

Scholars' Mine

Bachelors Theses

Student Theses and Dissertations

1885

A thesis on the improvement of western waterways

Fremont Wilson

Follow this and additional works at: https://scholarsmine.mst.edu/bachelors_theses

Part of the Civil Engineering Commons

Department: Civil, Architectural and Environmental Engineering

Recommended Citation

Wilson, Fremont, "A thesis on the improvement of western waterways" (1885). *Bachelors Theses*. 333. https://scholarsmine.mst.edu/bachelors_theses/333

This Thesis - Open Access is brought to you for free and open access by Scholars' Mine. It has been accepted for inclusion in Bachelors Theses by an authorized administrator of Scholars' Mine. This work is protected by U. S. Copyright Law. Unauthorized use including reproduction for redistribution requires the permission of the copyright holder. For more information, please contact scholarsmine@mst.edu.



1.46

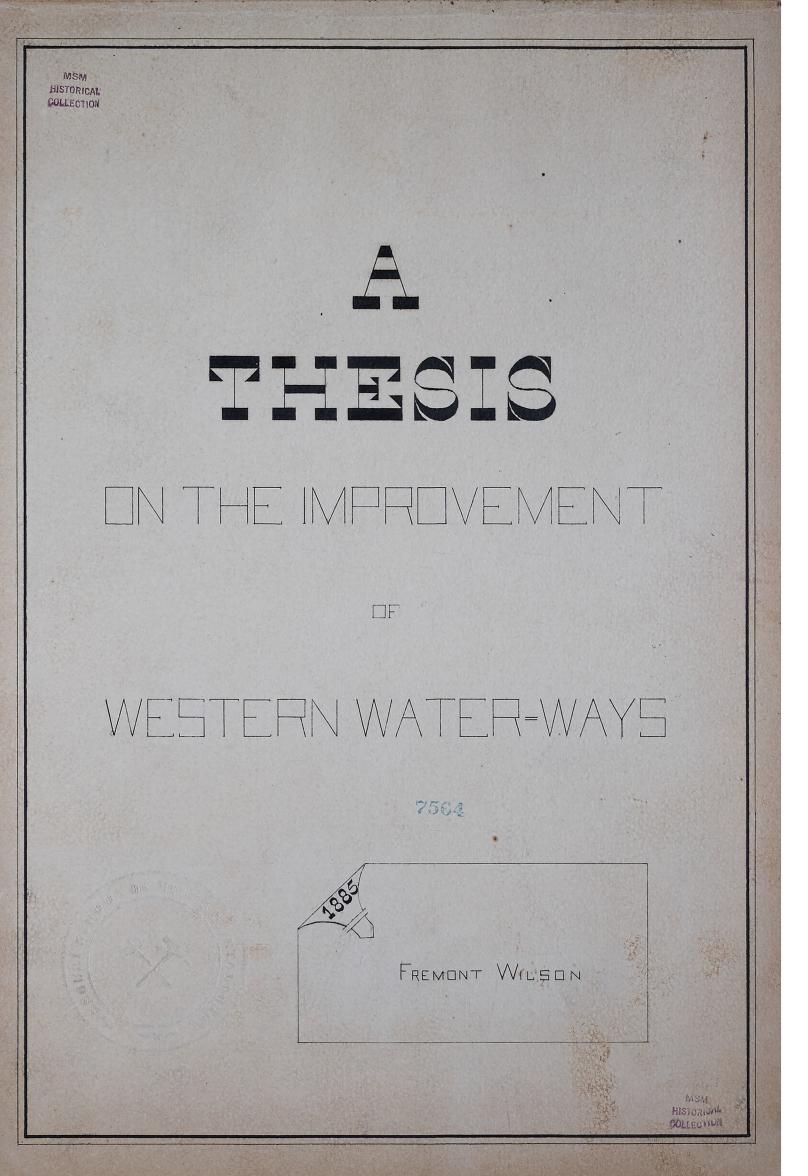
THESIS

-

Western Water-Ways

WILSON

1885



A Thesis On the Improvement of Western Water-Ways

> 1885 Fremont Wilson

There is no subject that falls within The province of The sugineer's art, That foreacuts greater difficulties and more uncertain issues than the improvement of rivers. Over subject to suportant changes in Herir regimen as the regions by which They are fed are cleared of Their foresto and brought under cultivation, one can tury sees Them deep, flowing with an equable current, and liable only to a graderal increase in volume during The seasons of freshets; while the most finds Their beds a firey to sudden and great freshets, which leave Them, after Then violant passage, obstructed and ever shifting bars and buds. Besides These revolutions brought about in the course of years, every obstruction tempovarily placed in the way of the current every attempt to quarte save point from Ar action his any arts freial man, instably producer some inspondug change of another, which can seldom be foresen, and for which The venedes applied may prove but a new cause of ham. This, a par removed from our point may gradually form lower down;

