres. This amount would cover the ground to a depth of between forty and fifty inches. To those unaccustomed to irrigation this seems unnecessary and is undoubtedly more than the actual amount of water applied. The supply of water from the mountain streams decreases from the first of July until the irrigating season is over, so the amount of water used by the consumer diminishes with the decrease. Crops can be produced with much less water, but the yield will not be as great as the land would produce if thoroughly irrigated. In Italy the duty of a flow of 450 gallons per minute during the irrigating season is seventy acres. This is where they have had 600 years experience and with an annual rainfall of thirty-six inches. Land which is irrigated for the first time will require more water, as the lower depths must be saturated. Comparatively level land will require more water than sloping land as the spread is slower, so that more of the water is absorbed by the lower depths. Judging from the experience with irrigation in this state, it is safe to say that a well with a flowing capacity of 2000 gallons per minute, will furnish an abundance of water for a section of land.

This may not be obtained during the first two years as the ground requires more water at the start. A knowledge regarding the lay of the land with some experience in distributing the water would also be necessary to accomplish it.

Distribution of water—The methods of distributing the water over the land are at present receiving a great deal of attention especially where the supply is limited, the object being to increase the duty of water.

In preparing a field for irrigation the location of the well should be selected with the view of securing a good site for a reservoir as well as the least expense in the construction of mains for carrying water to different parts of the field. Although a reservoir is not really necessary, no system of irrigation by artesian wells can be perfect without one. The best form for a reservoir is a circle or an ellipse. Either of these forms saves unnecessary construction of embankment and will, to a certain degree, overcome the erosion caused by the action of the waves. The embankment should be seven feet high with a slope of two to one on the inside and one and a half to one on the outside, 29 feet wide at the base and 4 feet wide on the top.

The size of a reservoir should vary from three to ten acres according to the amount of land to be irrigated. The mains or ditches should be laid out carefully with reference to the lay of the land. If the field has a general slope the mains should be placed along the highest side, or if it has a ridge running through it the mains should be placed on this if the fall is convenient. But where the unevenness will not permit this arrangement it should branch, keeping up as much as possible on the sides of the ridge. The fall necessary for a main as ordinarily built is over four feet to the mile. When the fall is less than this the width of the main must be increased. A ditch having a fall of four feet to the mile, would need to be five feet wide and a foot and a half deep to carry a flow of two thousand gallons per minute.

In constructing mains it is sometimes necessary to raise the banks or build flumes to get the water to certain parts of the field. When the rise is more than four feet above the ground it is cheapest to flume it to the desired point.

In Colorado an embankment is thrown up for the purpose of carrying water above the surface of the ground and is called a dike. The method of construction is to throw up an embankment the same as for a railroad grade, giving it the proper fall; a channel is then made on the top of this grade through which the water passes. The method most used in the artesian basin of Dakota is to throw up two embankments. The earth necessary for the construction is taken from between them. This makes a wide space between the two embankments necessary. The disadvantage to this arrangement is the loss of water which remains between the banks and in the excavation formed by their construction. It is however, the only practical way in this state on account of the peculiar condition of the soil. In constructing these banks the same slopes are used as in the embankment of a reservoir. Flumes may be placed on ordinary trestle work which should vary in strength, depending on the volume of water to be carried. A flume 18 inches wide and a foot in depth with a slight fall will carry all the water that flows from an ordinary well. It should be well braced and this can be done by placing two-by-fours, three or four feet apart all around it. The joints should be placed over the trestles. After everything has been arranged for carrying the water to different parts of the field, before it is ready for irrigation, laterals will have to be made. Sometimes these are made permanent, but as a general rule they are used for but one season. When not intended to be permanent they are run soon after the crop has been put in. The method of running and the construction of these laterals depends entirely on the lay of the land. When there is a general slope having a fall of from four to twenty feet to the mile, the laterals are run diagonal to the direction of the general slope and are made by plowing a single furrow, throwing it to the lower side or with the fall. The distance apart the laterals are placed varies from 50 to 150 feet. A field irrigated in this way is represented in figure 1. Permanent laterals are placed twenty rods apart and are constructed by plowing four furrows, throwing the two inside furrows on the two outside furrows to make the banks, as represented in the middle in Fig. 1. The same rule is followed when permanent laterals are made for the whole field. The objection here is that the field is cut into small strips which makes it inconvenient.

If there are ridges running through the field a main lateral should be placed on each one and from these, branch laterals run. The same rule is followed as in sloping land, that is, to run them diagonal to the general slope of the sides of the ridge as represented in Fig. 2. When hill points are to be irrigated the laterals are kept as nearly as possible on the line dividing the slope. These laterals are made by throwing a furrow both ways. What is known as a double mould board plow is used for running them. When there is too much land to be irrigated from one of these, branch laterals are run.

In irrigating, water is turned into three or more laterals, depending on the amount of water in use. Dams are then thrown in near the main. The water from each lateral is allowed to spread over the ground until it reaches the next below it, or rather until all the ground between the laterals which can be overflowed from that point has been thoroughly saturated. Another dam is then put in the lateral at a point below, from which the water can be spread to the ground which has been flooded from the dam above. In spreading the water over the ground attention must be given to it, as dams will have to be

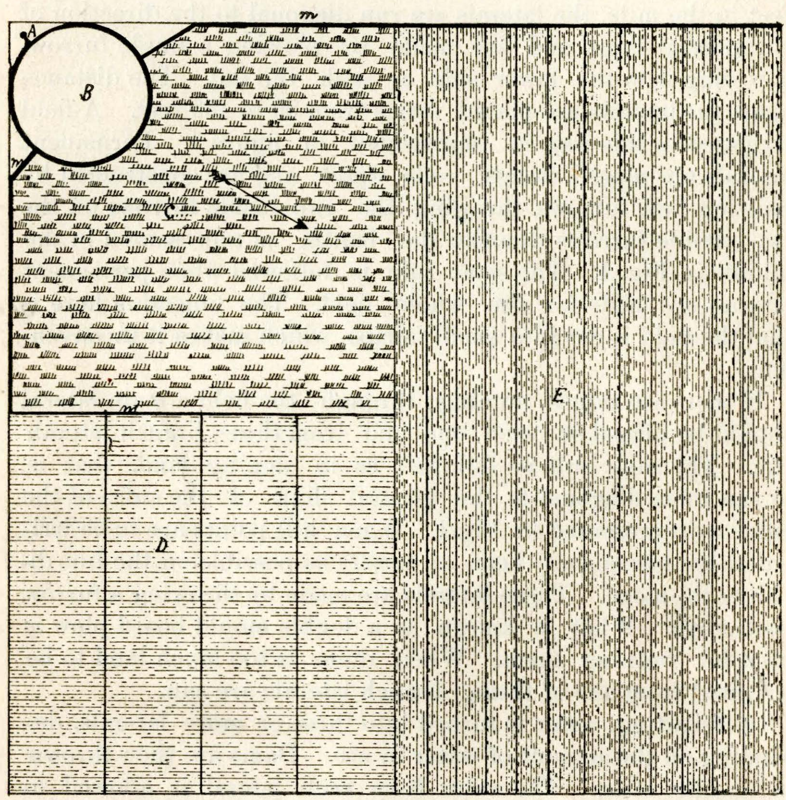


Fig. 1

Fig. 1 illustrates method for the irrigation of sloping land. A, well; *B*, reservoir; *m m m*, mains; *l l l*, laterals, *C*, corn field; *D*, meadow; *E*, small grain. The arrow indicates direction of the slope.

