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by

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Needed: More Science in Flood Control

A survey of the flood control methods utilized in the Mississippi valley and some pertinent recommendations (in particular, the establishment of a laboratory for the study of river hydraulics) for improved procedure

By JOHN R. FREEMAN, '76

CATASTROPHIC floods have caused destruction and death in two sections of the country this year and a discussion of their prevention is no less important to New England than it is to the Mississippi valley. The Review is fortunate in being able to bring to general attention, by publishing the accompanying article, a significant contribution to the literature on the subject by an authoritative and noted engineer.

It is not necessary to introduce the author. His work on the Panama Canal, on the Yellow River in China, on the great Keokuk dam, and on numerous other notable projects have placed him at the head of his profession. Last spring he was invited to speak before the Faculty Club and the accompanying article is an extension of his remarks before that body. During the summer he visited European hydraulic laboratories and was able to observe first-hand this efficacious method of investigation which he so strongly advocates for the study of American floods. Mr. Freeman points out the absurdity of the proposed spill-ways, storage-reservoirs, and reforestation plans soon to be submitted to Congress.

WE have for consideration a problem which considered broadly is the greatest hydraulic engineering problem in the world. It is not new. About seventy years ago the United States government, through the Army Engineers, started the most intensive study of the hydraulics of great rivers that had ever been undertaken. It was carried on under two young lieutenants, each about twenty-four years old, A. A. Humphries and H. L. Abbott. First of all, libraries and text books were searched, and an admirable bibliography was prepared as a starting point, and a review was made of the state of the art all over the world.

In the course of about five years much field work was performed and the derivation of fundamental formulas was attempted. The results were set forth in a big, thick volume entitled "The Physics and Hydraulics of the Mississippi River." This was a wonderful beginning on the general problem of river hydraulics. Then came the Civil War, and this kind of work in America stopped. It has never been taken up again on any such scale. Some of these early formulas and conclusions were premature. Measurements of the velocity of the river current by the method of double floats was afterward found less accurate than supposed and has long since been superseded by measurement with the current meter. In the sixty years that followed this publication, while detached items of new data have been secured and the *art* has been somewhat further developed, the *science* of river hydraulics and river control has slumbered. It still slumbers in America and most other parts of the world. It has had some awakening in central Europe in recent years, mainly through the remarkable developments of hydraulic laboratories in Germany, but river and harbor hydraulics with their problems of flood control, the training of rivers to dig their channels deeper, to cut through sand bars, to refrain from gnawing at the foot of a bank beneath a dike, and so on, still is far from having been advanced to the status of an exact science.

I have been interested in flood problems and river hydraulics, on and off, for about fifty years. It is fifty-one years since I graduated from the Civil Engineering Course at M. I. T. Eight or ten years ago I became intensely interested in these flood and river problems while I was studying the control of the Yellow River in China, and the rehabilitation of the Grand Canal. Incidentally, I sought the aid of Professor Hardy Cross, a graduate of Technology in 1908, also of Harvard, and at that time assistant professor of Civil Engineering at Brown University. In consultation with me he spent a large part of his time for eight months going through everything that could be found relating to river hydraulics. He sought data here in the library of the Institute, which among a wealth of other treatises, contains Loammi Baldwin's remarkable library, which ninety or one hundred years ago probably was the finest engineering library in America. It is noteworthy that its treatises on hydraulics were largely in Italian or French. He also worked through the Harvard Library, the Boston Public Library, the New York Public Library, the Library of the National Engineering Societies in New York, the Library of Congress in Washington, and in brief, studied in every place that we could think of as worth while. I should have mentioned first of all the Corthell Library at Brown University, which is one of the richest in books on river and harbor engineering. Elmer Corthell was James B. Eads' assistant in building the jetties at the mouth of the Mississippi, and afterward engineered on his own account much important river and harbor improvement in South America and elsewhere. He bequeathed to his Alma Mater the library that he had collected during a very active life.

Professor Hardy Cross thus compiled for me more than a thousand closely typewritten pages of condensed abstracts from these various authors. When he summed them up he found he had collected diametrically opposite opinions, expressed by equally eminent authority, on almost every important question relating to river and harbor engineering.

The whole state of the science of river hydraulics was found very largely to be like that of chemistry when they talked about phlogiston or in that of electricity before they had the C. G. S. units of measurement. Conclusions and rules of practice were very largely matters of opinion, with very few definite theories or formulas that rested on a sound scientific basis, and the rules of river and harbor engineering continue very much in that condition today.

I

Forty years ago, following the building of the Eads jetties and the experience of many floods, the Mississippi River Commission was formed, and it has practically had charge of the problems of flood control ever since. The Federal Government had ceded these low-lying lands obtained in the Louisiana purchase to the States with the clear understanding that they were to take care of their flood control. Thus, the subsequent contribution of the Federal Government toward levee building and revetment has been on the theory that the water would aid navigation. About thirty years ago, after ten years of experimenting, in course of which, for example, about two million dollars was expended in full-scale experiments on channel control in the Plum Point Reach — which was a failure — the Commission apparently got tired of experimenting, or felt that they need not go much further in that line. Experiments on a model in a laboratory are vastly cheaper than experiments with the river itself.

