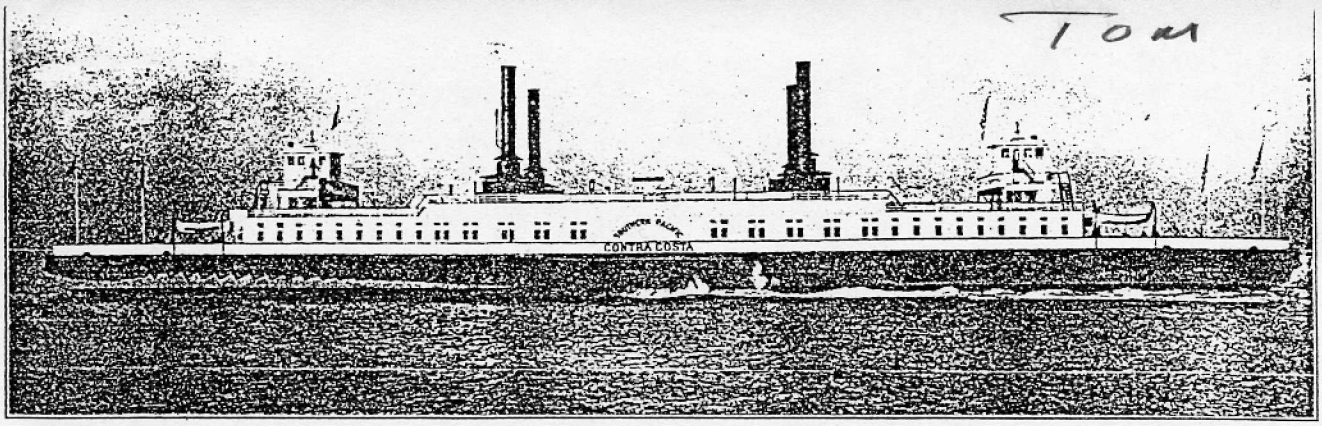

Fig. 1.—The *Contra Costa* on Her Trial Trip

Side-Wheel Car Ferry Contra Costa

Details of Design and Construction of Largest Side-Wheel Train Ferry in the World

BY EDWARD W. OLIN

The Southern Pacific Railroad Company recently placed in service the new side-wheel car ferry steamer *Contra Costa*, which is probably the largest car ferry of her type in the world. She was especially designed to carry freight and passenger trains across the Carquinez Straits between Port Costa and Benicia, Cal., which lie on the company's trans-continental lines.

The steamer is of the following dimensions:

Length overall	433 feet	4 inches
Length over transoms	420 feet	
Width over guards	116 feet	
Beam, molded	66 feet	6 inches
Depth, molded	19 feet	5 inches
Light draft	5 feet	10 inches
Light displacement	3,400 tons	

While a brief description of the *Contra Costa* appeared in the November issue of INTERNATIONAL MARINE ENGINEERING, it is the intention of this article to give a more detailed account of her design and construction, as several inquiries concerning her have already been made, testifying to a more than local interest in this boat.

The boat is constructed entirely of Oregon pine at an approximate cost of $400,000 (£82,500) and is to relieve the old steamer *Solano*, which has been in almost continuous service since 1879. Until the completion of the *Contra Costa* the *Solano* was regarded as the largest car ferry in the world, being exceeded in length by the new ferry by only 13 feet.

The service for which she is intended is unusually severe, making an average of 46 trips with trains every 24 hours. No especial rules are observed in loading or unloading trains other than to load the first train on the

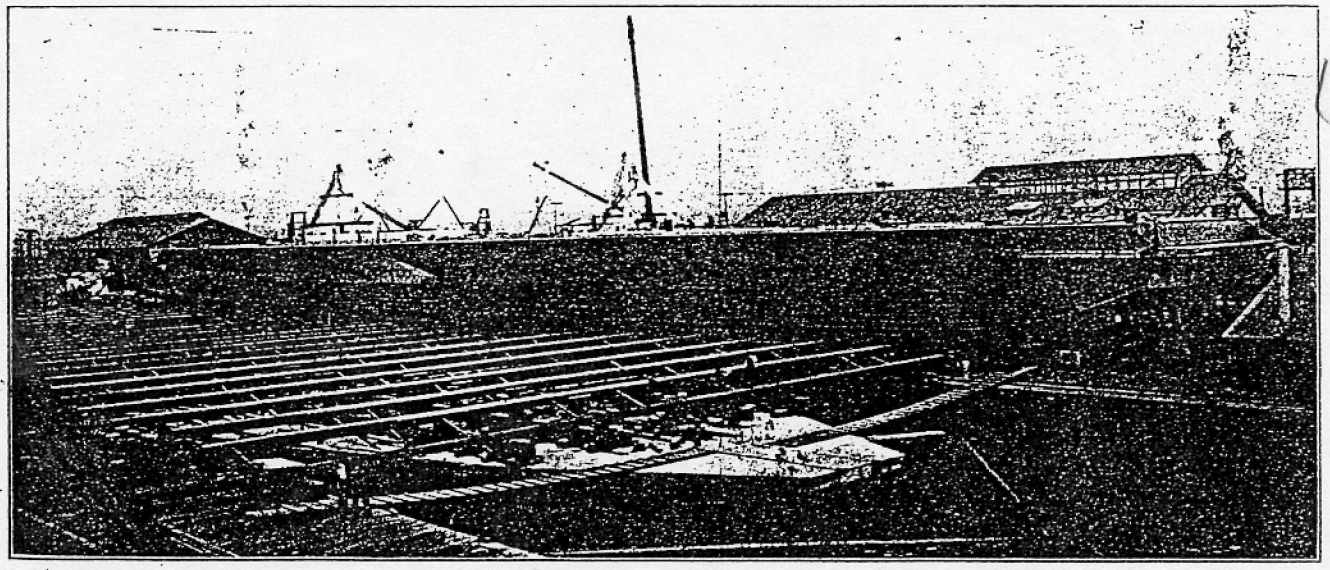

Fig. 2.—The *Contra Costa* Ready for Launching

Note that the boat is side hauled about 100 feet into a Crandall marine railway from which she was launched. Nineteen minutes were required to side haul the boat.

inside tracks. It is usual, in the case of long trains, for the locomotive to pull her train aboard after breaking the train in the several units, while a switch engine fills up the other tracks and goes across with the cargo. It is no uncommon sight to see the heavy locomotives stand on diagonally opposite corners, thereby subjecting the hull to very severe twisting strains. As the boat is operated in connection with the regular train schedules it is obvious that absolute reliability is a most essential factor, and any delay in the operation of the boat means a readjustment of the time-tables with its attending confusion. No expense was therefore spared in the equipment of engines, boilers and auxiliaries, all of which are designed with plenty of reserve power.

The Carquinez Straits is a narrow strip of water, one mile wide, connecting the San Pablo and Suisun Bays. There is a rise and fall of tide of 10 feet, while the ebb and flow of the tide create a current of 7 miles per hour. The trip across is made in 8 minutes, which includes making the boat fast in the slips and to the aprons.

