May 17, 1932. J. H. THORNLEY 1,858,976

DIKE

Filed June 2, 1930

Fig. 1.

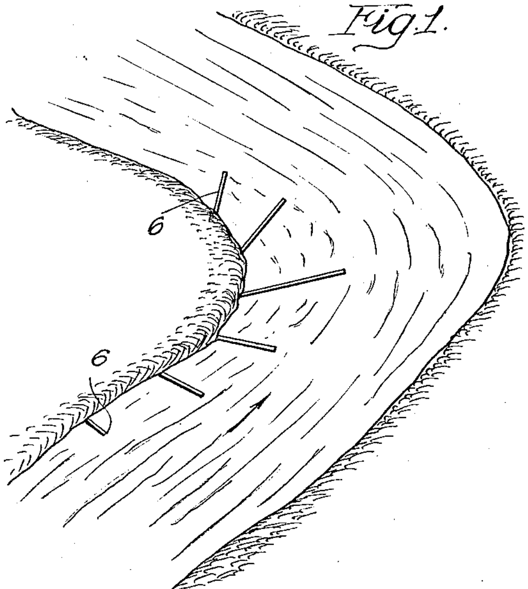


Fig. 2.

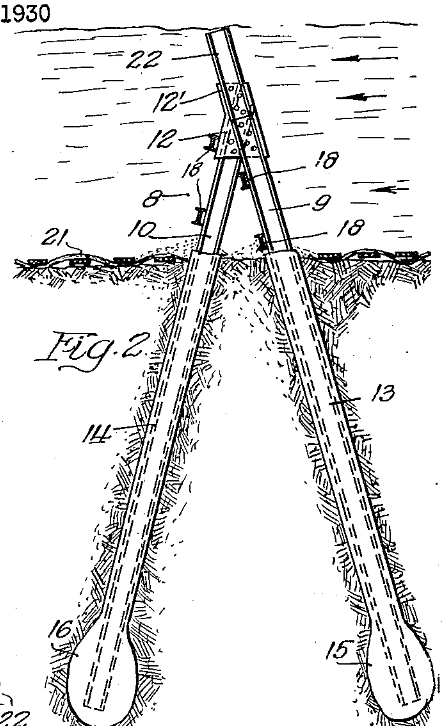
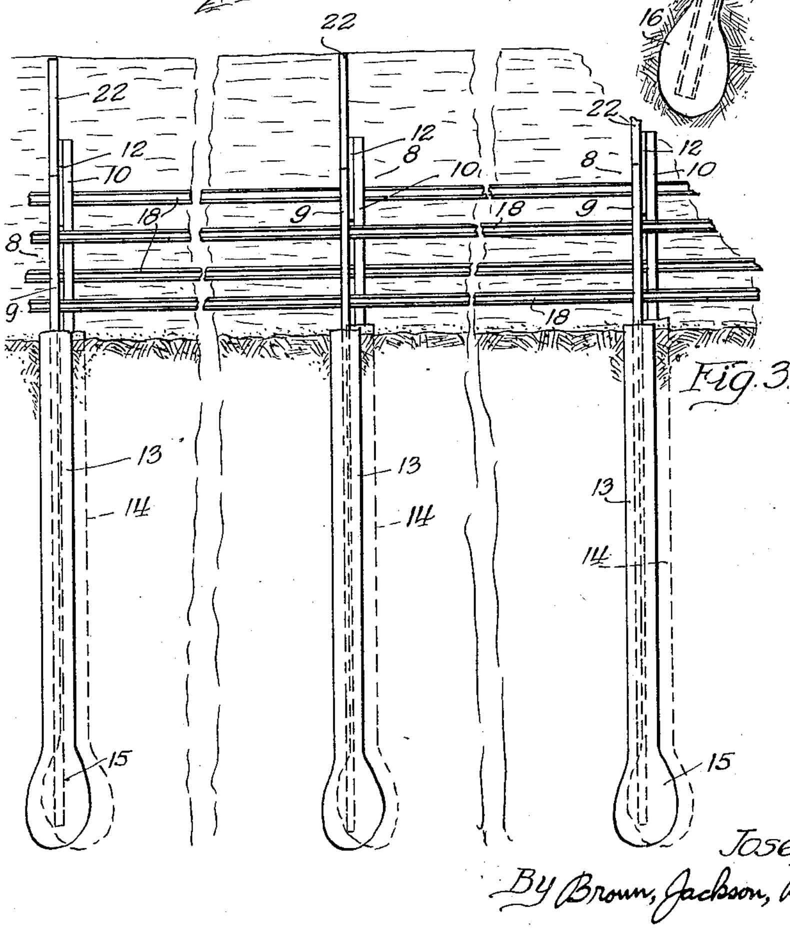


Fig. 3.