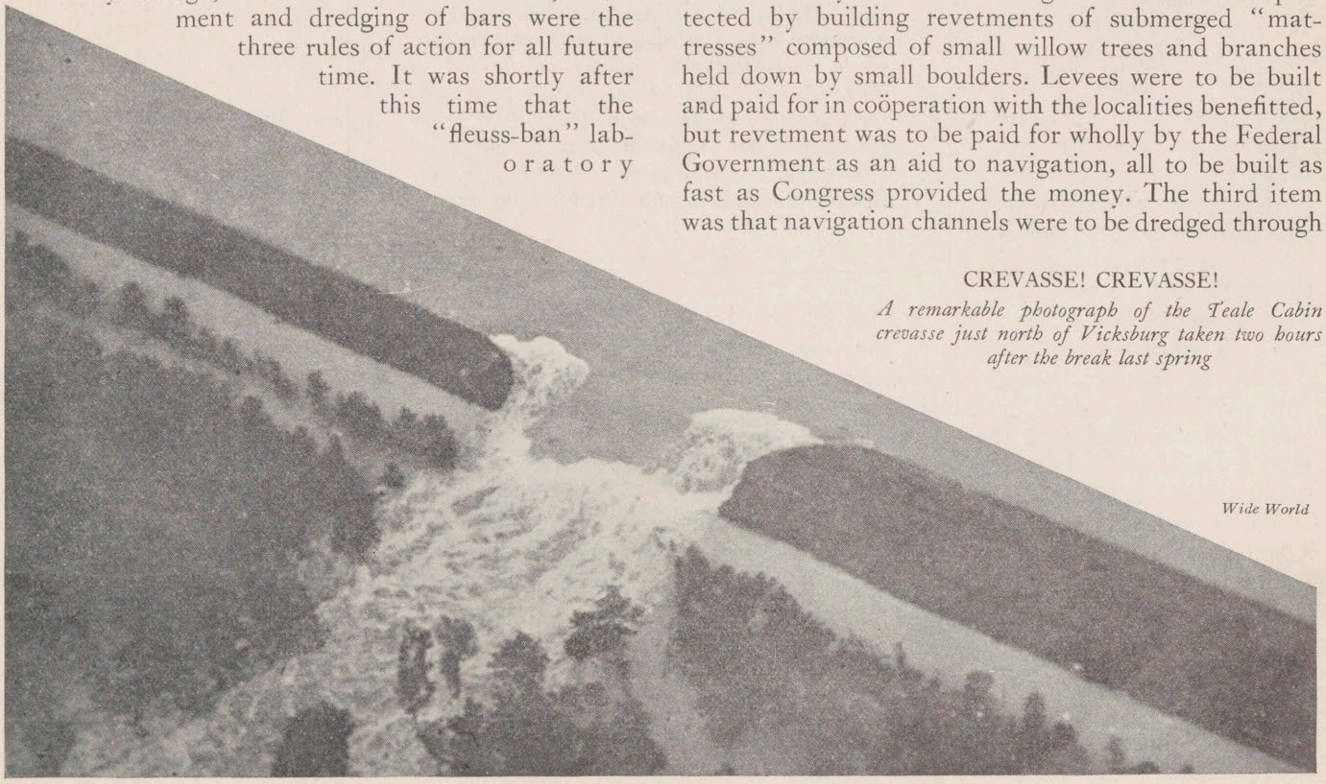
Scientific research into matters of cause and effect of the erosion of banks, the building up of gravel bars, the under-cutting of levees, the laws of percolation, and so on, seems to have mostly stopped thirty years ago, with the decision that levees, revetment and dredging of bars were the three rules of action for all future time. It was shortly after this time that the "fleuss-ban" laboratory idea began to be actively developed in Germany. The many problems of river control were then taken into laboratories to be studied with great success.

SANDBAGGING THE RIVER

A crevasse is dammed with sandbags during the 1922 Flood

The Commission, thirty years ago, seems to have settled down to a firmly established policy in accordance with which most of the construction work on river control has been done. For its foundation this had three chief items. One was that the so-called levee system was the correct system. High levees were to be made continuous along the river, confining floods to about a mile in width instead of permitting them to spread out thirty miles more or less in the state of nature for hundreds of miles below Memphis. It was concluded to be probable that the river, being so confined, would naturally dig its channel deeper, giving the water a better chance to flow off, or that whatever happened the sediments would not accumulate within this narrowed channel to an extent that would compel dikes to be continually built higher.

The second main item of policy was the protection of caving river banks along concave shores of river bends. This continuous caving and shifting of channel in the state of nature, cuts away nearly a square mile of land each year. These caving banks were to be protected by building revetments of submerged "mattresses" composed of small willow trees and branches held down by small boulders. Levees were to be built and paid for in coöperation with the localities benefitted, but revetment was to be paid for wholly by the Federal Government as an aid to navigation, all to be built as fast as Congress provided the money. The third item was that navigation channels were to be dredged through



CREVASSE! CREVASSE!