Four tracks, 12-foot centers, extend the full length of the deck, giving a total of 1,680 feet of track, which is

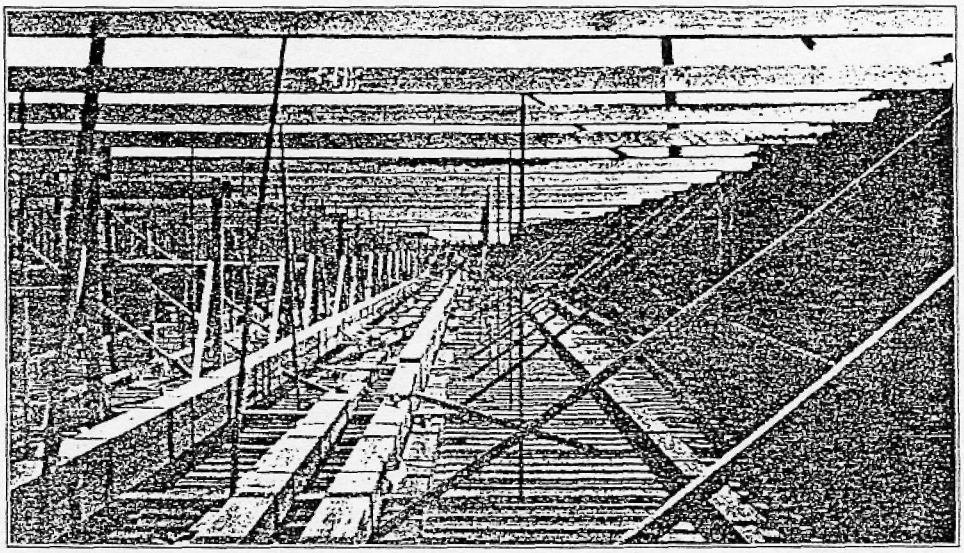

Fig. 3.—Inside View from One End of Hull, Looking Fore and Aft

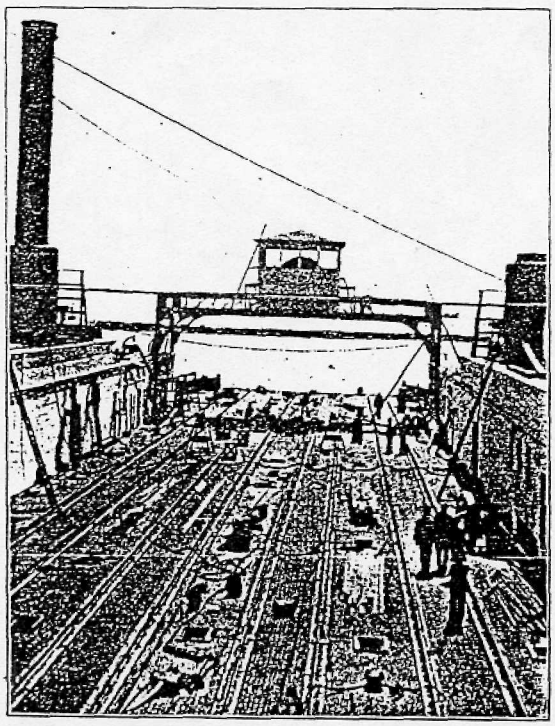

Fig. 4.—View of Main Deck, Showing Railway Tracks Spaced 12 Feet Between Centers

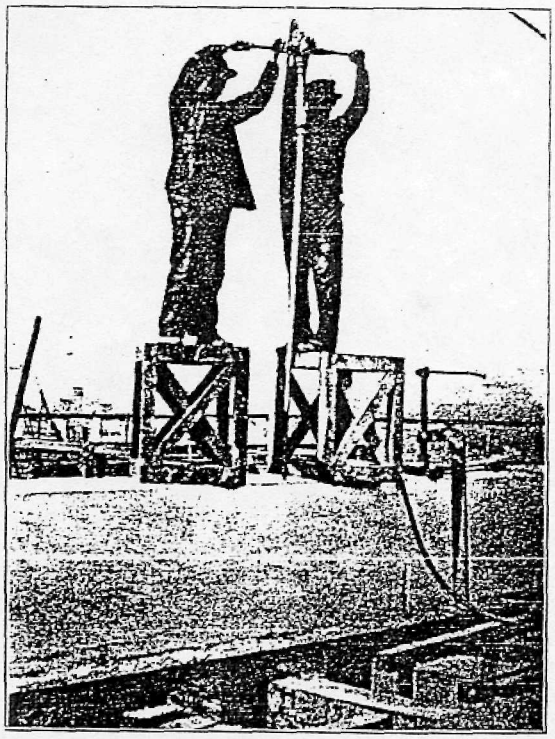

Fig. 5.—Driving a 1⅛-Inch Diameter Drift Bolt 7 Feet Long Through 26-Inch Waterway

entirely unobstructed by hog posts, hog chains or masts, giving a very clear and open deck. A pilot house is

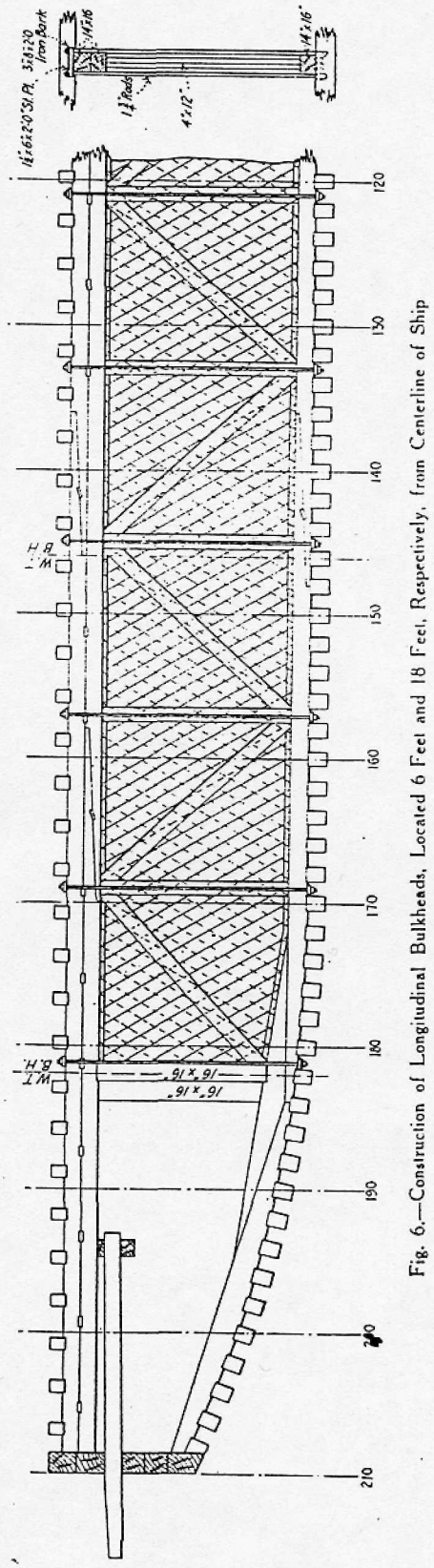

Fig. 6.—Construction of Longitudinal Bulkheads, Located 6 Feet and 18 Feet, Respectively, from Centerline of Ship

located on a steel bridge on each end of the boat. The superstructure extends 275 feet fore and aft on each side of the boat and encloses all the boilers, engineers' stands and operating platform; a restaurant and galley; a bar; a ladies' lavatory and waiting room; a men's lavatory and waiting room; a carpenter shop and ship stores, and the usual accommodations for the officers and crew, besides a waiting room and office for the accommodations of the train crew.

