# Pneumatic Caissons Sunk 110 Ft. for Vicksburg Bridge

**New Mississippi Railway and Road Bridge Required Caisson Work Under 52-Lb. Air Pressure—Swift Current Demanded Unique Anchor Construction and Timber Mats to Prevent Scour—One Caisson Used as Diving Bell to Level Up Reef**

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SUNK by pneumatic caissons to the unusual depth of 110 ft. below water, all but one of the piers for the combined railroad and highway bridge across the Mississippi River at Vicksburg, Miss., were completed in a short low-water season last year by a high-speed construction program. Construction of the last main river pier was continued early in August this year having been held up since last December by high water. Several of the caissons required an air pressure of 52 lb.

The bridge will be the first to span the river between Memphis and the Gulf, a distance of 850 miles. It will carry an 18-ft. highway and a single-track railroad, both inside the trusses and at the same level. The Yazoo & Mississippi Valley and the Vicksburg, Shreveport & Pacific railroads will use the bridge, abandoning the train ferries which have existed for years at this point. The highway crossing connects with existing highways in the south end of Vicksburg and with the Louisiana state highway system at Delta Point on the west bank.

As shown by Fig. 3, the main river crossing, 2,931 ft. long, consists of a cantilever structure about 1,665 ft. long and four truss spans of the dimensions shown by the illustration. The railroad approach on the Mississippi side is a single-track spur about 4,000 ft. long with heavy cuts and fills and a 160-ft. tunnel, followed by 300 ft. of steel trestle from the abutment to east pier No. 1. A separate steel trestle carrying the highway deck reaches this pier on a curve from the north. Thence a deck truss 180 ft. long extends out to the east anchor pier of the cantilever span. The Louisiana approach consists of a steel trestle 4,110 ft. long and a fill 3,600 ft. long. Creosoted pine piles were driven to carry the concrete pedestals of the steel trestle.

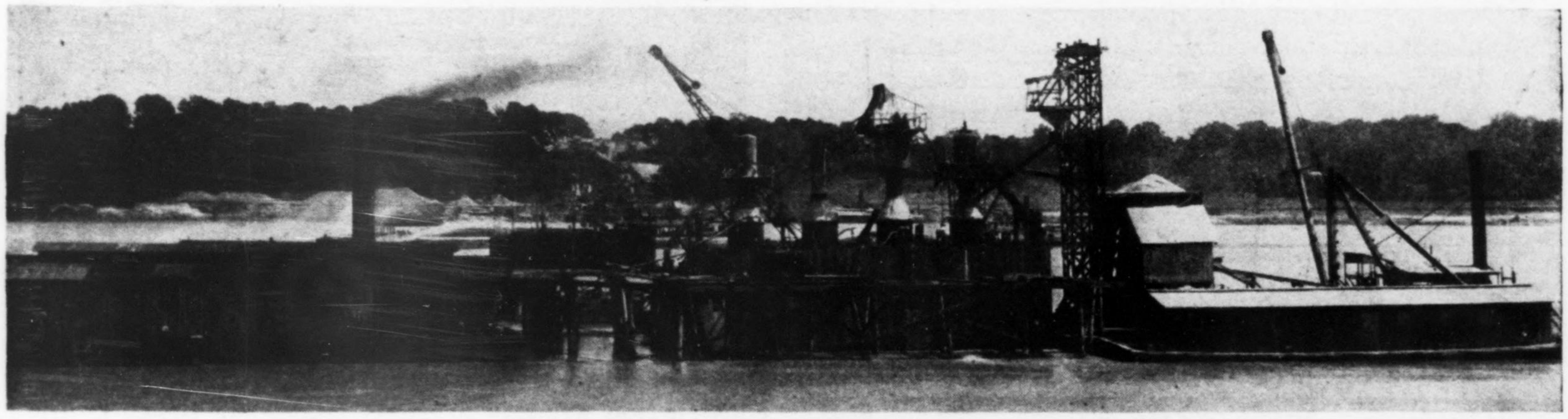

FIG. 1—SINKING CAISSON FOR PIER 6, VICKSBURG BRIDGE
Compressor boat shown at the left of the floating concrete plant and the sandhog house on the right of the caisson.