thrown in the low places to spread the water over the higher points. When there is too much fall care should be taken to keep the water well spread, as the ground will wash away if too much is allowed to run in one place. These operations are repeated until all the land under this set of laterals is irrigated, the water is then turned into another set of laterals. The benefits derived from laterals are as follows: The duty of water is increased, that is, more land can be irrigated with the same amount, and the water can be distributed more easily and evenly over the ground. One part of the field will not be drowned out while the water is spreading over another part.

THE IRRIGATION OF COMPARATIVELY LEVEL LAND.—Level land cannot be irrigated as cheaply or as easily as sloping or rolling land. Some ideas have been advanced regarding irrigation of level land. One suggestion is to throw up levees round the land high enough so that the water would have to spread over all the points in the field. Another is to build wide ditches or mains through the field raising the water above the level of the ground and carrying it over the fields in laterals. The last plan is the more feasible, as in the first, one part of the crop would be drowned out while the water was spreading over the other. In the latter plan a reservoir is necessary to complete the arrangement, the purpose of the reservoir being to give a volume of water for spreading it over the land rapidly. It will be found in the actual work, that it is very difficult to run water more than twenty rods from the mains. To overcome this difficulty a system of ditches will have to be constructed, running through the field, parallel to one another, at a distance of forty rods apart and twenty rods from the sides of the field. These will be connected with the reservoir which runs along one side of the field, perpendicular to the ditches. Both the main and the ditches should have the banks raised two feet above the level of the ground so the water can be raised a foot and a half above the surface. Laterals are run perpendicular to the ditches every ten rods. These are made by plowing two furrows, thus throwing up a bank on each side of the lateral so the water can be raised a few inches above the sur-

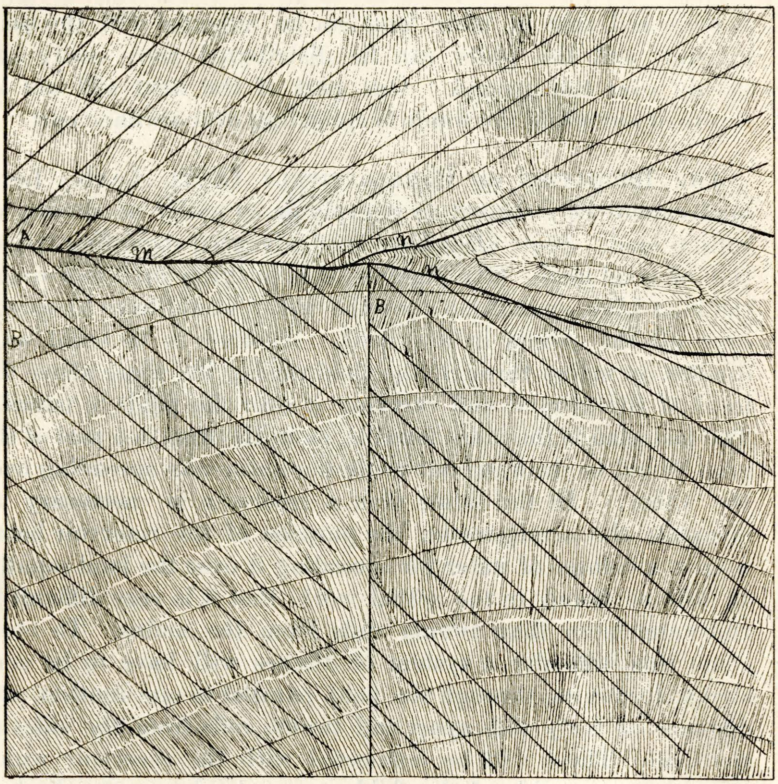


Fig. 2

Fig. 2 illustrates methods of running ditches and laterals into a field with ridge running through it. *A*, well; *m*, main, *n n*, branches of the main running along the sides of the ridge; *B B*, main laterals; *l l*, laterals.

face of the ground. A double mould board plow is recommended for constructing them. These laterals extend from one ditch to the other when place on a strip of land between two ditches. Fig. 3 represents a field irrigated in this manner.

In irrigating from these the water is turned into two of the laterals and these are dammed at the ends furthest from the ditch, or if between two ditches at a point about midway to them. The water is spread on the strip between the two laterals until it meets when it is changed to some point up the lateral or toward the ditch. This is continued until the strip of land between the two laterals is irrigated. In this method a volume of water is necessary to spread it rapidly and evenly over the ground.

When the banks are raised above the level, gates or boxes are necessary for letting the water out of the ditches into the laterals. Gates are also needed at the head of each ditch, and should be so constructed that the flow of water through them can be regulated. These gates may be made in different ways, one of the simplest forms being to nail four boards together in such a manner as to form a small culvert. A gate is then made at one end to turn the water on or off. This is so placed in the bank that the top of the culvert will be on a level with the surface of the water, the earth in the bank being packed round it to keep it from washing out. One of the simplest and one which will answer all ordinary purposes can be made as follows: the box should be of inch boards; four feet long, eighteen inches wide and two feet high. Two-by-fours are put around the ends and the centre for braces. The gate is placed midway between the first and second braces, cleats being nailed on the inside of the box to form a track in which the gate slides. The gate itself may be made in one piece or several; when in one piece, the flow is regulated by raising or lowering the gate, and when in several by taking out and putting in pieces. To secure the gate from washing, what are known as wings are placed at the end of the box on the inside of the ditch. These wings should extend about a foot and a half from the sides. When the box is set it should be made to rest firmly on the ground, trenches being dug for the sleepers underneath. Earth is then firmly