There is no subject that falls within the province of the engineer's art that presents greater difficulties and more uncertain issues than the improvement of rivers. Ever subject to important changes in their regimen as the regions by which they are fed are cleared of their forests and brought under cultivation, one century sees them deep, flowing with an equable current and liable only to a gradual increase in volume during the seasons of freshets; while the next finds their beds a prey to sudden and great freshets, which leave them, after their violent passage, obstructed and by ever shifting bars and bends. Besides these revolutions brought about in the course of years, every obstruction temporarily place in the way of the current, every attempt to guard one point from its action by any artificial means inevitably produces some corresponding change at another, which can seldom be foreseen and for which the remedy applied may prove but a new cause of harm. Thus, a bar removed from one point may gradually form lower down;

our bank protected from the cur. vent's force transfers its action to the apposite our, on any incrase of volume Grow freshets, widening The bed and frequently giving a new direction to The channel. Owing to these ever varyug causes of cleange, The best wighed plans of nor informent some times result in complete failure. The object in all nover improvements is to obtain a channel as maras practicable uniform in action, or gradually marcasing from The source to the mowth, having sufficient capacity to carry off flood-water without verflowing, with a velocity That shall not endanger The stability of the backs, Thus it will be seen That The sugneering works for the improvement of the upper prostion of a niver will consist chiefly of exavations to remove showing and the or obstructions, and to winder mar. row parts, regulating deplice to con-Tract wide shallows, diversions of The cleannel, and works for stopfing uscless branches.

one bank protected from current's force transfers its action to the opposite one, on any increase of volume from freshets, widening the bed and frequently giving a new direction to the channel. Owing to these ever varying causes of change, the best weighed plans of river improvement sometimes result in complete failure. The object in all river improvements is to obtain a channel as near as practicable uniform in section or gradually increasing from the source to the mouth, having sufficient capacity to carry off flood-water without overflowing with a velocity that shall not endanger the stability of the banks. Thus it will be seen that the engineering works for the improvement of the upper portion of a river will consist chiefly of excavations to remove shoals and other obstructions and to widen narrow parts regulating dykes to contract wide shallows, diversions of the channel, and works for stopping useless branches.

The work of Excavating The lead of a min for the furthose of dechaning its channel consists mainly of dredging. This operation may be performed by hand, by steam, or by means of the current itself. When performed by hand, an implement called a spon is employed. It consists of a pole, having at and and iron ring stacked on The forward edge, to which a leathern bag is attached. The end of the pole is held by a man, and the ring is King by who tackle capable of being wound up by mais of a crab. The man who holds the pole directs The forward Edge of The ring against The bottom while The spoon is bring dragged along by the winding up of the when the show arives beneath The crab, it is hauled up and its contents anatied into a barge In cases where The depth of water above not excood 6 ft, This system of alredoing may be employed with advantage as it is both affective and cleap. it having been ascertained That the labor and cost of the operation are not much greater Than in sins-

The work of excavating the bed of a river for the purpose of deepening its channel consists mainly of dredging. This operation may be performed by hand, by steam, or by means of the current itself. When performed by hand, an implement called a spoon is employed. It consists of a pole having at one end an iron ring steeled on the forward edge, to which a leathern bag is attached. The end of the pole is held by a man, and the ring is hung by rope tackle capable of being wound up by means of a crab. The man who holds the pole directs the forward edge of the ring against the bottom while the spoon is being dragged along by the winding up of the rope. When the spoon arrives beneath the crab, it is hauled up and its contents emptied into a barge. In cases where the depth of water done not exceed 6 ft., this system of dredging may be employed with advantage as it is both effective and cheap, it having been ascertained that the labor and cost of the operation are not much greater than in similar