A cross-section of the floor is shown by Fig. 2. The highway deck consists of a reinforced-concrete slab 18 ft. wide and 6 in. thick, on a structural steel floor system. The railroad deck is open, with creosoted ties placed directly on longitudinal steel-girder stringers.

The substructure of the truss spans consists of eight piers, one on each bank and six in the river. The bank

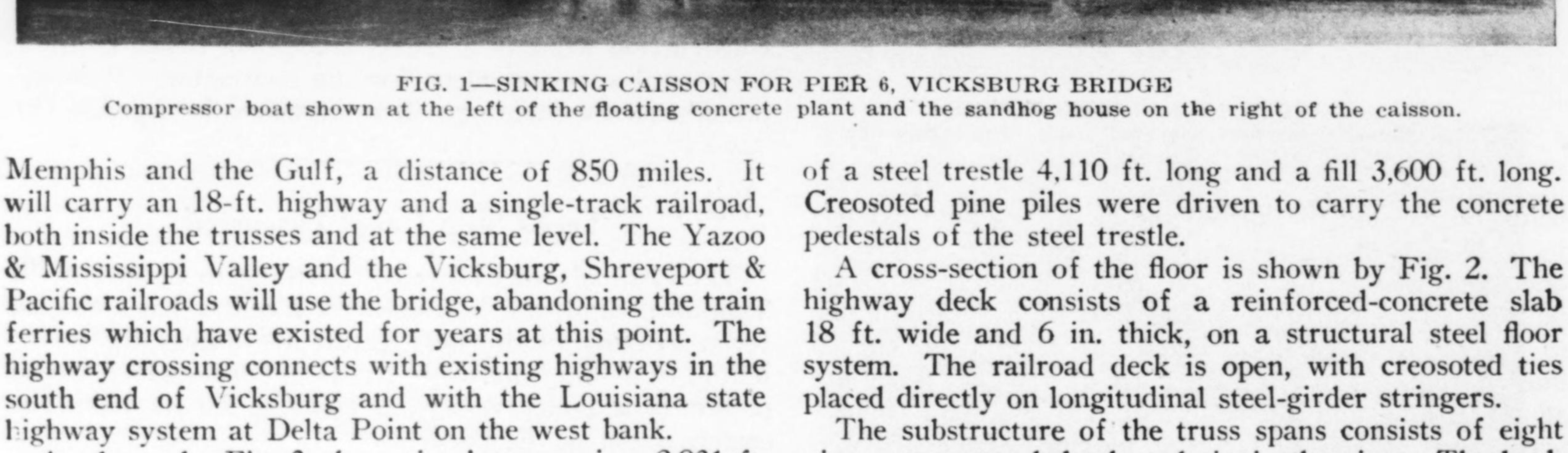


FIG. 2—CROSS-SECTION OF RAILROAD AND HIGHWAY DECKS

piers are carried on piling, the base of the west bank pier being 48 ft. below the ground line. The six river piers are founded on pneumatic caissons, their bases having the following dimensions: one 40x92 ft., one 40x80 ft., two 30x70 ft., one 28x68 ft. and one 25x67 ft. The bases are 50 ft. high topped by hollow shafts reaching in some cases to a height of 151 ft. Four of the pier foundations were carried 110 ft. below the average low-water stage. The foundation work required about 56,000 cu.yd. of concrete in the piers carrying the river span and about 10,000 cu.yd. of concrete in the approach trestle piers.

### *Construction Methods*

The Vicksburg bridge is a toll bridge financed by private capital, and early completion was of the utmost importance. Contracts were awarded in February, 1928, and completion was contemplated by the end of 1929. Although any schedule that is contingent on favorable conditions in the Mississippi River is problematical, it appears that the bridge will be completed by the scheduled time.

Progress was dependent on the completion of the deep river piers. The practical working stage of the river, 20 ft. on the Vicksburg gage, meant that 50 lb. of air pressure, the practical maximum for caisson work, would be required with the cutting edges at grade on the deep piers. River records showed that on the average 150 days could be expected in a season by starting work on a 25-ft. stage and reaching 20 ft. or less during the latter part of the 150 days. The schedule was made on this assumption.

