The Convention also remarked on the increase in tonnage made possible by the use of barges. In 1865, the towboat *Ajax* had taken a tow of 15 barges with 300,000 bushels of coal (11,400 tons) down the river with a crew of 25. Finally, the Committee, concerned about the number of proposed bridges across the Mississippi, recommended that the drawbridges at Rock Island and Clinton, Iowa, be removed as obstructions to navigation and replaced by high bridges with a span of 50 feet above high water, and that all future bridges be of similar design.

On February 14-15,1866, a larger and more varied convention was held at Dubuque, with rivermen, businessmen, senators and representatives in attendance. The purpose of this convention was to seek an immediate appropriation from Congress large enough to overcome the obstructions to navigation caused by the Des Moines and Rock Island Rapids.

The opening remarks at the convention echoed the sentiments of the region: "Now that 'the clangor of arms has passed away,' we may turn to the peaceful pursuits of life—the development of these vast resources that spread around us."'

The Dubuque convention was quick to point out that farmers and merchants in the Midwest were at a disadvantage compared with farmers in the East, since pries for grain and commodities were determined in New York. The price of grain around the country was the price at New York minus the cost of shipping it there. The price of wheat on February 2, 1866, was $1.77 per bushel in New York, $1.21 at Chicago, and $1.00 at Dubuque. An Eastern farmer who could get his grain to market for little or nothing was more than 70¢ per bushel ahead of the farmer in Dubuque, who had to ship by rail or through New Orleans and around the coast. In this kind of market, even the 10¢ or 15¢ per bushel that improving the rapids would save could aid local economy. In fact with the rapids improved, one member of the convention believed that a bushel of Dubuque wheat could be shipped to Liverpool, England, and sold for 50¢ per bushel less than its current price there.

The convention brought up another argument frequently used thereafter by both Engineers and rivermen: that improving navigation would increase competition and lower rail rates. There was some truth to that. The Illinois Central charged the same rate to ship a bushel of wheat from East Dubuque to Chicago as it did to ship the same wheat to St. Louis (more than twice the distance), where the railroad had to compete with the Illinois River and Mississippi traffic.

The Dubuque convention again raised the issue of how best to improve the Des Moines Rapids. Major Floyd, who had supervised work on the Rapids in the mid-1850's and who now lived at Keokuk, spoke in opposition to a lateral canal, as did many other critics. They pointed out that any significant increase in river traffic would make a lateral canal with locks a bottleneck, leaving the Mississippi as incapable of handling the growing commerce of the region as the railroads presently were.

In the end, however, the convention passed a series of resolutions that were similar to those of nearly every other river convention on the Upper Mississippi. The convention resolved that Federal money should be used for improvement of the rapids, that whatever the resulting improvement was it should be toll-free, and "that the mode of improvement should be left to competent engineers of the Government."[5]

In a very real way, even the railroads, already enemies of the steamboat interests, helped bring about river improvement at this point. Before the coming of the railroads, steamboatmen were content to limit improvement to the removal of snags and other dangerous obstructions. With no competition, they could charge high rates with little complaints from the merchants. The arrival of the railroads meant that more significant river improvement would have to be done to keep the steamboat competitive.

Under prodding from all these pressures, Congress moved toward much larger projects than be-

fore. They were assisted and sustained in this by a growing surplus in the United States Treasury. The beginning of permanent navigation improvement on the Upper Mississippi can be traced to the Act of June 23, 1866, which made appropriations for the repair, preservation, and completion of certain public works, and for surveys of the Upper Mississippi and its tributaries. With the understanding that a 4-foot channel was to be an eventual goal, Congress appropriated $200,000 for the Des Moines Rapids, $100,000 for the Rock Island Rapids, and $100,000 for other channel improvements and surveys north of St. Louis. These amounts were recommended by a Board of Engineers convened on March 1, 1866, and were identical with those suggested by a previous Board of Engineers which had met in 1854.

To carry out the improvements authorized by this Act, Chief of Engineers A. A. Humphreys appointed three Engineer officers to different posts. On July 31, 1866, he assigned Major G. K. Warren to duty at St. Paul. Warren was to examine the Upper Mississippi above the Rock Island Rapids as well as its tributaries (specifically, the St. Croix, Minnesota, Cannon, Chippewa, Zumbro, and Wisconsin Rivers], to examine "material necessary to determine the best manner of bridging the Mississippi from St+Paul to St. Louis so as to occasion the least obstruction to navigation."[6] He was also to determine the best means of securing a 4-foot channel from St. Louis to the Falls of St. Anthony.

Lieutenant Colonel J. N. Macomb was made Superintendent of Western Rivers Improvement outside the Ohio, with offices in Cincinnati. This post put Macomb in charge of more than 7,000 miles of waterway. His primary duty was the design, construction and supervision of snagboats. He designed and built two twin-hull snagboats along the lines of Shreve's earlier boats. Although these were primarily for the Lower Mississippi, Macomb did make several trips to the Upper Mississippi to assist Warren.

On August 3, 1866, Humphreys ordered Lieutenant Colonel James H. Wilson to take station at

Keokuk, Iowa, to superintend the improvement of the Des Moines and Rock Island Rapids, and to make a survey of the Rock River. On August 14, 1866, Humphreys further ordered Wilson to make a survey of the Illinois River from its mouth to La Salle.

Warren carried out his survey duties during August and September. He placed assistants in charge of examining the several tributaries and took charge of the survey of the Mississippi himself. Warren examined the whole length of the river above Rock Island both from shore and by packet, making careful surveys in 14 different places involving 74 miles of survey. He also considered several methods of dredging sandbars before deciding in favor of the Long Scraper previously developed by Long. The following year when Warren bought two large steamboats under his appropriation, he had them both outfitted with the scrapers.

Warren's orders of July 31 directed him to examine the Mississippi "with a view to ascertaining the most feasible means of economizing the water of the stream for insuring the passages of boats drawing four feet of water."[7] He assumed that the phrase "economizing the water" had been introduced into the Act of June 23 by Senator Ramsay of Minnesota, who agreed with rivermen and lumber interests in believing that closing side chutes and otherwise narrowing the natural channel of the river was the best means of improving navigation.[8] Although Warren was suspicious of closing dams and wing dams as means of permanent improvement, he interpreted his orders strictly, and became the first Engineer to request funds for wing dams on the Upper Mississippi. He determined to build two experimental dams, a closing dam at Prescott Island and a wing dam near the foot of Lake Pepin.

Meanwhile, Wilson went to Washington after receiving his orders of August 3 to confer with Chief Engineer Humphreys and to familiarize himself with previous surveys and reports on the Upper Mississippi. He also requested and received orders permitting him to travel back and forth to the various projects under his charge without prior individual permission.

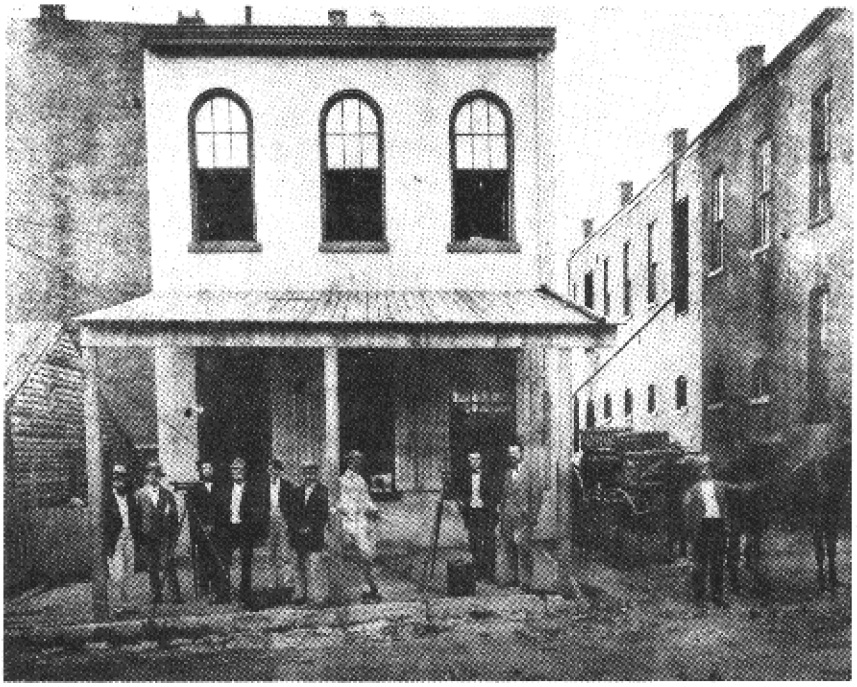
Wilson left Washington for Keokuk sometime after August 14, using this last order to visit Chicago for supplies. He then proceeded to Rock Island where he had requested those assistants who were to undertake the surveys of the Rock and Illinois Rivers to meet him on August 20.[9] During several days in Rock Island he arranged survey parties for both rivers.[10] He sent Captain Peter C. Hains ahead of him to Kmkuk and arrived himself a day later, on August 25. He and Hains took quarters at the Deming House in Keokuk.[11]

He had already made arrangements with a civil engineer, James Worrall, to undertake the Rock River survey beginning September 1. The Illinois River survey (for which he may have made arrangements in Chicago), was scheduled to begin September 10. Because the previous surveys and maps of the two rapids were not complete enough for the extent of improvement now contemplated, Wilson ordered Hains to Davenport, Iowa, to open an Engineer Office and to begin a survey of the Rock Island Rapids. Civil engineers H. A+Ulffers and E. F. Hoffmann were placed in charge of the resurvey of the Des Moines Rapids. All of these surveys were completed during the fall of 1866.

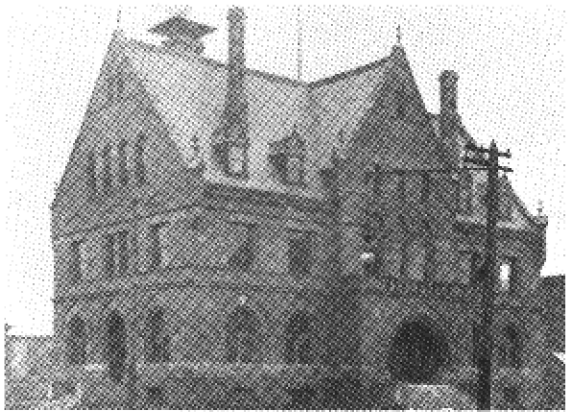
Wilson did not remain long in Kmkuk. Having gotten all of the surveys well under way, he wrote a letter to Humphreys on October 1: "I have the honor to request that I may be directed to take post permanently at Davenport or Rock Island, instead of Keokuk, as either of those points is much mors accessible, affords better means of communicating with the works under my charge, and greater advantages in the way of personal accommodations tu myself and assistants."[12] By October 25, Wilson had received orders changing his post to Davenport, and by the first or second week of November he had moved, leaving D. C. Jenne, a United States Civil Engineer, in local charge at Keokuk.

Early Rock Island District records suggest that Wilson established a U.S. Engineer Office in Keokuk in a two-story frame building at Main Street and Blondeau, two blocks above the Missis-

The first permanent Engineer Office in Keokuk, Iowa, opened in 1866 or 1868. This photo dates from about 1875.



The first District Office in Rock Island opened in 1869 on the second floor above a wine and tobacco shop (the building with the awning) on the corner of 19th Street and Second Avenue. The Office was across from Spencer Square and the famous Harper House, a hotel well known to travelers.



The first Rock Island Federal Building, home of the Rock Island District (on the second floor above the Post Office) from 1892 to 1934. In 1934 the District moved to its present location, the Clock Tower Building on Arsenal Island.

sippi River. Wilson may have set that office up before leaving for Davenport, but more likely, he established it in the spring of 1868 when he returned to a past at Keokuk to take more direct supervision of construction of the Des Moines Rapids Canal, which was turning out more complicated than he had expected.

The Davenport Office to which Wilson moved had already been set up early in September by Captain Hains on the second floor of a building at Second Avenue and Main Street.[13]

Surveys of the Illinois and Rock Rivers

During the fall of 1866 Wilson completed the survey of that portion assigned to him, but he decided that before any plan of improvement could be recommended it would be necessary to extend the survey all the way to Lake Michigan. Part of the difficulty was the Illinois and Michigan Canal, a 97-mile waterway with 16 locks, 110 feet long and 18 feet wide, with a 6-foot depth, whish had been built by the State of Illinois in 1848 to connect the Illinois River at Ea Salle with Lake Michigan at Chicago. The Illinois and Michigan Canal was adequate to handle traffic from the unimproved Illinois River, which was shallow but free of serious obstacles from La Salle to the Mississippi at Grafton, Illinois, hut Wilson realized that it would be a bottleneck to an improved Illinois waterway.