ilar excavations on dry land. When, however, The depth is great recourse must be had to The dredging machine With a steam dredging machine, The cost of excavating is about the same as that of similar operations on dry land. A straw dredger of 16 horse-power will, under fororable circumstances, vaise about 100 cub. yds. an hour. The most accononical mans of removing The materials of The bed of a niver when They consist of mid, sand, orlight gravel, in The employment of The cur. went for that purpose. The operation is firstonned by means of a kind of movable daw, usually consisting of a franzwork covered with boards attack. ed to a boat. The boat is moored in The stream, and The dam lowered to wither a few incless of the bottom. The water way being This greatly contract. Ed, The velocity of The current over the bed is proportionately increased, and Heis increased velocity will scourthe bed to a considerable defite in a short line. From 30 to 70 cub. yds, may be excovated in This way in a day and at a cost of only about \$.05 - per upd.

excavations on dry land. When, however, the depth is great recourse must be had to the dredging machine. With a steam dredging machine the cost of excavating is about the same as that of similar operations on dry land. A steam dredger of 16 horse-power will, under favorable circumstances, raise about 100 cub. yds an hour. The most economical means of removing the materials of the bed of a river when they consist of mud, sand, or light gravel, is the employment of the current for that purpose. The operation is performed by means of a kind of movable dam, usually consisting of a framework covered with boards attached to a boat. The boat is moored in the stream and the dam lowered to within a few inches of the bottom. The water-way being thus greatly contracted, the velocity of the current over the bed is proportionately increased and this increased velocity will scour the bed to a considerable depth in a short time. From 30 to 70 cub. yds may be excavated in this way in a day and at a cost of only about \$.05 per yd.

5-It must be born in mind That This mode of dredging acts only by disflacing the materials of the bed leav. ing Term free to be depoited elsewhere It can not therefore be applied where a necessity axists for the removal of The materials disturbed. Where The bed is conford of rock, recourse must be had to blasting. When The aballowness of a own is caused by excessive width, the defect may be medied by a orgulating dike or longitudinal embaukment, These tikes may be constructed either of dry stone or of wattled files and gravel. When built of stone, Tery should have a alope of about 1 to 1. The latter mode of construction is however the more usual, In This case the files should have a diameter of not less than our twentisth of the length; They should be driven into the ground in a doule. le now to a depth equal to Twice That of The water; The distance between The rows should be once and a half The Schitch of the water, and The distance of The files apart, longitudinally, should begual to The defith of The water.

It must be borne in mind that this mode of dredging acts only by displacing the materials of the bed leaving them free to be deposited elsewhere. It can not therefore be applied where a necessity exists for the removal of the material disturbed. When the bed is composed of rock, recourse must be had to blasting. When the shallowness of a river is caused by excessive width, the defect may be remedied by a regulating dike or longitudinal embankment. These dikes may be constructed either of dry stone or of wattled piles and gravel. When built of stone, they should have a slope of about 1 to 1. The latter mode of construction is, however, the more usual. In this case the piles should have a diameter of not less than one-twentieth of the length; they should be driven into the ground in a double row to a depth equal to twice that of the water; the distance between the rows should be once and a half the depth of the water and the distance of the piles apart, longitudinally, should be equal to the depth of the water.

After living tird Together transversele The mous of files are wattled with willow Twigs, and The space between filled up with gravel. The construction of dikes not anly increases the defitte by forcing The water to flow through a narrower channel, but The velocity of The water being There by increased, The had is scoured out until a sufficient Septh is reached to establish equilibrium between The current and The materials of which the bed is comhosed. This coursequence of creeting a depke must be carefully calculated beforchand, and the amount of con-Traction duly chhortiousd to the reaults. It may be marked here That The only certain means of hermanuntly dechang The bed of a river is The construction of contin nous longitudinal embaukments. Dikes built in the same as Those described above are used to stop up side branches. In This case, They are Thrown across The upper and of The stream from bank to bank. The effect of slopping up a branch is to throw a larger body of water