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UNITED STATES PATENT OFFICE

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DIKE

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The present invention relates to dikes and has particular relation to such structures erected in a river bed for controlling the channel thereof.

In a considerable part of the control work which has been carried on thus far along rivers such as the Missouri and Mississippi, which inundate vast areas of the surrounding country and also shift their beds at high water levels, efforts are being made to crowd the river into a comparatively narrow channel so as to increase the rate of flow to the point where a scour action will occur which will tend to deepen the channel and will largely eliminate the formation of migratory bars or shoals. The method now being used to narrow the channel is to extend dikes or jetties out from the bank of the river to the edge of the desired channel with the view to having these dike structures silt up from soil and débris deposited by the river so as to form a control bar extending out approximately to the edge of the desired channel. This practice is followed most extensively at bends or curves of the river, where the dikes are extended out from the convex side of the bend, and the opposite side is usually built up with a revetment. Wherever the dikes silt up from the deposit of the river and form a bar the desired result is usually effected, but in a considerable proportion of cases the dike is swept out by floods or caried away by the ice before the required bar is formed.

The general practice is to construct these dikes of upright wood piles driven into the river bottom. In the group type of dike a group of piles, usually three in number, is driven, the piles being spaced four or five feet between centers. After they have been driven the tops are drawn close together and bound with cables. The groups are spaced from ten to twenty feet apart and the intermediate space usually is baffled by stretching hog wire from group to group. In high water periods the baffled dike collects the débris carried down by the floods and forms a more or less continuous wing dam. As the velocity of the current decreases this dam causes the deposit of silt, thus forming a bar. In the trussed type of dike the piles, generally four in number, are driven one behind the other in the general direction of the current, and the upper ends are connected together by horizontal and diagonal reenforcing members arranged like trestle bents. These trussed piles are then connected together transversely of the river current by hog wire, spans of cable or other débris collecting means in substantially the same manner as in the case of group dikes. In erecting these dikes it is necessary in almost all cases to place mats of large area on the river bottom, usually directly behind the line of piles or pile groups, so as to prevent the current from scouring the soil out behind the piles during the early stages of forming the bars.

These methods of constructing dikes would be generally satisfactory if it were not for the large percentage of failures which occur before the necessary sedimentation has taken place to form the desired bar. Failures of these wood pile dikes occur in various ways:

(1) The piles act in cantilever and break at the fulcrum point. The resistance value of wood piles acting in cantilever under the condition described is small, whether they act singly or in groups.

(2) The trussed series of piles act as a unit and the tension piles are pulled out. It will be evident that if the trussed groups are to act as a unit they must depend on a tension value in the forward piles. This is an incalculable value for a tapered pile in the silt of a river bottom, and is usually a small value.

(3) Ice caps and flood water raise the piles. If ice forms around the piles and is then lifted by rising water, the piles again depend on the tension value, which is generally small for a tapered wood pile, particularly in the silt and soft soil of a river bottom.

(4) The piles are frequently sawed or cut off by ice. If rough pans of ice are driven against wood piles at high velocity by flood water they will frequently chew or saw the piles off. Wood, particularly soft wood, has poor resistance against this action.

(5) Piles deteriorate by exposure and break under load. Wood piles, exposed as river dike piles are bound to be, to alternate wetting and drying, lose their strength very

rapidly. It is usually specified that a wood pile will not be accepted for driving if it has been cut more than three months.

Considerable experiment with these structures has demonstrated that if a wood pile dike has not filled by sedimentation within the first twelve months it has a greatly reduced chance of withstanding the second flood period. Generally by the end of the first year rubbish and drift will have screened the dike. A screened dike in fifteen feet or more of water is taking a tremendous load, if it has brushed up by the accumulation of rubbish and drift before there is any considerable sedimentation around the pile to support the dike. If the dike brushes up without filling it will act as a wing dam in the river. Cross currents will inevitably follow, scour will occur and the dike will go out. I have pointed out in considerable detail the structures of these prior river control dikes, and the causes of their failure, in order more effectively to show the requirements of such dike structures and the manner in which I overcome these prior difficulties.