When fully loaded the *Contra Costa* will accommodate 36 freight cars and 2 locomotives, or 17 standard Pullman passenger coaches and 3 locomotives.

HULL CONSTRUCTION

As may be expected, the lines are similar to those of an ordinary barge; the sides are vertical, fairing in from 66 feet 6 inches beam amidships to 46 feet at the transoms,

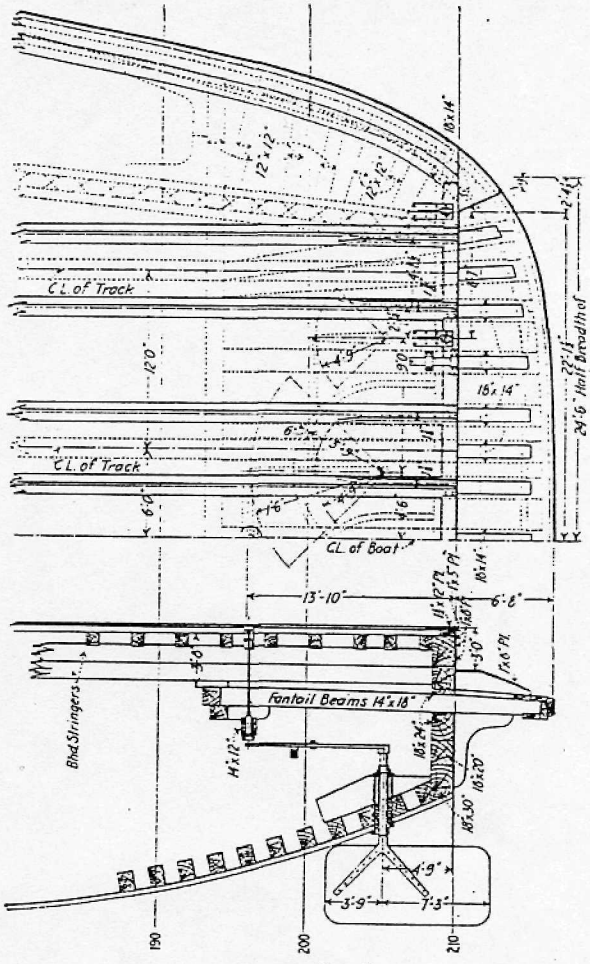

Fig. 7.—Fantail

with an 8½-foot rise of keel on each end, commencing about 35 feet from the transoms.

More than 2,000,000 feet of lumber were used in the construction of the hull alone and about 105 tons of galvanized iron fastenings. Some of the largest timbers in the boat were the six wheel beams, each of which is 18 inches by 18 inches by 116 feet long; two spring beams, each 26 inches by 36 inches by 66 feet long, and the timbers of the knuckle keelsons, which are 22 inches by 24 inches by 60 feet long.

The ordinary deck beams are 10 inches by 12 inches spaced 36-inch centers throughout and extend in one piece from guard to guard. The top timbers are 12 inches by 12 inches spaced 24 inches throughout, and the floor timbers 12 inches by 16 inches in one continuous length spaced 24-inch centers and fastened at the knuckle to the top timbers, which are notched 4 inches over the

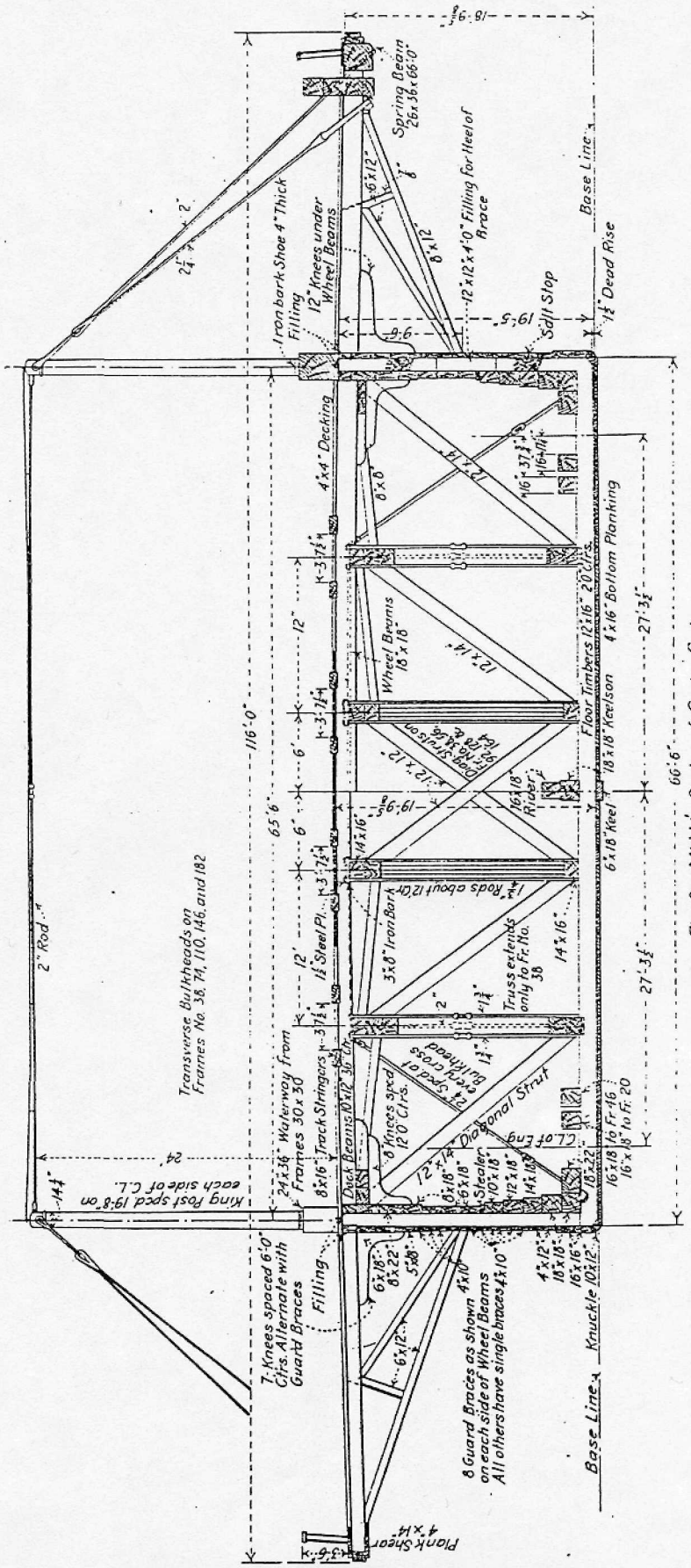

Fig. 8.—Midship Section of Conlra Costa

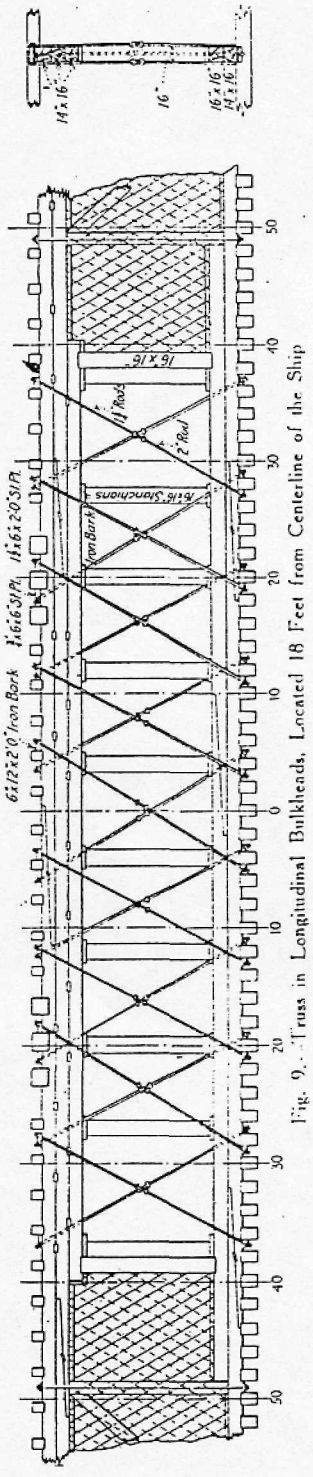

Fig. 9.—Truss in Longitudinal Bulkheads, Located 18 Feet from Centerline of the Ship