Ordinarily the 20-ft. stage would be expected about July 15, although in some few years it had been reached in May. This meant that equipment and organization should be lined up ready for starting in May if low-water conditions developed at that time. The season of 1928 proved an exception. Because of unusual high water in July a working stage did not prevail until Aug. 10, and early high water in the fall cut down the expected 150-day working period to 105 days. This prevented the construction of pier No. 4 until this summer, as high water prevailed from late last fall until Aug. 1 of this year.

*Caisson Design*—The original plans contemplated the use of all-timber floating caissons. At the contractor's request these were changed to permit the use of steel caissons 20 ft. high surmounted by timber caissons 30 ft. high and a timber cofferdam. This design permitted quicker construction and launching of the caissons. Further advantages were that reinforced concrete and steel were used instead of timber in the sides and roof of the working chamber, providing a tighter structure which was desirable in work involving high air pressures, and allowed more room in the working chamber by eliminating the rods and braces required in timber construction.

In order to have them ready in the event of early low water, the caissons were built and launched as rapidly as possible and tied up afloat until needed. They drew about 7 ft. when launched; after launching, the walls of the working chamber were concreted, causing the structure to draw about 13 ft. The timber work was then started, and concreting followed in lifts of 3 to 4 ft., each foot in height of concrete increasing the draft about 2½ ft.

The timbering and concreting were continued until the caisson was just floating with its cutting edge close to the riverbed. After careful lining up, enough concrete was poured to land the structure on the bottom and to offset the buoyancy resulting from putting air on the working chamber.

*Landing the Caissons*—Two of the caissons were sunk in comparatively shallow water, using the customary pile dock or slip for holding and lining the structure while afloat. These docks consisted of a decked pile trestle open at the downstream end. Besides assisting in landing the caissons, the decks provided space for material and machinery.

A departure from the usual method of landing caissons, with a detachable cofferdam in which the shaft is built up after the caisson is landed and sealed, was necessary for the four deep piers. As the nature of the foundation material required that the weight of the piers be kept as low as possible, the caisson bases of the deep piers were only 50 ft. in height. In the deepest piers, when the cutting edge of the caisson reached final grade, there was more than 60 ft. of shaft of the finished pier poured. This required unusual care in handling and sinking so that when landed and sealed, the top of the shaft would be in accurate position. In the early stages of sinking, with practically no skin friction developed on the caisson, the heavy weight of the structure made handling difficult. Fig. 1 shows the sinking of the caissons for pier 6.

*Caisson Anchors*—Because of the swift current, special anchors were developed to assist in landing and sinking the caissons. One type consisted of a concrete mushroom about 7 ft. in diameter and 2½ ft. high built around a light steel framework having a vertical member 7 ft. long with a shackle at the end for fastening the anchor cable. These mushroom anchors weighed about 9 tons each and were very effective in sand bottoms. If necessary they could be readily jetted down into the sand for additional holding power.

Two of the caissons in the deepest water required a heavier anchor. These consisted of 16-in. H-beams from 18 to 30 ft. long, fitted with a shackle near the top for cable connections, driven into the river bottom nearly full length. The anchors were driven 600 ft. upstream from the piers in water up to 70 ft. in depth by using