After being tied together transversely, the rows of piles are wattled with willow twigs, and the space between filled up with gravel. The construction of dikes not only increases the depth by forcing the water to flow through a narrower channel, but the velocity of the water being thereby increased, the bed is scoured out until a sufficient depth is reached to establish equilibrium between the current and the materials of which the bed is composed. This consequence of erecting a dike must be carefully calculated beforehand, and the amount of contraction duly apportioned to the results. It may be remarked here that the only certain means of permanently deepening the bed of a river is the construction of continuous longitudinal embankments. Dikes built in the same as those described above are used to stop up side branches. In this case, they are thrown across the upper end of the stream from bank to bank. The effect of stopping up a branch is to throw a larger body of water

into the main channel The stream in which will be both despend and accelerated thereby. Thus the consequent ces will be The same as Those produced by the longitudinal dike, and They will have to be calculated in The same way. When the course of a viver is 20 circuitous that the velocity of the amout is not sufficient to prevent deposits, The bed silts up and the dean wel becomes too small to contain flood-water. Hence result disastrous indetions; as is the case with the Missouri River which contains in manse deposite of puick Rand which gratly inpede the relocity and cause it to over flow its backs for several miles on each side during high water. These floods generally occur in the missouri very chang and do are immouse amount of daw age to fams lying in the course. The last one which occurred, and which was a very noted our, because of The great amount of damage dous was in June 1883. During This flood The Missouri was estimated to be 25 miles wide in sour places.

into the main channel, the stream in which will be both deepened and accelerated thereby. Thus the consequences will be the same as those produced by the longitudinal dike, and they will have to be calculated in the same way. When the course of a river is so circuitous that the velocity of the current is not sufficient to prevent deposits, the bed silts up and the channel becomes too small to contain flood-water. Hence result disastrous inundations; as is the case with the Missouri River which contains immense deposits of quick-sand which greatly impede the velocity and cause it to overflow its banks for several miles on each side during high water. These floods generally occur in the Missouri every spring and do an immense amount of damage to farms lying in the course. The last one which occurred, and which was a very noted one because of the great amount of damage done was in June 1883. During this flood the Missouri was estimated to be 25 miles wide in some places.

The damage done by one of Hise floods would pay for measary infrovements to prevent their recur. mice according to estimater made lif an able enfineer. These floods may be stopped partly by mbankmuch and partly by cut-offs as The over is very crooked in the upper hart of its course. The main points to be considered in the construct ion of a cut off are Hesse; The me deand must be made as Scepas possible, for Her Acudance of a mor is to widen outer than to dechau its cleannel, and this mis be kept in view in the readation of The cut off. Another important con dition is to connect the new chan mel with the old by a cure of a conarderable radius. Unless This condition be fulfilled, The stream will not enter at all, or if it onter, will not flow freely in the new cleannel. It is also an advantage to slightly cure the new channel, for the our. mut well Them kech constantly a gainst The concare bank; whereas, if The cleannel is straight, it will

The damage done by one of these floods would pay for necessary improvements to prevent their recurrence according to estimates made by an able engineer. These floods may be stopped partly by embankments and partly by cut-offs as the river is very crooked in the upper part of its course. The main points to be considered in the construction of a cut-off are these: The new chanel must be made as deep as possible, for the tendency of a river is to widen rather than to deepen its channel, and this must be kept in view in the excavation of the cut-off. Another important condition is to connect the new channel with the old by a curve of a considerable radius. Unless this condition be fulfilled, the stream will not enter at all, or if it enter, will not flow freely in the new channel. It is also an advantage to slightly curve the new channel, for the current will then keep constantly against the concave bank; whereas if the channel is straight, it will

dericte from side to side, and then tend to produce bends. The velocity, too, is somewhat cleecked by The curved channel, and in This will generally be an advantage. The new channel must not be opened to received the waters of the noir until The down-stream end of The ald our has been complete ly closed. For it has been found impracticable to divert The strain in-To The new cleanch unless This he down by reason of The impossibility of Throw. ing out The cut to a depthe inferior to That of The ald channel. It is also necessary to dear The bed of the new cut of all Tres, reds, or aquatic placets, as These impede the flow of The current and favor deposits. The simplest and most effective mean of protecting The odjacent land from undations in coursquares of a viver overflowing its backs, is to increase, artificially The height of The bank. at Hose parts liable to overflow. In doing His two to mothods have been used; our cousists in build ing lever on call side of the

deviate from side to side, and thus tend to produce bends. The velocity, too, is somewhat checked by the curved channel, and in this will generally be an advantage. The new channel must not be opened to receive the waters of the river until the down-stream end of the old one has been completely closed. For it has been found impracticable to divert the stream into the new channel unless this be done by reason of the impossibility of throwing out the cut to a depth inferior to that of the old channel. It is also necessary to clear the bed of the new cut of all trees, reeds, or aquatic plants, as these impede the flow of the current and favor deposits.