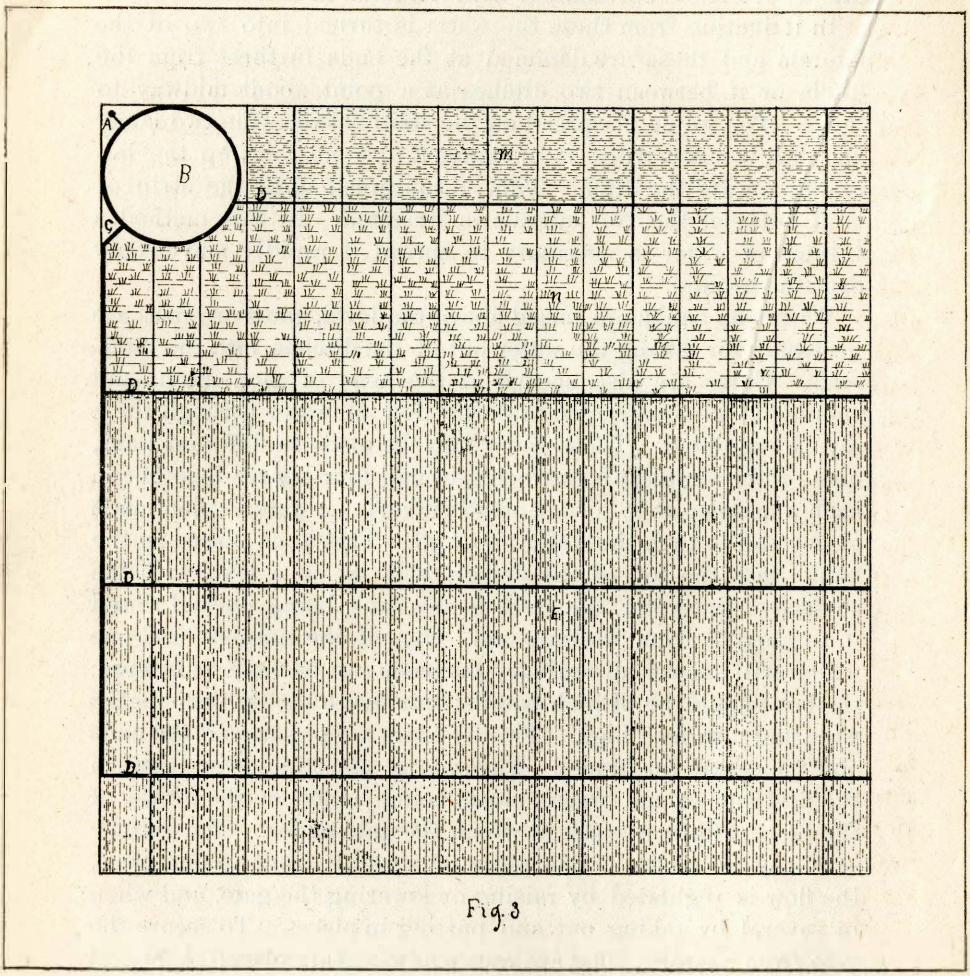
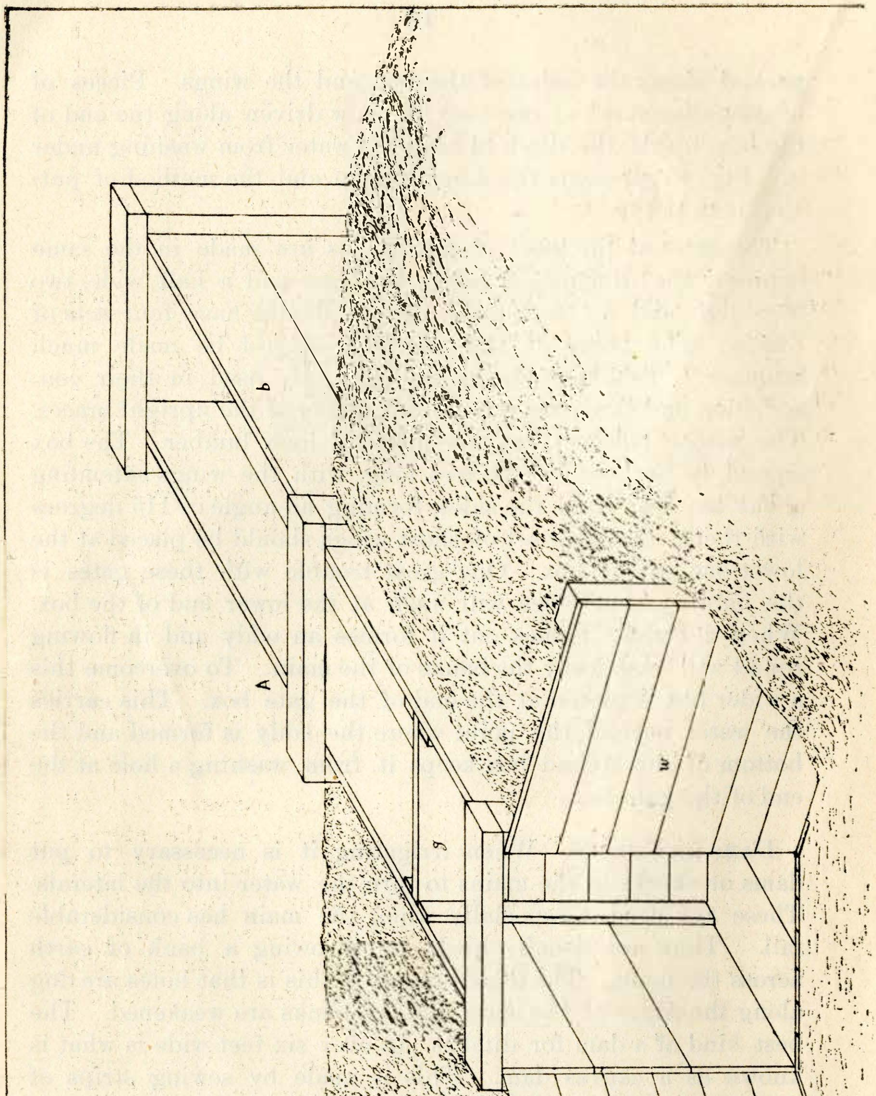


Fig. 3 shows method for irrigating level land. *A*, well; *B*, reservoir; *C*, main; *D D D D*, ditches; *l l l*, laterals; *m*, millet; *n*, corn field; *E*, small grain.

packed along the sides of the box and the wings. Pieces of boards sharpened at one end, are now driven along the end of the box inside the ditch to keep the water from washing under it. Fig. 4 represents this kind of gate and the method of putting it in the bank.