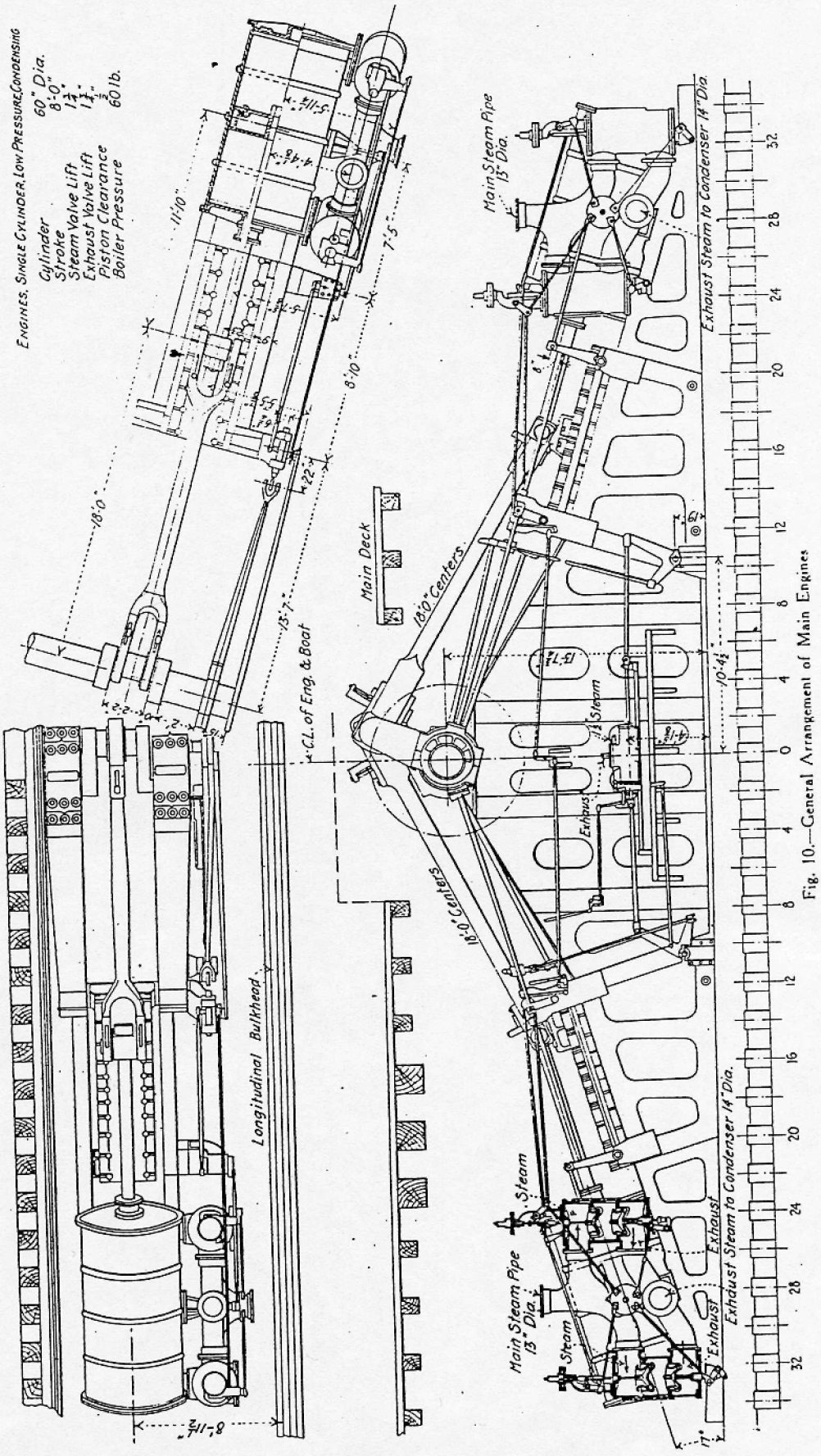

Fig. 10.—General Arrangement of Main Engines

floors and bolted together with two ⅞-inch bolts. The center keelson is 18 inches by 18 inches in lengths varying from 50 to 80 feet and is stiffened by a rider keelson 16 inches by 18 inches in lengths to break the scarphs of the center keelsons. The center keelsons are notched over the floor timbers 1 inch deep; the scarphs are 12 feet long with 4-inch nibs. Four fore and aft bulkheads extend from collision bulkhead to collision bulkhead, being spaced 12-foot centers and centering on the track centerlines. The hull is further subdivided into 11 watertight compartments by 10 cross bulkheads.

CEILING

The ceiling represents some of the largest timbers in the boat and runs in diminishing sizes from the knuckle keelsons, which are 18 inches by 22 inches and 22 inches by 24 inches, varying in lengths from 60 to 80 feet to the two clamp strakes, 8 inches by 22 inches, under the deck beams. The ceiling is really the backbone of the hull and is a network of steel fastening running up and down, and through from the sides securing the heavy ceiling timbers to the top timbers and floors and to each other. The edge fastening is driven through the lower ceiling timbers and riveted over clinch rings on the outside of the floor timbers, but in the upper strakes the edge bolts are driven through three of the lower strakes and staggered at intervals of 3 feet. All fastenings in the lower heavier strakes are 1⅛-inches diameter, but in the upper lighter strakes the fastenings are reduced to 1-inch diameter. All drift bolts were driven and clinched with a Boyer air hammer, the holes being drilled 1/16 inch smaller than the bolt.

All scarphs in the ceiling were 12 feet long with 4-inch nibs and each fitted with two flat laurel keys 2 inches by 8 inches wide driven through the joint, instead of relying entirely on the steel edge fastening. The seams in the upper five strakes of ceiling have 2-inch by 8-inch flat laurel keys driven at about 8-foot centers.

As a means of preserving or "pickling" the lumber, two rows of salt stops are fitted between the top timbers in the space between the ceiling and outside planking and packed with 36 inches of "Liverpool" rock salt. About 80 tons of salt were used for this purpose.

PLANKING

The bottom planking is 4 inches by 16 inches fastened to floor timbers with three 7 16-inch by 7-inch spikes and one 1¼-inch diameter locust treenail, which is driven through each floor timber and wedged on both ends. All butts have composition spikes fastening.