A second problem beginning in 1865 was the city of Chicago's project to divert part of the flow of the Chicago River from Lake Michigan to the Illinois and Michigan Canal and thus down the Illinois River. The growing metropolis was having pollution problems with the sewage it dumped into Lake Michigan, and hoped to send it the other way. Reversing the flaw of the Chicago River would not only affect the level of Lake Michigan, but the increased water flowing into the Illinois River would affect levels an that waterway as well, Wilson felt that no improvement plan could be determined apart from these other considerations,

Early in 1867 William Gooding, who had been the chief engineer for the Illinois and Michigan Canal, was assigned to assist with this expanded survey, authorized by Congress in the Act of March 2,1867. An appropriation of $20,000 for this survey was made by Congress on May 8, and on May 13 Wilson received orders to organize a Board of Engineers, consisting of Gooding and himself, to conduct a survey and examination and prepare plans and estimates for "a system of navigation by way of the Illinois River, between the Mississippi and Lake Michigan, adapted to military, naval, and commercial purposes, in accordance with the act of March 2, 1887."[14]

Wilson and Gooding surveyed not only the existing route of the Illinois and Michigan Canal via the Des Plaines and the South Branch of the Chicago Rivers, but also several alternate routes, including the feeder of the Illinois and Michigan Canal which met the Calumet River at Blue Island, and a connection to the Kankakee River through the Saganaska Creek Valley to Momence, Illinois. This creek was known in the area as "the Sag" and eventually became the route of the Calumet Sag Channel connecting the Illinois River with Lake Calumet and Lake Michigan.

The plan recommended by Wilson and William Gooding was a slack water system of five locks and dams from the mouth of the Illinois River to the head of Lake Joliet, giving a 200-foot channel with a 7-foot depth of water. Part of the plan called for the Illinois and Michigan Canal to be improved to coincide with the rest of the system. The State of Illinois had been agitating the Federal Government for this improvement for some years. Wilson estimated the cost of the entire project at $18,000,000.

In 1868 Congress appropriated $85,000 for the improvement of the Illinois River from La Salle to its mouth. Wilson made examinations to select sites for locks and dams, but considered the money appropriated too small to begin work, He recommended instead that $300,000 be appropriated, the amount needed to complete one lock and dam, but this money was not forthcoming.

While Wilson waited for further appropriations, the State of Illinois went ahead with its own plans. On April 10, 1869, the Illinois State Board of Canal Commissioners began construction of a lock and dam at Henry, Illinois. The State intended this dam to give Peoria, Illinois, good access to Chicago. The Henry Lock and Dam was completed in 1871 following specifications laid down by Wilson. The lock was 350 feet by 75 feet, with 7 feet over the miter sills. The pool above the dam could be raised to 7 feet by dredging and 1-foot flash-boards placed along the dam. At the same time that Illinois began the Henry Lock and Dam, Congress appropriated $84,000 for Wilson to use on the Illinois River.

Wilson used these funds to dredge a channel 7 feet deep from the Henry Lock 59 miles downstream to the site of the next planned dam at or near Copperas Creek. This dredging project convinced Wilson that a 7-foot channel would become much too expensive to complete and maintain, and in 1870 he reduced his plan for Illinois River improvement to a 4-foot depth.

The survey of the Rock River which Wilson was ordered to make represented mother continuation of the canal craze that had captured the East in the 1830's, and had already reached Illinois with the Illinois and Michigan Canal. As early as Major Long's explorations of 1823 there had been suggestions that connecting the Mississippi with the Great Lakes and the Eastern markets would be commercially desirable The completion of the Illinois and Michigan Canal had helped Chicago to double its size in a few years,

Wilson's orders concerning the Rock River directed him to make a survey and collect information "sufficient for a project by the Rock River route with all its details, adapted to the construction of Locks, Dams, feeders, and reservoirs, for a waterway admitting the largest boats now navigating the Western and Eastern waters that form the entrance to such a Canal route."[15]

Under Wilson's direction, James Worrall began

this survey on September 1 at Fond du Lac, Wisconsin, and finished on December 1 at Rock Island. Worrall and his party had access to the latest survey instruments, but they also made do at times with materials at hand. In order to measure the surface velocity of the river, Worrall used white apples which could readily be seen passing section lines along the

In his report Worrall pointed to the commercial need for such a route to the Great Lakes. The rising lumber industry was already producing 4,000,000 board feet of lumber annually in Wisconsin and Michigan – more than all the new rail routes existing or being planned could handle. Iron ore from Lake Superior also needed cheap shipping to new markets.

The canal route mapped out by Worrall ran from Green Bay on Lake Michigan to Rock Island on the Mississippi. A small canal already connected Green Bay with Lake Winnebago, but the remaining 286 miles of the route surveyed by Worrall all needed improvement. Using Lake Horicon in Wisconsin as a summit reservoir to provide water, Worrall planned a system that involved the construction of 117½ miles of anal with the remaining distance running through slack water sections of the! Rock River. The plan involved 56 lift and nine guard locks. Worrall drew up three separate plans with locks ranging in size up to 200 by 30 feet, large enough for the stern wheelers, but not enough far the "largest boats" called for by the Act of June 23, 186

James Worrall was not concerned by the size and length of canal he had planned. In a letter to Wilson from the field, Worrall reported that a long canal was not an objection "in a country like this where all the appliances for making a canal have been left by nature at the engineers' disposal."[18]

In his report Worrall imagined a day when ore from Lake Superior would combine with limestone and coal from the lower Rock River, and there would arise "Birminghams, Pittsburghs, along the Rock

River."[19] That was only a beginning:

> It is impossible to foretell statistics of this country. Attempt a prediction, and it will be ridiculed as preposterously large. Let a decade of years pass over the heads of the population, and reality will have so far outstripped the highest-colored, most visionary anticipation.[20]

Eventually, wrote Worrall, the cities of the Rock River—Fond du Lac, Beloit, Rockford, Sterling, Dixon—"all to be Buffalos, Rochesters, Uticas, in a shorter time than it took to develop the cities on the Erie Canal."[21]

Wilson's section of the Rock River report was much more conservative. He pointed out the limitations of the summit reservoir and the tremendous expense, estimated at nearly $15,000,000, for the project. This report was submitted to Congress on April 11, 1867, but no action was taken.

Improving the Rapids

While the surveys of the Rock and Illinois Rivers were baing carried out by his assistants, Wilson was busy examining the results of the resurveys of the two rapids made by his staff. By January 1, 1867, he was ready to report his recommendations for improvement. For the Rock Island Rapids Wilson determined to follow the plan generally recommended by Buford, Lee, Shreve, and Warren to excavate and straighten the existing channel. At the Des Moines Rapids, however, he departed from the recommendations of most previous Engineers and determined to construct a lateral canal along the Iowa shore, a modification of the plan suggested in 1836 by Henry Shreve.

In order to understand the different problems presented by the two rapids, it is important; to note hew structurally varied they were. The Wppar Mississippi River was formed during the four glacial ages of the Pleistocene epoch, and is not old as geological history goes.

Prior to the first of the ice sheets the Mississippi flowed down through central Iowa to just south of

Muscatine, then curved west around the present Des Moines Rapids. Then the Nebraskan Glacier pushed the channel over to its present location down as far as Clinton, Iowa. Here the edge of the ice sheet forced the river to run over hard rock rather than seek ita natural valleys. The river over a long period of time scoured down through this rock creating the deep valley hemmed in by bluffs that characterize the region today. From Clinton south the river went west around both the Rock Island and Des Moines Rapids.

Then the Kansan glacial age arrived several hundred thousand years ago and pushed the channel of the river east from Clinton until it met the Illinois River at Hennepin; from here it flowed with the Illinois River to St. Louis. As this glacier retreated it left a large flat plain in central Iowa in which valleys formed for the Cedar, Iowa, and Skunk Rivers. These three rivers joined just above Keokuk and came down over the present Des Moines Rapids. From here they flawed south to join the Mississippi River where the mouth of the Illinois now is.

During the third glacial age, the Illinois Glacier moved the Mississippi toward the west. It blocked the Cedar and Iowa Rivers and formed Lake Calvin, which covered much of central Iowa. Lake Calvin drained south over the Des Moines Rapids.

Finally, about 20,000 years ago, the Iowa and Tazewell Glaciers came together near Clinton during the Wisconsin Age and forced the Mississippi over the Rock Island Rapids. By the time these glaciers had retreated, the river had adopted nearly its present channel,

The last glacial sheet, the Mankato, arrived about 12,000 years ago and deposited huge amounts of gravel, silt, and sand near St. Paul, This eventually filled in the riverbed as far south as St. Louis. Erosion of this gravel bed left the valley with its characteristic terraces at the 25-and 75-foot levels. Wilson noticed these terraces. He pointed out that the t o m of Nauvoo was built on the 25-foot terrace while Sandusky was on the 75-foot level,

The Des Moines Rapids, then, is older by thousands of years than the Rock Island Rapids, while the sandbars that caused so much trouble for navigation and so many problems for the Engineers are wen more recent. Partly as a result of the age difference, the Des Moines Rapids were shallow but smooth, while the Rack Island Rapids were still rough.

Wilson brought with him to his work a thorough understanding of the geological theories of his time. The glacial theory was still too recent in 1866 for him to be aware of it3 details, but his examinations of the geological features above the Des Moines Rapids led him to the current conclusion that the Rapids had once been the nutlet of a large Iowa lake.[22]

Warren proved to be even more astute in his geological observations. He not only correctly assumed that the Mississippi had previously scoured a large valley which had subsequently partly refilled with sand (an assumption that helped determine the nature of improvement projects), but he also accurately charted the old channel of the river that had originally come down west of Kaokuk before it filled in, sending the river across the Des Moines Rapids. Warren was alar, the first parson to suggest, based on his survey of the Minnesota River In 1867, that the Minnesota River Valley had once been the outlet of Lake Agassiz, the ancient lake that covered a large area of mid-America. Warren reported these findings in a paper presented to The American Association for the Advancement of Science of Chicago in August 1868.[23] In 1884, in honor of Warren's discoveries, this ancient river from Lake Agassiz was named Glacial River Warren.[24]

Warren did not spend as much time speculating on the Rock Island Rapids, but here, too, he wa3 correct in concluding that the channel had once gone from Clinton to Muscatine, by-passing the rapids.

The Rock Island Rapids consist of seven chains of rock projecting into the channel from both the Illinois and Iowa shores. These begin with Lower

Chain near the foot of Rock Island (now Arsenal Island) and are scattered for 14½ miles upstream to Upper or Smith's Chain near Le Claire, Iowa. Not all of the chains reached all the way across the river. Between chains pilots could generally find deep water even during the low water season. The real problem on the Rock Island Rapids was not shoal water, but the narrow, tortuous channel that passed near one shore or the other, back and forth several times in the course of the rapids, forcing boats to the danger of moving sideways against the swift rapids current. Of the 14 miles of rapids, 11 miles were good water. Only three miles were difficult or dangerous. The problem for pilots was knowing where those three miles were.

Because a pilot who did know by heart where the bad stretches were could get a boat across the rapids in all seasons, a thriving business in piloting the rapids grew up in Le Claire at the head of the rapids. Captains would find these rapids pilots gathered under the Green Tree, a famous Le Claire landmark used as a guide by river pilots, and hire them to steer their boats through the channel to Davenport.

The rapids at Keokuk were completely different. Here the river in wearing a channel had come across an 11-mile-long strip of rock much harder than the rock above and below it. This was a layer of cherty limestone of the Keokuk series inclined at the same slope as the river. Rather than being constructed as a typical rapids, the Des Moines Rapids ran over a relatively smooth rock bed which behaved exactly like an artificial dam with deep water behind it. In several places through the 11 miles the water had worn indentations and holes, but they were not connected. During low water these rapids were almost impossible to cross. The shoal stretches of these rapids, too, were called chains, but they were not the kind of chains found at Rock Island. The water surface showed none of the traditional ripples common to other rapids, making it difficult for pilots to know where the deeper water was.

These two obstacles to navigation provided the

Rock Island District with its first real test of the Engineers' ability to adapt, to experiment, and to solve unique problems.