A remarkable photograph of the Teale Cabin crevasse just north of Vicksburg taken two hours after the break last spring

Wide World

the gravel bars, which nature builds up after each great flood across the river where its bends reverse their curvature. Thus levees, revetments and dredgings have been the three main items in the settled policies of Mississippi River control.

II

For twenty or thirty years there appears to have been remarkably little new scientific research relating to many of the underlying elements of river control. To an outsider the idea has seemed to be that the problem was *res judicata*, and that it would be almost *lèse-majesté* for any one to suggest that the problem needs to be studied further in a more scientific way. Meanwhile, the work of building revetments and levees has gone on as rapidly as appropriations could be secured from Congress and the states. This has been limited to about $10,000,000 to $12,000,000 per year, a tidy sum, but small when spread in spots far apart over a length of river bank of about 2,000 miles, for the lower reaches of tributary rivers must also be protected. If revetment is omitted on convex shores and islands there remains nearly 1,000 miles of shore line needing revetment.

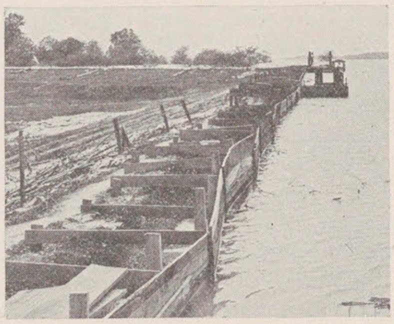
Official Photograph, U. S. Army Air Corps

WATER EVERYWHERE

McGehee, Arkansas, on June 1, 1927

The U. S. Army Engineers in charge of this construction have done wonderfully good work in carrying out these two main ideas of levees and revetments. I suppose there is no construction work of this kind along any river in the world as good as some of that which our Army Engineers have built along the Mississippi under the general rules laid down by the Mississippi River Commission, of which three of the members, including the chairman, are ex-officio Army Engineers.

The type of levee has been changed from old dikes, many of them only eight feet high, and too thin to withstand the percolation of a long continued flood, to levees twenty or thirty feet high, built of a thickness such that the hydraulic gradient through the cross-section is commonly not steeper than 1 to 10.

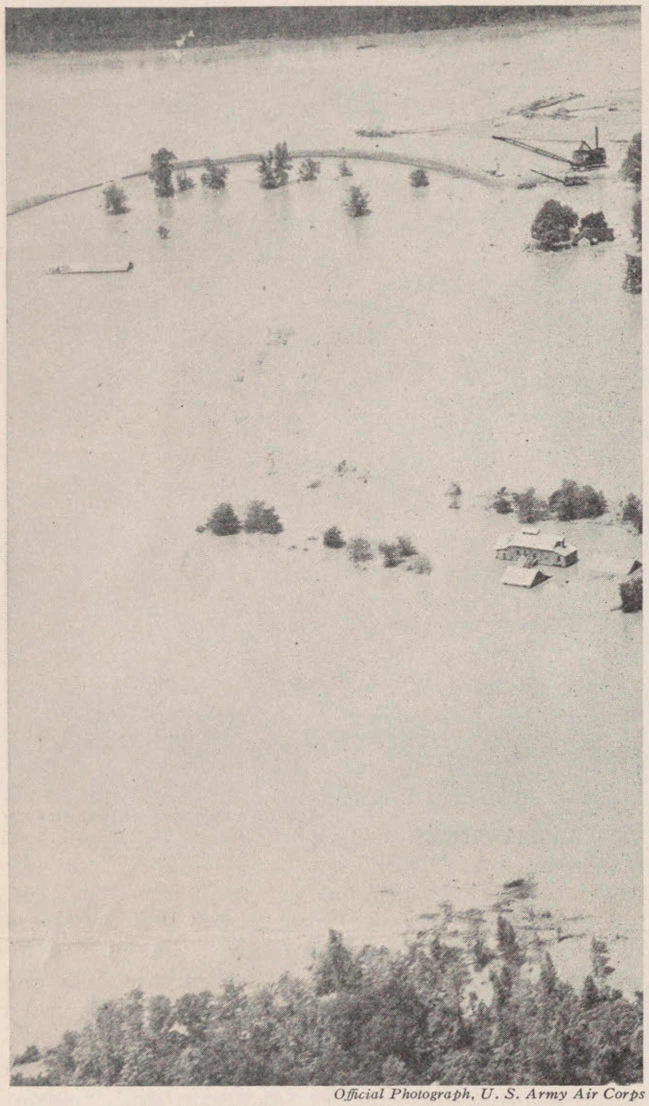


A THIN LINE

Flash boards for preventing waves from overtopping a low levee

Coöperation with state levee boards and local levee districts has been admirable under a recent plan by which two-thirds of the cost of levees is paid by the Federal Government. There has in all been 1,500 miles or more of levee built to a height three feet above the highest flood of record, according to a program which was more than three-fourths complete when the recent flood came. Where thirty years ago any flood of more than ordinary height broke many dikes and flooded many thousands of acres, so the possibilities of having to move out suddenly to higher ground were constantly in mind, conditions had been so improved by completion of higher levees that in the last great flood before the 1927 one, that of 1922, the levee system performed with really wonderful efficiency, and presented only two or three serious breaks in its entire line of more than 1,500 miles. Meanwhile, because of better levees the reclamation of swamp lands for agriculture proceeded rapidly and values per acre were vastly increased. Much of the recent distress is due to forgetfulness of the danger of flooding that has always hung over these reclaimed river bottom lands and probably always will continue.