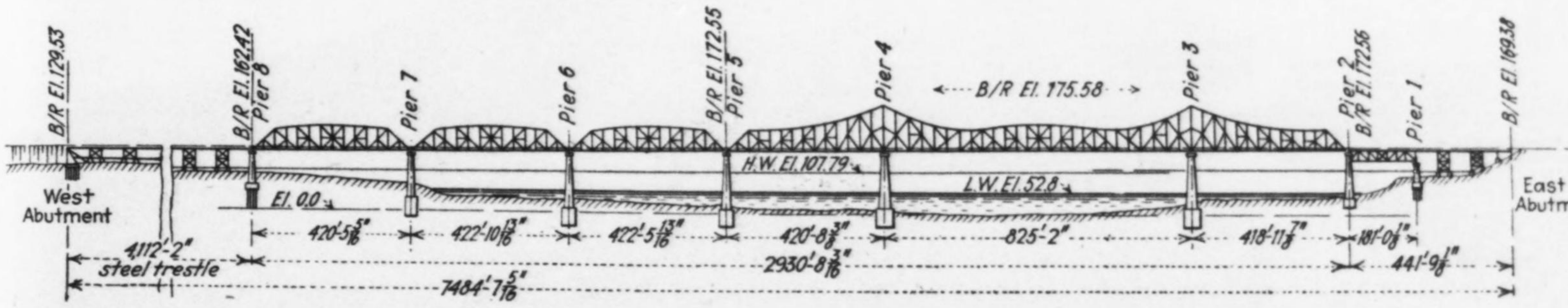

FIG. 3—GENERAL ELEVATION OF THE MISSISSIPPI RIVER BRIDGE AT VICKSBURG, MISS.

a special type of follower. Five of them were used for each caisson and they proved very effective, especially in hard material. Wire rope cables $1\frac{1}{2}$ and $1\frac{1}{4}$ in. in diameter were run from the pile anchors to an anchor barge placed midway between the anchors and caissons. On the barge, connection was made between the cables leading to the anchors and those going to the caisson by steel rope blocks and falls, which permitted control of the caissons in landing and sinking. The effective use of this anchorage system permitted the sinking of the deep piers without the use of a cofferdam or guide piles.

*Progress of Sinking*—In soft material the sand was removed from the working chamber by blowpipes. Hard material was removed by $\frac{2}{3}$-yd. buckets operating through the material locks.

Five caisson piers were completed in four months, four of which were in deep water and one of which went to a depth of 112.3 ft. below water. Pier 6 was sunk 80 ft. through sand in 22 working days. Pier 3, which is located on a reef of hard material, was sunk through 75 ft. of hardpan in 33 days. The last 17 ft. of pier 7 was sunk at the rate of $7\frac{1}{2}$ ft. per day, the material being all sand.

Despite the large number of sandhogs employed and the high air pressures used, there have been no fatal cases of the bends, or any case causing permanent disability.

The site of pier 7, above low-water line, permitted the use of an all-concrete caisson. The entire working chamber and sides were built of reinforced concrete and the caisson was sunk for the first 50 ft. by open dredging, after which the pneumatic method was used.

*Caisson Used as a Diving Bell*—Before landing the caisson of pier 3, it was necessary to use the caisson as a diving bell to level up the site. This pier, which carries the east end of the cantilever span, is located on a reef, part of which is soft rock and the remainder a very hard clay. At low-water stage there were 30 ft. of water and a fairly swift current in the river. In the 40-ft. width of this caisson the reef had a slope of about 7 ft. toward the channel. The riverbed was very irregular and the material was too hard to dig with a dredging bucket to level off the site for landing the caisson. Time did not permit of rigging up a submarine drilling and blasting outfit to level off the bottom. Therefore the caisson itself was used as a diving bell.

Derrick stones were dumped into the low places and the caisson was towed into place and concreted until its shoe floated just clear of the riverbed. Sandbags were deposited around the outside and the caisson was flooded with enough water to overcome the buoyancy developed by the air pressure. Air was put on and sandhogs worked inside, leveling up the bottom and removing obstructions. After the river bottom was leveled, the air was taken off, the water ballast pumped out and the caisson floated. Concreting was then resumed, the caisson being guyed accurately to position and sunk in the same manner as for the other piers.