The simplest and most effective means of protecting the adjacent land from inundations in consequence of a river overflowing its banks, is to increase, artificially, the height of the banks at those parts liable to overflow. In doing this two two methods have been used; one consists in building levees on each side of the

mor, and the other in deepening and widding The deamich. All the ways tried as far, hourver, have been found to afford only temporary relitef. The levers after braking de. mig floods and causing great daw age; while on the other hand the wi-Acued cleannel causes bars to be form ed which are continually changing position every new fresher and make ing mangation extractly intricate. The loves along the Mississippion about 13 ft. high and cost about 20 cents for cubic good in building. To fortect The backs, either The 22locity of the arrent in shore must be decreased so as to lesson its action on the soil; or clas a facing of some material sufficiently deerable to resist its action must be employed. The former method may be used when the banks are low and have a gentle declivity. The simplest plan for this purpose con sists atter in placeting such chub. bery on The declivity as well Thrive war water; or by driving hown

river and the other in deepening and widening the channel. All the ways tried so far, however, have been found to afford only temporary relief. The levees often breaking during floods and causing great damage, while on the other hand the widening channel causes bars to be formed which are continually changing position every new freshet and making navigation extremely intricate. The levees along the Mississippi are about 13 ft high and cost about 20 cents per cubic yard in building.

To protect the banks either the velocity of the current in-shore must be decreased so as to lessen its action on the soil: or else a facing of some material sufficiently durable to resist its action must be employed. The former method may be used when the banks are low and have a gentle declivity. The simplest plan for this purpose consists either in planting such shrubbery on the declivity as will thrive near water or by driving down

short pickets and interlacing them with willow twigs, forming a kind of wicker work. These constructions, which are used almost exclusively along the mississippi, break the force of the current, and diminish its velocity mear The chore, and thus cause The water to deposit its finer particles, which gradually fill out and stringthen The banks. If The banksare high, and are subject to cave in from Her action of The annest on Their base They may be either cut down to a gen The declivity as in The last case; or else They may receive a clope of warly 45° and be faced with dry stour, care bring taken to secure The base by blocks of loose stone, or by a facing of brish and stone laid in alternate layers. When aquatic Trick are abundant, fascines are after suployed. These fascines are bundles of wellow twigs from 9 to 12 m. in dianeter and about 12 ft. in leught. They are laid with their length up and down The slope and are fixed to The bank by stakes.

short pickets and interlacing them with willow twigs forming a kind of wicker-work. These constructions which are used almost exclusively along the Mississippi, break the force of the current and diminish its velocity near the shore, and thus cause the water to deposit its finer particles which gradually fill out and strengthen the banks. If the banks are high and are subject to cave in from the action of the current on their base, they may be either cut down to a gentle declivity as in the last case; or else they may receive a slope of nearly 45°, and be faced with dry stone, care being taken to secure the base by blocks of loose stone or by a facing of brush and stone laid in alternate layers. Where aquatic trees are abundant, fascines are often employed. These fascines are bundles of willow twigs from 9 to 12 in. in diameter and about 12 ft. in length. They are laid with their length up and down the slope and are fixed to the bank by stakes.

12 Works executed in This way do not, it is true, last very long, ten years being The limit of a fascine under water; but their duration is suf. fice ent in nors carrying much suspended matter, to give vise to depositions which eventually some To effect The abject intended in a more permanent way. Timber sheeting may also be resorted to in some cases. This may consist either of about filing or of guide files and horizoutal planks. The wales of The sheet filing or The guide files of the placking must be tied back to wooden an. choning plates fimly fixed in suitable situations. Sometimes it may be necessary to construct ortaining walls to preserve The backs of a river; but suclaim stances will seldom occur, and They will never extend beyond a very limited space.