Some few people are now in a hurry to condemn the levee system, where really it is entitled to abundant praise. There is a bright picture of the wonderfully successful protection by the levees in what happened during the great flood of 1922. The 1922



Official Photograph, U. S. Army Air Corps

NEAR PENDLETON, ARKANSAS

Two-thirds of a million people lived in the areas flooded like this

flood rose within a foot or two of the height of the present flood, and in all of more than 1,500 miles of levees there were only two serious breaks, although there were several narrow escapes. The levees as they stood in 1922 protected more than nine-tenths of the land that was relying on them for protection. Considering a period of more than ten years, levees have protected everything except ten per cent of the land flooded in one year out of the ten. That figures out to be a "batting average" of ninety-nine per cent; which really is doing wonderfully well.

There is now a loud outcry "Complete the levees."

Completing a single line of levees along each shore to full height and thickness *can never fully protect the low lands behind them.*

The dangers that remain after levees have been built to full height and standard thickness, have been so largely overlooked, during the recent popular discussion, that it seems to me now important to devote some time to these particular dangers of deep undercutting, a case of which may occur almost anywhere without warning, and may overnight get beyond control so as to inundate more than 1,000 square miles of most fertile land, and possibly cause a loss of more than ten million dollars from a large crevasse.

The chief weakness in this system of protection by levees and revetment lies in the ever-present danger that some new twist of deep current during a great flood will undercut some short piece a few feet in length in the more than 1,000 miles of river bank where there is no revetment; or that a stream of water will percolate somewhere beneath the high levee following a deep, hidden stratum of sand or gravel and burst up during the night in a "sand-boil," or that it may tear up the corner of an old revetment.

One or more crevasses through the best of these standard levees will be probable for many years to come in the high flood of each ten year period, with the further probability that once in, say fifty years, there will be a coincidence of large simultaneous floods on tributaries from wide-spread heavy rainfall, like that of a few months ago, which will result in the delivery of a flood carrying about as many cubic feet per second as that from which this region is now recovering.

The protection of levees against rupture from undercutting by the deep current, which is most active at the concave shore of the bends, is by a revetment, most commonly by means of a "mattress" composed of willow trees and twigs interwoven with steel cables, 200 feet in width, more or less; and extending for a few thousand feet up and downstream along the threatened bank. This mattress is placed on the river bed below the low water level and held in place by loading with stones. This work of mattress building is extremely costly, at present averaging about $375,000 per mile of length. It necessarily proceeds slowly, both from the slow supply of funds, and from the limited supply of small willow trees, which are cut along the neighboring river banks and wooded islands.

The several construction plants have an aggregate capacity of fifteen or twenty miles per year, but from three to five miles per year is about all that the actual construction for the past ten or fifteen years has averaged, and out of a total shore line of more than 2,000 miles between St. Louis and New Orleans less than 140 miles has been effectively revetted.

The need of revetment obviously is greater near the water front of cities like New Orleans, Greenville, and so on, and particularly along the concave shore of the bends, but history shows that other parts of the shore are not wholly immune from danger. To protect the entire length of both banks of the main river only downstream from Cairo, at the recent rates of cost and progress, would cost upward of 500 million dollars, and take more than 200 years, and when once put down, revetment is not imperishable for all time, and in some rare cases the current has torn it up.

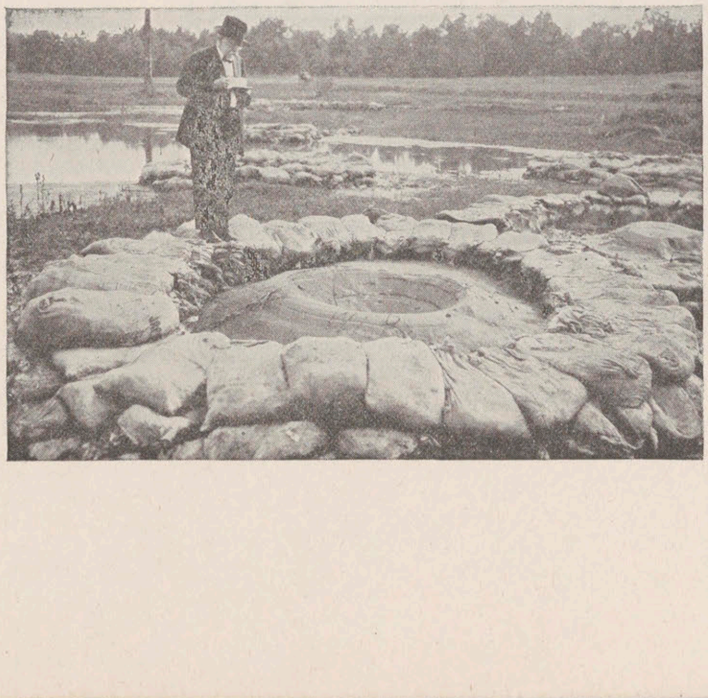
In the great flood of 1922, two serious crevasses occurred, one at Weecama on the west bank near the little town of Ferriday, the other on the east bank below New Orleans at Poydras, each of which I visited and carefully studied. Also, I visited and studied the scene of two near-crevasses: one on the east bank, near Tunica, about twenty miles below Memphis, the other on the west bank at the Stanton plantation five miles below