The Rock Island Rapids

In making assignments in September of 1866, Wilson ordered Captain Wains to Davenport to supervise the Rock Island Rapids Improvement. Hains was instructed to make a detailed survey of places on the rapids where boats experienced shoal water, swift currents, or twisting channels, and from this to make an estimate of the excavation necessary to make navigation on the rapids safe. He was also to locate the Rock Island Bridge on hi3 maps, ascertain the direction of currents through the bridge and assess the general influence of the bridge on navigation. Finally, he was to find out how much underwater rock excavation might cost using the different methods available.

Hains completed hi3 field work in September and convened a Board of Engineers at the Davenport Engineer Office on December 19 to consider alternate methods of improvement. In addition to Hains, the Board included three civil engineers: D.C. Jenne, in local charge of the Des Moines Rapids, and James Worrall and W. F. Shunk, who had made the Rock River survey.

The board considered three possibilities. Overcoming the rapids by locks and dams (three would be needed) was rejected because of a principle adopted early in the work that "no plan should be adopted for the improvement of navigation in low water that would be prejudicial to its present state in high water."[25] The second possibility was a lateral canal which would leave the main channel open for use in high water. But the Board chose the third alternative, improvement of the natural channel, as the best. A lateral canal would be expensive and would not be useful until the whole project was finished, while each small improvement of the natural channel would show immediate results. In addition, a lateral canal would need an annual appropriation for operation and maintenance

One potentially serious objection was raised to widening and deepening the natural channel. The chains of the rapids acted as a series of dams which held the watsr back in the pools behind the chains. Some rivermen argued that opening the natural charnel would let the water through faster, not only increasing ths already treacherous current but also lowering the water level along the entire rapids and making them an even worse obstruction. The Board had made careful calculations and were convinced that this would not happen, but it was a recurring argument that Warren had had to answer as early as 1854.[28]

The Board recommended that the present steamboat channel be enlarged to 200 feet wide by 4 feet deep, that the excavated material be deposited in the river bed so as to check cross currents and confine water to the main channel, and that wherever possible, excavation take place by the use of coffer dams. The cost of the improvement was estimated at just over $800,000.

In the spring of 1867 Wilson decided that the Hains survey was still not in sufficient detail to begin work and assigned Lieutenant E. F. Hoffmann to make a survey. Hoffmann, one of many employees of the Rock Island District who gave long years of devoted service to Upper Mississippi River improvement, began work at the end of May and completed soundings in August, He remained with the District as a civil engineer after resigning from the Army, and from 1870 until his death in 1884, served as engineer in local charge of improving the Rock Island Rapids. At the time of his death, the original project was virtually complete.

A contract for rock excavation was made with Case and Co. of Fulton, New York, in June of 1867. The first work began on the Duck Creek Chain that fall under the supervision of District engineers. Between September 8 and October 15 a coffer dam was built around the area to be excavated. Water was pumped out and the work of quarrying began on October 22, continuing until December 20 with an average force of 128 man per day.

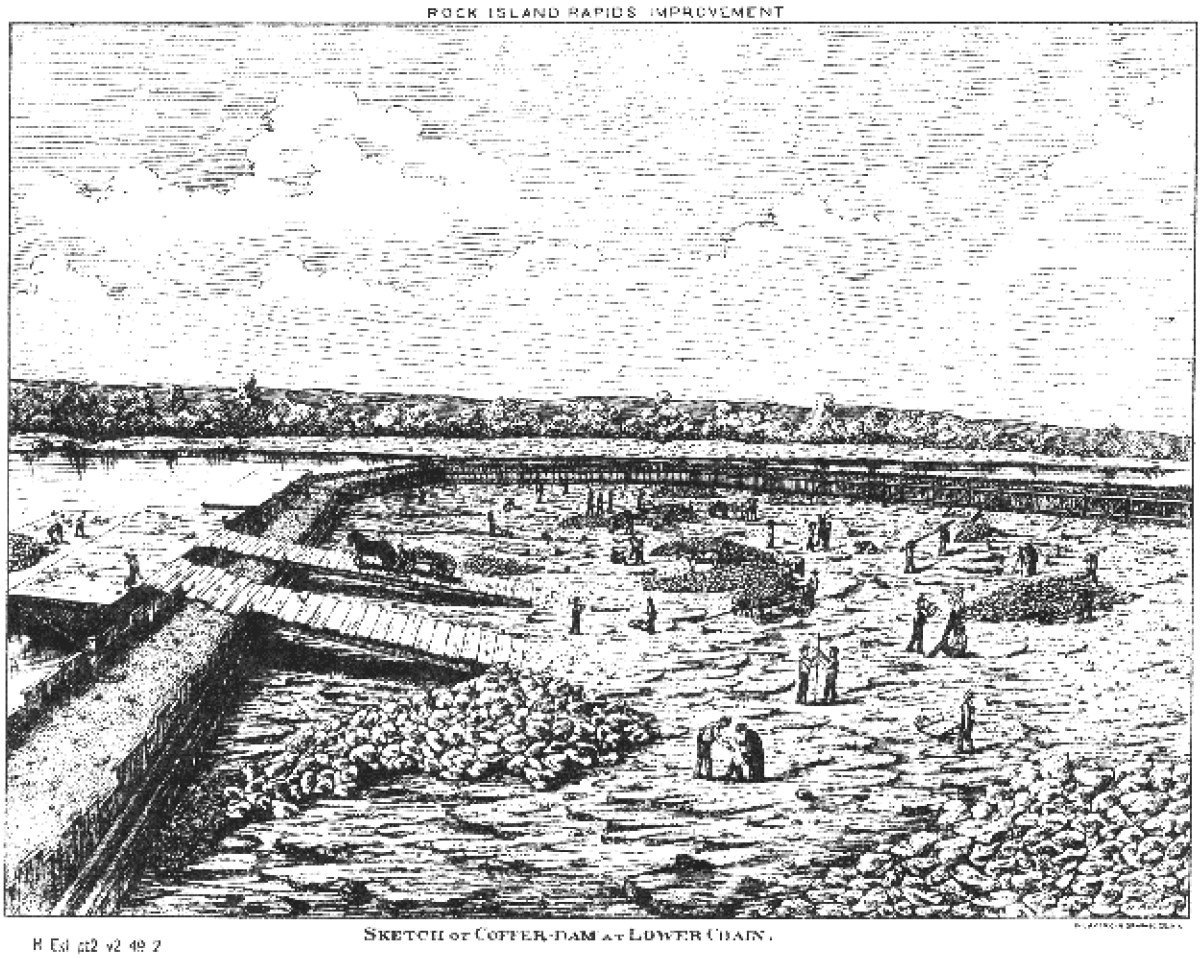
With their work on the Rock Island Rapids, Engineers of the Rock Island District developed a procedure they were to use in succeeding river projects. Rather than beginning at one end of the rapids and working methodically to the other, cutting the channel to it3 required dimensions, they began with the worst obstruction first, then moved on to the second-worst, and so on. This "little-here, little-there" policy must have looked terribly uncoordinated and unplanned to an outside observer, and it did not show immediate and dramatic results, but it was appreciated by the river captains and pilots,

Three methods were used to excavate rock on the Rock Island Rapida. The most frequent was by coffer dam and subsequent quarrying rock. Coffer darns were typically used where the river was shallow+from 6 to 14 feet, though a coffer dam at o m paint on Sycamore Chain reached 25 feet. Prior to work on the Rock Island Rapids, engineers in both Europe and America had fastened such dams in place with iron rods sunk 15 inches into the rock bed. These 2-inch rads were placed in parallel rows 10 feet apart. Contractors and Engineers at Rock Island believed that a coffer dam would remain in place of its awn weight. They proved to be right, effecting a significant saving of effort and material.

Coffer dams were constructed by forming a breaker ahead of the dam, then putting the dam down. The dam itself consisted of two parallel timber walls running from 10 feet apart at the head of a dam to 8 feet along the sides. The walls were braced and held together with flat iron tie rods secured by washers and pins. The walls were then filled with a mixture of clay and gravel (puddling] pumped from the river bed. Following this, the water was pumped out of this work area.

The smallest of these coffer dams enclosed an area of 2.26 acres on Upper Chain; the largest, at Campbell's Chain, enclosed 43.07 acres using 5,780 feet of dam.

Quarrying the rock was done mostly with hand



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Rock excavation inside a coffer dam on the Rock Island Rapids, the predominant method of excavation on the rapids project. This sketch was drawn by Henry Bosse, a draftsman in the District Office during the 1880's

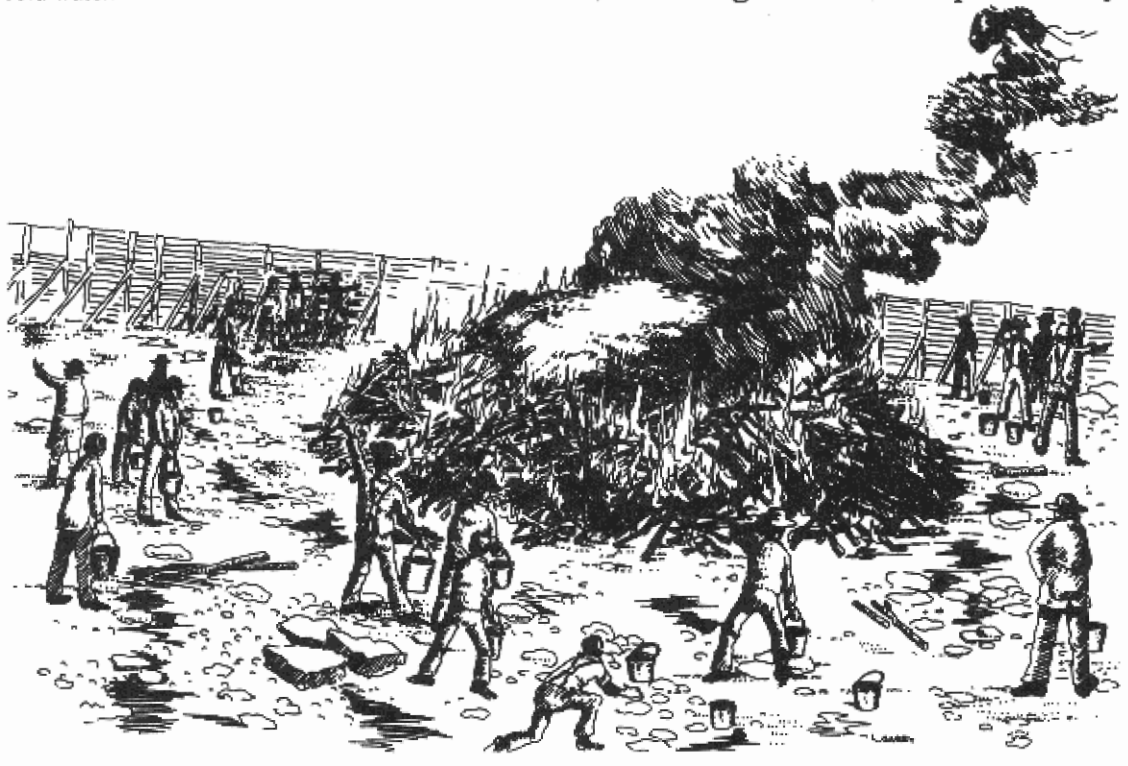
drills and blasting powder. Steam drilling was tried during 1868-69, but did not work well. Drill bits varied from 1½ to 2½ inches. Roles were drilled from 1½ to 4 feet deep. Then the water was sponged out, the holes filled with *clay* and drilled again to make a watertight Hole. One pound of powder was used for each 7/13 cubic yard of rock. The broken rock was then taken to the shore, or carried up inches built to the top of the darn, where it was transferred to flatboats and dumped outside the channel.