Works executed in this way do not, it is true, last very long, ten years being the limit of a fascine under water; but their duration is sufficient in rivers carrying much suspended matter, to give rise to depositions which eventually serve to effect the object intended in a more permanent way. Timber sheeting may also be resorted to in some cases. This may consist either of sheet piling or of guide piles and horizontal planks. The wales of the sheet piling or the guide piles of the planking must be tied back to wooden anchoring plates firmly fixed in suitable situations. Sometimes it may be necessary to construct retaining walls to preserve the banks of a river; but such instances will seldom occur and they will never extend beyond a very limited space.

12

When the general depth of water me river is insufficient for The draught of boats of the most autable size for the trade ouit. an improvement, termed clack-watar, or lock and dam mavigation, is resorted to. This cousists in dividing the course into several suitable houds, by forming dans To keep the water in The found at a constant head; and by passing from one found to another by locks at the ends of the daws. The position of the dams, and the required, will depend upon The locality. In strains subject to hear y firshets, it will generally be ad. visable to place The dance at The midest parts of the bed, to obtain The greatest outlet for water over The dam. The daws may be built either in a straight line between The banks and perficular to The Thrad of the current, or they may be in a straight line obligue to the current, or their plan may be couver, The couver surface being ech stream, or it may be a broken

When the general depth of water in a river is insufficient for the draught of boats of the most suitable size for the trade on it, an improvement, termed slackwater, or lock and dam navigation, is resorted to. This consists in dividing the course into several suitable ponds, by forming dams to keep the water in the pond at a constant head; and by passing from one pond to another by locks at the ends of the dams. The position of the dams and the required, will depend upon the locality. In streams subject to heavy freshets it will generally be advisable to place the dams at the widest parts of the bed, to obtain the greatest outlet for water over the dam. The dams may be built either in a straight line between the banks and perpendicular to the thread of the current, or they may be in a straight line oblique to the current, or their plan may be convex, the convex surface being up stream, or it may be a broken

live presenting an angle up stream. The Three last forms mu hourd offer a greater outlet Than The first to the water That flows aver The daw, but are more liable to cause myung to The bed below The stream, from the obligue di rection which the current may redan at top. The cross ecction of a dave is usually trapopoidal, The face up-strace being inclined, and the our down stream either vertical or includ. When The Sown stream face is vertical, The velocity of the water which flows over The dam is destroyed by The shock against the water of the found below The daw, but which are formed which are non destructive to the bed Than would be the action of the current upon it along the inclined face of a dam. In all cases The sides and bed of the stream, for some distance be-low The sam, should be pro-Ected from the action of the

line presenting an angle up stream. The three last forms mentioned offer a greater outlet than the first to the water that flows over the dam, but are more liable to cause injury to the bed below the stream, from the oblique direction which the current may receive, arising from the form of dam at top. The cross section of a dam is usually trapezoidal, the face up-stream being inclined, and the one downstream either vertical or inclined. When the downstream face is vertical, the velocity of the water which flows over the dam is destroyed by the shock against the water of the pond below the dam but whirls are formed which are more destructive to the bed than would be the action of the current upon it along the inclined face of a dam. In all cases the sides and bed of the stream, for some distance below the dam, should be protected from the action of the

current by a facing of dry store, timber, or any athet convenient con struction of sufficient durability for the abject in view. The dawn chould receive a suffi cient height ouly to maintain The requisite depth al water in The finds for the purposes of marreation. Any material at hand affering sufficient durability agaust The action of the water, I may be resorted to in Their con Struction, Dams of alternate layers of brush and gravel, with a facing of plank, facines, or dry strue, answer very well in gentle currents. If The dam is exposed to heavy freshets, to shocks of ice, and other heavy floating bodics, as driftwood, it would be more findent to form it of by stone entirely, or of arebwork filled with stone, or, if The last material cannot be obtained of a solid crib-work alour. If the tau is to be made, water tight, paud and gravel in sufficient quantity may be thrown in against it in the upper foud.

current by a facing of dry stone, timber, or any other convenient construction of sufficient durability for the object in view. The dams should receive a sufficient height only to maintain the requisite depth of water in the ponds for the purpose of navigation. Any material at hand offering sufficient durability against the action of the water may be resorted to in their construction. Dams of alternate layers of brush and gravel, with a facing of plank, fascines or dry stone, answer very well in gentle currents. If the dam is exposed to heavy freshets, to shocks of ice, and other heavy floating bodies, as driftwood, it would be more prudent to form it of dry stone entirely, or of cribwork filled with stone; or, if the last material cannot be obtained, of a solid crib-work alone. If the dam is to be made water-tight, sand and gravel in sufficient quantity may be thrown in against it in the upper pond.