New Orleans. Each of these occurred at a place not previously regarded as particularly dangerous. At the Ferriday (or Weecama) crevasse the land was flooded apparently from three feet to five feet in depth upstream, downstream and inland, as far as one could see. Only tree tops and the tops of houses were visible in a widespread scene of devastation. Conditions were much the same at the Poydras crevasse, which occurred very near to the spot where the levee was cut in the present flood. At each of these crevasses at the time of my visit a current was tearing through with a volume nearly equal to that of the Niagara or St. Lawrence Rivers. Until one has seen such a crevasse, imagination fails to tell what a terrible affair it is. You cannot visualize from the still pictures in the papers the mile-wide river swirling and dashing through a slight earth dam.

The Mississippi at high floods carries two million cubic feet of water per second, or ten times as much as the ordinary flow of the St. Lawrence. This gives some measure of the size of a spillway, natural or artificial, that would be necessary to produce any important effect in lowering the flood. The vast volume through the crevasse cuts to 100 or perhaps 150 feet in depth near its mid-channel for a distance of several hundred feet along its current, and apart from the damage to the farming property inundated, this leaves an awful gap to be filled up when the levee is restored after the flood has subsided. These possibilities of a breach of the levee by some new freak of the current in under-cutting the banks at a point where danger is not obvious have been mostly ignored in the recent discussions of what is necessary for safeguarding these reclaimed delta and swamp lands. After levees shall have been built everywhere from above St. Louis below New Orleans to the full height and thickness prescribed by the Mississippi River Commission, one who dwells behind the levee on low ground should live always in view of the possibility of a break which may drive him out and drown his hogs and chickens, although it occurs forty miles upstream from where he lives. A break less than ten feet wide at the time of discovery may within a few hours spread to cut out more than 1,000 feet in length of levee and it is then beyond all possibility of restraint.

WATERS UNDER THE EARTH

Above: Close-up of levee bank showing sloughing caused by cutting-under. Note snakes of bags used for protection. Below: A sand-boil being examined by Mr. Freeman. The ring of bags is for the purpose of giving back pressure to reduce the velocity of the water



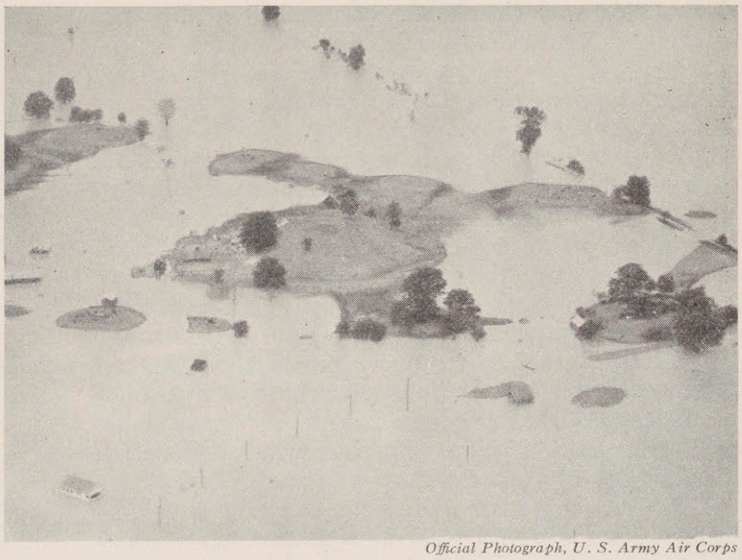
Picture a thin earth dam of very unstable material, built of whatever material can be scraped up close at hand, mostly river silt or damp mud, and 1,500 miles in length; for parts of its length resting upon a foundation of swamp mud at the site of old bayous or abandoned channels that may have left streaks of pervious gravel in their beds!

Super-structure and sub-structure must of necessity be vastly inferior to an earth dam such as is ordinarily built for reservoir purposes. One break in 100 miles in length once in forty years is within the reasonable probabilities for such a structure. I imagine that a count of all the separate breaches or crevasses along the main river in the recent great flood of 1927 might be found to give an average of hardly more than one break per 100 miles in the total length of levee.

The Mississippi River Commission's specifications had called for levees built to three feet above the level of the highest known flood. The recent flood having proved higher for long distances than any previously known, a new prescription doubtless will be written for dikes three feet higher than the new level, with a corresponding thickness, and whatever these higher and thicker dikes may cost, there is no question in my mind that they should be completed with all possible dispatch, as being the best safeguard yet developed; but while this work is going on, studies along many lines should be made for something better. As to obvious safeguards, the newspapers have been carrying a lot of amateur advice. Most of it is utterly absurd to those who have a broad view of the conditions. The proposition that is frequently mentioned for storage reservoirs is perhaps the most absurd of all, and next in point of absurdity is that of restraint by reforestation.