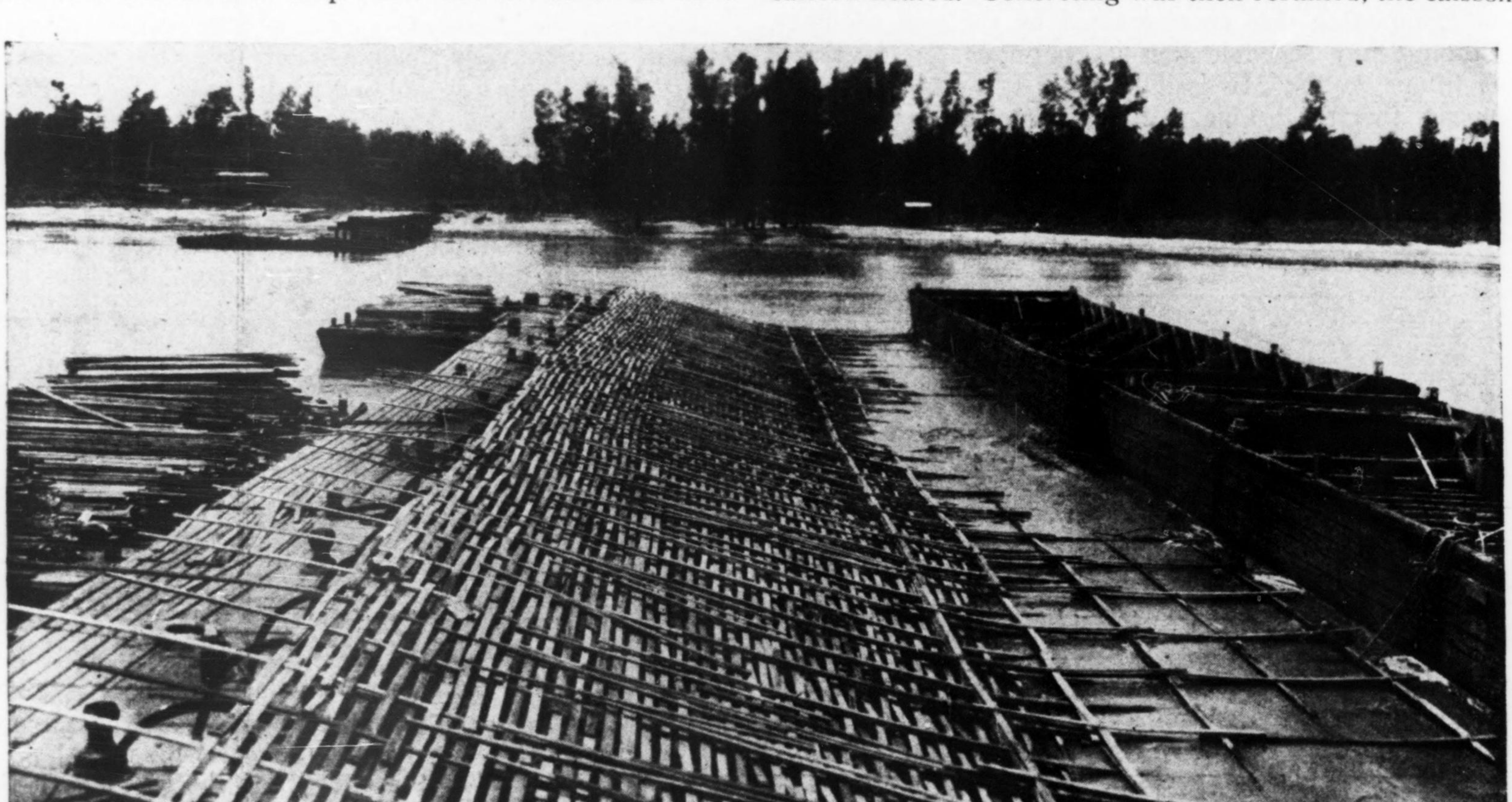

FIG. 4—WEAVING ONE OF THE TIMBER MATS PLACED TO PREVENT SCOUR

*Lumber Mats Prevent Scour*—To prevent scour at the three piers located on sand, the plans provided for placing either lumber or willow mats to be constructed according to the U. S. Engineers' standard specifications. Lumber mats were used, woven of 1x4-in. boards, and were sunk by weighting with one-man stones. The mats were 400 ft. long and 250 ft. wide and centered with the piers. They were constructed on barges at the pier sites as shown in Fig. 4.