One of the principal objects of my invention is to provide a control dike which does not depend solely on a cantilever reaction in resisting flood conditions. The members of my improved dike act in direct tension and compression. In prior dikes with wood piles depending on a cantilever reaction for developing their movement of resistance there was always an uncertainty as to the depth of the center of fulcrum reaction but in the present type of dike structure herein disclosed this is no longer of any importance. The effect of scour, which in the previous dikes will cause the lowering of the fulcrum point with the resultant failure, is negligible in the present construction unless it goes to so great a depth as to destroy the bearing value of the piles, which would be a very exceptional condition. In the prior dikes the depth of water has a direct effect on the resistance of the dike because in those constructions the distance between the fulcrum and the load is the vital factor, but in my improved construction the depth of water has practically no effect on the resistance value of the dike.

A further object of the invention is to provide a structure which will develop an enormous resistance to uplift so that there will be no possibility of the piles being raised by the lifting of ice caps due to rising water.

A further object is to avoid the destructive sawing and battering by ice pans or floes impinging against the dike. The steel and concrete construction of the present dike is proof against this action. In this regard, it is a further object to provide a structure which will tend to clear itself of the force of a heavy jam of ice, by tending to cause the ice to mount over the obstruction of the dike and so clear the structure. It will be evident that the steel and concrete construction of my improved dike will be proof against rapid deterioration from alternate exposure to wetting and drying. Such construction will last for many years even without painting or other attention, and in far less time than that the dike will have formed a bar and so served its purpose.

It is a further object of my invention to provide an improved method by which the sedimentary bar can be built higher each year in a progressive operation until the full height of the required bar has been deposited. The danger of scour is thereby reduced to a minimum.

Other objects and features of my invention will be apparent from the following detailed description of a preferred embodiment thereof, taken in connection with the accompanying drawings, in which:

Figure 1 illustrates a typical river control project with the dikes extending outwardly from the bank on the convex side of a curve in the river.

Figure 2 is an end or profile view of the dike structure, illustrating one of the A frames which are located at spaced points outwardly along the length of the dike, and

Figure 3 is a fragmentary side view of a portion of the dike structure, illustrating the inter-connection between the A frames.

In the typical installation represented in Figure 1, the dikes 6 may be extended out into the river varying distances, in some instances to a half mile or more, depending upon the particular conditions. As previously described, these dikes function as a barrier which brushes up with an accumulation of driftwood and other débris until there has been sufficient retardation of the current to cause a sedimentary deposit sufficient to make a bar which narrows the channel of the river.

In constructing these dikes I propose erecting at spaced points along the intended line of the dike a series of frame structures 8 having outwardly and downwardly inclined legs, resembling an A frame. Both of these legs 9 and 10 consist of heavy steel bars, preferably of standard section, such as I-beams. Both of these beams are set edgewise to the current for maximum strength and their intersecting upper ends are lapped and joined together by a gusset plate 12 to which both beams are bolted.

The lower portions of said frame bars are embedded in concrete shafts or columns 13 and 14, each of which terminates at its lower end in a mushroom or pedestal base portion 15 and 16 into which the frame bars 9 and 10 also extend. In erecting each of these A frame structures, a casing is first driven down into the river bed at the desired angle for one of the legs, through the operation of a specially constructed pile driver arranged for performing driving operations on the incline.

After sinking this casing to the desired depth, which will vary with conditions but will probably be generally in the neighborhood of thirty feet below the river bottom for a fifteen foot high water level, the frame bar is lowered into the casing and concrete is then poured into the casing to form the outer concrete sheath 13 or 14 enclosing the frame bar. The enlarged mushroom portion 15 or 16 can be made by the performance of the method disclosed in my prior Patent No. 1,775,217, granted September 9, 1930, it being noted that the steel bar 9 or 10 extends into and is anchored in this mushroom base. The casing is then withdrawn and the derrick structure is moved to again drive or sink the casing at the desired reverse angle for the other leg of the frame structure, the same operation being repeated for this leg. If desired, one leg may be offset slightly with respect to the other to facilitate the connection of the intersecting upper ends of the bars 9 and 10, through the gusset plate 12, but this offset relation is not essential owing to the lateral give in the long lengths of the legs which enables the intersecting upper ends of the bars to be spread to opposite sides of the gusset plate, substantially as shown. It is preferable to lap the upper ends of these bars for the greater strength thereby afforded, but if desired the bars might terminate short of their intersection and be joined by a triangular gusset plate connected with both bars below their upper ends. The result is two inclined piles joined together in the form of an A frame. It is preferable to extend the encasing shaft of concrete 13 or 14 up to approximately the bed of the river, thereby increasing the weight of each leg, but, if desired, the concrete may be confined to the lower portion of each leg or only to the pedestal forming charge 15 and 16.