The side planking consists of two strakes of 6-inch by 16-inch plank at the knuckle, but as it would be impractical to fasten through the knuckle keelson with treenails on account of the extreme lengths, short locust treenails were resorted to and wedged on the outside in the usual manner. The rest of the planking is 4 inches by 10 inches, and besides having the regular spike fastening is treenailed through the top timbers and ceiling with 1¼-inch diameter treenails, being in some cases 36 inches long. All treenails were driven with an air hammer. The sheer strakes consist of two strakes of 6 inches by 18 inches and one 5 inches by 18 inches, varying in lengths from 50 to 80 feet, and are bolted through top timbers and clamp strakes with 1-inch threaded bolts having flat, oval heads.

The guard, which extends around the hull of the ship, is of a rigid construction, the deck beams, as before mentioned, extending through the hull in one continuous piece. On the outside of the hull each alternate deck beam is fastened to the outside planking and sheer strake with 7-inch knees, which are fitted in place and dirft bolted through the planking, top timbers and ceiling. On the inside of the hull 8-inch knees are hung and fitted to the the deck beams at 12-foot intervals, being fastened to the same deck beams as the outside knees and taking the same fastening. The outer ends of the deck beams are covered with a 6-inch by 14½-inch Oregon pine facia, to which is fastened the regular 4-inch by 14-inch iron bark fender. Two strakes of 4-inch by 14-inch covering board on the top and bottom cover the ends of the deck beams. Filling blocks are fitted and fastened between the deck beams at the gunwale, as well as at the ends of the beams.

Each end of the boat has an apron pit 50 inches deep built into the transom, consisting of 14-inch by 18-inch timbers radiating from a common fantail beam located inside the hull and somewhat below the regular deck beams. This part of the boat is of particularly rigid construction, as it receives all the heavy pounding of locomotives and trains running on and off the boat. The bottom transom timber is 18 inches by 30 inches by 46 feet long, while the others are 18 inches by 24 inches. All stringers, keelsons, ceiling and fantail beams terminate at or are fastened to the transom with 1¼-inch diameter drift bolts through 10-inch, 14-inch and 16-inch knees. The outside of the transom, as well as around the nose of the boat, is pretty well covered with 1-inch by 8-inch steel plates to protect the wood from being marred by chafing against the heavy steel aprons.

RAILWAY TRACKS

The track stringers are of 8-inch by 16-inch Oregon pine notched 1½ inches over each deck beam and extend from transom to transom. To these stringers is fastened the 90-pound R.A. rail, which rests on 7 16-inch tie plates in much the same manner as in land practice. Tee-headed lag screws ¾-inch diameter are used to bolt the rails down, about 10,000 being used for this purpose. The tracks terminate on a 1½-inch by 12-inch steel plate which rests on 5-inch of iron bark 14 inches wide, which protects the softer wood in the transom timbers from the severe pounding of the trains. At the end of each track are two bumper blocks, which comprise a very simple though effective arrangement, consisting of 10-inch square Oregon pine blocks anchored across the rails and held in place by a steel collar and chains made fast to the eyebolts in the deck. To clear the tracks the deckhand slips the collar off the blocks and rolls it aside.

The seams of the bottom and sides as far up as the waterlines were calked with four threads of oakum and then cemented, the heavier strakes receiving 5 threads. Seams in the wake of the paddle wheel were puttied. Decking was calked with two threads with the intention of adding two more threads in a year or so after all fastening has pulled itself tight.

As may be expected, all the lumber was furnished under a very rigid set of specifications and considerable difficulty was experienced in procuring first-class ship's lumber of the quantity and dimensions required. The lumber was furnished by the Tacoma & Eastern Lumber Company, the Eastern and Western Lumber Company, of Washington, and the C. R. McCormick Lumber Company, of Oregon, and was, in the opinion of experts, very fine material.

While it is possible to design a more modern gear for controlling the rudders, the arrangement finally adopted can best be appreciated when the condition under which the boat operates is considered. As the straits across

which the boat operates is very narrow the tide runs like a millrace which is ever threatening to carry the boat towards the submerged rocks that line the shore. When this happens the rudders are sheered off like so much brush, and as it is almost impossible to tie up for more than a couple of hours at a time, some simple, efficient and inexpensive gear must be designed that can be replaced within a very limited time. There are four rudders at each end of the boat made of 4-inch Oregon pine planks with 5-inch diameter forged steel rudder stocks. The rudder stocks are shipped up through a bored cast iron sleeve, which is built into the hull, and are suspended from the top of this sleeve by a split clamp or collar fitted into a turned recess near the top of the rudder stock. To renew a rudder all that is necessary is to remove the tiller arm and split collar and let the disabled rudder and rudder stock drop overboard. A new rudder is then shipped up through the rudder stock sleeve and the split collar and tiller arm put on again, all of which can be done in 30 minutes.

STEERING ENGINES

Hydraulic power is used for operating the steering engines, being supplied at 250 pounds pressure by two Knowles special 16-inch by 6-inch by 18-inch duplex pumps, one of which is a spare pump. The steering engine proper consists of an 8-inch single-acting cylinder with the usual leather cups, hydraulic piston packing, and is controlled from the pilot house by a horizontal lever directly connected to a 2-inch fourway plug cock. Fresh water is used, a 7,800-gallon tank being furnished for this purpose. The discharge is led back to this tank.

The boat also supplies the power that lowers the aprons in the slips, connections being made with the hydraulic line from the steering engine, which terminate in valve connections at each end of the boat and which are readily connected to a flexible line from the cylinders on the aprons operating them.

The aprons are heavy steel structures having four tracks, 12-foot centers, the same as the boat. They are 104 feet long, the shore end hinged and the other end floated on a pontoon 45 feet long, 25 feet wide by 11 feet deep. When not used the apron is always up, and to lower it requires but a clamp coupling and the turning of a valve, which is done by the deck hands on the boat and requires no attendant on the aprons whatever.

PROPELLING MACHINERY

The main engines operate independent paddle wheels on each side of the boat, each operated by a two-cylinder simple jet condensing engine 60 inches diameter by 8 feet stroke developing 3,000 indicated horsepower at 20 revolutions per minute with 60 pounds boiler pressure.

The cylinders are arranged one on each side of the wheel shaft, the line of motion being inclined 17 degrees with the horizontal. The connecting rods are 18-foot centers with strap gib and key ends; both rods connect with the same crank pin, one of the rods being forked for this purpose.

The valves are of the balanced poppet type, operated by a Corliss valve gear. The steam valves are controlled by an auxiliary cut-off of the releasing hook type, with an air-cushion dash pot on the top of the valve stem to prevent slamming of valves.

The reversing engine has a 9-inch cylinder 30-inch stroke and is located between the two reversing links. The connections are so arranged that when the engines are reversed one link is lowered and the other raised, thus taking advantage of balancing weights.

Although the engines and auxiliaries are located below the main deck, complete control is obtained from the engineers' stand on the main deck.

The engines, including the handling gear and condensers, were built at the Southern Pacific Company's railroad shops at Sacramento, Cal.