Coffer dams generally worked well, but they were subject to two hazards. Passing steamboats were not always as careful a3 they should have been in their attempts to make time (and therefore money). In the treacherous currents of the rapids, they frequently ended up colliding with the dams and delaying the work. Second, the Mississippi was subject to sudden spells of high water, causing several dams

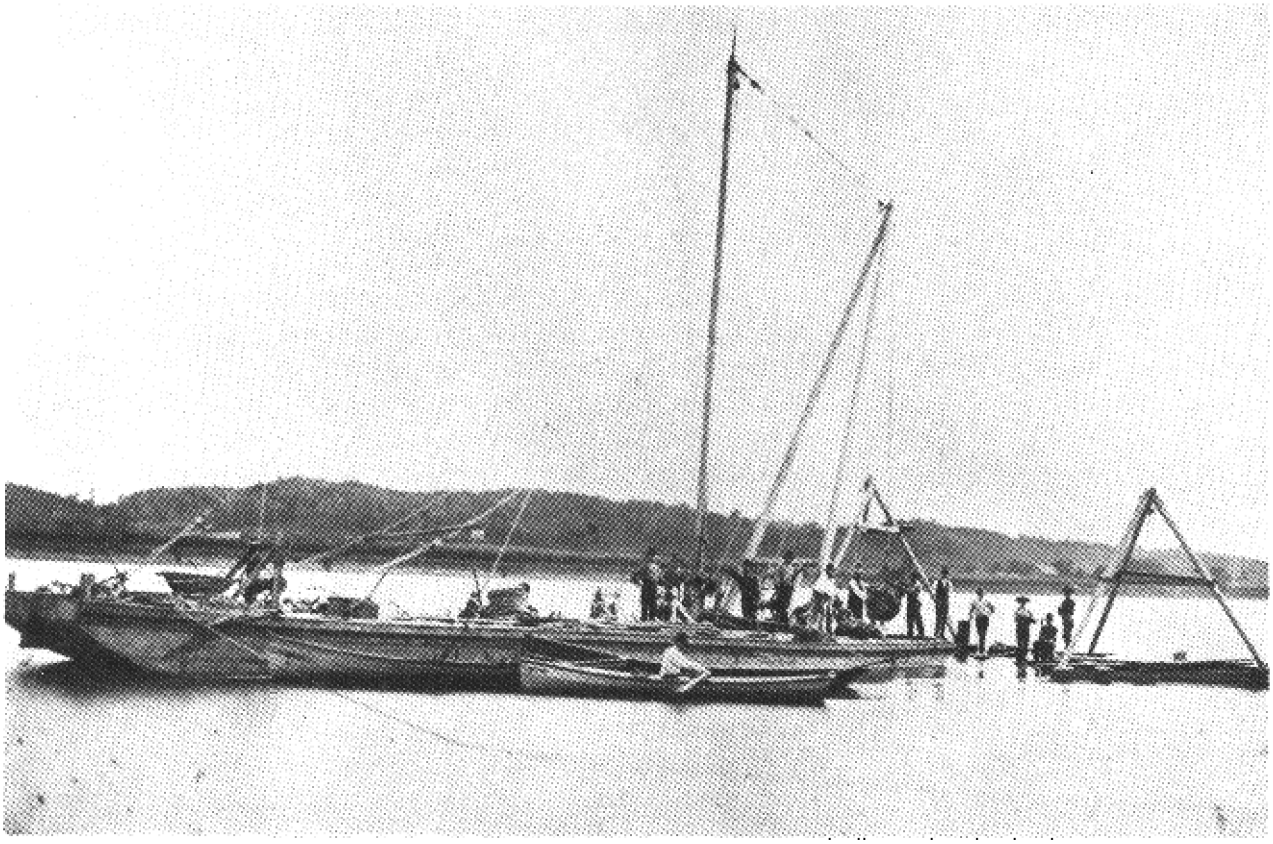
[which were built no higher than absolutely necessary) to flood.

Where cofferdams were not practical because of a deep or very uneven bottom, or where the area to be enclosed was too small, rock wa3 removed by chisel boat and dredge using equipment similar to that developed by Major Floyd in 1853. The chisel was a 12-inch square beam 12 feet long suspended between iron rails over the downstream and of the chisel boat. The beam was headed by a conical shoe of wrought, iron with a steel point welded to it. Until 1872 when a Mr. A. J. Whitney invented exchangeable points, the whole 3½-ton chisel had to be shipped by rail to Chicago for frequent sharpenings. In addition to the slowness of operation, chisel dredging invariably missed spots, and very careful work was necessary to clean up all the broken rock,

Coffer dam excavation and chisel dredging were supplemented by a small amount of submarine blasting carried on between 1875 and 1880 at St. Louis and Moline Chains. Never as successful as other methods, blasting was accomplished by



A unique method of rock excavation on the Rock Island Rapids project. A large rock in the channel near Campbell's Chain was heated and then cracked to pieces by buckets of cold water.



Drilling tripods and a derrickboat being used to blast and remove rock from the Rock Island Rapids. These tripods were not very different from those devised by Captain Robert E. Lee for work on the Des Moines Rapids in 1837.

timber tripods erected to rest on the river bottom. A narrow platform was built around the outside of the tripod at the water level. Here two men operated the drilling equipment and stuffed holes with blasting powder. When a large area was to be blasted, a chain of tripods was erected and connected by catwalks. The broken rock was removed by ring bolts split at the straight end, with a wedge inserted in the split. The bolt was driven into cracks in large pieces of broken rock, where it wedged tight, The rock wa3 then lifted out onto flatboats by the use of boom dredges.

One particularly large rock in the channel near Campbell's Chain succumbed to Corps ingenuity in an especially interesting manner. This rock, sometimes above water and sometimes below, depending on the season, was a constant hazard to navigation. It was on this rock that Lieutenant John Campbell and his men became grounded in July of 1814 while

fighting Indians in the westernmost battle of the War of 1812. The Indians, allies of the British, attacked the helpless boat, killing 16 men and wounding 21, including Lieutenant Campbell who h y near death for several months.

The rock was finally destroyed in 1870. While it was exposed during a period of law water, cordwood was piled on its surface and set afire. When the flames died down a crowd of men with buckets threw cold water on the hot rock, causing it to split and break into pieces. Explosives were placed in fissures that remained and the rest of the obstruction was blown apart.[27]

Work on the 4-foot channel through the Rock Island Rapids continued until the 6-foot channel project in 1907 made it necessary to revise the whole plan. In 1851 a veteran riverman had appeared at a river improvement convention at Burlington, Iowa, and offered to undertake to improve the Rock Island Rapids to accommodate the largest boats for $20,000 "for the simple reason that he could make money by doing it."[28] That proved to be a rather low bid. By 1886 when the project was finished with the exception of several small isolated patches, the Corps of Engineers had supervised the removal of 87,926 cubic yards of rock at a net cost of $1,166,608.[29] The final cost of the project by 1907 was $1,508,458.

The Des Moines Rapids

The Des Moines Rapids had long been a more annoying obstruction to navigation on the Upper Mississippi than the Rock Island Rapids. Many groups in addition to the Engineers had made attempts to improve them before Wilson arrived in 1866. From 1829 to 1866 the Corps of Engineers had spent $335,000 on the rapids, though only abut 25,000 cubic yard3 of rock had been removed. Mora of the money had been spent on surveys, experiments, and preparations for the different plans suggested than in actual work.

Private groups had developed several plans for getting around the rapids. In 1837 a charter was granted to a private company for the Des Moines Rapids Railroad which was to run along the Illinois side from Warsaw to Commerce (later Nauvoo). The promoters felt that this would be the most valuable rail line in the United States, carrying steamboat cargo around the rapids.[30] The company ran into financial difficulty before the road could be built, but the Mormons who had recently moved to Nauvoo intended to carry the project out until their leader Joseph Smith was killed in 1844. Such a rail line at this time might have been a success. Nearly 300,000 tons of merchandise was carried around the Des Moines Rapids in 1837.[31]

Private individuals and groups made several attempts to build dams at the rapids for both power and navigation A wing dam of earth covered by stone was built at the head of the rapids in 1841. Water from thia dam powered a grist mill for two seasons before the dam washed away, A similar attempt at Nauvm in 1842 met a like fate. When Joseph Smith was killed the Mormons had been planning a larger project that might have been successful. Smith planned to construct a large darn nearly all the way across the river to Montrose, leaving only a small channel open. The dam was to have provided power, and the closure of the channel was to have backed up the river, giving Nauvm a deep harbor.

In spite of these dreams and actual attempts, navigation over the Des Moines Rapids had not significantly been improved by 1866. During low water steamboats still had to transfer their cargo to lighters or to a railroad on the Iowa aide which began running from Kaokuk to Montrose in 1866. Passengers, too, had to make this transfer, going by rail or stagecoach.

The business of lightering was an old one at the Des Moines Rapids. Father Francis Xavier, who travelled in the area in 1721, wrote about the rapids where passengers were obliged to unload and carry their pirogues.[32] When the French fur trade developed, the Sac and Fox Indians sat up villages near

the future sites of Nauvoo and Keokuk to serve as guides on the rapids. When Lieutenant Zebulon Pike came up the Mississippi in a keelboat in 1805, he was met by a party of Sac lightermen who relieved his boat of 31 heavy barrels of supplies so that it could cross the rapids.[33]

Later, the towns of Montrose and Keokuk arose to support the lightering trade. By 1850 there were two shipyards at Montrose specifically for the repair of lighters (which received hard usage). Lightering employees, called "ratters," developed what was perhaps the first union west of the Mississippi to protect their interest.

As Warren had discovered in 1854, lightering was costly to the steamboat industry. In 1866 an average steamboat crossing the rapids in low water spent $500 per day in lost time and wages, in addition to the $1 per ton lighter freight charge, plus the cost of labor to load and unload goods from the steamboat and transfer them to and from the lighter. Wilson estimated that the 90 days of low water during the 1866 season had cost boats passing the rapids $250,000 in extra labor in addition to the $1 per ton for freight. This meant that the Des Moines Rapids was costing farmers, merchants, and steamboatmen of the Upper Mississippi Valley a half million dollars a year. During the 1867 season the Northern Line Packet Company alone paid $200,000 in lighterage fees.[34]

The need for rapids improvement was pressing. By 1866 the five states bordering the Mississippi above the Des Moines Rapids were producing between one-half and one-third of the produce in the United States. Three hundred and four steamboats with value of more than $10,000,000 were serving the Upper Mississippi. In addition, the lumber industry was coming into its own. More than 400,000,000 board feet of lumber was being rafted downriver annually. The Des Moines Rapids done added 2% to the price of this lumber.

Wilson found previous maps of the Des Moines Rapids of little help in determining the best method

of improvement. Lee's map he found to be of use only a3 a general picture, and Warren's map, though more detailed and accurate, was limited to illustrating the project for excavating a natural channel. Wilson put civil engineer H. A. Ulffers in charge of a resurvey, assisted by E.F. Hoffmann. During this survey, which took the entire fall to complete, Ulffers and Hoffmann made between 40,000 and 50,000 soundings of the rapids.

The Des Moines Rapids extended for 11% miles from just above Keokuk to just north of the village of Montrose. Gentle waves in the continuous rock shelf which comprised the rapids were identified as chains. There were five of these: Lower, English, Lamallee's, Spanish, and Upper.

Wilson investigated several methods of improving the rapids at Keokuk. He rejected the earlier plans of Buford, Lee, and Warren to excavate the natural channel because the expense involved in cutting a channel through the whole 11¼ miles of rock would be prohibitive, and because a narrow channel out in the river, where the surface would not indicate its whereabouts, would be difficult to use during the day and impossible at night or in fog. Both day and night boats would be liable to be blown out of the channel onto the rapids.

Wilson rejected locks and dams for the same reason that they were rejected on the Rock Island Rapids: they would be a hindrance in high water. Several local groups made proposals to Wilson, but the only feasible one seriously investigated came from "certain parties in Illinois."[35] This was to build dams of rock and brush in cribs across the river to within five or six hundred feet of the Iowa shore. From here a rock and brush wall would be built parallel to the shore for one mile downstream. One of these L-shaped dams was to be built at each of the five chains. The constricted channel would act as a sluiceway, shooting steamboats over the chains. Wilson rejected this plan because he felt such dams would not withstand the movement of ice in the spring.

Based on the evidence he had assembled, Wilson decided on a lateral canal as the best solution, This was the plan which Henry Shreve alone had recommended in all previous Corps of Engineer surveys, but which rivermen had long favored. Editorials in the Kmkuk *Gate City* before and after Wilson's arrival show strong sentiment for a canal. Two days before Wilson arrived one headline read: "Know you not, Oh! city reader, that Keokuk can be made the Lowell of this Western Country, if we but have a canal?"[36] A canal was endorsed by the Keokuk City Council two days after Wilson arrived, and on October 3, representatives of the Merchant's Exchange met with Wilson to push for a canal.