### Plant and Organization

Because of the short working season, it was necessary to have enough equipment and men to work simultaneously on two of the deep river piers, the shore piers, the approaches and topping out the river piers as the foundations were completed. This required about twice the amount of plant that would ordinarily have been used on such a job. Three steam-operated compressor boats were used for supplying air to the caissons, two on steel barges. These floating plants had 3,000 cu.ft.

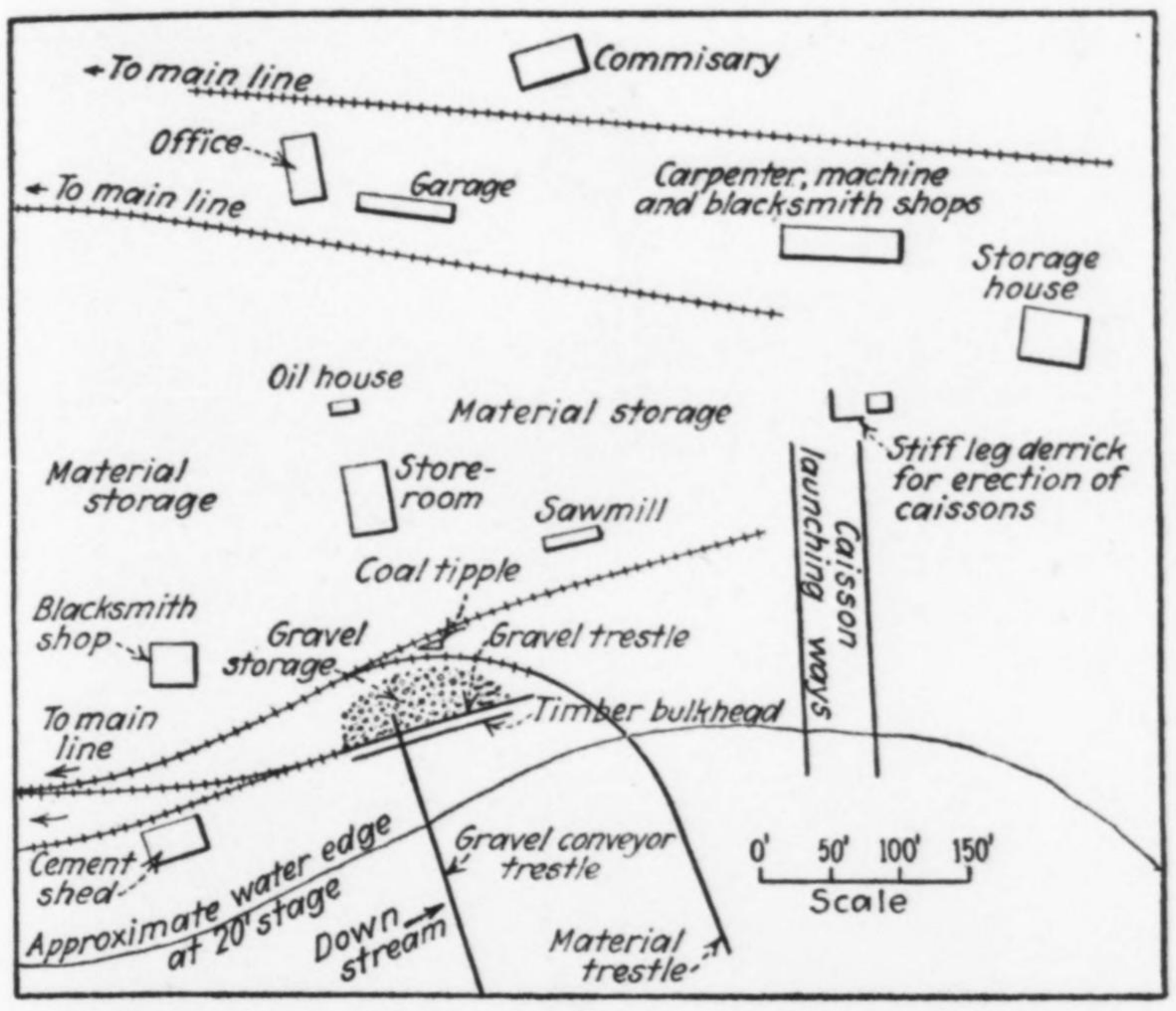


FIG. 5—MAP OF THE CENTRAL PLANT LAYOUT ON THE VICKSBURG SIDE

per minute capacity. Derrick boats with 75-ft. boom revolving steam cranes were used in place of the usual stiff-leg derrick mounted on barges. These proved very satisfactory because of the stabilizing influence of the counterweights in all positions of the boom. Also these cranes could be quickly fitted for work on land when needed. Two floating concrete plants were used, one of $1\frac{1}{2}$-cu.yd. and the other of 1-cu.yd. capacity. Both plants were equipped with storage bins loaded by a stiff-leg derrick handling materials from barges alongside. Each floating plant had a hoist tower, one being 125 ft. high, for use in topping out the piers. A complete fleet required for building one pier is shown in Fig. 1.

A locomotive crane was used in the yard work, three crawler cranes on the approach work and in material handling, and three revolving cranes on wide-gage track, two with 85-ft. booms, were used on the shore piers for land piledriving, and when needed were run onto barges to supplement the derrick boats. A large fleet of barges was available for handling sand, gravel, cement, coal, timber and piles. Steel barges were used in most cases. Most of the equipment was designed and developed especially for this job.

During the peak of operations, more than 700 men were employed, 300 of them being sandhogs. A system of ferry transportation was operated between the base yard and all portions of the work for the distribution of the men. Gasoline-operated boats carrying 40 men each were on a definite schedule 24 hours a day. Despite the frequent changing of shifts, especially of the caisson workers, the men were handled without confusion or loss of time.