These A frames are erected at spaced points along the intended line of the dike at distances to meet local conditions but probably ranging anywhere from eighteen to forty feet apart. Because the calculated resistance value of one of these A frames equals that of approximately sixty average wood piles it will be evident that these A frames can be spaced much further apart than wood pile groups. As successive frames are erected they are joined together by suitable connecting members for the purpose of intercepting brush and other débris, such connecting members preferably consisting of I-beam or channel stringers 18. These stringers are bolted or otherwise suitably joined to the frame bars 9 and 10 and to the gusset plate 12. These stringer bars may be disposed either on the upstream or downstream legs of the A frame, although in the preferred arrangement shown I dispose some of these stringers on both legs but on the downstream side of the front leg 9 so as to permit ice to slide upwardly over this leg easier. Hog wire or the like may also be used in lieu of or with the stringers, if desired. According to my improved method of progressively building the desired depth of bar a certain amount each year, I propose screening only the lower portions of the A frames the first year, that is, the stringers 18 are only applied to a limited height, say in the neighborhood of three or four feet. After the sedimentary bar has been deposited to this depth at the end of the first year or other time required, the screening is carried progressively higher each year or other time interval by the addition of higher stringers 18, until the full height of the required sedimentary bar has been deposited. This progressive method greatly reduces the action of scour because at no one time is there a very large differential between the water levels on the up stream and down stream sides of the dike. The existence of a large differential between levels sets up a considerable waterfall on the back side of the dike, creating a turbulence, cross currents and eddys which frequently tend to scour out the soil along the line of the dikes. Heretofore, in attempting to overcome this scouring action it has been the practice to place mats of large area, composed of interwoven wood strips or the like, along the line of the dike in immediate proximity to the piles. These mats are an item of considerable expense to make and lay, and it will be evident that their efficacy is limited solely to the soil below the mats because any sedimentary deposit above the mat is just as susceptible to being scoured out as if the mat were not there. In the case of the ordinary wood piles it is of decided importance to prevent this scour because of the relatively close proximity of the fulcrum point of each pile to the bed of the river and the decided weakening of the resistance value of the pile as soil is scoured out in rear of the pile down toward this fulcrum point. Because the pile structure of my invention does not depend on a cantilever reaction there is a much wider latitude, of permissible scouring action, being only limited by a depth of scour which would destroy the bearing values of the piles. Hence, the provision of these mats is not of such importance with my type of dike, and particularly if the sedimentary bar is built up progressively a limited amount each year. Where it is desirable to use such mats they are preferably disposed in front and in rear of the pile structures, substantially as indicated at 21 in Figure 2 and, if desired, small portions of mats may be disposed or extended in the space between the inclined legs 9 and 10.

Because of its metallic construction the present A frame pile structure is readily adapted to the provision of extension portions 22 which may be secured in place in the initial erection of the frames or which may be added later for continuing the sedimentary bar up to a greater height. These extension members also preferably consist of bars of standard section, such as I-beams or channels, and are bolted to the projecting upper portions 12′ of the gusset plates 12. In localities subjected to ice conditions it is of advantage to dispose this extension member 22 at a rearwardly extending angle, such as, for example, co-extensive with the inclined front leg 9 of the frame. By virtue of this rearward inclination of the front frame bar 9, and of the extension 22 where the latter is used, there will be a tendency to deflect heavy jams of ice in an upward direction so that the ice can mount over the top of the dike and so clear the structure. Of course, with the addition of these extension members 22, supplementary stringers 18 will be secured thereto so that brush and débris will be intercepted at the greater height of the extensions.