A lateral canal on the Iowa side of the river was not a recent idea with Keokuk residents. They had long favored such a canal as the best way of improving the rapids and serving Keokuk's interest at the same time. Local residents had never agreed with the plans proposed by Lee, Floyd, and Wmen for improving the natural channel, After repeated attempts to get Congress to listen had failed, Keokuk had acted on its own. On January 15, 1849, Iowa Governor Ansel Briggs had approved the Iowa General Assembly's authorization of the "Navigation and Hydraulic Company of the Mississippi Rapids" to acquire right-of-way for a canal. The estimated capital stock needed to complete the project was gut at $500,000.[37]

AS chief engineer the company hired a former West Point graduate, Class of 1831, Samuel R. Curtis"Curtis had served on frontier duty at Fort Gibson, Indian Territory; had resigned in 1832 to become chief engineer of the Muskingum (Ohio) River Improvement Organization, where he had attempted to use locks and dams to make that shallow river navigable; had served as a lawyer before joining the Ohio Militia during the Mexican War (during which he was appointed Adjutant General); and had most recently (1847-49) served as chief engineer for a Board of Public Works created by the Iowa General Assembly to improve the Des Moines River by locks and dams.

General Curtis, as he came to be known in Keokuk, was a man who dreamed large. He had surveyed the Des Moines River as far as Ottumwa by 1849, and foresaw a day when the Des Moines River valley would have canal connection to the St. Peter's [Minnesota] River and others, lading to nationwide trade connection far Iowa's coal and gypsum. The sandstone cliffs along the Des Moines "that have stood for ages as silent and gloomy sentinals guarding the clear bright river that, flows at their base will be sent by the blast and broken by the workmen, and their fragments will be removed and erected Into mansions."[38]

Curtis entered hi3 new duties with the rapids canal company with the same enthusiasm. Hi3 engineer's report recommended that a canal and wing dam improvement be built from the Upper Chain at Montrose down to the upper end of Keokuk, The canal.was to be constructed by building an embankment out in the river, than excavating the space between the embankment and the shore. Curtis' plan called for one lock at the foot of the canal with a lift of 24 feet, the only difference between his and Shreve's plan, which had not called for any locks. Curtis also felt that the canal could be used for an enormous mill-race to generate enough hydroelectric power to operate "all the machinery that human invention can locate within reach of its influence."[39]

When the money backing the project turned aut to be inadequate, General Curtis left for several years to practice law and survey for railroads in Iowa, but he returned to Keokuk in 1868 and was elected mayor, His inaugural address; in May 1856 called far an even larger and better canal around the rapids. Keokuk would become a "port of entry" with 2,000 steamboat arrivals a year. Curtis envisioned a canal two or three hundred feet wide which would serve as a "great steamboat harbor" all the way from Keokuk to Montrose, and which would be "sufficient to safely moor all the steamboats of the upper Mississippi."[40]

From 1857 to 1861 Curtis spent three terms in Washington as a U.S. Representative. He joined the

Second Regular Iowa Volunteers during the Civil War and returned home to Keokuk in the spring of 1866. Although General Curtis died in December 1866 shortly after Wilson arrived, his long and enthusiastic interest in a Des Moines Rapids canal must have been an important contribution to the Keokuk canal fever which met Wilson. The plan which Wilson finally adopted was close to that suggested 17 years before by Curtis.

Wilson's report on the Des Moines Rapids recommended that a navigation canal be built dong the Iowa shore from Kmkuk to Nashville, a distance of 7.6 miles. From Nashville to the Upper Chain boats would use the natural channel, which was deep enough without improvement. At the Upper Chain Wilson proposed to cut a channel 200 feet wide, 6 feet deep, and 2,400 feet long. The canal itself would have a 300-foot width and a 6-foot depth, with three locks. The 6-foot depth recommended by Wilson was two feet more than called for in the Act of June 23, 1866, but he accurately predicted that within 50 years the low water depth of the Mississippi would be increased to six or seven feet.

Wilson decided on a canal as the best method of improvement because it would leave the natural channel free both during and after construction, because it would be easy to navigate, and because, with its slack water, the canal would be an especial aid to boats ascending the rapids. During high water, shallow draft boats and log rafts could use the natural channel if they wished.

The actual plans and estimates for the canal were dons by Wilson's assistant, D. C. Jenne, who had previous experience in canal construction. Jenne's estimate of $3,390,000 to build the canal was not too far off, but his estimate that the work could be done by 1869 was eight years too short.

Chief of Engineers Humphreys found Wilson's report satisfactory and presented it to the House of Representatives in early February 1868. Here the Committee on Commerce considered it and made provisions for the canal in the general appropriations bill. However, objections arose in the Senate

when doubts were raised about the canal plan, considering that all previous Engineer reports had rejected the idea of a canal. The Senate voted the bill out and in its place appropriated $500,000 for "improving navigation at the Des Moines or lower rapids, according to such plan as the Secretary of War shall, on the report of a board of engineers, approve."[41]

Accordingly, Humphreys convened a Board of Engineers which met at Keokuk on April 16, 1867, to examine the rapids and make recommendations. The Board consisted of Wilson, T. J. Cram, Macomb, Warren, Hains, and W. Milnor Roberts, who had been superintending engineer improvements an the Ohio River. After examining the rapids, the members of the Board adjourned until April 30, when they reconvened at the U.S. Engineer's Office in Davenport and remained in session until May 13.

In addition to the plans Wilson had previously considered, the Board investigated several alternatives, including the possibility of dams across the entire river, Livermore's Improved Chute, and Brunet's Improved Float Gate for sluices in dams. The latter was a hollow gate hinged so that when the desired level of water in a sluiceway was reached the gate could be flooded, sinking it horizontally on the bottom, permitting the boat to ride the crest thus produced.

In the end the Board's recommendations were almost identical to Wilson's original proposal, except that some of the dimensions were reduced. On July 19, 1867, the Board reported its results to the Secretary of War, who had been given power to make the final decision. He instructed Wilson to "proceed at once to carry out the plan of improvement reported by the Board."[42]

The Board had decided that the canal was to be built by constructing an embankment in the water to form the river side of the canal, then excavating the prism between the embankment and shore to obtain a 5-foot depth. The embankment was to be built first because, being built out in the river, it was the

most uncertain part of the construction; because once built, it would serve as protection for the excavation and for building the locks; and because the total of $700,000 now appropriated for the canal would just about complete the cost of the embankment.

Wilson advertised in newspapers throughout the country in July for bids to construct the embankment and prism. Bids were opened September 4 at Davenport, and on September 25, 1867, he signed a contract with William Henegan and Son of Mt. Vernon, Ohio.[43]

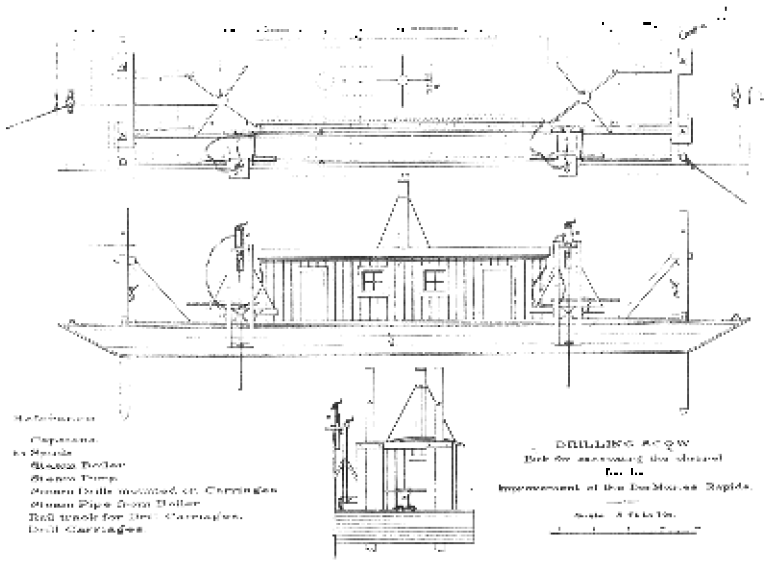
On October 18, 1867, Wilson and his assistants, and William Henegan located the centerline of the canal, and moved the first wagon load of earth for the guard bank connecting the outer embankment of the canal with the shore. Regular work crews began the next day.

Almost immediately the contractor fell behind schedule. The boats he had promised to provide had not yet arrived at the end of November, and fewer men had been hired than were necessary to keep on schedule. Nevertheless, there was some progress. By March 1, 1868, 5,000 feet of earth embankment had been laid seven feet high, and 5,280 feet of rip rap wall had been put down. On shore, 7,500 feet of new rail line and 76 rods of public highway had been completed to replace those taken by the project. One casualty of the canal construction that could not be replaced was the tow path along which horses used to had lighters up and down the rapids.

Early in March Wilson foresaw that problems with the contractor on the Des Moines Rapids would increase. With the work at the Rock Island Rapids going smoothly, Wilson requested that hia station be changed from Davenport to Keokuk. He received permission to do so, and by April 10, the headquarters of the Rock Isknd District had moved to Keoknk. Wilson retained this office in Keokuk until he retired in 1870. At that time, Colonel Macomb moved the office permanently ta Rock Island.

After repeated admonitions from Wilson, Henegan and Son were declared to have violated their contract on October 26. Perhaps realizing that they had undertaken too much, the contractors made little protest. Until a new contractor could be found, Wilson and his assistants took over the work using hired labor and the machinery left behind by Henegan. That machinery included four small boats (not powered), 18 double teams, 13 carts, 66 railroad cars and two locomotives. The two locomotives had been built especially for this project, and were part of the shortest, smallest railroad in Iowa. The 4-foot gauge track ran from the quarry on shore out over the top of the embankment. They were extended as the embankment was built. The locomotives had two pair of 3-foot drive wheels and resembled switch engines except that they lacked a pony truck in front. Flat cars hauled stone from the quarry while dump cars hauled earth. There is some irony in the fact that the Rock Island District came into possession of a railroad and horse teams before it owned a single steamboat.

Contractors were not the only problem for Wilson. The guard embankment was safely out in the river, but the prism crossed land owned by people. Some of it was farmland; other places had developed businesses on the land. At one place the Gibbonsville



Plan for a steam drilling scow built for the Des Moines Rapids Canal project. Because of the experimental nature of most of the improvement work in the 19th century, the Rock Island District designed and built much of its own equipment.

Distillery stood on the way. Both highway and railroad had to be relocated. Wilson had funds to indemnify the owners of property taken or damaged by canal construction, but by the end of 1867, the claims of those willing to make a "reasonable" settlement amounted to only $15,500.[44] Many others hoped to get more money from a jury settlement, and others did not want to sell at all. At least one injunction had already been issued by an Iowa court prohibiting the contractors from entering private property along the canal line.

Humphreys early in 1868 requested the Governor of Iowa to get the Iowa Legislature to amend the Iowa statutes "so as to enable the Government of the United States to enter upon any and all lands of quarries adjacent to the work referred to and necessary to its progress."[45] Land claims were eventually settled, but not before these legal problems had delayed construction for a time.

On November 28, 1868, a new contract was signed with J. J. Dull of Harrisburg, Pennsylvania, who bought all the old machinery. The work went better under this contractor. During the 1868 season the average work force had been 15 foremen, 113 laborers, and 104 quarrymen. By 1870 the canal force was up to 1,000; it reached 1,600 by 1875 as the canal neared completion.

Dull added equipment as the work progressed. Eventually he had four locomotives, 500 flat and dump cars, and 20 miles of track. The main track ran atop the guard embankment, with spur lines to the pits and to the quarries on the shore.

The embankment in the river was constructed by laying down a rip rap toe of broken rock taken from a quarry at Price's Creek or excavated from the prism. Rail tracks were Lid down on this foundation, and the railroad was used to haul the dirt necessary to complete the embankment. The finished embankment was about 20 feet high and 10 feet wide at the top. Much of the dirt and rock in the embankment came from the points of land extending from the shore line of the canal into the prism which had to be removed to even the shoreline.

Because the railroad tracks were temporary, constantly being moved and extended as the work progressed. and because they rested on settling ground, accidents were frequent, Cars and locomotives regularly tipped over, resulting in many crushing injuries and several deaths among workmen." Nevertheless, the little engines worked hard. They hauled cars, pulled out stumps, whistled for lunch, and even towed lighters up the rapids, replacing the horses and towpath that had been taken for the improvement work.