The gates at the head of the ditches are made in the same manner, the dimensions being two feet and a half wide, two feet high and six feet long. These should have four sets of braces. The gates of the reservoir should be made much stronger. Two-inch planks are generally used in their construction and these are put on the outside of the upright braces. The wings, however, may be made of inch lumber. The box should be at least sixteen feet long, with the wings extending about ten feet from the sides, forming an angle of 115 degrees with them. Another set of short wings should be placed at the lower end of the box. One great trouble with these gätes is the liability that holes will wash at the lower end of the box. When the water rushes out it formes an eddy and in flowing round will wash away the banks of the main. To overcome this a wider box is placed at the end of the gate box. This carries the water beyond the point where the eddy is formed and the bottom of the second box keeps it from washing a hole at the end of the gate box.

Dams or Checks.—When irrigating it is necessary to put dams or checks in the mains to turn the water into the laterals. These are needed especially when the main has considerable fall. They are usually made by throwing a bank of earth across the main. The disadvantage of this is that holes are dug along the edges of the main and the banks are weakened. The best kind of a dam for ditches not over six feet wide is what is known as a canvas dam. This is made by sewing strips of ducking on poles. The ducking should be from four to eight feet long according to the width of the main and from four to six feet wide for a depth of two or three feet. In using these canvas dams two are needed,as they cannot be put into the main when the water is running in it. Before the water is turned in, one of these dams is put in at that point of the main highest in



b
A
w
g
w

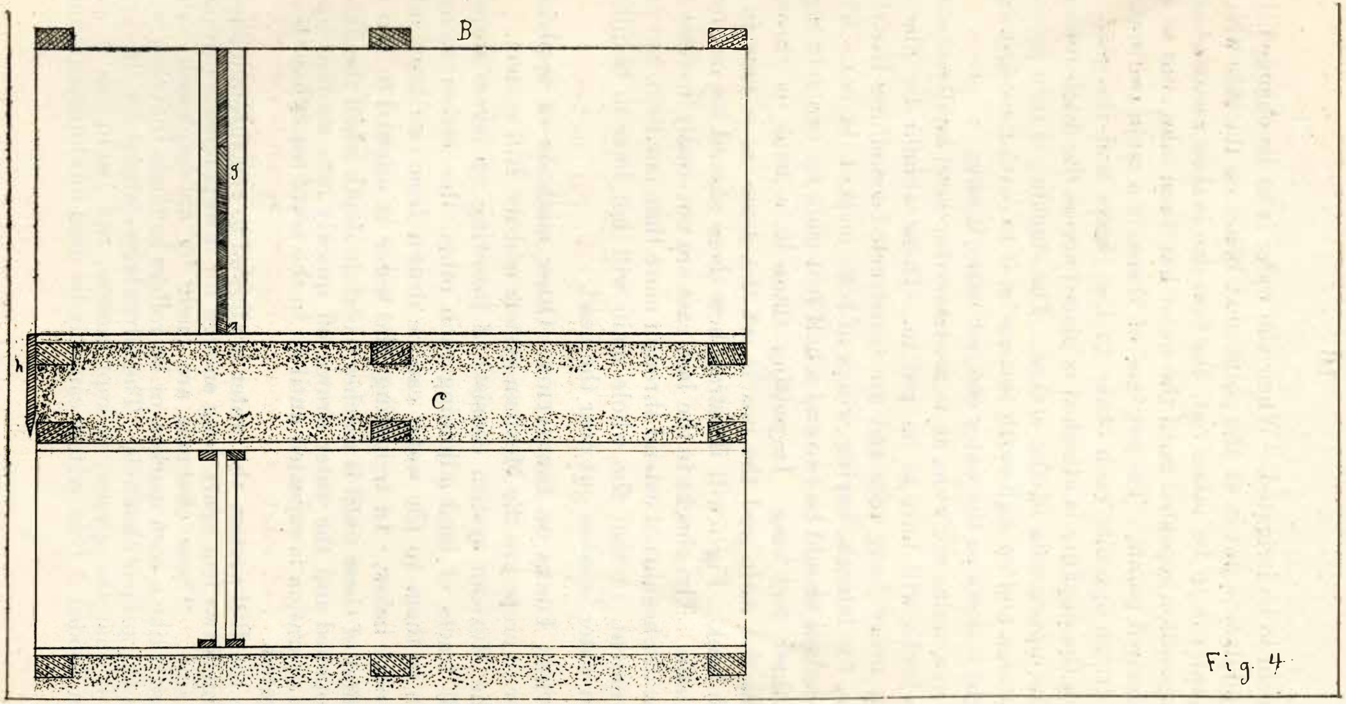


Fig. 4. *A*, gate for letting water from main into laterals. *b*, box. *w w*, wings. *g*, gate.
B, vertical section of the box. *g*, gate shown as made in pieces. *C*, horizontal section of box. *g*, gate.

the field to be irrigated. When the water is to be changed the second dam is put in at the point next below on the side where the water is to be taken out, the first one is then removed and the operation repeated until the water has been taken out at all the desired points. To put one of these in a main two stakes are driven opposite each other in the banks and the pole to which the ducking is attached is placed across the ditch resting on the upper side of the stakes. The ducking is then spread up stream and enough earth thrown on it to cover the edges and weight it down so the water can not carry it away.

When mains are wide, as is necessary for level land, permanent checks will have to be put in. These should be placed about every forty rods and are constructed something like the gates, for laterals, having wings at both ends of the box. The dimensions should be two and a half feet wide by two feet high and three feet long. In putting these in, a bank is thrown across the main and the box is set the same as a gate in a ditch bank. Fig. 5 will illustrate how these should be put into the main. The checks in the last case are not really necessary if the ditches do not extend through more than one field, but are convenient, in that the whole main will not have to be filled when water is taken out near the head.

Other Forms of Irrigation.—Other methods of applying water to crops are the Mexican system and the Rill system.

The Mexican system consists of throwing up levees around small tracts of land adjoining each other, the levees having gates in them so the water can be drawn from one tract into the next below. In irrigating, the water is allowed to run in the first of these until it reaches a certain depth when the gates are opened and the water drawn off quickly into another tract This operation is repeated until all in the set of tracts have been irrigated.

In the Rill system the water is allowed to run through small channels two feet apart, long enough for it to percolate through the soil. These channels are made by an implement constructed like a corn marker, or by rollers so made that they will form the proper channels. The advantage claimed for this system is that the ground is kept mellow, not baking as it will when flooded. This system can only be used on sloping ground.

WHEN AND HOW MUCH TO IRRIGATE.