*Central Base and Material Yards*—Convenient railroad facilities were obtained on the Mississippi side about a mile above the bridge site, where a central base and material yard (Fig. 5) was established. Separate yard tracks were built to handle each class of material. A trestle carried one track out into the river as a dock, permitting easy transfer of material from cars to barges. Gravel was dumped from a trestle permitting storage of 1,200 cu.yd. Under the stockpile a short tunnel was built through which a belt conveyor operated to a dock, where the belt discharged directly into barges. At one end of the yard were the launching ways for the steel caissons. The base yard also contained offices, storehouse, sawmill, carpenter shop, machine shop and blacksmith shop.

A separate plant layout was built on the Louisana side for the construction of the long approach trestle. A light pile dock out in the river was connected to the shore by a trestle carrying a narrow-gage railroad track. This track continued inland along the center line of the trestle piers, and all material and concrete were handled over this railway. Concrete was furnished by one of the two mixer plants used for the river piers. From the floating plant the concrete was chuted into 1-yd. bottom-dump buckets set on flat cars. The cars were hauled along the track to the site of operations and the dump buckets were handled directly to the forms by crawler cranes. The foundation piles for the approach piers were driven with swinging leads handled by a wide-gage revolving crane carrying an 85-ft. boom.

### *Contractors and Personnel*

The bridge is being constructed for the Vicksburg Bridge & Terminal Company, Harry E. Bovay, president, as a toll bridge. The total cost will be about $7,000,000. The design was made by Harrington, Howard & Ash, consulting engineers, Kansas City, Mo., who are also supervising the construction. P. V. Pennybacker is resident engineer for the consultants. The American Bridge Company is contractor for the steelwork of the river spans and east approach, and the Virginia Bridge & Iron Company furnished and erected the steel for the west approach trestle. J. A. Kreis & Sons Company is contractor on the tunnel and grading work. The U.G.I. Contracting Company, of Philadelphia, a division of the United Engineers & Constructors, Inc., is contractor for the river piers and Louisiana approach substructure. Woods Brothers Construction Company, of Lincoln, Neb., built the channel mats, and the St. Louis Structural Steel Company designed and built the floating steel caissons, both acting as subcontractors to the U.G.I. company, for which F. S. Harvey is field supervising engineer, with the author as superintendent and John R. Flick and James J. Dennedy as assistants.

FIG. 6—RIVER PIERS COMPLETE EXCEPT PIER 4