It will be evident that under ordinary conditions of resistance the upstream leg 9 of each A frame will be acting in tension and the downstream leg 10 will be acting in compression. In a composite steel and concrete construction such as I have shown the limiting factor will not be the strength of the structure but rather the bearing and tensile values of the anchorages. These values will, however, inherently be very high without requiring objectionably large dimensions of frame structure or anchorages, as will be evidenced from the fact that under average conditions a pile having a thirty inch mushroom base will withstand an uplift tension in excess of fifty tons. This tension value in the front leg, together with the high compression value in the rear leg, establishes a resistance moment normal to the plane of the stream, of a value which cannot possibly be obtained by cantilever reaction in any structure of moderate or permissible dimensions. Moreover, this resistance moment is practically unaffected by the depth of the water, whereas in the ordinary cantilever reaction pile this depth is a vital factor when it increases the distance between the fulcrum and the load. Another important load bearing value arises from the rigidity of the connection between the upper portions of the piles. As previously described, the gusset plate 12 rigidly joins both piles together, which gusset plate may be of any area, and the pile beams 9 and 10 may also be lapped and bolted together. The rigidity of this connection compels all of the parts of the A frame to act as a rigid unit in resisting any rotative tipping tendency. For example, the force of the stream has a tendency to tilt the dike backwardly with a rocking motion about a fulcrum point corresponding substantially to the expanded pedestal portion 16 of the rearward pile 10. However, because of the rigid, reinforced connection between the upper portions of the piles, the rearward pile cannot rock backwardly about said fulcrum point 16 without also swinging the front pile 9 about this same fulcrum point in a forward and upward direction. Obviously, such swinging motion of the front pile can only occur by displacing a large mass of soil in front of and above the pile, which would be impossible even under the most extreme conditions. Stability of anchorage of each A frame is also assured by reason of the fact that the center of mass of the combined weights of the pile beams, the concrete sheaths 13, 14, and the concrete pedestals 15, 16 is considerably below the bed of the river, being in relatively close proximity to the pedestal ends 15, 16 because of the greater weight of the concrete. The resistance of the present piles to being raised by the lifting action of ice caps due to rising water is also very high. At this time the tension values of both pedestal bases 15 and 16 are effective for resisting such lifting, but even in the absence of these enlarged pedestal portions such lifting would be almost impossible owing to the wedge-shaped inclination of the two legs tied together at their upper ends.

Attention is also directed to the fact that any upward movement of either of the spread-foot anchorages 15 or 16 requires not only that the soil immediately above that anchorage must be displaced but also requires that all of the superposed soil between the upwardly extending critical angles of the soil must be displaced. This is best illustrated by reference to the critical angles extending downwardly from each spread-foot anchorage when that anchorage is resisting downward forces. It is well known that the load bearing pressure is not confined to that vertically defined section of soil immediately beneath the anchorage but that this pressure is distributed downwardly and outwardly along inclined lines, so that the pressure is distributed over a conical section of soil defined between lines radiating outwardly and downwardly from the sides of the anchorage. The angle of this conical section over which the load bearing pressures are distributed is approximately the critical angle for that particular soil. In like manner any upwardly acting force on one of the spread-foot anchorages is resisted by a conical section of earth defined between the critical angles radiating outwardly and upwardly from the sides of the anchorage, and this conical section must be displaced in any upward movement of that anchorage. The fore and aft spacing illustrated between the front and rear footings 15 and 16 in Fig. 2 establishes the wedge shaped inclination of the two legs 9 and 10, as previously described, and, in addition, this spacing avoids interference between the critical angles radiating upwardly from the two footings of each A frame. That is to say, there is no appreciable overlap of the conical sections above each footing, which would otherwise diminish the tension resisting values of the two footings of each A frame. Likewise, in the plane of the dike, as viewed in Fig. 3, the individual A frames are spaced relatively far apart and hence there is no interference between the critical angles of the footings of adjacent A frames, i. e., there is no overlap of the upwardly extending conical section of soil at one A frame with the conical section of soil at the next A frame. Since there is no interference between the critical angles extending upwardly from the two anchorages of each A frame and since there is no interference between the critical angles at adjacent frame, each A frame has maximum tension value both for resisting straight upheaval stresses caused by ice and for resisting rocking stresses tending to tip the frame backwardly by rocking the front pile upwardly. Also, the spacing illustrated between the front and rear footings 15 and 16 of each A frame, resists this backward rocking force exerted on the frame by interposing a sufficient span of soil between the two footings so that there can be no tendency for the soil to shift or migrate from the space under the downwardly pressing rear footing to the space under the upwardly pulling front footing.