When to irrigate and how long the water is to be left on is another problem for beginners to solve. Anyone familiar with crop growing can tell when rain is needed and this is the time to irrigate. When there is a large crop to be irrigated it is not prudent to wait until the crop really needs the irrigation but it should be begun while there is still some moisture in the ground, one advantage of irrigation being that the ground can be kept moist.

Some plants will require more moisture than others and different kinds will also require different treatment in irrigation just the same as in cultivation.

Irrigation of the Cereals.—If there is not, as a general rule, enough moisture precipitated to bring these plants up as soon as sown, it is well to irrigate the ground some time previous to sowing. It is not, however a good plan to sow the grain and then irrigate to bring it up, as the surface of the ground is liable to bake so the growing grain can not get through the crust. If it should be necessary to irrigate the ground for germination, or in fact at any time before the grain is high enough to shade the ground, the Rill system should be used wherever possible. When once the grain is high enough to shade the ground, it grows rapidly until it heads and during this period requires a great deal of moisture, therefore it should be irrigated from one to three times, depending on the soil and amount of rainfall. When more than one irrigation is necessary, the last should take place just previous to shooting as there is danger of rusting the grain if irrigated after this time.

The length of time the water should be left on the ground varies from one to ten hours or until the ground is thoroughly saturated as far down as it has been plowed. If the water is left on the grain for more than 24 hours it is liable to do it some damage. In this respect oats will stand more water than either wheat or barley. When the intention is to irrigate the crop but once, the ground should be plowed in tne fall to a depth of six or eight inches. The grain should be put in early to a depth of two or three inches, a press drill being the best for this purpose. The time to irrigate will always be when the grain needs moisture but if possible wait until it is six inches high.

Fall irrigation can be used to advantage for the cereals. In this state there is usually a dry period lasting through a part of April and sometimes the whole of May. The grain that comes up at this time suffers for the want of moisture, and that which is put in late does not sprout until after the rains, which come, as a rule, in June. What is needed to make good crops, is moisture through this season. This can be supplied by fall and winter irrigation. In much of the fall and winter irrigation, which has been done in this state, too much water has been applied, so that the grain could not be sowed at the right season. Just as much judgment is required for fall and winter irrigation as when a growing crop is being irrigated. The following method for fall irrigation is recommended by Hon. B. S. Lagrange, who was employed by the government to direct the experiments in irrigation at Huron and Aberdeen. Flood in the same manner as for irrigating a crop of cereals. The laterals which have been closed during harvest are opened again and the water is turned on the ground long enough to saturate it as far down as it has been plowed. Just as soon after as the ground is dry enough, it should be plowed. If this can be done in the fall it will insure that the ground will not be too wet in the spring for sowing. Some advocate plowing the ground and then irrigating. Of course these two ways will have to be tested before it can be ascertained which will produce the better crops. Winter irrigation will not do for the cereals as the soil will be too wet in the spring to get the crops sown in the right season. It may do for flax and other crops which can be sown late

IRRIGATION OF FLAX.—The ground on which flax is sown should contain considerable moisture in order to insure its coming up and on this account the ground is best irrigated during the previous fail or winter. While growing it should receive water once or twice. If the ground has been well irrigated before sowing, once will be sufficient. Flax will be greatly damaged if the water is allowed to remain on it for twenty-four hours.

MILLET.—This being a rapid grower, requires a great deal of moisture after it comes up. It may be irrigated at any time, but like the cereals water must not remain on it long. If it is grown for seed it is best not to irrigate after it heads.

CORN.—In irrigation of corn another method is used known as irrigating between the rows. In this method the water is run in the furrows made by the cultivator, not allowing it to touch the hills. In this way the soil is not packed and baked round the roots but is kept loose and mellow. Corn does not require as much moisture in the ground when it is growing, as wheat or millet, and it is seldom necessary to irrigate it until the tassels begin to appear, then a good head of water is turned on, and run through the rows as rapidly as possible. When it has run entirely through one set of rows it is turned into another, leaving a small stream running in each of the rows through which it has passed long enough to percolate through the soil to the roots. In Colorado, corn is grown without irrigation on ground which was irrigated the previous summer but the best crops are obtained when the water can be turned on at the time of tasseling. As there is generally enough rain in South Dakota to keep the corn growing in the fore part of summer it is not best to irrigate until the tassels begins to appear.

POTATOES.—Potatoes, as a rule, should not be irrigated until the sets appear, but like everything else, if suffering for water before this time, it will be necessary to irrigate them. They should first be cultivated, the shovels of the cultivator being set so the dirt will be thrown toward the rows, thus ridging them up. The water is then turned on and the irrigation is done in the same manner as described for corn. After once being irrigated care must be taken not to let the ground get dry as that is liable to scar the potatoes, and on the other hand, if kept too wet the growth will all be in the vines. After the first irrigation the potatoes should be cultivated again as soon as possible in order to keep the soil loose and mellow. In no case should they be flooded as it is sure to damage them if it does not entirely destroy the crop. For this reason it is difficult to irrigate potatoes on level land.

SUGAR BEETS.—Sugar beets are at present attracting a great deal of attention in this state. The only method of irrigating them with which the Irrigator is familiar is by flooding. This however, compacts the soil too much, as to obtain the best results the ground should be kept as mellow as possible. The only way to overcome this crustiness is to make a small trench between the rows and run the water through these until the soil around the beets is saturated. Sugar beets should be irrigated only during the early part of the season as too much moisture in the latter part will lower the percentage of sugar.

THE IRRIGATION OF THE GARDEN.—Nearly all garden vegetables can be irrigated by running the water between the rows and allowing it to seep through the soil around the roots When it is necessary to flood garden vegetables the ground should be hoed as soon thereafter as it is dry enough, to prevent surface baking. When there is not enough moisture to bring the seed up the ground should be irrigated before planting. Garden plants generally require a great deal of moisture to give the very best results. Cabbage, as a rule, will do well without much moisture, while cauliflower and celery will flourish if water is kept running between the rows, but celery will not have as fine a flavor if treated in this manner as if less moisture is applied. It should be irrigated about once each week until ready for blanching. Tomatoes do not need much water after reaching a certain stage of growth unless the soil is sandy, as all the growth will go to the vines, and such vines will not bear well and the tomatoes on them will not ripen. In setting