The points where The dam four The banks, which are torned The roots of The daw, require particular attention to prevent the water from filtering around them. The ordinary precaution for This is to build the dam some dis. tauce back into the banks. The safest mans of comunication between The houds is by an ordinary lock. It should be placed at one extremity of the daw, an excavation in the bank being made for it, to secure it from dauage by floating bodies brought down by the armit. The sides of The lock and a portions of The ban mar it should maised sufficiently high to hr. vent Three from being overflowed by The heavest freshets. When the height to which the Archits vise is great, The leaves of the head gates should be formed of two parts, as a single leaf would, from its size, be to inwickdy; The lower portion being of a suitable height for the ordinates manourers of the lock:

The points where the dam joins the banks, which are termed the roots of the dam, require particular attentcution to prevent the water from filtering around them. The ordinary precaution for this is to build the dam some distance back into the banks. The safest means of communication between the ponds is by an ordinary lock. It should be placed at one extremity of the dam, an excavation in the bank being made for it, to secure it from damage by floating bodies brought down by the current. The sides of the lock and a portion of the dam near it should be raised sufficiently high to prevent them from being overflowed by the heaviest freshets. When the height to which the freshets rise is great, the leaves of the head gates should be formed of two parts, as a single leaf would, from its size, be to unwieldy; the lower portion being of a suitable height for the ordinary manoevers of the lock:

The upper, being used only daring The frishets, and a arranged that Their bottom cross frices shall vest when The gates are closed, against The top of the lower portion. An an vaugement concubat simi. las to This may be made for the tail gates, when the lifts of the locked are great, to avoid the diffi cutty of manouvring very high gates, by permanently closing the upper part of the sitrance to the lock at The tail pates, either by a wall built between The side walls, or by a permanent frame-work, below which a sufficient height is left for the boats to pash. A common but unsafe worthod of praising from one frond to another, is That which is termed flashing; it ansists of a chice in the daw, which is aponed and closed by means of a gate or olving on a vertical axis, which is so arranged That it can be manouved with case. One filan for this purpose is to divide The gate into two un-

the upper, being used only during the freshets, and so arranged that their bottom cross pieces shall rest when the gates are closed, against the top of the lower portions. An arrangement somewhat similar to this may be made for the tail gates, when the lifts of the locks are great, to avoid the difficulty manoeuvring very high gates, by permanently closing the upper part of the entrance to the lock at the tail gates, either by a wall built between the side walls, or by a permanent frame-work, below which a sufficient height is left for the boats to pass.

A common but unsafe method of passing from one pond to another is that which is termed flashing; it consists of a sluice in the dam which is opened and closed by means of a gate revolving on a vertical axis, which is so arranged that it can be manoeuvred with ease. One plan for this purpose is to divide the gate into two

aqual parts by an axis, and to place a value of euch dimensions in The greater, That when opened The surface ogainst which The water presses shall be less Than That of The maller hart. The play of The gate is thus rendered very simple; when The valve is shut, The pressure of water on the larger surface closes it against The eides of The chice; when the value is apened, The gate swings round and takes a position in the direction of the current. Various other plans for flashing, on similar principles, are to the met with.

unequal parts by an axis and to place a valve of such dimensions in the greater, that when opened the surface against which the water presses shall be less than that of the smaller part. The play of the gate is thus rendered very simple; when the valve is shut, the pressure of water on the larger surface closes it against the sides of the sluice; when the valve is opened, the gate swings round and takes a position in the direction of the current. Various other plans for flashing, on similar principles, are to be met with.