This flood of 1927 originated from widespread heavy rainfall in the middle of the vast drainage area, not on the headwaters. A few figures will show there is no sufficient area of land anywhere that can be devoted to reservoir purposes; as to reforesting, the land of the middle drainage area is worth far more to the country in farms than in forests. Spillways cannot possibly serve to reduce height of floods upstream from Natchez.

The first obvious immediate safeguard is for the inhabitants to live in expectation of an occasional break in the levees, and to maintain plenty of boats, as did the early settlers, and build mounds fifty or one hundred feet in diameter with their flat tops three feet above maximum flood height, at frequent intervals along the highways and crossroads, say not more than a mile apart, to which families can retreat and live stock be driven as the first stage of emergency relief.*



Official Photograph, U. S. Army Air Corps

GREENVILLE, MISSISSIPPI

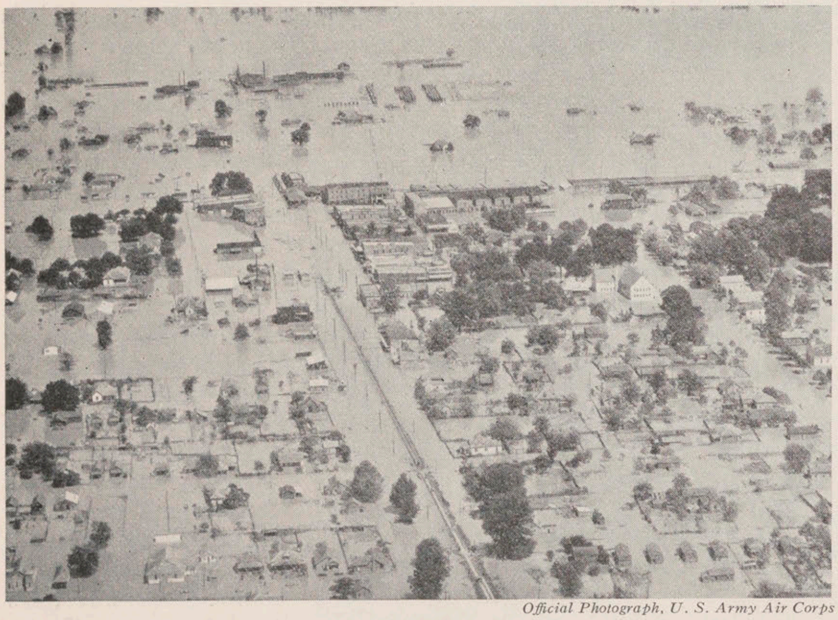
An Indian Mound, a haven for refugees, surrounded by the flood waters. The local paper was published throughout the flood period

III

One of the greatest safeguards would be to resume a painstaking study of the physics and hydraulics of the Mississippi under the best talent available, by means of several hydraulic laboratories worked in conjunction with a constant and thorough field study of the river itself.

In spite of all that a single line of standard levees can do, unless certain remote possibilities which I will mention later can be brought about, I repeat, the people on the bottom lands of the Mississippi for a hundred years to come, should live in anticipation of a repetition of inundation, in view of the lay of the land and the possibilities of widespread heavy rainfall and the dangers of under-cutting and crevasses. On the theory of probabilities, once or twice in every half-century they are liable to a repetition of last spring's disaster, if reliance is placed on a single line of levees. Even if levees are three feet high beyond the utmost flood, there remains the liability of this river gnawing at the banks deep down at the foot of the levee at some unseen, unsuspected spot as at Weecama or Poydras or Stanton in 1922. The present method of building levees is simply that of scooping up so much near-by silt and sand and dumping it in a bank, so as to fit the outlines of the standard cross-section and letting it settle mostly under its own weight, all at the lowest possible price per yard.

I found a vast difference in permeability during high floods of continuous stretches of levee. Some say those built in the old way with mules and ox carts were the most impervious because of compacting in this process. This suggests a more scientific study, and much variation here and there in a series of standard cross-sections to fit methods of building, quality of material and conditions of soft or pervious substrata. The most difficult question of all is that of protecting the foot of the bank at a depth of fifty or one hundred feet vertically below the flood level, so it will not be scoured out in at least one spot in a hundred miles. This liability will exist along many miles of levee, until they can get the edges of the banks of this crooked river revetted for its entire length, and when revetted, failure, or near failure has sometimes come.