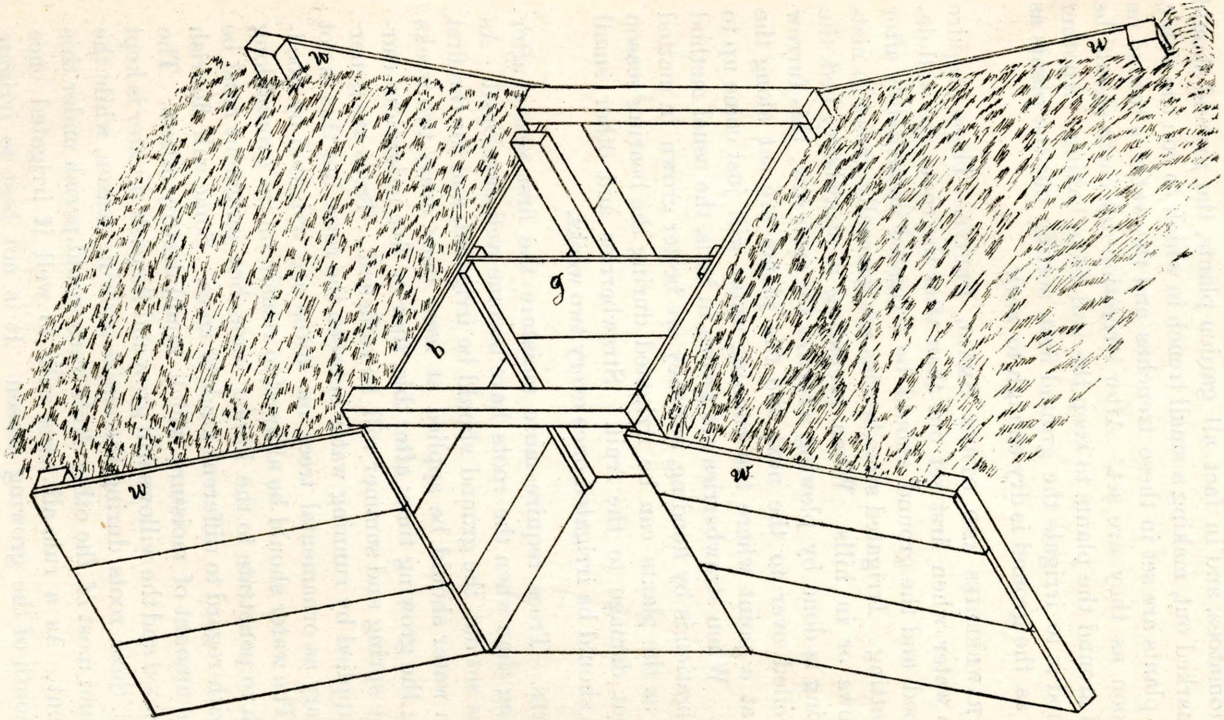


Fig. 5. Check for wide main. *b*, box; *w*, *w*, *w*, *w*, wings; *g*, gate shown as made in one piece.

out tomatoes, and in fact all garden plants, the ground should be marked out, making a small trench in which to run the water. The plants are set in these trenches and the water is turned on as soon as they are set. After irrigation dry earth should be hoed around the plants to keep the soil from baking. Another method is to irrigate the ground first, setting out the plants as soon as the ground is dry enough to work.

STRAWBERRIES AND OTHER SMALL FRUITS.—These require more water when first set out than after the roots are well developed, and the ground should be irrigated immediately after the setting. Irrigated strawberries are generally grown in matted rows or in hills. When preparing a strawberry bed, the marking is done by plowing a furrow for each row; this furrow is levelled over to the next and the plants are set along the edge at a point where the running water will just come up to them. When strawberries are grown in beds, the usual method of irrigation is by flooding, but they are better grown in matted rows, as the plants can be irrigated during the bearing season without damage to the fruit. Strawberries and other small fruits should be irrigated once every two weeks.

TREES.—Trees require more moisture the first season after planting than when the roots have become well developed. As soon as set out the ground should be irrigated, and for the first season water should be applied at least once every two weeks during the growing time; after this, four or five irrigations during the spring and summer will be sufficient. Trees are generally supplied by running water between the rows, but this is not necessary as ornamental trees on lawns are irrigated by flooding. The water should be allowed to remain on the ground long enough to penetrate to the lowest roots, but judgment must be used with regard to different kinds of trees. Some will flourish with an amount of moisture which would destroy others. The cottonwood and the willows will grow and flourish if water is kept around their roots during the entire growing season, while the apple and most of the other fruit trees would perish under this treatment. As a rule all trees will do well if irrigated once each month of the growing season. It is not best to irrigate late in the summer for some species, as time must be given for the wood to ripen.

MEADOW LAND.—Native meadow lands require most moisture during the spring and consequently should, if possible, be irrigated during winter and in the early spring. The irrigation of other meadows depends on the kind of grass but as a rule, water should be supplied in the spring. Timothy, in particular, needs a great deal of early moisture to make a good crop. Where more than one crop is produced during the season, the meadows are irrigated as soon as the hay is taken off. For alfalfa, the best results are obtained if it is irrigated about the middle of May for the first time, the second and third irrigations following the taking off of the first and second crops. It can be grown with only one irrigation during the season, but it will not be as good in yield or quality. Clover, to do its best, requires a great deal of moisture and during the first season should be irrigated several times. For both clover and alfalfa it is not best to irrigate during the fall and winter, as the action of the frost on the wet ground causes the plants to winter kill. Orchard grass may be treated the same as alfalfa, irrigation taking place just as soon as the crop is taken off the ground. All meadow lands should be thoroughly saturated, the water remaining on the ground from 6 to 24 hours. The danger of damage through leaving the water on them is not so great as in other crops but unreasonable length of submergment may cause great damage. The irrigation of meadow land requires just as much judgment to secure the best results as that of other crops.

In all irrigation a great deal depends on the surrounding conditions, as the amount of rainfall at the time or the moisture in the soil. The methods given are, with a few exceptions, those used in Colorado and the same rules, with some slight changes in the details, can be applied in this state.

EFFECT OF IRRIGATION ON RAINFALL.—Will the filling of natural reservoirs and channels increase the rainfall enough to insure sufficient moisture for raising crops? It is believed by many that it will, because good crops were raised during the period when all the lake beds contained water. The cause of this rainfall can no more be attributed to the lakes, than can the lakes to the excessive rain and snowfall of this period. This moisture when it filled the lake beds, saturated the ground at the same time, and was stored in the lower depths and was used by the crops which followed. During the last ten years, hundreds of lake beds have been filled in Colorado as reservoirs and by seepage water but no increase of rainfall is yet noticed, and in Utah agriculture depends on irrigation, even to the shores of the great Salt Lake. On this question, nothing but opinions, with reasons for the same, can be given. The following theory has been advanced to account for these seasons of sufficient moisture. A part of the Dakotas is in what is known as the semi-arid region, and over this belt, the line of sufficient moisture to produce crops, vibrates back and forth.