It will be seen from the foregoing that I have provided a dike structure which opposes immeasurably greater resistance to the destructive action of flood water, ice, scour, etc. than the wood pile structure now employed. This is of extreme importance because in some localities it has not been uncommon for a high percentage of the wood pile structures to be swept out by the second season's flood water or ice, through the failure of the dike to silt up an adequate height of bar during the first season following erection. With these wood pile structures every effort must be made to silt up a high control bar during the first season by providing a maximum depth of screening, and if this screening should brush up with débris without depositing sufficient sediment the pile structure is subjected to very high pressures and to intense scouring.

Because of the ability of the present dyke to withstand immeasurably greater forces the percentage of failures will be reduced to a minimum and it will not be of such importance to have the dike silt up during the first year. In fact, as I have described above, it may be desirable in some instances intentionally to build the control bar by small accretions of sediment successively deposited over several years, through progressive raising of the height of screening.

While I have disclosed what I regard to be the preferred form of my invention and what I regard to be the best manner of carrying it into effect, it will be understood that such are merely exemplary and that numerous other structures and practices may be adopted without departing from the inhert features of the invention.

I claim:

1. A dike for creating a sedimentary control bar in a river including a plurality of A-shaped frame structures spaced laterally from each other along the line of the dike by such intervals as to develop substantially the full strength of the anchorages of each frame structure, each frame structure comprising front and rear piles having their major portions extending into the soil below the river, said front pile being inclined downstream to react in tension and said rear pile being inclined upstream to react in compression, means projecting laterally from the lower portion of each front pile for establishing a tension resisting anchorage of said front pile in the river bed, means projecting laterally from the lower portion of each rear pile for establishing a compression resisting anchorage of said rear pile in the river bed, said anchorages of the piles of each A frame structure being disposed far enough apart to avoid interference between them, means rigidly joining the upper portions of said front and rear piles together, and connecting means extending transversely between said frame structures to brace the same and to intercept débris in the stream.

2. A dike for creating a sedimentary control bar in a river including a plurality of A-shaped frame structures spaced laterally from each other along the line of the dike, each frame structure comprising front and rear steel piles having the major portions of their lengths extending into the soil below the river, said front pile being inclined with its upper end sloping downstream to react in tension, and said rear pile being inclined with its upper end sloping upstream to react in compression, an enlarged concrete pedestal portion on the lower portion of said front pile engaging in the river bed for resisting tension forces in said front pile, an enlarged concrete pedestal portion on the lower portion of said rear pile engaging in the river bed for resisting compression forces in said rear pile, concrete sheaths encasing both of said steel piles above said pedestal portions, means rigidly joining the upper portions of said front and rear piles together, and connecting means extending transversely between said frame structures to intercept débris in the stream, said concrete pedestal portions being spaced far enough from each other in all directions substantially to avoid interference.

3. The method of constructing and anchor-

ing an A frame structure in the bed of a river which comprises sinking a casing into the river bed at the desired angle to the vertical for one of the legs of the A frame structure, introducing concrete into said casing and forcibly expanding the concrete outwardly below the end of the casing to form an expanded pedestal portion, joining the lower end of a pile to said expanded pedestal portion, and sinking a casing into the river bed at a reverse inclination to the vertical for the other pile and at an angle causing said latter pile to intersect the line of the first pile, introducing concrete into said casing and forcibly expanding the concrete outwardly below the end of the casing to form an expanded pedestal portion, joining the lower end of a second pile to said latter pedestal portion, and rigidly joining the upper portions of said first and second piles together.

4. A dike for creating a sedimentary control bar in a river including a series of A-shaped frame structures disposed in the general plane of the current at longitudinally spaced points along the length of the dike, each of said frame structures comprising a front pile having its upper end inclined downstream and a rear pile having its upper end inclined upstream whereby said piles act respectively in tension and compression in resisting the force of the current, each of said piles comprising a flanged steel bar and a shaft of concrete encasing the lower portion of the bar and being expanded outwardly at the lower end of the pile to form an enlarged mushroom base, the greater part of the length of each pile extending below the bed of the river, the upper portions of said front and rear bars overlapping in angular relation, a gusset plate connected with the upper portions of both bars, and stringer bars connected with the successive A frame structures along the line of the dike to intercept brush and other débris in the current.