Official Photograph, U. S. Army Air Corps

DERMOTT, ARKANSAS

"The greatest peace-time calamity in the history of our country," said Herbert Hoover of the Mississippi Flood on May 29, at New Orleans

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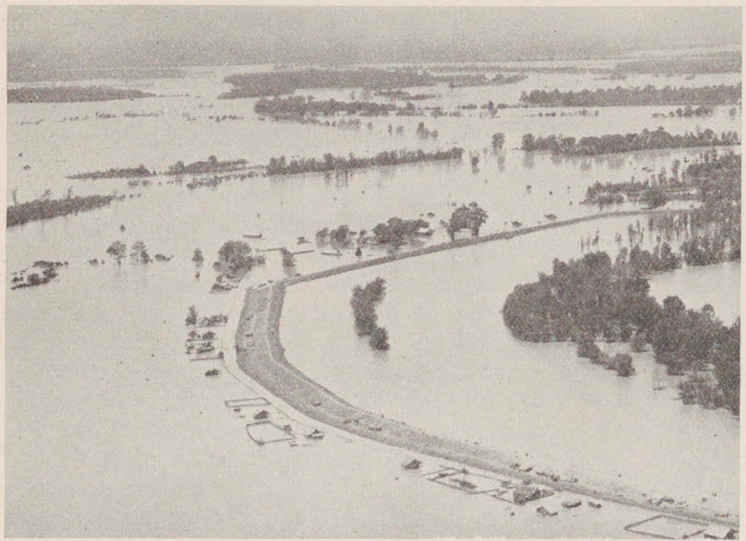
* For the future, notwithstanding its vast cost, the most obviously efficient safeguard would be a system of secondary dikes say half a mile back from the present main dikes or levees, and nearly parallel thereto, with occasional cross connecting dikes of full height built in order to prevent the starting of a new river channel between the two lines of dikes, if a break occurs. This arrangement has been carried out along some parts of the River Po in Italy. The first step toward this, or any other comprehensive scheme, should be a survey and careful reckoning of the cost in relation to the values to be protected. Also there should be storehouses at intervals of say five miles each containing tens of thousands of grain sacks, treated chemically to withstand vermin and decay, ready to be rushed to a point of danger and filled with sand.



Official Photograph, U. S. Army Air Corps

NEAR SOUTH BEND, ARKANSAS

Four hundred lives lost, seven hundred thousand persons made homeless, thirteen million acres engulfed, and three hundred million dollars' worth of destruction!

Revetting the foot of caving banks on the concave shore is not enough. The crevasses of 1922 at Weecama and Poydras, and the near-crevasses at Tunica, Stanton, and so on, were not on concave shores, but were on places which looked relatively safe.

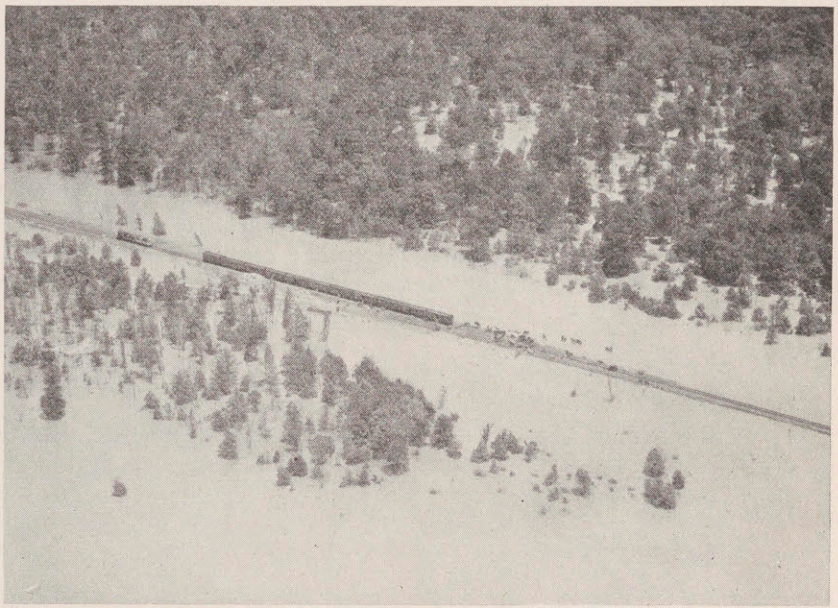
To illustrate the need of some change in methods, we may note that revetting the foot of the river banks continued at the average rate of the last twenty years would take about two hundred years more to finish the job. Revetment of one shore costs about $375,000 per mile and to complete the whole length would cost perhaps five hundred million dollars, to say nothing of maintenance. Willows of which to make the revetments do not grow fast enough on the banks and islands to permit very greatly hurrying completion. The Army engineers have been using concrete slab revetment and successfully trying various expedients in hastening the work. Up to the present time, in the past thirty or forty years, a total of only about 140 miles out of the 1,500 has been completed. Therefore, conditions of cost and progress lead me to call attention to the less costly system of double dikes and to possibilities of new methods of control, which may be developed through more scientific study.

I look upon this problem of protection of the foot of the bank against being cut out and then rapidly sloughing off in sections, carrying levee and all with it, as the most difficult of all, and one that *needs much scientific study as to cause of the whirlpools* that may do this cutting.