The railroad was also used to show visitors around the construction site. The Des Moines Rapids Canal project attracted attention in magazines and newspapers throughout the United States, with frequent stories on the progress of the work. As a result, engineers and other visitors came to visit and inspect the work. To accommodate these visitors, a special flatcar was outfitted with board seats to haul visitors around the site. Famous visitors showed up, too. On February 24, 1868, Horace Greeley, who had come to Keokuk to give a lecture, spent the day being shown around the construction.[47]

Most of the work on the canal was hard hand work. All of the earth from the prism was removed by hand with shovels and wheelbarrows after a huge, horse-drawn plow had loosened the dirt. At regular intervals along the canal, temporary cross embankments were built from the outer embankment to the shore. The resulting sections were called "pits," and in each of these, a pit crew of up to 60 men worked. A majority of laborers who worked on the canal were new immigrants from Sweden, and many of the remainder were Irish. These workers lived in shanties rented at a nominal sum from the contractors, who had built them all along the shore from Keokuk to Montrose.[48]

When the rock bottom of the prism was reached, it had to be blasted out, again by hand, using drills to make the holes and black powder to do the blasting, Steam drills were used where blasting had to be done underwater, and tin tubes extending to the

surface of the water were used to load the powder charges. Such charges did not break up the rock very effectively, but they made noise. Local residents reported that, for 25 or 30 miles around, the canal construction sounded like a distant battle.[49]

The finished embankment contained a total of 884,325 cubic yards of earth in addition to 97,000 cubic yards of rock excavated from the canal prism and from the chains at Nashville and Montrose. The embankment varied between 60 and 90 feet at the base, with a slope of 1½ to 1. It varied from 16 feet high at its lowest point to 27 feet at its highest.

Within the prism of the canal were two lift locks and one guard lock, completed between 1870 and 1874 after the embankment was finished. The locks were built under a separate contract, The lower lift lock was located at Keokuk; the middle lock was 2.5 miles above the lower; and the guard lack was 1/10 mile above the middle lock, At each of the locks a 27-foot-square stone engine house held the 30 horsepower steam engines used to operate the locks. This machinery was manufactured from an original design of Major Amos Stickney, who assumed local charge of the canal in 1872, and was manufactured at the Buckeye Foundry in Kmkuk. The engines operated pumps which provided hydraulic pressure to open and dose the gates, permitting the use of only one man at each of the locks to operate the gates.

The locks were constructed of magnesian lime stone laid in hydraulic cement. The stone was quarried from the Sonora Stone Quarries on the Illinois bluffs adjacent to the river. The rough blocks of stone were taken across the river by the light draft steamer *Cricket* to stone yards at Nashville and Price's Creek. Hare the stone was dressed and numbered, and than taken to the site by rail. The lock gates were built of cedar and cypress wood which proved to be so sturdy that when the gates were removed for repairs 25 years later, workmen had trouble taking them apart.

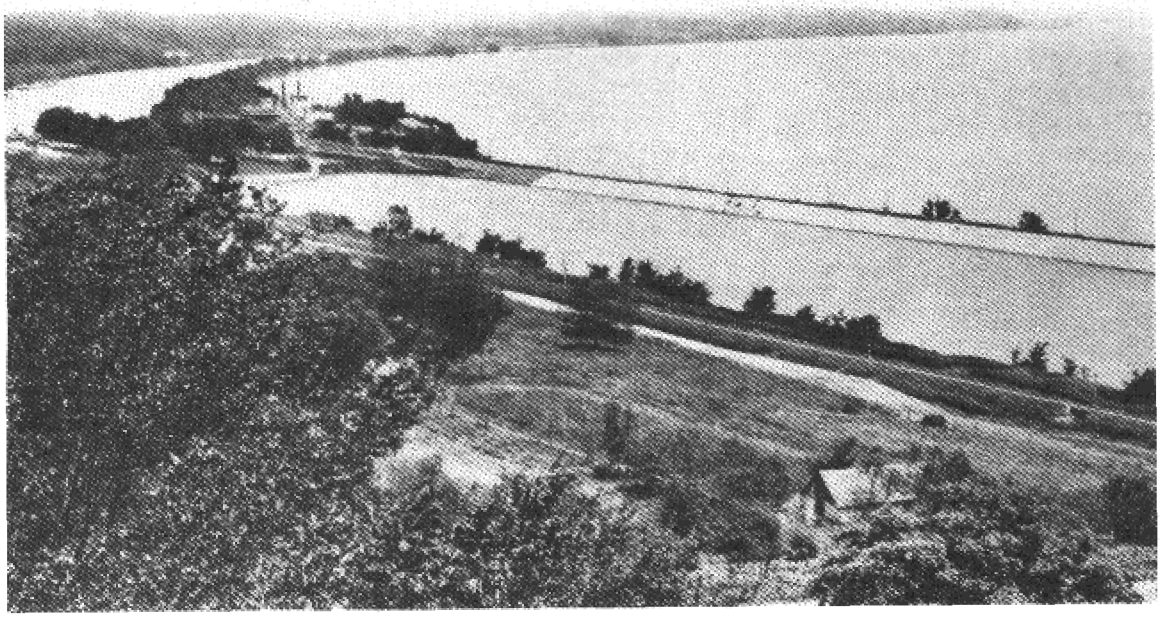
Each lock provided a chamber 310 feet long by 80 feet wide at the surface, giving it, a usable length of

291 feet by 78 feet. Larger boats could be locked through by maneuvering and using one gate at a time, but the only regular steamboat larger than 291 feet on the Upper Mississippi was the 302-foot *St. Paul.* The locks were filled by culverts which led to the gate recesses, and they were discharged by openings in the chamber wall. Depending on the river level, a lock could be filled or emptied in from five to ten minutes.

Delays caused by changes in contractors, by contractors' unfamiliarity with problems encountered, and by limited appropriations postponed completion of the Des Moines Rapids Canal far beyond its projected 1869 date and nearly doubled the costs. The Engineers frequently had to wait for new appropriations before resuming work.

Wilson also ran into another problem that caused delays in these early years of improvement work: the conflict between the District Engineer's perceptions of how to proceed with the work at hand, and the insistence of the Office of the Chief of Engineers

The guard lock at the head of the Des Moines Rapids Canal. This was not a lift lock. Rather, it kept out debris and provided slack water in the canal.



Middle lock at the Des Moines Rapids Canal. 2.5 miles above the lower lock at Keokuk, Iowa.

on strict observance of military orders and adherence to the letter of the law in contracts. Wilson was not permitted the kind of autonomy that Rock Island District Engineers later in the 19th century enjoyed after OCE and the District had learned better how to cooperate. The process by which Districts were given some allowance to adapt procedures to their individual needs was a gradual learning experience, and Wilson and Washington had just begun to learn.

Some of the problems Wilson encountered with regulations were annoying but minor. In January 1868 one of Wilson's civil engineers, Robert Shanley, needed to have $2.25 worth of repairs done to a survey instrument. Wilson's request for payment of this sum to Shanley (who had paid the repairer out of his own pocket) was returned from OCE because "it is not perceived how, under the regulations, this voucher can be paid without the presentation of a sub-voucher from the person making the repairs."[60] A month later both voucher and the new sub-voucher were returned to Wilson be-

cause "the sub-voucher must state that the payment was received *from Mr. Shanley*. The auditing officer requires this particularly."[51] Mr. Shanley was finally reimbursed late in March.

Wilson had similar small problems with OCE over the official number of times bid advertisements had to be inserted in newspapers, and over the hiring of workmen. Wilson discovered that he needed written authority from the Chief of Engineers to hire each clerk, foreman, and overseer, but that it was left to the discretion of the officer in charge to hire as many rodmen, chainmen, axemen, and boatmen as he needed. Correspondence on each of these items took time and helped prolong the work.

More serious than these minor irritations were problems which arose from a strict interpretation of the rules regarding contractors. Wilson, for instance, felt that it would be good economical procedure to let contracts that would stop when any given appropriation ran out. This loose type of contract would have permitted Wilson to use the contractor for whatever seemed necessary at a given time, to handle unexpected problems arising from the kind of unfamiliar work being done at the canal. This would have made the contractor more like a supervisor of a work force of hired labor, to be used as the Engineer in charge saw fit. Standard procedure, however, was to let bids on one specific job which could be done within existing appropriations, and this is what Colonel Wilson was held to.

Wilson also objected to another OCE policy, the requirement that he let out bids for new contracts each year as new appropriations became available. This meant that contractors such as Dull, had to bid anew each year on each job at the canal. Each of the sections of the canal and each separate lock, for example, were under separate contracts. Wilson had such good working relationships with J. J. Dull during the first year that he requested OCE to permit him to continue contracting with Dull without new bids. This was denied, new bids were let, and eventually five sections of the prism were under five different contractors, Dull submitting the low bid for

only one of the sections. By 1874 the contract work proved so unsatisfactory that the project was taken over by the Government using hired labor and completed that way.

On at least one occasion, Wilson's persistence did win a change of mind from OCE. When the excavation of the prism reached the rock bottom early in 1869, the contractor discovered that the rock to be blasted lay in uneven layers, and that it was impossible t,~excavate the prism exactly in every place t ·~ it four-foot depth. The rock came aut in layers, and to get a minimum depth of four feet, parts of the prism had to be excavated deeper. Dull requested payment [which was contracted by the cubic yard) for al of the rock actually removed, and Wilson supported that request, noting that planes of stratification seldom coincided with the line of cutting. OCE, however, pointed out that "the contract calls for a channel 200×4 feet. The wording, spirit, and intention of this contract is clear that just so much rock is to be removed as will give the depth of water specified and no more . . . the question of stratification should not be regarded."[52] OCE authorized Wilson to annul the contract with Dull, but he continued to plead their case, and on June 19, 1869, he received permission to pay the contractors for the extra rock removed.

Other delays at the Des Moines Rapids Canal had nothing to do with OCE, the lack of money, or defaulting contractors. The Upper Mississippi weather and the river itself continually conspired to show their power, One manifestation of this power occurred as the last section of the canal was being completed—the cutting of a channel through the Montrose Chain above the canal.

On August 24, 1875, contractors completed a coffer dam on the Montrose Chain enclosing 95 acres of river. On September 3 the dam sprang a leak, flooding the work in 40 minutes. 9/6 leak was repaired by September 8, but on that day an unusually heavy rainstorm raised the small streams throughout the Upper Mississippi basin, and the river rose to the heights of the spring floods. The high water

threatened the dam, so the contractors made a cut in the darn and flooded the pit. But the difference in elevation between the head and foot of the coffer dam caused a strong current which washed away 600 feet of the dam, and created a cross-current which caused a heavy passing log raft to float in and unship the engine and pump at the lower end. Engine, pump, and a number of small tools were lost in the river.

The water continued high, so repairs to the darn were not completed until October 12, at which time 900 men were put on the job of excavating until January 2, 1876. Then a repeat of the September 8 flood washed the dam away. This time the Chief of Engineers was consulted, who determined to go ahead. The dam was rebuilt and contractors began pumping water out on January 31. During the pumping a cold snap formed six inches of ice on the water inside the dam, which, settling on the tracks In the pit, causing considerable trouble. After removing the ice, the men resumed work on February 7.

Three days later, on February 10, a recurrence of soft weather and heavy rains threatened another overflow. A dredge was at hand, and by continuous effort for three days and nights, workmen raised the walls of the coffer dam above flood level.

With the river met and temporarily conquered, work resumed until February 24, when appropriations ran out and the work halted. By this time all but a small patch at the head of the chain had been completed. A series of hardahips this extended might have been unusual, but such disappointment was an ever-present companion in the work of navigation improvement.

The canal itself was not immune from troubles caused by contractors' sub-performance and the whims of nature. In the spring of 1875 a large leak developed under the canal bank one-half mile below the middle lock. Engineers discovered a crevice in the bed rock of the river two to four feet below grade which was pouring thousands of gallons of water into the canal. To get at the crevice, half of the em-

bankment for a length of 500 feet had to be removed, the channel excavated, and the crevice exposed and filled with concrete.

The Des Moines Rapids Canal was not opened to traffic until 1877. It had cost $4,155,000. On the morning of August 22, the Rock Island District sidewheel snagboat *Montana*, with District Engineer Macomb on board, and with colors flying, bands playing, and spectators who thronged both boat and shore cheering loudly, entered the guard lock at the head of the canal, becoming the first boat to enter. At 5 p.m. the Keokuk Northern Line steamer *Northwestern* entered the lower lock, passed the *Montana*, went up to the head of the canal and came back at 9 p.m. Colonel Macomb reported that "the adjacent bluffs were lined with spectators."[53] The steamer *War Eagle*, one of the grandest boats on the Upper Mississippi, brought a large delegation from St. Louis for the event, but she ran aground on a sandbar below the rapids and missed the ceremonies.