BOILERS

There are eight Scotch dry back boilers 11 feet diameter by 13 feet long, in 4 units of two boilers each, with a total heating surface of 16,688 square feet. Each unit has a steam chimney superheater 94 inches outside diameter by 15 feet 6 inches long, with a corrugated flue 54 inches inside diameter. Each boiler has 276 3½-inch tubes and two Morison corrugated suspension furnaces

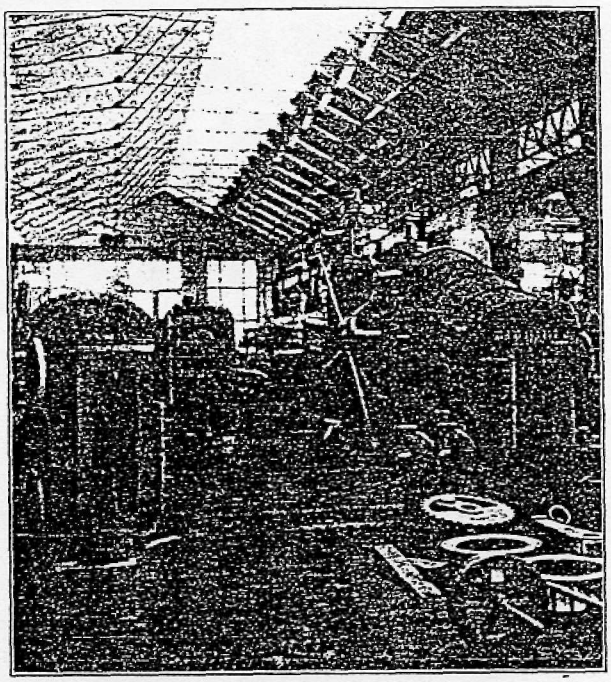

Fig. 11.—View of Main Engines, Being Assembled in the Southern Pacific Company's Shop at Sacramento

48 inches inside diameter. All boilers are located on the main deck on the guard nearly centering on the gunwale line, the two units on the same side of the boat being connected by a 19-inch main steam pipe; and as the boilers are about 100 feet apart the pipe line is made very flexible by swivel elbows at each boiler unit, which takes up all expansion and allows for all sagging or hogging to which the hull may be subjected without injury to the steam line. The boilers are equipped with a steam-atomizing oil-burner system, using a G. E. Witt burner.

AUXILIARIES

The auxiliary equipment is very complete, consisting of 27 pumps, as follows:

Four 16-inch by 32-inch by 21-inch vertical single-acting twin beam air pumps.

Four 10-inch by 7-inch by 10-inch vertical duplex boiler feed pumps.

One 10-inch by 7-inch by 10-inch vertical duplex locomotive filling pump.

Four 6-inch by 4-inch by 6-inch vertical duplex oil pumps.

Eight 4½-inch by 2¾-inch by 4-inch vertical duplex boiler circulating pumps.

Two 14-inch by 8½-inch by 12-inch vertical duplex bilge pumps.

Two 14-inch by 8-inch by 12-inch horizontal duplex deck fire pumps.

Two 16-inch by 6-inch by 18-inch horizontal duplex steering engine pumps.

It is to be understood that the main engine, boilers and auxiliaries are in duplicate on each side of the boat—that is, each side of the boat has an entire independent steam plant. The air pumps are located on each side of a jet condenser and are of such size that either can maintain a vacuum of 19 inches, if for any reason one of the pumps should become disabled.

As the injection water is forced in by atmospheric pressure a 5-inch Dean vacuum breaker has been attached to the condenser to prevent the flooding of the condenser and endangering the engines, should both air pumps for any reason stop at the same time. The air pumps are controlled from the engineer's stand on the main deck. To simplify the piping the air pump discharges into a hotwell or "dump," consisting of a cast iron well 28 inches diameter and 9 feet high with a 12-inch outlet to the bottom of the boat. Although the boiler feed pumps are located in the hold complete control of them is obtained from the fireroom by manipulating the boiler check, the pumps being regulated by a Williams pressure regulator controlling the steam to the pumps by the pressure in the discharge line.

Each boiler is fitted with an independent boiler circulating pump, which is also connected to suction line of the inspirators and can thus be used as an auxiliary boiler feed. Each boiler has also a No. 50 stationary type Hancock inspirator.

The exhaust steam from the auxiliaries is utilized for heating the feed water, a Wainwright corrugated tube feed water heater being used for this purpose.

Fresh water for the galley and general purposes is supplied by gravity from two 2,000-gallon tanks located on the top of the superstructure.

Paddle Wheels

The paddle wheels are of the radial type, each with four cast steel wheel flanges of very light design keyed to a 20-inch diameter wheel shaft. The wheel is 28 feet diameter over buckets and has 3-foot, 4-inch dip when light-loaded. There are 20 buckets 3¾ inches by 28 inches wide by 16 feet long, which are bolted to the wheel arms with four ¾-inch stirrups. The arms are 4 inches by 15¾ inches of Oregon pine.

Current for all electrical requirements is furnished by two 25-kilowatt turbine generating sets located on the main deck. There is a 13-inch General Electric searchlight projector for each pilot house and the usual side lights, which are worked directly from the telltale board in the pilot house.

The main deck is illuminated with 20 vapor-proof 13-inch Crouse-Hinds Company reflectors. Six of these lights nearest the pilot house at either end are under the control of the pilot house.

The electric fixtures in the restaurant, bar and waiting rooms are equipped with XE Holophane reflectors. The engine and boiler rooms are equipped with vapor-proof conduits. Each of these rooms is wired in two circuits, the lights for the general lighting being alternated. At the steam gages and water glasses there are lights from each circuit, so that in case of a fuse blowing out in one circuit there will always be a light at these important points.

The compartments below deck, of which there are 45, are lighted by lamps placed in vapor-proof globes and in such compartments as have valves, steering gear, rudders, etc., there are watertight plug boxes. The engine and boiler rooms also have watertight plug boxes, which arrangement is such as to permit a number of portable lights.

There are four telephones, connected in multiple, from the pilot house to the engine rooms, also an electric call-bell system from pilot house to pilot house. There are also electric return calls for filling oil tanks for the purpose of signaling the attendant at the oil filling valves. Bell signals are always exchanged before filling the oil tanks to ascertain if everything is working properly, as the tanks might be flooded if bells should fail. There is also a push button at the side of the house at each quarter of the boat for man-overboard signals.

The electric fire-alarm system consists of 12-inch Faraday electric gongs in each engine room and directly under each pilot house. All wiring on this boat conforms to the National Electric Code standard rules.

Interior Views of the Great Northern

Passenger Accommodations of the Luxurious Steamers of the Great Northern Pacific Steamship Company

Supplementing the illustrated description of the design and construction of the 23-knot turbine-driven steamships *Great Northern* and *Northern Pacific*, published in our December, 1914, issue, we are now able, through the courtesy of the Great Northern Pacific Steamship Company, to publish in the following pages several views of the passenger accommodations of these magnificent vessels.

The *Great Northern* and *Northern Pacific* are sister ships, differing only in minor details. They were built by the William Cramp & Sons Ship & Engine Building Company, Philadelphia, Pa., and classed A-100 in accordance with the rules of British Lloyd's and also equipped to pass the laws now in force by the United States Steamboat Inspection Service. To recapitulate, the main particulars are: Length overall, 524 feet; length between perpendiculars, 500 feet; beam, 63 feet; depth, molded to A deck, 50 feet 8 inches; draft, full load, 21 feet; deadweight carrying capacity, 2,185 tons; shaft horsepower, 25,000; speed, 23 knots; passengers, first class 550, second class 108, third class 198; total passengers, 856; crew, 198; total number of persons on board, 1,054; gross tonnage, 8,255.