5. A dike for creating a sedimentary control bar in a river including a series of A frame structures spaced laterally from each other along the line of the dike, each frame structure comprising a front pile inclined downstream to react in tension and a rear pile inclined upstream to react in compression, concrete sheaths encasing the major portions of both piles, enlarged concrete pedestal bases at the lower ends of both piles, the greater part of the length of each pile including the concrete sheath and pedestal base thereof being disposed below the bed of the river whereby said A frame structure is firmly anchored against tension and compression, with the center of mass thereof disposed considerably below the bed of the river, means including a gusset plate rigidly joining the upper ends of said piles together whereby any tendency of the force of the stream to tilt the dike backwardly around the pedestal base of the rear pile as a fulcrum is resisted by the necessity of the front pile rotating forwardly and upwardly through its anchoring soil in any such tilting action, and connecting means extending transversely between the upper portions of said frame structures to intercept débris in the stream.

6. A dike for creating a sedimentary control bar in a river including a series of A frame structures spaced laterally from each other along the line of the dike, each frame structure comprising a front pile inclined downstream to react in tension and a rear pile inclined upstream to react in compression, enlarged concrete pedestal bases at the lower ends of both piles, the greater part of the length of each pile including the pedestal base thereof being disposed below the bed of the river whereby said A frame is firmly anchored against tension and compression, with the center of mass thereof considerably below the river bed, means rigidly joining the upper portions of said piles together whereby any tendency of the stream to tilt the frame structure backwardly around the pedestal base of the rear pile as a fulcrum is resisted by the necessity of the front pile rotating forwardly and upwardly through its anchoring soil in any such tilting action, and connecting means extending transversely between said frame structures to intercept débris in the stream.

7. A dike for creating a sedimentary control bar in a river including a series of A frame structures spaced laterally from each other along the line of the dike, each frame structure comprising a front pile inclined downstream to react in tension and a rear pile inclined upstream to react in compression, concrete sheaths encasing the major portions of both piles, enlarged concrete pedestal bases at the lower ends of both piles, the greater part of the length of each pile including the concrete sheath and pedestal base thereof being disposed below the bed of the river whereby said frame structure is firmly anchored against compression and tension, with the center of mass thereof disposed below the river bed, means rigidly joining the upper portions of said piles together whereby any tendency of the force of the stream to tilt the frame structure backwardly about the lower portion of the rear pile as a fulcrum is resisted by the necessity of the front pile rotating forwardly and upwardly through its anchoring soil in any such tilting action, connecting means extending transversely between said frame structures above the river bed to intercept débris in the stream, and extension bars secured to said frame structures and projecting upwardly therefrom for receiving an additional height of débris intercepting means.

8. A dike for creating a sedimentary con-

trol bar in a river including a plurality of A-shaped frame structures spaced laterally from each other along the line of the dike by such intervals as to develop substantially the full strength of the anchorages of each frame structure, each frame structure comprising front and rear piles having their major portions extending into the soil below the river, said front pile being inclined downstream to react in tension and having an enlarged concrete pedestal portion on the lower portion thereof engaging in the river bed and providing an anchorage for resisting tension forces in said front pile, said rear pile being inclined upstream to react in compression and having a bearing the value of which is as great as or greater than the value of the anchorage of said front pile, the lower ends of the piles of each A frame structure being disposed far enough apart to avoid interference between the reactions of said lower ends upon the river bed in which they are disposed, means rigidly joining the upper portions of said front and rear piles together, and connecting means extending transversely between said frame structures to brace the same and to intercept débris in the stream.

9. A dike for creating a sedimentary control bar in a river including a plurality of A-shaped frame structures spaced laterally from each other along the line of the dike by such intervals as to develop substantially the full strength of the anchorages of each frame structure, each frame structure comprising front and rear piles having their major portions extending into the soil below the river, said front pile being inclined downstream to react in tension and having means projecting laterally from the lower portion thereof for establishing a tension resisting anchorage of said front pile in the river bed, said rear pile being inclined upstream to react in compression and having a bearing value as great as or greater than the anchorage value of said front pile, means rigidly joining the upper portions of said front and rear piles together, and connecting means extending transversely between said frame structures to intercept débris in the stream.

In witness whereof I hereunto subscribe my name this 27th day of May, 1930.

JOSEPH H. THORNLEY.