When the abstriction in a over caust be overcome by any of the fire. coding means, as for example in Those considerable descents in The bed known as repids, where the water acquires a velocity so great That a boat can oneither ascend nor descend with safety, resor must be had to a cardal for the purpose of uniting its mavigable parts above and below the ob-Aruction. The general direction of The canal will be parallel to the bed of the over. In some cases it may oc. anky a hast of the bed by form. ing a dike in The bed parallel to the back, and sufficiently for from it to give the requisite width to The canal. Whatever position The anal may occupy, every fore. caution should be made for their taken to excure it from daw gge by freshets.

When the obstruction in a river cannot be overcome by any of the preceding means, as for example in those considerable descents in the bed known as rapids, where the water acquires a velocity so great that a boat can neither ascend nor descend with safety, resort must be had to a canal for the purpose of uniting its navigable parts above and below the obstruction.

The general direction of the canal will be parallel to the bed of the river. In some cases it may occupy a part of the bed by forming a dike in the bed parallel to the bank, and sufficiently far from it to give the requisite width to the canal. Whatever position the canal may occupy, every precaution should be made for their taken to secure it from damage by freshets.

A lock will usually be mecssary at each extremety of The canal where it joins the over. The positions for The extreme locks should be carefully chosen so that The boats can at all times enter Them with case and safety. The locks should be secured by gaard gates and other suitable means from freshets; and if they are liable to be abstructed by deposits, arrangements should be made for Their removal either by a chase of water or by machinery If The river should not present a sup ficient depth of water at allerasous for entering the canal from it, a dam will be required at some point mar the lock to obtain The depth requisits. It may be advisable in some call instead of placing the extreme locks at the outlets of the canal to the nor to form a capacious basin at each extremety of the canal between The lock and river, where the boats can lie in cafety.

A lock will usually be necessary at each extremity of the canal where it joins the river. The positions for the extreme locks should be carefully chosen so that the boats can at all times enter them with ease and safety. The locks should be secured by guard gates and other suitable means from freshets; and if they are liable to be obstructed by deposits, arrangements should be made for their removal either by a chase of water or by machinery. If the river should not present a sufficient depth of water at all seasons for entering the canal from it, a dam will be required at some point near the lock to obtain the depth requisite.

It may be advisable in some cases instead of placing the extreme locks at the outlets of the canal to the river to form a capacious basin at each extremity of the canal between the lock and river, where the boats can lie in safety.

The last report of The Mississippi River commission spraks very favor able of such mothods of infirormentas & have given in this the. sis. By the rise of these methods many of the western rivers, such as Her Missouri, Osage, Jaccoude and Atess may be made mavigable for many miles toward Their cource and thus greatly increase western facilitics for cleap transportation. The report says of work done; We see no reason for doubting the ultimate entire enccess of the improvements. On the upper Mississippi below was moisne work is carried on in detached portions, and so paronly at Those place where mavigation is most impeded; but on The Missouri anly continuous work beginning at some point of stable regimen, affords any prospect of encess. By doubling or Trebling plants, which cannot be done under the present allotmant of appropriations, The work could be done in a much short. er time without any increase of The ultimate cost."

The last report of the Mississippi River commission speaks very favorably of such methods of improvement as I have given in this thesis. By the use of these methods many of the western rivers, such as the Missouri, Osage, Gasconade and others may be made navigable for many miles towards their source and thus greatly increase western facilities for cheap transportation. The report says of work done; "We see no reason for doubting the ultimate entire success of the improvements. On the Upper Mississippi below Des Moisne work is carried on in detached portions and so far only at those place where navigation is most impeded; but on the Missouri only continuous work beginning at some point of stable regimen affords any prospect of success. By doubling or trebling plants, which cannot be done under the present allotment of appropriations, the work could be done in a much shorter time without any increase of the ultimate cost."

The report gives in detail the plans upon which the commission is at work below Cairo, The main principle being a contraction of the width of The over and the protection of the banks, to excure the ecouring out of the bottom and the prevention of the formation of bars. The works have already passed beyond The experimental stage. They have ve ceined practical teste at various points on The Mississippi and Missouri Rivers, and even recent. work of the commission already shows Their correctness.

The report gives in detail the plans upon which the commission is at work below Cairo, the main principle being a contraction of the width of the river and the protection of the banks, to secure the scouring out of the bottom and the prevention of the formation of bars. The works have already passed beyond the experimental stage. They have received practical tests at various points on the Mississippi and Missouri Rivers, and even recent work of the commission already shows their correctness.