Problems with the embankment of the canal caused it to be closed for repairs on September 10 after only three weeks of operation. It was opened again on September 22, but closed for 15 days on October 1. On October 11-12, 1877, at a meeting of the Mississippi River Improvement Convention (one of the conventions that led to the formation of the Mississippi River Commission two years later], the canal came in for severe criticism by rivermen, "Twelve years for nothing," one of the speakers called it. Protests against the Corps of Engineers included charges that the Government had hired a steamer at $50,000 per *year* to throw hunting parties for those building the canal.[54]

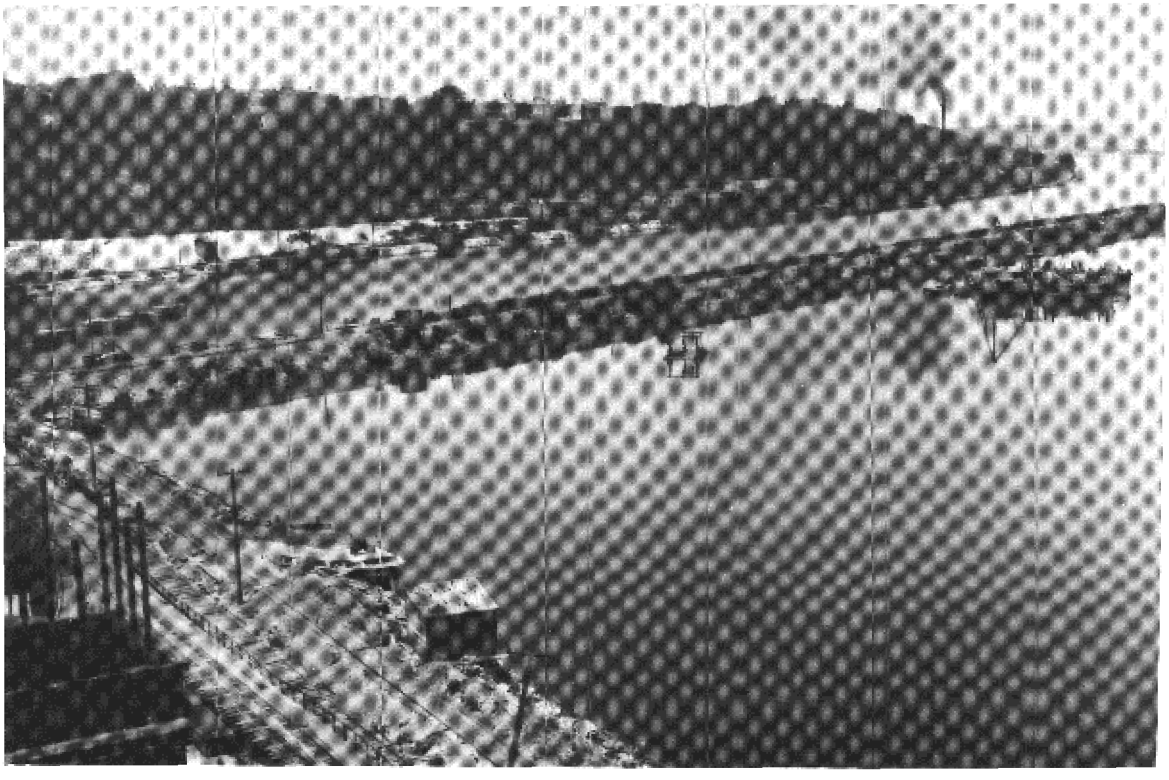
Present at that convention was a relatively new employee of the Rock Island District, Montgomery Meigs. Meigs was the son of Lee's assistant in 1837, and was an assistant engineer at the Rock Island Office with the rank of United States Civil Engineer. When Meigs was given a chance to answer these charges, he outlined the problems, most of which he charged to contractors' failure to put the

rock down correctly in the embankment, in so clear and reasonable a way that the members of the convention and the reporters present accepted hi3 explanation. The mood of the convention toward the Corps of Engineers changed, and Meigs was referred to thereafter by the convention members as either "General" or "Major" Meigs.[66] Although Meigs had never Been in the Army, the "Major" stuck, and throughout hi3 long career with the Rock Island District, he was known as Major Meigs.

Montgomery Meiga grew quite knowledgeable about the Upper Mississippi and about District operations as he served a aeries of District Engineers as an innovator and advisor. In 1884 he was put in local charge of the Des Moines Rapids Canal at Keokuk where he remained until his retirement in 1926.

Lower lock at the Des Moines Rapids Canal, with construction already underway on the Keakuk and Hamilton Water Power Company Dam

The Des Moines Rapids Canal continued to serve steamboats on the Upper Mississippi until it was flooded out in 1913 by Lake Cooper, the long pool of water that backed up behind the new Keokuk water



power dam. As part of the agreement with the Corps of Engineers, the Keokuk and Hamilton Water Power Company built a larger single lock as part of the dam. Montgomery Meigs remained in charge of these new facilities. The 60-mile pool behind the dam also flooded out the last vestige of the Des Moines Rapids.

Other Activities on the Upper Mississippi 1866 to 1877

While Wilson supervised the improvement of the Rock Island and Des Moines Rapids, Warren worked at his several projects between St. Paul and the Rock Island Rapids. In the fall of 1866 he began the surveys assigned to him. These were general surveys to locate areas needing improvement and to determine methods for doing so. Based on the surveys completed by the winter of 1866-67, Warren published a preliminary report on January 21, 1867, in which he recommended that money be appropriated for a lock and dam at Meeker's Island, for building and operating two dredge and snagboats, and for small experiments with wing dams, closing dams, and beacons—a total of $340,465.[56] Warren also requested $775,600 for a 4-foot channel between St. Louis and St. Paul, or as an alternative, $117,000 for a 2- or 3-foot charnel.

On March 2, 1867, Congress appropriated money for two snag boats for the Upper Mississippi, one snag and dredge boat for the Wisconsin River. and $37,000 for removing snags and boulders from the Minnesota River by contract.

Warren had also been assigned to survey the Wisconsin River far a possible route from the Mississippi to Lake Michigan similar to those surveys of the Rock and Illinois Rivers assigned to Wilson. In 1867 Warren completed an extensive survey of the Wisconsin River and hid down a canal route from Portage City to Prairie du Chien. Warren considered a canal the most reliable means of obtaining navigation between Green Bay and the Mississippi. He estimated that such a canal following the

natural river valley and using the Wisconsin River for crossings would give a 4-foot depth for just over $4,000,000.

Both Warren and Wilson realized that Congress would probably not fund any such major project, but they knew that; Congress would certainly not fund two major routes to the Great Lakes, and a friendly rivalry grew up between the two. Neither man actually favored such a project at all. According to Wmen, he "had a private understanding with [Brevet] General Wilson in 1866 that neither of us should go into this business."[57]

However, the appropriation by Congress of $85,000 for actual improvement work on the Illinois River in 1868, brought a hurried request from Warren for funds to buy mother boat for the Wisconsin River project. The appropriation for the Illinois River, wrote Wmen, "compels me to commence on the Wisconsin work at once to keep even with General Wilson."[58] Even more displeased were representatives of the Green Bay and Mississippi Canal Company, who had much to gain by a Wisconsin River route. "These Wisconsin men," wrote Warren, look upon the Illinois appropriation "as a trick of the Illinois politicians to steal a march upon them, and get judgment from the Engineer Department in favor of the Illinois route over the Wisconsin route."[59] Knowing the ways of Congress, Warren agreed that spending even a small amount of money on the Illinois River "will thus place this improvement on the list of works *in course of prosecution by the government.' "[60]

Following completion of his surveys, Warren next looked into purchase of the snag boats provided far in the March appropriations. Following adjournment of the Board of Engineers which met at Keokuk to consider the Des Moines Rapids in the spring of 1867, Wmen left for St. Louis and Cincinnati to examine available boats whish could be adapted to snagging operations. He returned to St. Paul on June 9. In June Warren placed advertisements in several newspapers inviting bids for selling steamboats to the United States to be used for scraping sandbars; he also advertised for contracts to remove snags from the Minnesota River.

A satisfactory bid was received for snagging the Minnesota River, but bids for snag boats were too high and involved unsuitable boats. Early in September, Warren returned to St. Louis and, after careful examination, decided to buy two sidewheel steamboats, the *Montana* for $30,000 and the *Caffrey* for $8,500. Warren had already purchased several small skiffs and a quarterboat for his surveys the previous fall, but these two boats were the first Corps-owned steamers on the Upper Mississippi. In September of 1868 Warren bought a third boat, a small steamer *Winneconne* for $8,500. The *Winneconne* was intended for the Wisconsin River improvement, but proved to have too great a draft.

Prior to the spring season of 1868, Warren adapted the *Montana* and *Caffrey* for both dredging and snag operations. Both boats were fitted with a Warren adaptation of Long's Scraper. Long's Scraper was a triangle of massive oak timbers attached base downward at the stern of the vessel. This triangle was raised or lowered by purchase rigging, and steadied by a heavy oak beam attached to the stern of the boat and running through a slot in the triangle. Attached to the bottom of the base timber were half-cylinder scrapers set lengthwise with the keel of the boat. At the head of a bar, the scraper was lowered until it was a few inches below the existing riverbed. The boat then backed downstream. As the scrapers plowed up the bottom, the churning wheels washed the material dredged out of the channel, where the current carried it away and deposited it downstream. One scrape across a bar took from four to ten minutes. Depending on She size of the bar, clearing a channel deep enough for steamers to pass took from an hour to an entire day.

In addition to scrapers, the *Montana*, the larger of the two boats, was strengthened at the bow and outfitted with boom machinery for snagging.

Warren's experiments in channel improvement showed gratifying results the first season. During 1868 the *Montana* worked 67 days and the *Caffrey* worked 112. When the *Caffrey* began work on July 12 the water was so low that large boats could not

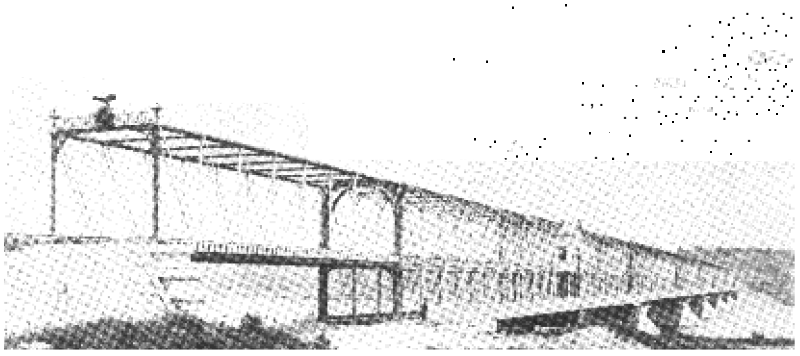
navigate. The scraping of bars by the *Caffrey* made it possible for all boats to operate for the rest of the season. The one problem with scraping as a means of channel improvement was that it was not permanent. The next cycle of high-low water would leave an entirely new set of bars up and down the channel.

Warren also pioneered the marking of the channel to guide pilots during the 1868 season. When the *Montana* or *Caffrey* had put a section of channel in good condition, the crew would place guide boards on either side of the river along the banks. The guide boards were three-quarters- or one-inch boards held together by cleats, about five or six feet square. They were painted white with a large red cross in the center, and fastened 20 or 30 feet above ground on trees. Steamboat pilots at first ridiculed these guides, but by the close of the season there was universal acknowledgment of their benefit, especially on dark, cloudy nights.[61]

In the fall of 1868 Warren was sent West as a special commissioner to examine the construction of the Pacific Railroads under direction of the Secretary of the Interior.[62] He did not return until June of 1869.

When Warren returned, it was to take charge of construction of the new railroad bridge at Rock Island. This bridge had been authorized in 1866 when the Government determined to relocate the tracks of the railroad to the southwestern tip of the Island of Rock Island to facilitate use of the island as a United States arsenal. A new bridge for that location had already been designed by Brevet Brigadier General Thomas Jefferson Rodman, Commandant of the Arsenal. The bridge was to include two levels, one for the railroad and the other for a wagon road. Specifications called for a drawspan with two clear openings, each 160 feet wide, for steamboats, and a span for rafts next to the draw 250 feet wide.