Few modern passenger ships of the same tonnage and type can boast of more commodious promenade decks or of more tastefully decorated or conveniently arranged public and private rooms. As can be seen from the photographs published in this issue, and from the plans previously published, these vessels are in every respect entitled to the popular designation of "floating palaces."

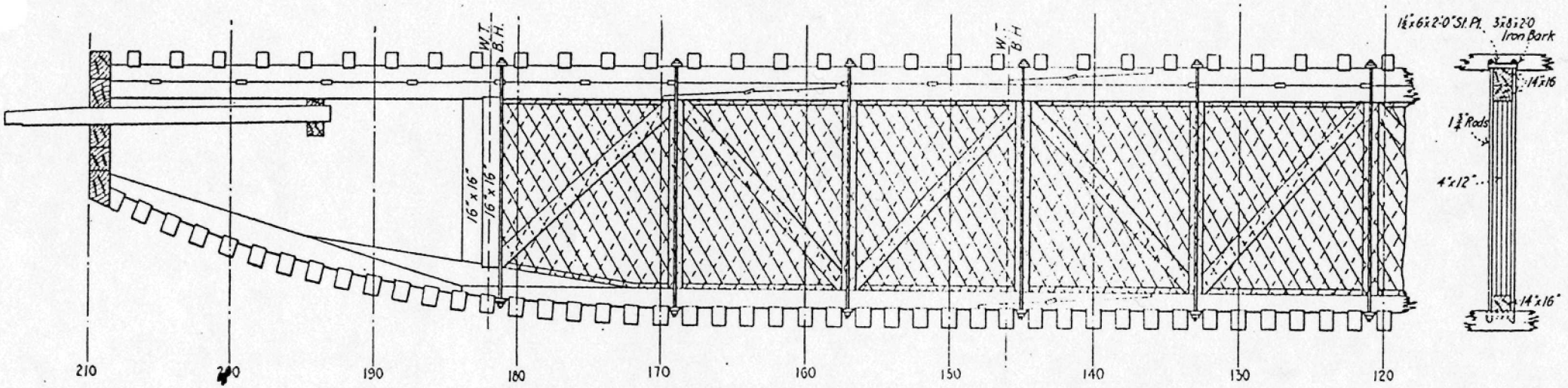

Fig. 6.—Construction of Longitudinal Bulkheads, Located 6 Feet and 18 Feet, Respectively, from Centerline of Ship