EXPERIMENTS IN IRRIGATION.

The decision of the Board of Trustees of the South Dakota Agricultural College to conduct experiments in irrigation was not reached until so late in the spring that operations could not begin before the 20th of April.

As everything had to be done after this date, the small grain was not sowed until too late to obtain the best results. As the experiments were for the purpose of showing methods of distributing the water over the crops, as well as its effects upon them, Stations were selected at the following places: Mellette, Frankfort and Huron.

Mellette being the chief Station, work was begun there as soon as possible after the arrival of the Irrigator. The experimental grounds at this place contained twenty-six acres, being in a strip 29 rods wide. A main was run from a well down through the center of this strip; laterals were run perpendicular to the main about every ten rods, making the dividing lines for the plats.

WHEAT.—On the 21st and 22nd days of April the ground was plowed to a depth of five inches. It was in good condition for sowing and the grain was put in with a press drill on the 22nd of April. It came up and grew well until the 20th of May when it began to need moisture. The main not being completed at this time the grain was not irrigated and the rain of May 30th made it unnecessary until the 12th of June when it again need moisture. The plats containing the different varieties of wheat were irrigated as follows: Blount's Hybrid, No. 17, June 13th; Kubauka and Velvet Chaff, June 15th Saskatchewan, June 22nd; the latter was not irrigated at the right time on account of an accident to the main, consequently many of its stools were killed by the drouth. The straw of all these varieties averaged over four feet in height and their average yield was 25 bushels to the acre by machine measure. The Saskatchewan yielded over 27 bushels to the acre, and, had it been irrigated in time, it probably would have given over thirty. The average yield of wheat in the surrounding fields did not go over ten bushels to the acre and that which was sown about the same date yielded not more than six bushels to the acre. The wheat in this experiment not only had the disadvantage of being sown late, but was also put in on spring plowing which alone would tend to lower the yield. It did not receive any more care than is usually given to irrigated grain, and on account of scarcity of laborers the main was not completed until it had suffered from lack of moisture. After the water was turned in the main, the work was delayed by its banks giving way.

Barley.—The ground was plowed on the 27th and 28th of April and the grain was put in on the 19th with a press drill. The condition of the ground was not favorable for germination, as the wind rapidly dried the moisture out of the plowing. Part of the seed did not come up till after the rains, beginning May 30th. The barley was not irrigated until the 30th of June. The straw of the Danish and Manshury barley averaged three feet and that of the White and Black Hulless two feet and a half in length. The average yield of the two former was over 28 bushels to the acre and that of the Hulless varieties a little over 20 bushels. Here, as with the wheat, the deferred irrigation, on account of trouble with the banks of the main, lowered the yield but it was still much better than the unirrigated barley in the same vicinity.

Oats.—The oats were sown on the same date and under the same conditions. Part of the seed did not come up until after the rain and one plat was nearly drowned out on account of the banks of the main giving way. Two plats were irrigated on the 29th and 30th of June; one being the White Belgian and the other the Black Prolific. The average length of the straw of the first was four and a half feet and the second five feet. The yield of the White Belgian was forty-five bushels to the acre,

THE GARDEN.

The garden vegetables that were planted grew splendidly and were kept green and fresh during the long period in which but little rain fell.

Tomatoes.—These were set out on the 28th day of May. The ground was marked with a plow and the plants set in the edge of the furrow, water being let in as soon as they were put out. Although the next day was very warm and dry, but few of the plants died. The soil was kept almost too wet for the best results, as the vines grew very rank without maturing many tomatoes.

Early Cabbage.—These were planted at the same time and in the same manner as the tomatoes and received the same treatment. They grew well and the heads were solid and ready for use the first of August. Cabbage grown in the same neighborhood but not irrigated was, as a rule, a failure. Late cabbage was also grown successfully, and cauliflower, which naturally requires more moisture than ordinary plants, did well.

Celery.—The plants were set out on June 20th on ground which had been irrigated. They were small and but half of them survived the hot days which followed. The remainder was kept moist and the crop was extra good.

Trees.—Three varieties of trees, Willow, Poplar, and Ash, all of one year's growth, were planted at this place. These were irrigated soon after setting out, and several times during the summer and only three per cent. died, most of them making a good growth.

Some apple grafts were planted at the same time, nearly all of which survived and grew well; the loss being only about ten per cent. All these trees were planted the 8th of May when the ground was very dry and doubtless would not have survived the rainless period which followed, without irrigation.

rows. The yield of the irrigated beets was better than those on the same plat not irrigated and the chemical analysis shows an equal per cent sugar.

THE GARDEN.

The garden vegetables that were planted grew splendidly and were kept green and fresh during the long period in which but little rain fell.

Tomatoes.—These were set out on the 28th day of May. The ground was marked with a plow and the plants set in the edge of the furrow, water being let in as soon as they were put out. Although the next day was very warm and dry, but few of the plants died. The soil was kept almost too wet for the best results, as the vines grew very rank without maturing many tomatoes.

Early Cabbage.—These were planted at the same time and in the same manner as the tomatoes and received the same treatment. They grew well and the heads were solid and ready for use the first of August. Cabbage grown in the same neighborhood but not irrigated was, as a rule, a failure. Late cabbage was also grown successfully, and cauliflower, which naturally requires more moisture than ordinary plants, did well.

Celery.—The plants were set out on June 20th on ground which had been irrigated. They were small and but half of them survived the hot days which followed. The remainder was kept moist and the crop was extra good.

Trees.—Three varieties of trees, Willow, Poplar, and Ash, all of one year's growth, were planted at this place. These were irrigated soon after setting out, and several times during the summer and only three per cent. died, most of them making a good growth.

Some apple grafts were planted at the same time, nearly all of which survived and grew well; the loss being only about ten per cent. All these trees were planted the 8th of May when the ground was very dry and doubtless would not have survived the rainless period which followed, without irrigation.

EXPERIMENTS AT FRANKFORT.

Mr. H. S. Riggs, by request, sends the following report of the work done at Frankfort:

The following is a synopsis of tests made in farming by means of irrigation: While the results may not be as great as might be expected, yet, considering the circumstances under which these tests were made, they are entirely satisfactory. The artesian well at Frankfort, in fault of construction has, since it first commenced flowing, thrown muddy water, in fact, there is so much sediment that in a week's time it fills the main ditch to the top with mud. The main is constructed above ground and is 10 feet wide and 4 feet deep, The water must be carried a half mile before it reaches the land to be irrigated, which lies 30 inches above the level of the land at the well. It will be seen that the cleaning of this amount of sand out of the ditch was no small item in time and expense. The main was cleaned through a number of sluice gates. By opening them, the sand is washed out by force of the current. At times when water was needed the most, we had to stop and sluice out the ditch.