In the spring of 1869 the Government decided to place the job of actual construction with the Corps of Engineers, partly to permit better coordination



1 Bridge at Bennetsbridge, Ireland,
replaced by the present structure

to turn the actual construction over to Major Amos Stickney as soon as the construction had begun. It was not, in the first place, a design with which Warren agreed. Among his other 1866 duties, he had been assigned to investigate and report on the construction of railroad bridges across the Mississippi. The book length report which resulted was not published until 1878, but in It Warren clearly demonstrated his belief that the wellbeing of steamboats ought to be a prime factor in the design of such bridges. He had recommended in that report that all bridges have spans of up to 500 feet wide, and high-water clearance of as much as 100 feet.[63]

It is no wonder then that Warren made changes in General Rodman's design to favor the boats. He redesigned and relocated the drawspan, placing it next to the island shoreline (which General Rodman cldmed would interfere with steamboat landings at the Arsenal), and he included two raftspans, one in the channel and one next to the Iowa shore, to account for different river conditions. Next., he reversed Rodman's design and placed the railroad on the top level and the wagon road beneath so as not to let the trains frighten the horses with sparks, smoke, and noise coming up from below. He made the bridge single-track, with the wagonway 30 feet above low water and the railroad level 12 feet above that. The 366-foot drawspan which Warren designed to operate on a pivot was by far the heaviest drawspan operating on that principle yet built.[64] Though much of the bridge has since been done, the pivot machinery is still in good operating condition. The Rock Isknd Arsenal Bridge was 1,546 feet long and cost $999,281 to construct, just within the $1,000,000 limit.

On August 3,1869, in order to supervise construction of the bridge, Warren requested that his office for bridge matters be changed to Rock Island, retaining his St. Paul Office for other works in his charge. On May 27, 1869, Wilson's sub-office in Davenport had also been moved to Rock Island, perhaps because boats were easier to dock on the Rock Island side of the river.

Warren was occupied with bridge: construction until the following June when he was put in charge of the Lakes Survey with headquarters in Detroit, ending his long service to the Upper Mississippi River. He was replaced by Colonel John N. Macomb, wha had been Superintendent of Western River Improvement.

Macomb established his office on the second floor of a commercial building at the northeast corner of 19th Avenue and Second Street in Rock Island. This office was across the street from Spencer Square and the Harper House, one of the notable hotels in the Mississippi Valley. These quarters remained m the main office! of the Rock Island District until 1896, when the Corps moved *into* the newly completed Federal Building.

When Wilson resigned from the Army in October of 1870 to become Vice-President of the St. Louis and Southeastern Railroad, Macomb assumed his duties in addition to Warren's.

Under Macomb work continued on the Rock Island Bridge. By the fall *of* 1872 it *was* nearing completion. On November 18 running ice in the Mississippi stopped the ferry between Davenport and Rock Island. In response to 3 request from the Arsenal, Macomb opened the bridge to wagon traffic the next day, though trains had been crossing the bridge since October 8.

The *Montana* and the *Caffrey* continued to operate with success. During the 1872 season the *Montana* ran 4,089 d e s and the *Caffrey* ran 2,641 miles in pursuit of their duties. By 1877 when Major Farquhar assumed command of the Rock Island District, both boats were beginning to show the effects of hard work. 1877 was the last season for the *Caffrey*. Because of low appropriations that year, she was not put in commission, and was sold soon after. The *Montana* continued to operate until the close of the 1878 season, when she was rebuilt into a completely different boat.

By 1873 the partially improved Rock Island Rapids were less of an obstruction than the channel

north to St. Paul. Under Macomb the first permanent improvement of this section of the river was begun in 1873 when the crew of the *Montana* closed the chute at the head of Pig's Eye Island, five miles below St. Paul, after navigation had become blocked there. A jetty was built from the head of the island to the eastern shore, followed by similar jetties at Rollingstone Bar and at the head of Betsy Slough above Winona, Minnesota.[65]

These jetties were built by driving piles close together and then placing two-inch planks on the upstream side. When the *Montana* returned to Pig's Eye Island, she found that the jetty had given way. C. W. Durham, who was in charge of the experiments, decided to build a wing dam by driving two tiers of poles along the length of the dam nine feet apart, and filling the space with willow brush weighted down with sacks of sand. The finished wing dam was 600 feet long and varied between six and ten feet high. Within days, this dam had opened the channel. Furthermore, it remained open, a permanent improvement.

Macomb also continued the work which Wilson had begun on the Illinois River, dredging the channel and building wing dams. In 1875-77 a second lock and dam was built at Copperas Creek, with the Government laying the foundation for the dam in 1875 and the State of Illinois completing the project by 1877. The more extensive lock and dam system proposed by Colonel Wilson was still in doubt because of the out-of-date Illinois and Michigan Canal, and because the courts had still not decided just how much water to let the City of Chicago divert from Lake Michigan down the Illinois River.

During the Engineers' work on the Illinois River, the civil engineer in local charge, Robert McMath, developed a mechanical sounding machine that was used for some years after in the Rock Island District. The problem with hand soundings, in addition to the time and expense (remember that the Des Moines Rapids required between 40,000 and 50,000 soundings), was that it was hard to get a clear picture of the bottom, especially the bumps

and ridges which even close soundings often missed. McMath's machine operated like a pantograph, recording a continuous profile of the ground passed over by the boat using the machine. Macomb tested this machine and recommended it to the Government, which purchased it.[66]

On November 15,1877, when Macomb was placed in charge of Defense and Harbor Improvements on Delaware Bay, the Illinois River project was assigned to Captain Garrett J. Lydecker of the Chicago District. The reminder of the Illinois Waterway story can be found in the Chicago District history.[67] In the nine years from 1869 to 1877, the United States had spent $344,000 on the Illinois River, $235,000 of this for dredging.

By 1877 steamboat and barge arrivals from the Upper Mississippi and Illinois Rivers at St. Louis had exceeded those from the Lower Mississippi, the Missouri, and Ohio Rivers. In 1877,834 boats arrived at St. Louis from the Upper Mississippi, while 780 arrived from the Lower Mississippi. The Illinois River sent 252 boats to St. Louis, while 145 arrived from the Missouri and 139 from the Ohio River.[68] The improvement work done by Wilson and Macomb shares some of the credit for this.

Macomb also undertook the first comprehensive surveys of the Upper Mississippi under an 1874 appropriation for Transportation Routes to the Seaboard.[69] Warren's surveys in 1866 had only been at selected locations. If the Corps of Engineers was to develop a plan of permanently improving the channel, they would need a more complete survey.

Consequently, when Montgomery Meigs joined the Rock Island District in 1874, his first assignment was to carry out such a comprehensive survey. A quarterboat, the *Hoffmann* [named after the engineer in charge of the Rock Island Rapids], built just for this survey, was finished on August 27 and towed to St. Paul by the *Montana.*

With C. W. Durham as his assistant in charge of the sounding party. Meigs began the survey at

Frenchman's Bar, 1½ miles below St. Paul on September 2. There was only time and money to do the worst stretch of river, that part between St. Paul and La Crosse. In that area the survey crew located 44 sandbars that were obstructions to navigation. Twenty-three of these had three feet of water or less at low water.

The quarterboat *Hoffmann* did not use a steamboat on this trip to move from location to location. Instead, Montgomery Meigs rigged up a sail which proved satisfactory enough to maneuver downstream. Meigs reported that he kept the boat close to shore because "she doesn't have very good sailing qualities."[70] During this trip he also adapted a rowboat for use on Lake Pepin by adding a false keel and installing a sail he bought from a fisherman for $2.50.[71] These were the first examples of Meigs' tinkering that would eventually produce a superb fleet of boats for the Rock Island District fleet.

In his report of this survey, Meigs recommended that wing dams similar to the one constructed at Pig's Eye Island be used to constrict the channel in order to deepen and scour it. In 1878 when the Government adopted the 4½-foot channel, wing dams became the predominant method of achieving the goal.

Notes

Chapter 3

1. Lippincott, p. 632.

2. *Annual Report*, 1892, II. p. 1760.

3. Lippincott, p. 633.

4. *Proceedings of the Mississippi River Improvement Convention Held at Dubuque, Iowa, Febuary 14 and 15, 1866* (Dubuque, Iowa: *Daily Times*, 1866), p. 3.

5. *Ibid.*, p. 39.

6. U.S. Congress, House, *Letter from the Secretary of War, in Answer to a Resolution of the House, of December 20, 1866, Transmitting a Report of the Chief of Engineers, with General Warren's Report of the Surveys of the Upper Mississippi River and Its Tributaries*, Report of G. K. Warren, Executive Doc. 58, 39th Congress, 2nd Session, 1867, p. 2.

7. Major G. K. Warren to Chief of Engineers, August 27, 1866, File 25, Letters Received, RG77, NA.

8. *Ibid.*

9. James Worrall to Lt. Col. Wilson, August 16, 1866, Rock Island District Historical Files.

10. Colonel J. H. Wilson to Chief of Engineers, August 26, 1866, File 25, Letters Received, RG77, NA.

11. Keokuk *Gate City*, August 26, 1866, p. 4.

12. Colonel Wilson to Chief of Engineers, October 1, 1866, File 25, Letters Received, RG77, NA.

13. *Davenport City Directory for 1870.*

14. War Department, *Annual Report*, 1867, p. 270.

15. U.S. Congress, House, *Report of Brevet Maj. Gen. James H. Wilson, Lieutenant Colonel Thirty-fifth Infantry, on the Survey of the Rock River in the States of Illinois and Wisconsin*, Executive Doc. 15, 40th Congress, 1st Session, 1867, p. 1.

16. James Worrall to Colonel Wilson, October 17, 1866, Rock Island District Historical Files.

17. *Report of Brevet Maj. Gen. James H. Wilson*, pp. 2-8.

18. Worrall to Wilson, October 17, 1866.

19. *Report of Brevet Maj. Gen. James H. Wilson*, p. 8.

20. *Ibid.*, p. 9.

21. *Ibid.*, p. 10.

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23. Major G. K. Warren, "On Certain Physical Features of the Upper Mississippi River," *American Naturalist*, II (1868), pp. 497-502.

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26. General Warren is quoted on this point in C. W. Durham, "A History of Improvement of the Rock Island Rapids, Mississippi River," *Annual Report*, 1886, III, pp. 1429-1472. Captain Hains also mentions the problem in his report, *Annual Report*, 1867, p. 294.

27. The source for this information is an unsigned, handwritten manuscript found in the Rock Island District Files.

28. *Annual Report*, 1886, II, p. 1431.

29. *Ibid.*, p. 1428.

30. Donald Enders, "The Des Moines Rapids: a History of Its Adverse Effects on Mississippi River Traffic and Its Use as a Source of Water Power to 1860" (unpublished Master's thesis, Dept. of History, Brigham Young University, 1973), p. 62.

31. Fort Madison *Patriot*, April 18, 1838.

32. Ben Hur Wilson, "Over the Rapids," *Palimpsest*, IV (November 1933), p. 362.

33. *Ibid.*, p. 363.

34. *A Memorial to Congress to Secure an Adequate Appropriation for a Prompt and Thorough Improvement of the Mississippi River* (St. Louis: John J. Daly and Co., 1881), p. 12.

35. *Annual Report*, 1867, p. 329.

36. Keokuk *Gate City*, August 23, 1866, p. 4.

37. Ben Hur Wilson, "The Des Moines Rapids Canal," *Palimpsest*, V, No. 4 (April 1924), p. 120.

38. Samuel R. Curtis, quoted in Ruth A. Gallaher, *Iowa Journal of History and Politics*, XXV (July 1927), p. 335.

39. Curtis, quoted in "The Des Moines Rapids Canal," p. 120.

40. Samuel R. Curtis, "Mayor Curtis's Inaugural," in Orion Clemens, *City of Keokuh in 1856* (Keokuk, Iowa: O. Clemens, 1856), p. 10.

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43. Unless otherwise noted, the material here and on the following eight pages comes from the *Annual Reports*, 1867-1870.

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45. General Humphreys to Governor of Iowa, January 9, 1868, File 22, RG77, NA.

46. Wilson, "The Des Moines Rapids Canal," p. 126.

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48. *Ibid.*, p. 128.

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50. OCE to Colonel Wilson, January 21, 1868, File 22, RG77, NA.

51. OCE to Colonel Wilson, February 15, 1868, File 22, RG77, NA.

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54. St. Paul and Minneapolis *Pioneer Press*, October 12, 1877.

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