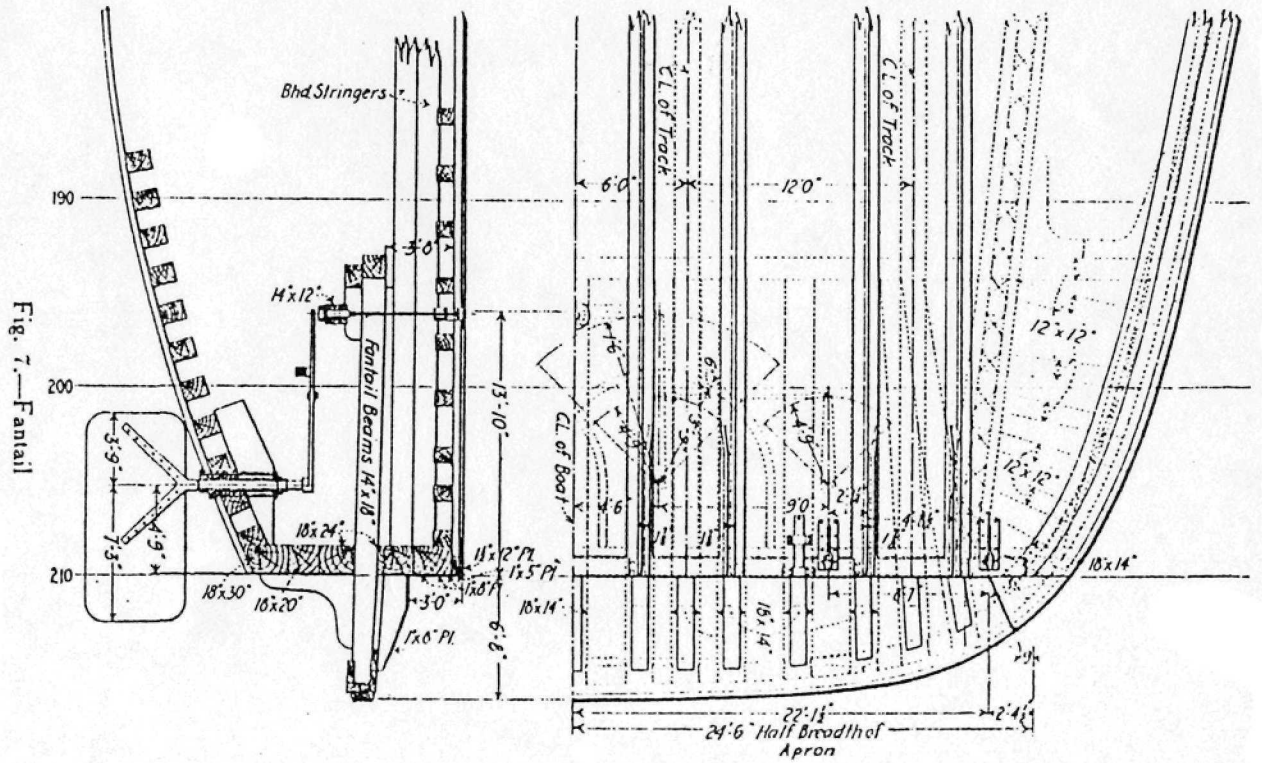

Fig. 7.—Fantail

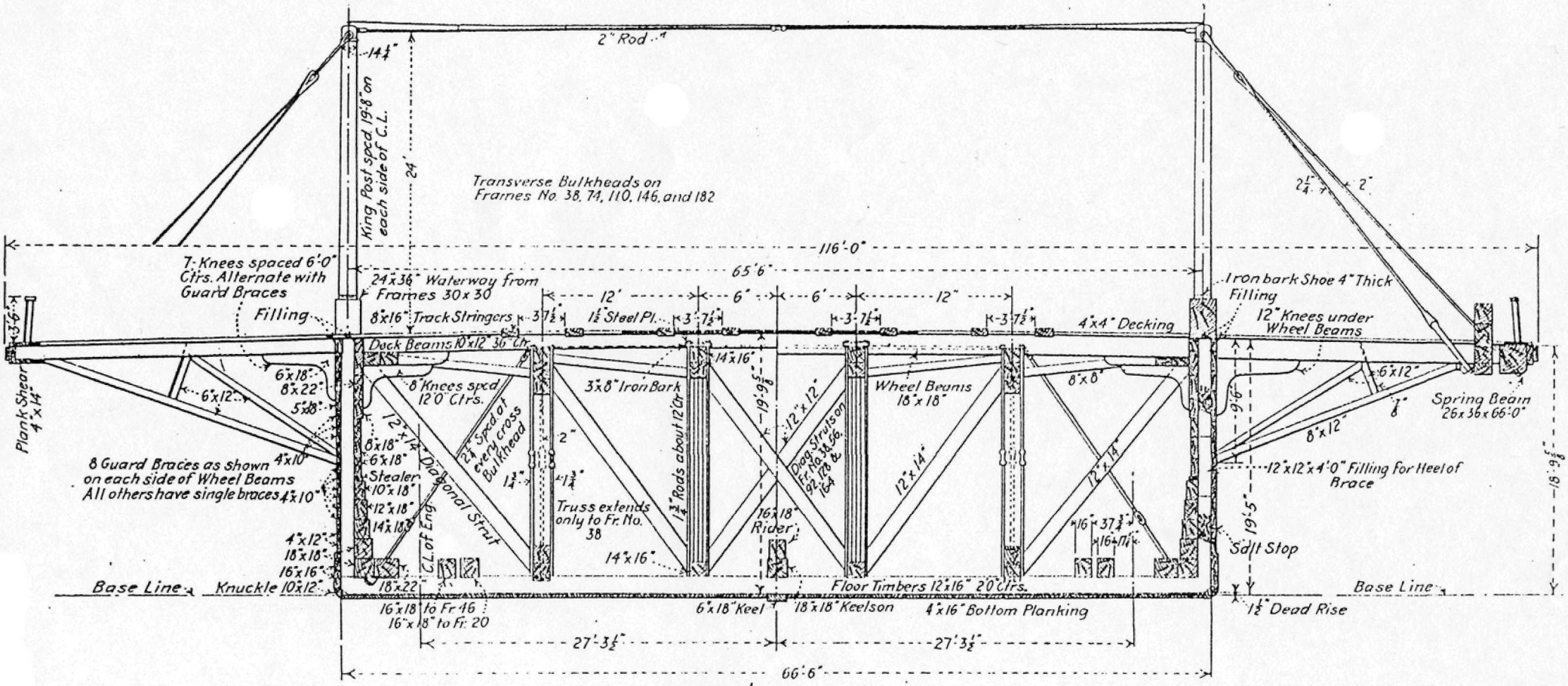

Fig. 8.—Midship Section of Contra Costa

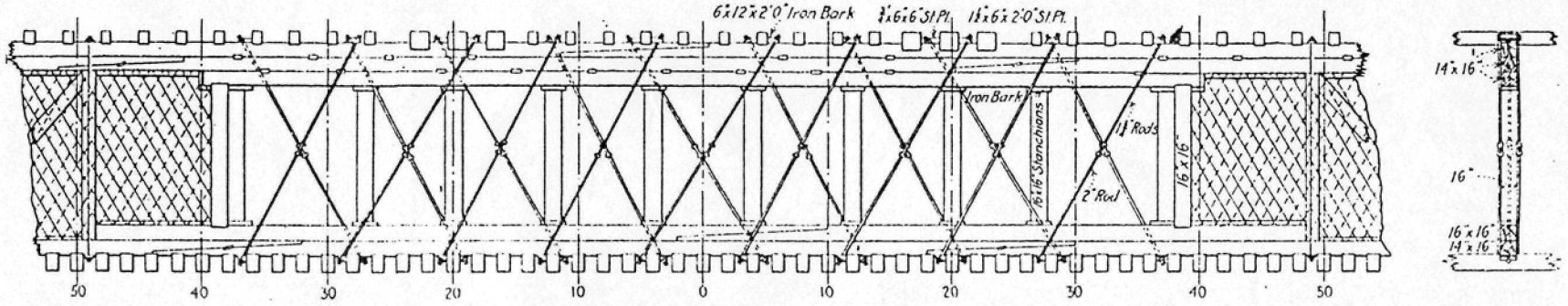

Fig. 9.—Truss in Longitudinal Bulkheads, Located 18 Feet from Centerline of the Ship

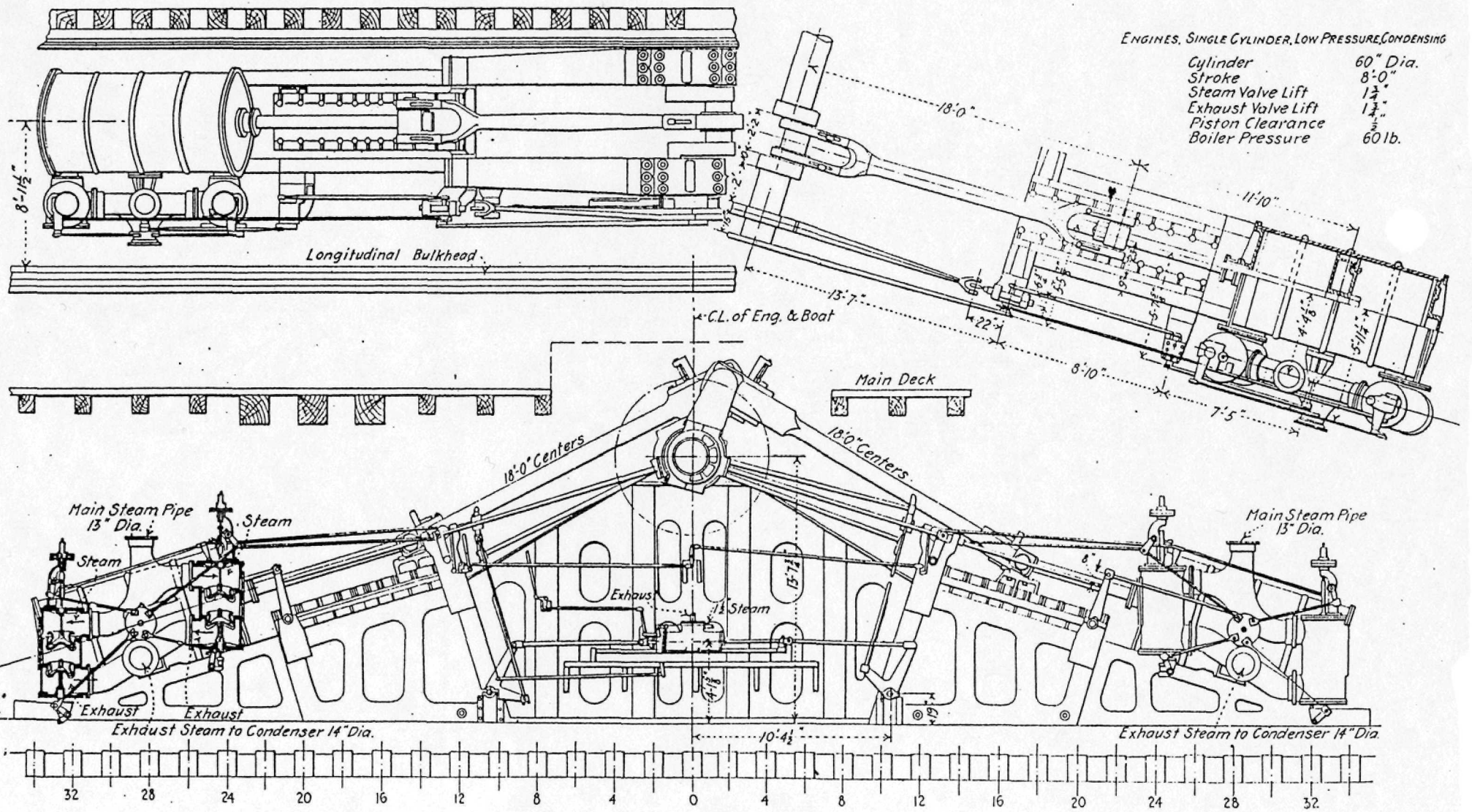

Fig. 10.—General Arrangement of Main Engines