Some Results.—Sept. 20, 1890, winter wheat was sown in corn ground. The land was too dry to germinate the seed and had to be irrigated to bring it up. It made a poor fall growth and went into winter rather puny, was all alive in the spring, irrigated May 1st, made a fine growth and was harvested July 1st. The yield was 30 bushels of fine plump wheat of Fultz' variety. A plot of winter rye sown, irrigated, harvested and threshed at same time as the wheat, gave a yield of twenty bushels. A field of fifteen acres was soaked during the winter and was so wet in the spring we could not get on the land to seed until May 20. The soil seemed cold and clammy and the wheat did not get started during the good growing weather when the other crops were making fine growths. It did not make much growth until the weather was too hot for best results with wheat. The hot sun caused it to rust but after irrigation the rust left. The crop was harvested and threshed and made an average of eighteen bushels. Some spots that were above water did not grow 6 inches high and did not produce a kernel. A field that had been in millet and irrigated last year was sown to wheat May 12, came up and made a fine growth, was irrigated the last of June and yielded twenty-two and one-fourth bushels. Hulless barley that was sown June 1st made a yield of thirty bushels machine measure and weighed 61 lbs. Spots in the field that did not get any water grew about as high as buffalo grass. A plot sown to flax June 15th on land that had been in sod for ten years, and was almost the same as wild sod, land was irrigated once and yielded sixteen bushels. I may add that this land had been covered with water all of last winter. I believe, under favorable circumstances, wild sod land, well soaked and sown in good season, will give a yield of twenty bushels. Last year, on old land, flax sown about the same date as above made twenty-one bushels; millet, four tons per acre; corn, forty-five bushels, etc.

It will be seen that the times of sowing the above crops were all out of proper season. Planted at such late dates it would have been almost imposaible to grow any crop without irrigation.

While I am convinced that irrigation is going to be a grand success in grain farming, it is equally important in stock growing, mixed farming, and the raising of many kinds of fruits.

The most satisfactory test made was with Kentucky Blue Grass. I have never seen such a growth of tame grass, not even in the native home of the Blue Grass. I don't think I overdraw it, when I say that one acre well set in Blue Grass and well irrigated, will yield more pasture than twenty acres of native grass without irrigation. This will hold true of the wild grasses. In both cases it will take two years to get the best result as a good bottom has to be made.

The success in irrigation so far as tried in Dakota may not be up to the expectation of the public, yet, the fact should not be forgotten that we have it all to learn and the methods of other countries may not be the best for Dakota. The system of irrigation in California and Colorado has undergone many changes and those states have made more advancement and learned more of the science in the past two years than in all of the thirty years before. I am convinced that winter soaking of the land is not the best method, but think the best time to flow the land for the next crop is as soon after harvest as it can be done. Then after wetting the land thoroughly, as it dries enough, plow and fit for the next crop. By this method the land will have plenty of moisture to start the crop in good shape and then one good irrigation about the time wheat and other grain is in bloom which will insure a good crop.

Economic Distribution.—After much study on methods, I have come to the conclusion that with water from artesian wells the only economic use is by means of a suitable reservoir to collect the water, and instead of using it direct from the well, draw it direct from the reservoir. A larger amount of water can be used at a time, thus getting over the same land in less time and with the saving of a great amount of water. It is thought that from 6 to 10 inches of water will be abundant with our natural rainfall, but without a reservoir the trouble is to get that amount on the land without getting much more. A well flowing 1,200 to 1,300 gallons, the water used as it flows, will put more than two feet of water on the ground before it can be spread. Now, if three to five times this amount of water could be used as cheaply, a much greater amount of land would be watered with less water and in a shorter time, which would be a great saving and of special advantage when all crops are needing the water at the same time. Land watered quickly would not be baked but it would have the same effect as from a good heavy rain. It may be claimed that rushing a large amount of water over a crop would injure it, but I have had the water on wheat, barley and oats a foot deep while distributing it over other portions of the field and my experience is that where the water was deepest the crop was best.

HURON EXPERIMENT.

The work here was under the local management of Mr. A. W. Wilmarth.

The only land obtainable that could be conveniently irrigated from an artesian well was not a desirable piece on account of its contour and occasional "gumbo" spots. It had been flooded during the winter and was consequently too cold and wet for seeding until very much too late for good results. A heavy rainfall immediately followed the first irrigation and made the amount of moisture on the whole piece excessive, overflowing and completely drowning out the grain on the lower portions. Considering these disadvantages, the general results were quite satisfactory.

The experiment added proof to what was shown at Frankfort, that winter irrigation is not the most advantageous for grain raising, especially for those kinds that require early seeding

CONCLUSION.

In these experiments there was not a single case which showed in any way that the water was injurious to the plants, the only damage done resulted from allowing it to remain on the ground too long. The water contains salts of lime, magnesia, potash and soda which may be termed fertilizers. It also contains considerable ammonia which is a solvent and puts much of the material used by plants in a condition to be absorbed by them.

If anything is needed in the artesian water it is animal and vegetable organism. This, however, may be obtained by storing the water in reservoirs.

The water is not cold enough when applied directly to the growing plant to check or in any way interfere with the growth. In Colorado if the water which comes from the melting snows in the mountains be appliad to corn during the fore part of the summer its effect will be seen during the remainder of the growing season as the corn will have a sickly appearance. This is due to the chilling effect of the water upon the growing plant. The cereals are checked in growth for a day or so from the effects of the cold water but soon recover and begin to grow with all the more rapidity and vigor.

There is much reason for believing that if the ground be irrigated in the fall and early winter, so that the seed can be planted in time, a good crop of the cereals may be produced without any further application than the annual rainfall.

With the aid of irrigation trees can be grown, and, when these are scattered plentifully over the plains, it will no donbt have a decided effect on the hot winds which prevail here at times during the summer. If the effects of these winds can be neutralized in any part of the state, it will be a great benefit to its agricultural interests. All of the experiments go to show that irrigation by means of artesian wells is a success in South Dakota and there seems to be no reason why the James River Valley, once famous for its fertility and productiveness, will not become one of the most prosperous agricultural sections in the United States. It has all that is necessary, the fertile soil and the water which may be obtained in abundance from artesian wells. All cannot be obtained at once, as time and experience will be necessary to reach the highest state of perfection.