Probably this undercutting is not the result of simple erosion by a straightforward current. These whirlpools in the river doubtless can be simulated and studied in a properly designed hydraulic laboratory. On the river they work beyond observation under a vast depth of muddy water. The vertical depth of water at the foot of a bank near the peak of the flood may be more than 100 feet. Some freak of nature or perhaps an old water logged sunken tree or snag may start an eddy or swift current gnawing at the foot of the bank. The erosive vortex may be the result of larger eddies impinging one on another, causing an intensified velocity and force such as that produced in the air in a cyclone or a Kansas "twister." This vicious current may cut fast and deep on a small area — perhaps only a spot 100 feet in diameter. Painstaking scientific study of such conditions is greatly needed. I cannot find evidence in technical publications, or in conversation, that the Army engineers have done very much in studying the hydrodynamics of this or other rivers. Whenever I have suggested the value of a hydraulic laboratory for such researches to any of my friends in this corps, I have failed in getting the idea of modern laboratory methods home. A laboratory is a place in which to separate out the elements that go into these problems and *study the effect of each element without confusion of causes*, by going along with observation on the river and experiments in the laboratory hand in hand.

This is not a problem of building a little miniature Mississippi River two or three feet wide, with the expectation that it will perform just as the big river performs. It is a matter of first studying the laws of transportation of sand and gravel along a river bed and long continued study in laboratory and field, in order to show how the river could be straightened and its flood plain lowered so that for much of the way no levees would be needed.

The precise method of the forming of cross-over bars, of conditions under which a channel can be cut



Official Photograph, U. S. Army Air Corps

IN ARKANSAS

"Men saw marvels of engineering topple like toothpick fortresses" — "There is something sinister about the Mississippi; it almost seems alive. . ."

and maintained through them by the current, and of studying the generation of erosive vortices by impact of currents; also of studying the precipitation of sediments from fresh water by admixture of salt water; the movement of "sand-waves"; the laws of transportation of gravel bars slowly downstream, all should be studied.

Meanwhile an intensive, widespread geologic survey should be one of the lines of research. When my classmate, Professor William O. Crosby, former head of the Department of Geology at M. I. T., was helping me study conditions prior to building the dam at Keokuk, he told me that back in geological times, when the continental ice cap was melting, the Mississippi was a far more majestic stream than it is today, probably ten or twenty times as large, and perhaps carrying a hundred times the volume that it now averages through the year. The river then filled the broad area between the bluffs which you now see commonly three to five miles apart above St. Louis. The bottom land has been deposited within what was once the bed of the river, down as far as Cairo. At times the tributaries doubtless brought a different kind of sediment than that which comes down in the mud of the Missouri River today. In many localities there is more or less coarse gravel scattered through the strata of these alluvial deposits.

Borings in the ancient preglacial channel a few miles west of Keokuk show a rock bed more than 200 feet below the present surface. The present river flows in a refilled bed probably more than 200 feet deep to bed rock near Cairo, and possibly a thousand feet at New Orleans and Natchez. These alluvial deposits with which the ancient bed has been largely refilled are soft and easily eroded, the average grain size being less than 1/100 inch, but with a sprinkling of coarser material and gravel mixed in.

Some curious facts have been observed that appear to result from this mixture of coarse and fine materials. The river at a given locality is sometimes found from one foot to five feet higher after a flood than before the flood, with precisely the same quantity in cubic feet per second flowing in both cases. The explanation is that one of the first acts of a great flood is to restrain itself by rolling up gravel and building a series of low dams across the bed of the river. (The pilots call them "cross-over-bars"). There is likely to be one of these bars at every point of contraflexure where the river turns from a right hand to a left hand bend. The erosion, transportation, and deposit that finally results in these obstructing bars is explained by the river in flood being wider and larger and slower in flood-cross-section at the points of change of curvature than within its course through the bends, while at low stages of water the velocity is smallest in the deeper, narrower pools through the bend.

After having followed the literature pretty carefully I believe that the really intimate hydraulics of many of the important phenomena along the Mississippi and Missouri Rivers have never yet been studied.

I am tempted here to mention an idea that I have carried in the back of my head a long time, that is, that perhaps the river can be straightened in many places; that it can be made to do its own straightening and to carry its own burden of sediment to the sea. The drift of this line of thought can be made clear if you understand that at St. Louis the river surface is 380 feet above the Gulf, and that the aggregate river is more than fifty per cent longer than a straight line between the points. In other words, if you could take out the curves and the extra length you would have about 200 feet in head to spare, by which the river can be lowered. In other words, if the Mississippi flowed in a straight line, and if you could find a way to hold its banks after you had once straightened them, then the straightened river at its extreme flood stage for all of the distance above Vicksburg would be entirely below the level of these bottom lands. This idea is anathema to the engineers engaged on the Mississippi control with whom I have talked, and I desire to make clear that it is at the present time merely an iridescent dream, perhaps with a chance of one in ten, or maybe only of one in a hundred, that the dream could be made to come true. What its realization might mean, is worth thinking about, and suggests one of the many lines of research that a first class hydraulic laboratory would permit.

I am inclined to believe that ten years of good earnest experimenting and observation, with work in the laboratory and the work in the field going hand in hand, that one could make vast additions to present knowledge about many of the important problems of how best to control the floods of the Mississippi, and how best to fit it for greater navigation between St. Louis and Vicksburg.

I hope that some day we may have at the Institute a laboratory in which young engineers can be trained to study river problems of this kind wherever they may go forth and find them, anywhere in the wide world.

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